Paolo Taticchi
Editor

Business Performance Measurement and Management

New Contexts, Themes and Challenges

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This book is written in memory of Prof. Piero Lunghi, smart academic, brilliant innovator, great friend. Moreover, it is dedicated to Manuela, which has felt the pain and joy of this project, and I thank her for her love and support.

Foreword

I am delighted to be writing the foreword to this new book on performance measurement, not least because it introduces a new generation of performance measurement scholars. It is clear from the papers contained in this book that this new generation of scholars is building on work that has gone before, but taking performance measurement in new directions. These new directions can be conceptualized in three ways – by context, by theme and by challenge.

New contexts are illustrated by the papers on measurement in small and medium sized enterprises and measurement in fast moving organizations – e.g. the motor sport industry. These two contexts have been under-researched in the past. Much of the traditional research in performance measurement has focused on large private and public sector organizations, often operating in relatively slow moving environments. To enhance this work by exploring the challenges of measurement in small and medium sized enterprises, as well as in fast moving environments is welcome.

In terms of themes – the papers in this book extend the existing research literature by exploring issues such as the link between measurement and environmental performance and between measurement and risk. Two themes that are clearly growing in prominence and that are set to have significant implications for the world in which we live.

In terms of challenge – it is particularly pleasing to see new research on the dynamics of measurement systems. An underlying theme in many of the papers is the implicit – and sometimes explicit – criticism that much of the work on measurement to date assumes a static environment. The authors of these papers are right to highlight this shortcoming and clearly nothing can be further from the truth. Organisations are complex and dynamic entities. Their operating circumstances constantly change. Feedback and feed forward loops exist within and between organizations and these loops connect different dimensions of organizational performance. Too often our frameworks for performance measurement ignore this fundamental organizational complexity.

In drawing out these contexts, themes and challenges this book not only moves our understanding of performance measurement on, but also illustrates the rich stream of future research that is required.

Congratulations to all involved in pulling this book together and to the reader – enjoy the thought provoking papers you'll find within the book.

Cranfield, UK Andy Neely

Preface

Eighteen years have passed since Eccles (1991), in the Harvard Business Review, proclaimed the "*Performance Measurement Manifesto*". That publication could be identified as a radical innovation, seeing that it created a discontinuity in the research field evolution, based on decision to shift from treating financial figures as the foundation for performance measurement to treating them as one among a broader set of measures.

From then on, we attended the birth of many models, which tried to link strategy and operations by using performance measures, such as *The Determinants and Results Framework* (Fitzgerald et al., 1991), *The Balanced Scorecard* (Kaplan and Norton, 1992), *The Cambridge Performance Measurement Process* (Neely et al., 1996), *The Consistent Performance Measurement System* (Flapper et al., 1996), *The Integrated Performance Measurement System* (Bititci et al., 1997), *The Comparative Business Scorecard* (Kanji, 1998), *The Manufacturing System Design Decomposition – MSDD* (Cochran et al., 2001), *The Performance Prism* (Neely et al., 2001), *The EFQM Excellence Model* (EFQM, 2004), and others. In this evolution, transition from "Performance Measurement" (PM) to "Performance Measurement and Management" (PMM) is evident.

Neely et al. (2002) define "*performance measurement*" as the process of quantifying the efficiency and effectiveness of past action. Instead, a "*performance measurement and management*" system, it is a widely system, which has the role of collecting, integrating and analyzing performance measures for enhancing decision making processes, verifying strategies and creating alignment (Taticchi, 2008).

Nowadays, it is possible to affirm that PMM is a new consolidated discipline, that encompasses and gives more structured support to a large diversity of businesses.

Besides the traditional areas of applications, for instance production companies, service companies or public organizations, emerging research if focusing in new contexts, such as small and medium enterprises, collaborative environments and others.

Moreover, the multidisciplinarity of PMM is enlarging from the traditional perspectives of accounting, strategy and operations to new-ones, as confirmed by the growth of research exploring connections between PMM and project management, risk management, human resources management, or emerging topics as sustainability.

Finally, research on PMM is continuing its theoretical path so as to enhance the effectiveness of PMM systems and consequently their diffusion. Particular focus is given to the fulfillment of the "*knowing-doing gap"* (Cohen, 1998) which expresses the difficulty of companies in effectively translating information coming from the measurement of processes into effective tasks. As a consequence of that, emerging research focuses on the development of new PMM models, the test of traditional systems as well as the exploration of new way of measurement.

Therefore, the question "*What is next?*" in PMM research arises, and answer is needed in order to address future research and define a proper research agenda for next years.

The 1st International Summer School Piero Lunghi (*ISSPL '01*) on "Perspectives of Business Performance Management", New York – 2009, was an international event which grouped leading academics, scholars and practitioners to discuss PMM perspectives and present emerging areas of research.

This book includes a number of selected papers from the *ISSPL '01*, providing a comprehensive overview of recent advances in PMM research.

The book is organized in three sections, so as to address futures research in terms of "What is Next?" by context, by theme and by challenge.

Perugia, Italy Paolo Taticchi

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Moreover, a special thank to the chapters’ authors for their contributions and to Prof. Neely for writing the book’s foreword.

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Paolo Taticchi performs scientific research in performance measurement and management, business networks and operations sustainability. These research activities have been documented in many books, chapters, journal and conference papers.

He teaches managerial courses at both the undergraduate and graduate level, and seminars in international MBA and EMBA programs.

Moreover, Paolo Taticchi is involved in the organization of the International Master in Innovation and Business Administration of the University of Perugia, and he was the Director of the 1st International Summer School Piero Lunghi, New York 2009.

Part I
What is Next by Context: PMM in Small and Medium Enterprises

Chapter 1
Performance Measurement and Management in Smes: Discussion of Preliminar Results from an Italian Survey

Paolo Taticchi, Andrea Asfalti, and Francesco Sole

Abstract Performance measurement and management (PMM) is a topic of increasing interest both in the academic and industrial ambits. While a large number of frameworks, case studies and surveys are available for large enterprises, little research has focused on small and medium enterprises (SMEs). As a consequence of that, little knowledge exist about the SME adoption of performance measurement systems, their use of financial and not financial indicators, the benefits in terms of strategy implementation and alignment. This paper present and discuss the preliminary results obtained from a survey research carried out within Italian SMEs. Interesting remarks are highlighted in terms of PMM diffusion, best practices and benefits in SMEs.

1.1 Introduction

The interest on Performance measurement systems (PMS), defined by Neely et al. (1995) as "the set of metrics used to quantify both the efficiency and effectiveness of actions", has notably increased in the last 20 years.

Rose stated that "performance measurement is the language of progress for the organisation. It indicates where the organisation is and where it is heading. It functions as a guide to whether the organisation is en route to achieving its goals. It is also a powerful behavioural tool, since it communicates to the employee, what is important and what matters for the achievement of the organisation's goal" (Rose, 1995).

While a control role was initially given to these systems, later emphasis was placed on the effective use of PMS in performance management processes. As a consequence of that, it is important to note the evolution of PMS as performance measurement and management (PMM) tool suitable to contribute to the continuous

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improvement of performance (Neely et al., 1995), to the definition, deployment and diffusion of strategy (Kaplan and Norton, 1996), to the alignment of operations with strategic objectives, to managerial development (Garengo et al., 2005), and to organisational learning (Kueng et al., 2001).

In recent years, literature has highlighted that PMM could play an important role also in supporting managerial development in small and medium-sized enterprises (SMEs). Moreover, some researchers point out that, even if general models were applied correctly, they would be inadequate for the particular characteristics of SMEs (Taticchi et al., 2008).

In particular Barnes have highlighted that "SMEs' approach to performance measurement and management is often informal, not planned or based on a predefined model; performance measurement is introduced to solve specific problems and performance measures grow out of this process spontaneously rather than as a result of planning" (Barnes et al., 1998).

According to Garengo "in SMEs, planning is usually absent or limited only to the operation levels where performance is measured. In addition, performance measures usually focus on past activities. In other words, the aim is to gather information to support the control activities rather than the forecasting and planning processes" (Garengo et al., 2005).

Consequently, SMEs do not take advantage of the implementation of the PMM as a holistic tool aimed to plan strategy and to establish strong linkages from strategy to operations.

However, there is a lack of survey-based investigations of the current practices related to the implementation and use of PMM in SMEs. In order to fill this gap, an exploratory survey research has been carried out in 2009 aimed to investigate the characteristics of the PMM practices in the Italian SME context.

The goal of the research presented here is to contribute to a better understanding of the adoption and use of PMM in SMEs, with specific attention to the presence of a PMM system in these companies, the use of performance indicators, the design of the PMM system. The level of satisfaction expressed by the managers about the PMM they have implemented.

The remainder of this paper is organized in four sections. First, the research methodology is presented and the main research phases described. Second, the structure of the questionnaire is analysed making reference to the five sections it is composed. Third, the survey's results are explained and finally some conclusions are summarized.

1.2 Research Methodology

The research methodology at the base of this paper relies on the work of Forza (2002), which provides the guidelines for conducting survey research in the field of operations management and related topics.

First of all, Forza (2002) classifies the different typologies of survey research as "exploratory survey research", "theory testing research" and "descriptive survey research”. Based on the different definitions, this work can be classified as “exploratory survey research”, since the main objective of gaining preliminary insights on the topic of performance measurement and management in the SME context.

Moreover, while “theory testing” is not part of this work, “descriptive survey research” fits partially in the scope of the survey, since the willing of exploring the diffusion of performance measurement and management systems within SMEs.

The choice of using “exploratory research” is justified by fact that performance measurement and management is not yet a consolidate theory such as manufacturing strategy or quality management, and therefore exploratory research is needed. In the case of “exploratory survey research”, the guidelines suggested by Forza (2002) are an adaptation of Pinsonneault and Kraemer (1993) work.

Particularly, it is highlighted the need of describing and justifying the following: unit of analysis, respondents, research hypotheses, representativeness of sample frame, representativeness of the sample and sample size, pre-test of questionnaire, response rate and data collection method. Remarks on the mentioned aspects are presented ahead.

The survey unit of analysis is the company as overall (the same unit will be used for interpreting the results). Consequently, since the company can not give answers, the respondent of the survey is identified in a person working in the company.

Particularly, in order to select the proper respondents for the questionnaire, entrepreneurs, plant directors, financial managers and quality managers have been identified as the people knowledgeable about PMM facts. Since the exploratory nature of the survey, hypotheses have not been formulated as not necessary.

Regarding the population frame, sample and sample size the survey focuses on SMEs as defined by the European legislation. Particularly, the survey is not sector dependent and the planned number of respondents for the exploratory study is fixed in 100. To date, 27 questionnaires have been compiled after 50 companies were contacted.

Regarding the data collection methodology, the authors asked respondents to visit a website (www.knowledgeasset.org/CVM/PMI) where the questionnaire could be filled while an assistant supported the respondent in the explanation of questions and questionnaire fulfillment over the telephone.

Such a solution has advantages in terms of costs and resource employment; and, at the same time, offers advantages in terms of data collection and analysis.

In fact, the fulfillment of the electronic questionnaire records data in an access database, from which a dedicated matlab application extracts automatically data and plots graphs and results of analyses.

The questionnaire wording (measurement instrument) relies on closed questions with nominal scaling (multiple choice items).

In order to increase the probability of the success of data collection, as indicated by Forza (2002), the protocol to be followed in approaching sampling units and administering the questionnaire has been developed and two scholars have been carefully trained on it.

Moreover, a pilot test of the questionnaire has been done through its submission to a target respondent. Such a test highlighted a good design of the survey as well as an excessive length for fulfillment. As a consequence of that, that authors went over the questionnaire and cut it of about 20%.

1.3 Structure of the Questionnaire

The questionnaire used for the survey is structured in five sections.

Section 1 is composed by the respondents and company contacts, company sector of business (ATECO code), company number of employees and turnover, market information.

Section 2 is composed by questions related to the presence of a PMM system in the company, the use of performance indicators, the implementation of the project in terms of reference frameworks used and problematic experienced.

Sections three refers to the design of the PMM system. A first group of questions focuses on the understanding of the company strategy definition and implementation. Particularly, the company strategy is defined through the SME's Strategic Box (Fig. 1.1) proposed by Lunghi and Taticchi (2007), which has been developed starting from the Ansoff Matrix (Ansoff, 1957) and from the adaptation, accomplished by D'Amboise and Muldowney (1988) of Porter model to be applied in the SME's contest.

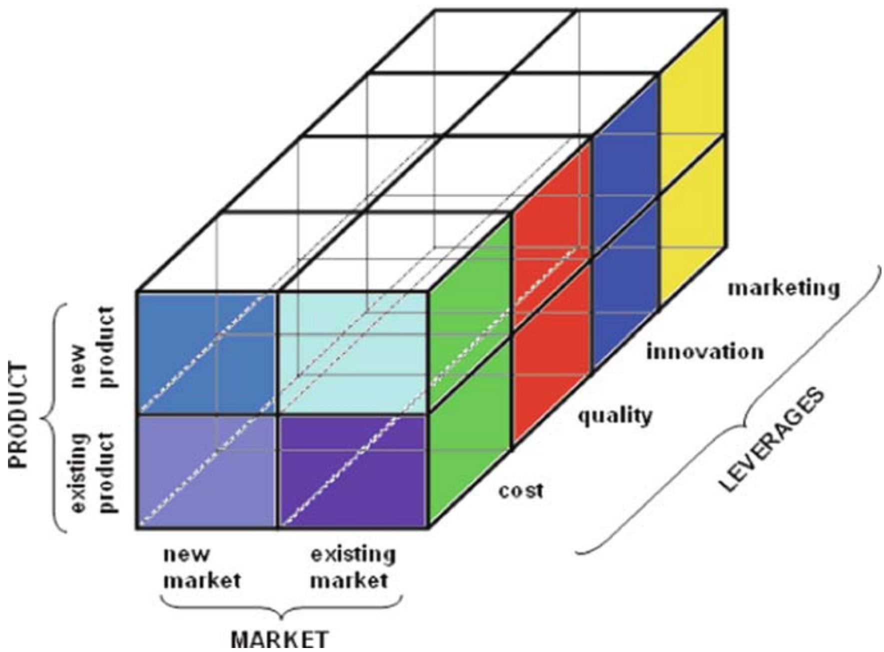

Fig. 1.1 Smes strategic box

Each strategy, available for a company to be pursued, is represented by a "little cube" in the Strategic Box. The building of SME's Strategic Box is based on the idea that, for SMEs, two parameters are needed in order to completely identify a strategy, respectively a "*positioning choice*" and a "*strategic leverage*".

Positioning choices concern the market and the product. In these two fields SMEs can be considered as "Master of the Game". This status implies that they can adopt, during their decision making process, a proactive approach instead of a simple reactive approach based on the choices made by other larger companies.

The third dimension (Martinez and Bititci, 2001) of the Strategic Box allows to evolve from the Ansoff model. The following Strategic Leverages are indeed considered:

- *Cost:* reduction of total costs related to the transformation and sale of product/service;
- *Quality:* enhance the quality level of the product/service by modifying the main product's features;
- *Innovation:* innovate products, production processes and services;
- *Marketing:* improve the perception for customers of company's brand.

The mix of Positioning choices and Strategic Leverages utilised by a company allows to identify 16 different typology of strategies that are therefore properly identified through the questionnaire.

Thereafter, the remaining questions of Section 3 focus on exploring PMM practices in terms of informatics systems, costs, stakeholders, planning, benchmarking, communication and alignment actions. Such information is essential to evaluate the integration and effectiveness of the PMM system, as highlighted by Taticchi and Balachandran (2008).

Section 4, the largest of the questionnaire, explore the use of performance indicators with reference to stakeholders, processes and capabilities available. SMEs' stakeholders have been identified in suppliers, customers, shareholders, legislators, partners and employees (Taticchi, 2008). SMEs' processes have been classified based on the the value chain representation of Porter (1985): logistics, operations, marketing & sales, service, procurement, technology development, human resource management, firm infrastructure and value creation. Capabilities affecting performances have been classified in IT capabilities and HR capabilities (Taticchi, 2008).

Finally, Section 5 poses a number of questions regarding PMM system effectiveness, benefits and satisfaction by using a Likert (1932) scale.

1.4 Results of the Survey

As before mentioned, the objective of this survey is to investigate the current practice about performance measurement and management systems in SMEs. The population frame was taken from the Chamber of Commerce database and we used ATECO code to identify SMEs operating both in manufacturing and service sectors.

Using a random sampling process, 50 organizations were targeted and 27 companies have participated in the survey. In the following table (Table 1.1) the most significative survey results are shown gathered in four sections (the data of the first section are not reported due to privacy issues).

Table 1.1 Survey's results

Section 2	*YES(%)*	*NO(%)*
Has your company implemented a structured PMS?	11	89
Has your company implemented Key Performance Indicators (KPIs)?	52	48
Section 3	*YES(%)*	*NO(%)*
Has your company implemented a business strategy?	89	11
Is your strategy focused on a new market?	75	25
Is your strategy focused on an existing market?	58	42
Is your strategy based on a new product?	38	62
Is your strategy based on an existing product?	71	29
Is the price a key factor of your competitiveness?	29	71
Is the quality a key factor of your competitiveness?	92	8
Is the innovation a key factor of your competitiveness?	46	54
Is the marketing a key factor of your competitiveness?	42	58
Has your company implemented a sistematic KPIs review process?	42	58
Has your company implemented a performance reporting system?	38	62
Are performance objectives linked to a rewards system?	42	58
Are strategic performance objectives communicated to all organizational levels?	63	37
Section 4	*YES(%)*	*NO(%)*
Have you defined customers' KPIs?	83	17
Have you defined suppliers' KPIs?	62	38
Have you defined investors' KPIs?	4	96
Have you defined employees' KPIs?	29	71
Have you defined partners' KPIs?	13	87
Have you defined legislators' KPIs?	4	96
Have you defined KPIs for logistics?	81	19
Have you defined KPIs for operations?	89	11
Have you defined KPIs for marketing and sales?	70	30
Have you defined KPIs for service?	56	44
Have you defined KPIs for procurement?	85	15
Have you defined KPIs for R&D?	56	44
Have you defined KPIs for Human Resource management?	63	37
Have you defined KPIs for firm infrastructure?	67	33
Have you defined KPIs for financial value creation?	85	15

Table 1.1 (continued)

Section 5	1(%)	2(%)	3(%)	4(%)	5(%)
On a scale of 1–5, how is important for your company a PMS? (1 = not important; 5 = very important)	4	0	22	41	33
On a scale of 1–5, what is your level of satisfaction about the actual PMS of your company? (1 = not satisfied; 5 = very satisfied)	0	11	44	26	19

The results of Section 2, related to the presence of a PMM system in the company, highlight that only 11% of SMEs have implemented a structured PMS but 52% of them use key performance indicators (KPIs).

This suggests that there are substantial barriers to structured PMS development and implementation in SMEs.

The results of Section 3 related to the characteristics of the company strategy show that 89% of SMEs have implemented a business strategy which is focused more on a new market (75%) than on an existing market (58%).

The answers of the managers highlight that some SMEs are implementing a strategy focused both on a new market and an existing market. Otherwise 71% of companies have based the strategy on an existing product and only 38% have developed a new product.

About the key factors of their competitiveness, the results reveal that quality is the most important (92%) then innovation (46%), marketing (42%) and price (29%). The other results of Section 3 strictly linked to the practice of performance management point out that only 42% of companies have implemented a sistematic KPIs review process and only 38% have developed a performance reporting system.

The data suggest that a lot of SMEs have KPIs which are not used in an effective way. Finally the results of Section 3 highlight that 63% of SMEs communicate the strategic performance objectives to all levels of the organization and 42% of them have linked the rewards system to the performance objectives agreed on.

The more interesting results of Section 4 are relating to the use of performance indicators with reference to stakeholders and processes. The table shows that most used KPIs about stakeholders are focused on customers (83%) and suppliers (62%), while only 29% of companies have implemented KPIs related to employees.

Very few SMEs have adopted KPIs aimed to analyze the performances related to investors (4%) and legislators (4%). In this case the results suggest that SMEs focus the attention on the stakeholders strictly connected to the revenues dimension (customers) and cost and quality dimensions (suppliers).

Finally, the answers of the managers about the use of KPIs aimed to investigate the performance of the processes shown in Porter's value chain, highlight that all the processes are monitored.

In particular 89% of companies have implemented KPIs for operations, then 85% for procurement and financial value creation, 81% for logistics, 70% for marketing and sales and 67% for firm infrastructure. The human resource management process is monitored by 63% of SMEs while service process and research and development (R&D) by 56% of companies.

The results of the last section (Section 5) point out that the managers evaluate the PMS as an important tool in order to correctly manage company's performance and at the same time they are satisfied about the actual PMS currently implemented, even if, as we know, it is not a structured PMS.

1.5 Conclusions

This paper has presented the results of an exploratory survey research aimed to investigate performance measurement and management best practices within the SME context. Substantial barriers to structured PMS development and implementation in SMEs have been highlighted, while the use of KPIs is today quite popular. Moreover, assessment procedures and structured reporting find little space as well. Interesting results arose in terms of performance measurement versus stakeholders, where customers and suppliers receive large attention, while the contraire happens for company employees. The measurement of processes is definitely developed, and operations represent the process most controlled.

Finally, companies' owners and managers consider PMS essential tools to drive businesses, and declare to be satisfied about the effectiveness of their today systems.

Such a consideration, in relation to the poor structure of PMS available today in SMEs, opens the need of future research in this field, as well as big margins for PMS effectiveness improvement in such a context.

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Chapter 2
New Integrated Information Systems and Management Control Change in Small and Medium Enterprises

Maria Pia Maraghini

Abstract This research attempts to explore the process of change and to examine in more depth the nature of the changes in management control which accompany the adoption of the new information technologies within small and medium enterprises. In particular, recognizing that management control change is a continuous organizational process (rather than an outcome), the trajectory of which is shaped by an incessant inter-play of several influences, this research intends to explore the way in which the implementation of a new integrated information system contributes to this process. To address this issue, the current research combines theoretical and empirical insights. After having reviewed the literature on the main topics and produced a theoretical understanding to illuminate the nature of the aforementioned changes, the research relies upon an illustrative case study concerning a medium-size cooperative society based in Italy. Recognising the complexity of organizational life, the field study does not aspire to isolate and define how and by how much ICT has been a driver of the management control change, but rather to explore the whole process of change in order to appreciate the diversity of interrelated influences which have shaped its trajectory and how these influences interacted with each-other. Among this inter-play of influences, the study aims then to investigate the particular role played by the two-way relationship between ICT and management control. The implementation of the new integrated information system has opened up several opportunities for the business management and in particular for the management control. However, so far, only part of these opportunities have been exploited. Furthermore, while it could be acknowledged that the new system facilitated the changes in management control both in its material and immaterial dimensions, it could not be concluded that they were the result of the implementation of the new system. Many other factors have interacted within the process of management control change. For example, of paramount importance has been the controller's determination to enact the change. The case study analyzes

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these factors and the way in which they have jointly facilitated and/or hindered the management control change.

2.1 Introduction

Management control in Small and Medium Enterprises (SMEs) is usually very simple: unstructured, centralized upon the entrepreneur and generally based on “historical information”.

However, nowadays several factors are pushing SMEs towards the adoption of more sophisticated (or structured at least) management control systems.

Above all, the globalization of the markets and the consequent increased competition, the context instability and the SMEs’ often severe financial situation lead to the need for much more information (and more efficient – i.e. reliable and quick) for the enterprise management.

Furthermore, some specific requests to adopt more sophisticated management control practices are now coming from the institutional context (requests which sometimes become obligations – i.e.: Basel II). Several more generic calls have also been made by public officers in charge of economic development, trade associations and professional bodies, and also by academics. In this sense, in the last few years particularly vigorous has been the push made by the consultants and software houses which try to persuade firms of the need for more control in order to sell their services and/or computer packages to management.

But is management control in SMEs actually changing? And, if so, how (what is the nature of the change) and by how much? Who or what leads the change? In particular, what is the contribution of the implementation of the new Information and Communication Technologies (ICT), especially integrated information systems?

The numbers of adopters of these ICT solutions among SMEs (mainly medium enterprises) is increasing rapidly. The reasons for implementing a new integrated information system in a SME are various (economic, technical, strategic and/or institutional reasons).

Despite the numerous arguments that could jointly explain the decision to adopt a new integrated information system within a SME, the roots of such decisions seldom reside in management control.

Although the new integrated information systems are not primarily designed to facilitate management control, it does not mean that they have no significant implications for the latter. Many changes could be expected due to increased integration of the business information flows and consequently easier and faster access to operational data (for example, see Johnson and Kaplan, 1987; Henson, 1997; Anastas, 1997; Wagle, 1998; Cooper and Kaplan, 1998; Sutton, 2000; Chapman and Chua, 2000; Quattrone and Hopper, 2000). Also, it is a common practice that when major scale changes are carried out regarding information systems, the logic of accounting and control also becomes a subject of evaluation and possible change.

However, so far there exists little published scientific evidence on the actual manifestation of these changes. After several calls to study the interrelationship between accounting and information technology (for example, Chapman and Chua, 2000; Hunton, 2002), in the last few years some experimental, field and analytical research has explored the effects of the new ICT systems on management accounting and management accountant's work (for example see: Fahy and Lynch, 1999; Maccarone, 2000; Booth et al., 2000; Beretta, 2001; Granlund and Malmi, 2002; Caglio, 2003; Hyvönen, 2003, Scapens and Jazayery, 2003). However, these studies seldom focus on management control, especially in SMEs: the effects of the adoption of the new integrated information systems (mainly enterprise resource planning systems – ERPs) are usually studied within multinational organizations or large companies at least (Caglio, 2003, provides a longitudinal case study of a medium-sized company which explores the change in accountants' expertise and role). On the other hand, it is also a fact that so far only large firms have experience of these systems for a relatively long time period: few SMEs have adopted a new integrated information system and most of the implementation projects still tend to be ongoing. We felt, however, that now is the right time to study these issues, as the actual developments in the firms can be observed. We are thus not forced to rely on accounts of what happened a long time after the fact (Granlund and Malmi, 2002).

Recognizing that, this study focuses on two different research questions:

- How does the process of implementing new ICT, especially integrated information systems, affect and is affected by management control change?
- What is the impact of the new integrated information systems upon traditional control methods, systems, practices, tasks, organization and role?

2.2 Background

The theoretical framework that informed our research combines the so-called "structurational model of technology" (Orlikowski, 1992) and its "practice-based extension" (Orlikowski, 2000) for analyzing the nature and role of technology in organizations, with the institutional framework provided by Burns and Scapens (2000) for studying processes of change (and particularly management accounting change). Both of these frameworks refer to the fundamental contribution of structuration theory (Giddens, 1976, 1979, 1984).

In particular, in the context of our study, we look at ICT as *one* of the factors that could affect (and which is affected by) the continuous process of management control change. More specifically, we recognize management control systems and practices as organizational rules, roles and routines that encode the existing institutions within the organization (see also Scapens, 1994; Busco, et al., 2001). The adoption of new information and communication technologies can lead to a change of these rules, roles and routines. If it actually does modify them, how and with what *magnitude* is neither predictable a priori, nor generalizable. It depends on many disparate factors which are different, not only from one company to another, but also within the same organization if we consider two different points in time. Furthermore, these various factors interact with each other in a continuous, dynamic and dialectical process which make it very difficult, if not impossible, to agree on what has determined the trajectory of change and to what degree.

Recognising the complexity of organizational life, our research does not aspire to isolate and define how and by how much ICT has been a *driver* of the management control change, but rather to explore the whole process of change in order to appreciate the diversity of interrelated influences which have shaped its trajectory and how these influences interact with each-other. Among this inter-play of influences, we propose to investigate the particular role played by the two-way relationship between ICT and management control (we speak about a two-way relationship because ICT can both shape and be shaped by the management control).

More specifically, two main aims are central to this research: first, to produce a theoretical understanding to illuminate the nature of the aforementioned changes; second to provide detailed empirical evidence of such a change process by means of an interpretative longitudinal case study.

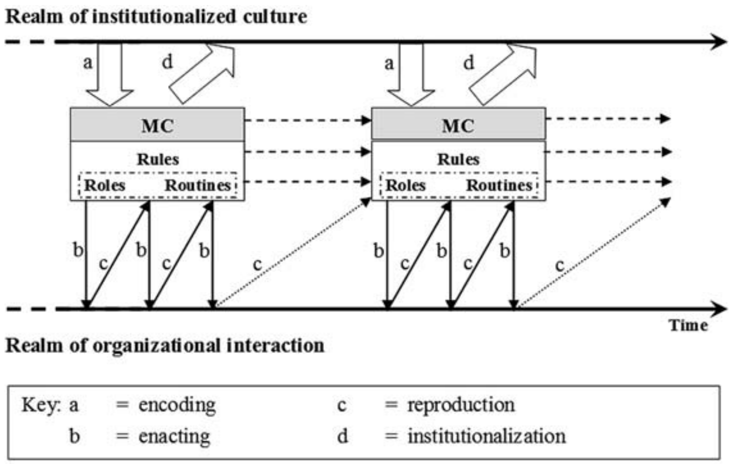
2.3 Theoretical Foundations: Conceptualizing the Role of ICT in the Management Control Change Process

For understanding the nature and role of ICT and management control in organizations we refer to the fundamental contribution of structuration theory (Giddens, 1976, 1979, 1984).

The usefulness of structuration theory in studying management accounting, and hence management control, has already been explored by Macintosh and Scapens (1990) who argued that management accounting can be theorized as modalities of structuration in each of the three dimensions of signification, domination and legitimation. The same has been done by Orlikowski (1992) with reference to technology in general and by Caglio (2003) with regard to ICT in particular (specifically ERPs).

Hence, recognizing that human activities (action) and institutions which structure these activities are not independent (as there is a *duality* between action and institutions), we identify ICT and management control as modalities of structuration. As such, they can both shape and be shaped by the human action and the institutions which govern organizational activity.

However, as noted by Archer (1995) structuration theory, since it does not incorporate historical time, is not particularly helpful for exploring process of change. Recognizing that, Barley and Tolbert (1997), starting from structuration theory, explored the relationship between agency and structure over time, and then outlined a framework describing the process of institutionalization. Afterwards, Burns and Scapens (2000) modified the Barley and Tolbert's framework to develop an institutional framework for studying management accounting change (Fig. 2.1). We will apply their institutional framework to explain some of our observations. This framework has been demonstrated to offer a credible and intelligible basis for the analysis and explanation of the forces that may drive accounting change and continuity (see Granlund, 2001; Busco et al., 2001).



Source: adapted from Burns and Scapens (2000)

Fig. 2.1 Institutional framework

On the other hand, as regards technology, Orlikowski (2000) proposed an extension to the structurational perspective in order to study the ongoing use and change of technology in the workplace ("a practice lens for studying technology in organizations"). Starting from the "practice-based extension to the structurational model of technology" (Orlikowski, 2000), the Fig. 2.2 sketch a theoretical framework for studying the process of ICT change within organizations and its fundamental characteristics

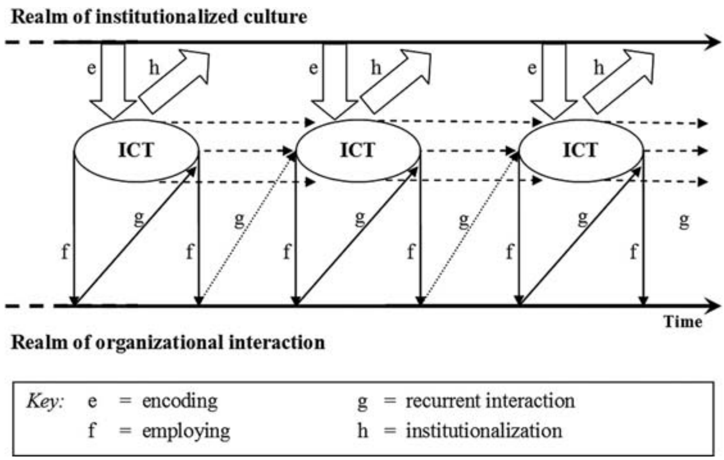


Fig. 2.2 Theoretical framework for ICT process analysis

The next section of the study will extend these perspectives to propose a model which aims to provide a better understanding of the relationship between ICT and management control processes of change.

2.3.1 Institutional Framework for Studying the Relationship Between Management Control and ICT Processes of Change

The two processes of ICT and management control change within an organization are closely linked and each influences the other in various ways in a continuous and dialectical process through time, as diagrammatically shown in Fig. 2.3.

Unfortunately, paper is not three-dimensional. So, in order to show all the linkages in a comprehensible way, we have drawn the two processes of management control and ICT change and their interrelationships sequentially. However, we are aware – and we want to underline – the possibility that squared boxes and ovals in Fig. 2.3 could be (and usually are) overlapped and the different processes and their respective influences take place at the same time.

The Fig. 2.3 combines elements from Figs. 2.1 and 2.2. Thus, we refer to the explanation of these figures for elucidations about the individual components of the scheme. What we want to do now, instead, is to draw attention to the relationships which exist between the two processes of ICT and management control change.

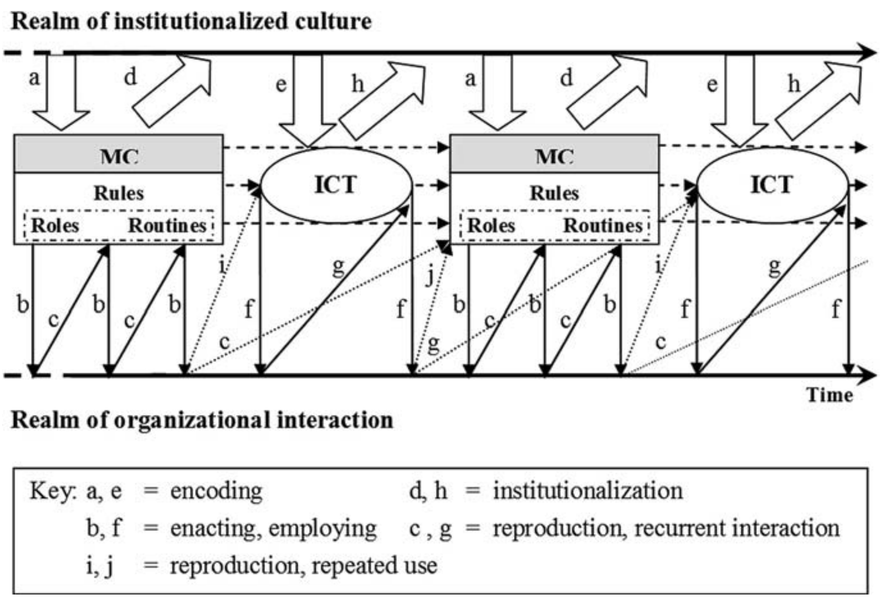


Fig. 2.3 Realm of organizational interaction

Relationships which could be various, which could have different directions and which are difficult – and even impossible – to distinguish from one another: each of them influences the other and often overlap. However, in order to have a better comprehension of the connections between ICT and management control change processes, and purely for analytical purposes, we will analyze all these relationships one by one.

We will start by studying the way in which management control and its process of change might affect ICT within an organization. However, we want to underline that this is an arbitrary starting point for our analysis: the processes of ICT and management control change are continuous and simultaneous: thus, it is impossible to define which first influences the other. Consequently, it is also important to highlight that, as for Figs. 2.2 and 2.2, there is not a beginning (neither an end) for Fig. 2.3 (except the formation and the ending of the organization itself) and that on the farthest left there could be an oval instead the squared box.

The management control and its change process could influence ICT change in a variety ways. First of all, management control could be one of the *reasons for ICT development* within an organization: new ICT solutions could be designed (and/or bought) and deployed in order to solve specific management control problems and/or to help controllers to accomplish their routine work. In effect, since the first ICT solutions were developed to be used by business organizations, management control has always been related to it: ICT is the platform for company information – which constitutes the base and the output of management control activities – and it allows certain sophisticated queries to be performed (Granlund and Mouritsen, 2003). Thus, management control often looks to ICT for help to accomplish its goals and to sustain and/or promote its change.

However, this relationship between ICT and management control, could have an opposite direction: the management control (rather than being one of the reasons for the development of ICT) could be one of the *explanations for its stability*. For example, it is sometimes the controller who hinders the adoption of new technologies because concerns on his role and power within the organization (the new technologies may facilitate a diffusion of business information, whereas before it was accessible only to the management control function) (for a case in point see Caglio, 2003).

Secondly, the management control may not only motivate the development and/or the stability of the ICT system, but may also help and/or stimulate them, in particular by way of its process of change through time. More specifically, the repeated behaviour by controllers through time might *help the development* of the ICT system as it contributes to the formation and/or reproduction of control routines. A routine behaviour is easier to standardize and ICT systems work best with standardized activities and processes. However, as described before, repeated behaviour by controllers could lead not only to a formation and/or reproduction of control routines, but can also modify them. In this case, if these routines are codified within the ICT system, it might be necessary for the ICT system itself to be modified in order to help in the execution of the new control routines. Thus, the management control change can *stimulate the development* of the ICT system.

The routinization of the controller's behaviour, on the one side can facilitate the ICT change process, but on the other side may hinder it. The adoption of a new ICT system may require certain modifications to at least of some of the previous control routines to fit the new technology. If these routines are institutionalized within the organization, they may be quite resistant to change and, thus, they could *discourage the implementation* of the new technology. But if sometimes the consolidation of control routines can inhibits the ICT development, it is also their possible failed institutionalization (i.e. their continued change through time) that might prevent it. If control routines are often modified, it may not be convenient to adopt a new ICT system for the management of control activities. Firstly, it could be difficult to codify these activities in the new system. Then, the effort to configure and implement the new system could produce advantages only for a short period of time since the continued change of control activities may soon make it incoherent with them and, hence, there could be the necessity to modify it.

Thus, the repeated behaviour of controllers through time, which contributes to a formation, reproduction and/or modification of control routines, could affect the ICT process of change in various ways and with different directions; that is, it could contribute to the development and/or the stability of the ICT system (*arrow i*).

Besides the aforementioned relationships, there are other possible ways in which the management control change process could have an effect on the composition of the ICT system and its modification and/or stability through time. First of all, management control affects the configuration of the ICT system. The extent of this influence could be various and depends on several factors; including the specific reasons for the adoption of the ICT system, and the controller's motivation and participation in the design, implementation and development process. In any event, with the exception of the eventuality that the ICT system is intentionally adopted to change the whole control system currently in use, most of the management control rules, roles and routines existing at the moment of the configuration will be embedded on the new ICT system (*dotted horizontal arrows between squared boxes and ovals in* Fig. 2.3).

Then, the management control process of change also has an indirect effect on ICT change. More specifically, it could reinforce and/or modify the organizational culture (*arrow d*) which will then shape the whole process of ICT change (*arrow e*). Also in this case, the influence might be in different directions; that is, it could create a favourable context for the development of ICT or, on the contrary, for its stability.

On the other hand, the ICT change process itself could influence the management control change process. Also here there are many possible relationships. First of all, the ICT change process could be one of the *causes of modifications* in management control: it is a common practice that when major ICT changes are implemented, the logic of accounting in general and management control in particular is a subject for evaluation and possible change (for example, see Johnson and Kaplan, 1987; Henson, 1997; Anastas, 1997; Wagle, 1998; Cooper and Kaplan, 1998; Chapman and Chua, 2000; Quattrone and Hopper, 2000). There are two main reasons for these potential modifications. In the first place because, as it is often very difficult to modify an ICT system, especially the more recent ones (e.g.: ERP systems – see Davenport, 1998), it is the organizational practices and, thus, management control, that are typically changed to fit the new technology, not *vice-versa* (Granlund and Malmi, 2002) (*dotted horizontal arrows between ovals and squared boxes in* Fig. 2.3). In the second place, the adoption of a new ICT system is a good opportunity to review the management control techniques and practices currently in use in order to make them more efficient and to exploit the opportunities offered by the ICT. In the case of ERP systems, for example, these opportunities are represented by the possibility to follow the best practices embedded in such systems and by the business process re-engineering (BPR) that usually (and hopefully) precedes their implementation.

However, it is insufficient to take a simple one-way view which sees the role of ICT as being only to support and enhance management control procedures (Granlund and Mouritsen, 2003). In effect, as ICT facilitates modern management control, it may also *limit the design and implementation* of new management control systems (see Granlund and Malmi, 2002). One possible way in which ICT processes of change could hinder the development of management control is related to the difficulties and the long project times of ICT projects. To face the several problems that frequently arise during the implementation of a new ICT system (particularly in the case of ERP systems), effort is needed from all the members of the organization whose attention, thus, is turned away from other important development initiatives (such as the adoption of new management control techniques). Another possibility is related to the complexity and/or modest quality of certain ICT applications designed to support the more sophisticated management control solutions (i.e. ABC, BSC, etc.), which could make controllers reluctant to promote the adoption of such solutions.

In addition, it is important to emphasize that the analysis of the effects of the ICT change process on management control should not be limited to simply studying whether ICT drives or delays the implementation of new control techniques. The adoption of a new ICT system might have important implications for other dimensions of management control; that is, the nature of management control, the organization of control activities, the role of controllers and his/her relationship with operating managers (for more details see Scapens and Jazayery, 2003; Caglio, 2003).

Thus, even in the relationship which links the ICT process of change to management control change, there could be both direct (as the ICT change modifies directly, for example, reporting practices) and indirect effects (as the ICT changes alter, for example, the organizational structure), each of them in different directions (that is, they could contribute to the management control development and/or stability).

Moreover, these effects could be shaped through time (*arrow j*). Even if the initial implementation of a new ICT system may have relevant impacts on management control it is after the first deployment that the major effects may be expected (the so-called temporal-lag – see Granlund and Malmi, 2002). For example, as mentioned before, through time problems linked with the adoption of a new ICT system could be solved and members of the organization could find new ways to interact with it. Hence, more attention could be paid to how to make the best use of this new system and/or to adopt new advanced control systems. Additionally, the use of ICT, especially the more recent ones, generally contribute to greater team working and more cross-functional communication and cooperation, which in turn could lead to different activities and change the role of the controller and, consequently, give rise to a need for different competencies and skills. On the other hand, by the continued use of the ICT system the actors could become used to it and the ICT system itself might be difficult to change. Thus, in order to avoid possible resistance, it could be decided not to modify the management control system if it also involves alterations on the ICT.

Furthermore, through time, the ICT process of change could have another (indirect) effect on management control change. In particular, the continued use of ICT could reinforce and/or modify the organizational culture (*arrow h*) which will then shape the whole process of management control change (*arrow a*). Also in this case, the influence might have different directions; that is, it could create a favourable context for the development of management control or, on the contrary, for its stability.

The brief analysis presented so far about ICT and management control processes of change and their potential interactions, illustrates the complexity of the relationship which links these two processes. But the complexity does not end there. The possible mutual effects of each process of change on the other, besides being numerous and with different directions (i.e. they may contribute to change and/or stability) and different time scales (i.e. they may be immediate or take time to be produced), could take place simultaneously, so they continuously determine and influence each other. For example, as discussed earlier, the existing control rules, roles and routines could affect the configuration of the ICT system (dotted horizontal arrows between squared boxes and ovals in Fig. 2.3). However as these rules, roles and routines are codified in order to be embedded in the ICT system, they could be modified themselves (dotted horizontal arrows between ovals and squared boxes in Fig. 2.3).

Furthermore, the two processes of ICT and management control change often overlap. For example, when the members of a company use ICT, and consequently they constitute, maintain or change it, they reproduce the control rules, roles and routines embedded in it, either by reinforcing them (more typically) or by transforming them (less frequently). These effects are often not consciously reflected upon by users, who are generally unaware of their role in either reaffirming or disrupting existing control rules, roles and routines. When users conform to the ICT's embedded rules, roles and routines, they unwittingly reinforce them and so sustain the institutional structures in which the technology is deployed. When users do not use the ICT as it was intended, they may undermine and sometimes transform the embedded rules, roles and routines, and hence challenge the institutional context and the strategic objectives of the ICT's creators, sponsors and implementators. Thus, the appropriation and use of ICT by the members of an organization (*arrow g*) implies a change or reinforcement of the rules, roles and routines embedded in it (*arrow c*) and, consequently, of the institutional properties of the organization (*institutional consequences of interaction with technology*) (*arrows d and h*).

Finally, the complexity of the relationship between the ICT and management control processes of change is further enhanced by the interaction of other multiple factors, which might be of both organizational and extra-organizational in nature, and which could affect all the individual elements and relationships shown on Fig. 2.3 (organizational culture, human action, ICT, management control rules, roles and routines, etc.).

All the aforementioned complexities make it difficult – and even impossible – to predict the outcome of a specific intentional attempt to introduce a change that involves ICT and/or management control (in order to put the accent on such impossibility, Quattrone and Hopper [2001] suggest replacing the concept of organizational change with the notion of "drift"). However, a recognition of all the interrelationships which form the framework depicted in Fig. 2.3, will enable those involved in the processes of change to anticipate and to be sensitive to the potentialities, the issues and the difficulties which can arise and, hence, to act in manner which exploits the synergies between the ICT and management control process of change and avoids possible problems.

Thus, the framework described above is not an attempt to reduce to simple terms the complexity of the ICT and management control processes of change. On the contrary, we want to highlight this complexity and, in the meantime, to provide a means of understanding it. Furthermore, this framework could help researchers to explain the relationships between ICT and management control processes of change in specific organizations, after they have taken place. At the same time, insights from such interpretative case studies could also be used to refine the theoretical understanding itself. Thus, detailed interpretative case studies are needed in order to comprehend the complexity of the ICT and management control processes of change. The following section is built around one such study, concerning the investigation of ICT and management control processes of change within I.V.V., an Italian medium-sized firm.

2.4 The Case Study

2.4.1 The Methodology

The empirical evidence which is used in this paper is based on an ongoing longitudinal case study of an Italian medium-sized firm.

Our contacts with the company began in November 2001, when, on the occasion of a seminar organized by the University of Siena on the theme: "*Integrated information systems for SMEs: potentialities, limits and benefits*", it was agreed about a research co-operation.

The primary method of data collection has been in-depth interviews with personnel from different levels of the organization and from various functions. In order to appreciate the evolution experienced by the ICT and the management control function during the period of our investigation, the same persons have been interviewed several times. To date, approximately 15 interviews have been conducted, mainly as unstructured or semi-structured discussions in order to minimize interviewer bias. For the same reason and also to talk in a more confidential way, the interviews were not tape-recorded.

Our data, however, are not limited to that gathered in the interviews: a large quantity of internal material has also been collected. Furthermore, our co-operation with the company is not limited to this research, it is also related to a certain amount of internal training activities. This dual role gives us wide-ranging access to the organizational setting and allows us to participate actively in the process of organizational transformation.

2.4.2 The Firm

The focus of the case study is I.V.V. – Industria Vetraria Valdarnese, an Italian medium-sized cooperative society which operates in the glassware sector (for home use and gifts) since 1952. Its workforce is composed of 140 people (of which 128 are "partners") and its sales are around 17 million Euros per year. In 2008 its profits were approximately 170,000 Euros.[1]

About two million items are produced per year; the company catalogue contains over than one thousand products (which, if we consider the possible variations of each product – some can have as many as than fifty variations! – there are nearly four thousand separate products). This makes I.V.V. one of the leaders in the glassware sector, both in the national and international markets.

2.4.3 The Adoption of a New Integrated Information System

Our research has explored the process of change that has involved ICT and the management control function in I.V.V. since the year 2000, when a new integrated information system was implemented.

The decision to adopt the new system was taken in 1997 by the top-management (Direzione Aziendale [DA], composed by the Director and the Production, Sales and Administrative Managers). Various factors jointly influenced this decision. In the opinion of the interviewees the main ones were the following:

- *Increased complexity of the business management.* Although largely artisan production, I.V.V. is a medium-sized firm which requires management to control a multitude of dimensions: millions of goods produced per year, thousands of different articles, many clients both in Italy and abroad, etc. The management

[1] The relatively low amount of I.V.V. profits is due to the particular form of the society. According to the Italian system cooperatives have some restrictions about their abilities to earn profits.

of this complexity had already induced I.V.V. to modify its previous information system in the early 1990.

- *Inadequacy of the previous information system.*

  Need to renovate the system's technology. The previous information system had been built on a rigid, Unix, environment and in a programming language which is no longer used (Cobol).

  Need to achieve a greater system flexibility. The need to manage the rigidities of the previous system had already made it necessary to support it with other computer applications but, as Paolo Casalini, the Assistant Manager of the Product Planning and the Person in Charge of the Packaging and Shipping Department, testified:

  > We bought new functionalities, but while we used them we realized that there was somethings we could not do.

  Need to achieve stronger system integration. The previous system was made up of a series of standard applications customised to the peculiarities of the business by internal employees or external consultants. However, each application was different from the others and each time a new functionality was implemented, new interfaces to integrate it with the others had to be produced. Nevertheless, as Marco Casucci, the Manager of the Data Processing Center (Centro Elaborazione Dati [CED]), remarked:

  > ... often the data passages from one computer application to an other were manually made. Obviously, the copying by hand of the information that came out from one application to put them in another one, required us a lot of time: if someone asked us 'How much are the total sales today?' we could not give him the answer in less than five days, when the information was no longer necessary.

  Need to improve the system's efficiency. The increased need of information due to the greater complexity of the business and the rigidity of the previous system, linked to the relative low number of employees in charge for the business information flow (two persons which on the half of 2002 enlarged to three) were the causes of the increased inefficiency of the CED (the office responsible for the information management). It was necessary to support the CED Office to give reliable and timely information and, moreover, to allow managers and final users to consult the database directly in order to extract the information they need.

- A relevant factor in the decision to implement a new integrated information system was the relative inadequacy of the previous legacy system to deal with the Y2K problem and the euro currency.
- But, above all, as claimed by most of the interviewees, the choice to renew the information system had been a strategic decision. In this respect, Marco Casucci, the Manager responsible for the CED Office, admitted that "*it was strategic to make the change*", because, in the words of Dino Guidelli, the Director of I.V.V.:

  > The previous system was quite simple and it would have not allowed us to develop both our internal and external business.

However, the decision to change the previous information system rapidly showed itself to be a contingent choice, rather than a strategic decision. If we consider the huge developments of the ICT and the increase in I.V.V.'s business complexity in recent years we can easily assume that the previous system would soon have been stopped working.

I.V.V. chose not to buy a pre-constituted information package (ERP) in order to protect its critical source of advantage. I.V.V. strongly believes that its business processes are unique and crucial to the success of the company. Since they did not want to change their way of doing business in order to employ an enterprise system offered by the market, the DA chose to produce a customized application: the only standard package implemented was the administrative one, which had been developed using proprietary application modules.[2]

Furthermore, it was decided to involve the final users in the configuration of the new system, even though it would require numerous discussions and, consequently, longer times for implementation. The participation of the final users in the configuration process was judged the best solution because:

- the final users know in more depth the business activities and the actual information needed; consequently, their participation ensure the efficiency of the system as well as being an important vehicle for training;
- the involvement of the final users also helps to reduce internal resistance to the new system.[3]

Thus, the DA decision was limited to the strategic management of the implementation process of the new information system (i.e. it was its responsibility to define the objectives and to supervise their achievement). The operational management of the project was the responsibility of consultants, the CED Office and all the other business functions members which took care of this on the inside of the work groups specially composed for the configuration of the system. Five groups were created: (1) Gruppo Direzione (Top-management Group); (2) Gruppo Amministrazione (Administrative Group); (3) Gruppo Commerciale (Sales Group); (4) Gruppo Produzione (Production Group); (5) Gruppo Logistica (Logistic Group). These groups can be defined as "fundamental groups". There were also several other groups which were called together from time to time to discuss particular problems (such as the Purchasing Group, etc.). Targets of the groups were to:

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[2] The choice to implement the standard administrative package is due to the peculiarity and complexity of the Italian fiscal and economic regulation and because it isn't a key process for the I.V.V. success. Using a standard solution makes it easier to revise the system for the changes which often occur in national regulations: it is the responsibility of the seller to update the system in order to follow the change in the law.

[3] Related to this, it is important to remember the particular form of the society: in a cooperative firm where more than the 90% of the employees is also partner decisions imposed by the top-management cannot be easily accepted.

- standardize the business processes and practices:
  - explain the I.V.V. business process to the consultants and to the CED members;
  - list the information needs;
  - choose/assess the validity of the solutions proposed by the CED members and the consultants;
- learn to use of the system;
- test the new system (and its modules) before deployment and, hence, demonstrate through use that employees know what they have to do and that the system could be sufficiently stable.[4]

The meetings of the work groups took place in 1998 and 1999. In the same period the modules of the new information system were produced. The deployment of the new integrated information system started on 2nd January 2000. After 3 months the whole system was operative (the implementation process is shown in Fig. 2.4).

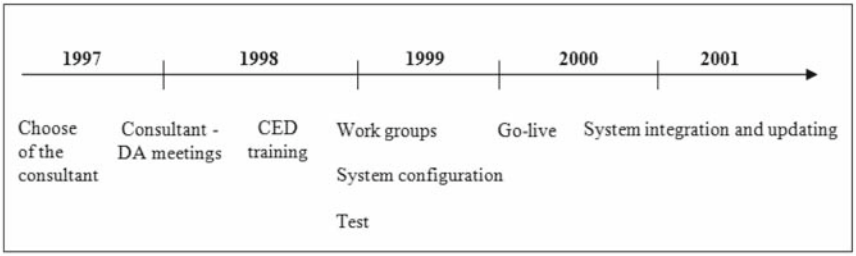

Fig. 2.4 Implementation process scheme

[4] Each group comprised a few people (the biggest one, the Production Group, had 7/8 members) and it convened one/two times a week for about 3 h (from 3:00 p.m. to 6:00 p.m.) within the span of different periods on depend the particular group. For example, developing the module to manage the bill of materials (considered the crucial factor for the company success) required about 1 year of meetings. The others were more brief. For each meeting minutes were produced. This has been important because:

- making clear and formalizing what emerged from the meetings reduced the risk of misunderstandings (some meetings had been very inflamed);
- the minutes maintain memory of the decisions taken during the meetings (often many days passed before one group got together again: it could cause the dispersion of some information);
- the minutes were always read by the DA which could ensure all decisions were coherent with the goals they had been originally fixed (if they were not, the next meeting would start with the re-discussion of these decision).

2.4.4 The Management Control Change Process

In this section of the paper we analyze the change that has been involved the management control function in I.V.V. since the beginning of 2000, when the new integrated information system was adopted. In particular, we focus on the transformations that have interested the work and the role of the controller in the broader organizational process. Thus, we use a narrow concept of management control as compared to the traditional concept, which encompasses all those practices which are primary directed to guide managers in achieving the objectives of the organization (Otley, 1994; Riccaboni and Merchant, 2001; Catturi, 2003).

Since the deployment of the new integrated information system, the management control function in I.V.V. has experienced several changes, which could be considered in part as consequences of the implementation process.

Referring to this, it has to be said that any advanced management control technique (Activity-based Management, Balanced Scorecard, etc.) has not been introduced with the new integrated information system. Furthermore, the initial configuration of the system did not include any specific functionality to support the management control function: the budget and all the reports continued to be produced using the spreadsheets developed by the controller, with the some help from the CED Office. Although the new system has not led to the introduction of new, more sophisticated management control techniques, nor to the computerization of the control tasks, there have been changes in this function.

First of all, some transformations have been a consequence of the integrated management of the organizational information flows. Before the implementation of the new system, the controller had to apply to the CED for most of the information he needed. By the 1990s such requests for information by the management control and other organizational functions had become excessive for the CED, which had difficulties meeting them. As a result, the information provided were progressively less reliable and timely. As previously described, the need to solve these problems was one of the reasons that motivated the decision to change the previous information system (but it was not the only, nor the main, reason). Thanks to the implementation of the new system, the controller is now able to directly consult the database (without asking to the CED) to extract nearly all the information he needs.

In addition, the new system provides much more information which is also now more reliable, timely, integrated and articulated. Thus, the controller can now provide more articulated budgets and more frequently reports, which are more often used by the management in taking its decisions. As testified by Paolo Casalini, the Assistant Manager of the Product Planning and Person in Charge of the Packaging and Shipping Department:

> The previous system provided only final information. So, it was impossible for us to change before negative effects had been produced. With the new system we can also do some simulations. A great progress had been made, for example, with the implementation of the module which manages the bill of materials: before that, sometimes we decided the price of our product at random!

Consequently, besides the management control techniques are formally the same, they are now substantially different and used in a different way.

Secondly, with the adoption of the new information system, and in particular as a consequence of the work groups organized for its configuration, all the business processes have been modified in order to make them simple and more efficient, and the whole organizational structure has been altered. This fact has led to a change also in the management control function and principally in the cost accounting system (84 different cost centres have been identified compared to the 19 before).

Third, the adoption of the new integrated information system has had some impacts also on the management control activities. Nevertheless, opposite to what might be expected, the new system has not eliminated any routine jobs for the controller. Although some of the controller's previous routine jobs are now carried out automatically by the new system or directly by the operating personnel, most of them have remained of his responsibility and additional others activities have taken their place. To give some examples: with the new information system some of the reports about the sales and the stock are now directly managed by the departments responsible. Furthermore, the allocation of costs among the different cost centres is largely done automatically by the system or at the time of the data input (when the operating personnel enter a cost into the system they also insert the cost centre for that cost). However, this elimination of previously routine jobs has been accompanied by an increase in other activities. In particular, during the implementation, the controller worked for months to create historical information about the new cost centres (i.e.: he had re-process many of the invoices of the previous years in order to re-allocate the relative costs). Now, the controller has to constantly check the allocations of costs (i.e. whether the input made by the operational employees is correct). Initially, until employees acquired familiarity with the new information system and the new accounting language, the controller verified all their inputs into the system, but nowadays he restricts his control to random tests.

Thus, many of the controller's previous routine activities continue to be done by him. But though he can now directly obtain the information he needs without asking the CED Office, he still has to copy information from the system to his spreadsheets and this occupies a considerable amount of the controller's time. Remember the system initially did not include any specific functionality to support the management control function. Consequently, almost all the controller's time is still spent doing routine jobs (relocation of the information from the system to the spreadsheets, checking the accuracy of the information, drawing up of the financial reports, and so on . . .).

Fourth, as mentioned before, the adoption of the new information system has contributed to another important change: by infusing "non-accountants" with a common language of accountability based on financial and non-financial metrics, it has stimulated the progressive diffusion of a new shared vocabulary based on management accounting and control knowledge. For example, having to input cost centres for every particular cost each time they register it into the system, employees have started to understand what a cost centre is and its function and, consequently, the importance of their correct data input for the firm's results.

Moreover, due to the new system, the controller can rely on more timely information which allows him to provide managers with monthly reports. Thus, every month top-managers discuss variances, ROI, ROE, and many other financial (and also non-financial) performance measures. As a consequence, at least the top-managers within I.V.V. are increasingly understanding the financial and control aspects of their own activities.

All these things have played an important role in the process of diffusion of a new language. This process, once started, continues to feed itself: beginning to understand a new language creates enthusiasm and, consequently, interest in it. Then, when a certain language starts to spread, people who do not know it feel themselves "shut out" from the business management (for example, when financial reports are discussed in the general meeting). Many employees, nowadays, would like to understand better the performance measures provided during the company's general meeting and how the business is managed (an indication of such interest is that at the last training course arranged for I.V.V. employees, the module on management control was the largest participation).

Referring to the last point, we want to underline the role played by the controller in the diffusion of the new control language. Since the initial configuration of the new system his role has been of paramount importance: he has participated in most of the work groups and he has been one of the main people responsible for creating the new "rules of the game" (identification of the cost centres, etc.). Moreover, he has played a key role also in teaching the workforce new concepts useful to the efficient use of the new system. As recognized by all the interviewees:

> Claudio [Salmeri, the controller] is an obstinate, meticulous and very competent person who strongly loves and believes in his work and puts a great effort in doing it. He is always obliging to anybody who needs his aid. Furthermore, his help doesn't stop at giving the information required, but he wants to be sure that we have completely understood all the underlying logics.

An evidence of the value of the controller's work is a report (2–3 pages long) that he monthly submits to the DA since the 2001, where he gives some interpretations to the management control data provided. Nobody ever requested to the controller to set down such document, but he decided to do so because:

> "The work I was doing was not appreciated and understood. The DA did not make use of it in taking its decisions" (Claudio Salmeri, I.V.V. controller).

Initially the report was not considered by the members of the DA to be of much importance, but as the time passed much more attention has been given to it and nowadays the controller himself is invited to take part to the DA meetings in order to explain his report.

At the beginning of 2003 something else changed in I.V.V. management control's function: some specific functionalities to support this particular function were included to the system. More specifically, two different computer applications were deployed: one for the allocation of overheads to products and one for the management of the budget system. Referring to the latter, it has to be said that the decision of implementing it was taken since 2001. However, at that time it was chosen to not adopt this particular functionality because the budget application offered by the consultant was judged as not sufficiently reliable. This application, in fact, even if included in the software package offered by the consultant, had never been tested before and the controller, in his assessment of it, found many defects. Thus, during all the year 2002, the controller, the CED responsible and the consultants have worked together in order to check and to correct these defects, to strengthen the system and to customize it.

The adoption of the new functionalities has led to a substantial reduction in the controller's routine jobs, even though much time is still spend on checking the data and information produced.

The process of management control change in I.V.V. is still ongoing. Furthermore, in the next future this process is expected to accelerate or, at least, to be more evident, as I.V.V. managers are now assessing the possibility to implement a Balanced Scorecard.

2.5 Findings and Preliminary Interpretation

The study of I.V.V. offers an insight into the complexity of the interrelationship between management control and ICT processes of change. In this case it is possible to identify many of the potential linkages between the two processes.

First of all, it has been possible to see how management control can be one of the reasons for ICT development: the new integrated information system was introduced in I.V.V. also in order to offer to the controller the more reliable, timely and articulated information he needed and to allow him to have a direct access to the information without the intermediation of the CED Office.

On the other hand, the ICT process of change itself can be one of the reasons for management control transformation: the adoption of the new integrated information system within I.V.V. has stimulated numerous changes on the management control function. The more integrated, reliable, timely and articulated information provided by the new system has allowed a greater efficiency of the function; the reform of the organizational structure has led to a modification in the cost accounting system; both these factors have also induced different reporting practices and schemes in order to gather and show new and different information. Furthermore, as described before, the adoption of the new integrated information system has also encouraged the change in the management control activities, in the role of the controller within the enterprise, as well as in the nature of management control.

Nevertheless, such changes are all of indirect nature. The implementation of the new integrated information system has had no direct impact on the management control system and practices: so far, no advanced management control technique have been adopted; furthermore, until some months ago, the new system had even not included any specific functionality to facilitate the controller to accomplish his particular tasks.

However, by the beginning of 2003 two computer applications have been included in the system in order to support the management control function. This time lag may be explained in economic terms: only once all the functionalities needed for the company to maintain its basic activities and to meet legal requirements worked well, could extra complexities be added to the system for the management of the other activities (such as management control). In that way, the ICT process of change can be viewed as one of the reasons for management control stability.

Nevertheless, if this may be a probable explanation of the time lag between the first implementation of the new integrated information system and the design and deployment of some functionalities to support the management control, it is not the only possible justification to it. The potential reasons are multiple and only considering all of them and their continuous inter-play we can really understand the causes of a certain process of change. For example, another reason which may explain the aforementioned time lag could be linked to the specific organizational culture.

When the new integrated information system was built, management control was not considered as a priority: at that time in I.V.V. there was no "control culture" (see also Catturi, 2000; Catturi and Riccaboni, 2001). Thus, it was not judged necessary jeopardize the system in the first phase adding extra functionalities to support the management control (institutional conditions of interaction with ICT: *arrow e* in Fig. 2.3).

But, since that time, the interest on management control has considerably grown, in part due to the implementation of the new information system. As just mentioned, such implementation has caused some changes in the management control rules, routines and roles (*dotted horizontal arrows between oval and squared boxes*). Furthermore, through time, the employment and continued use of the new information system by the member of the company (*arrows f and g*) has continued to stimulate the diffusion of new management control rules, routines and roles (*arrow j*). For instance, the availability of the more timely, reliable, articulated and accessible information offered by the new system has gradually stimulated the managers to meet together more often – every month – to discuss about the wider range of financial and non-financial performance measures provided them by the controller. In addition, it has enabled to produce better forecasts, facilitating a more forward-looking emphasis in the use of management control information.

However, this change has required time and it is still ongoing. As testified by the controller, even after over a year since the first implementation of the new information system, the DA did not make use of much of the management control information in taking its decisions. For this reason, starting from 2001, the controller decided to integrate his monthly report with a 2–3 pages long interpretation of the data provided. This report is one of the controller's activities which have stimulated and sustained the progressive diffusion of management control knowledge and competencies within all the company's members. These activities encompass the daily support tendered to anyone who needs his help and aimed not only to submit the information required, but also to enlighten and explain to the counterpart the logic which stand behind it.

Moreover, the progressive diffusion of such management control knowledge and competencies have also allowed, through time, the spread of a new language within

I.V.V. and a new wider and more significant role is now starting to be assigned to – and covered by – this function.

The continue enactment and reproduction of such new management control rules, routines and roles through time (*arrows b* and *c*), has led the employees and the managers to find mutually acceptable ways of working, i.e., some management control practices have become institutionalized (*arrow d*). For example, nowadays, at I.V.V., the controller is expected to draw up a monthly 2–3 report where he provides an interpretation of the management control information. Not only, he is also expected to take part in the DA monthly meetings in order to personally explain his report. Consequently, the logics underlying this practice are becoming institutionalized. The I.V.V. organizational culture and knowledge is being infused with shared metrics of performance accountability and a new control culture is now progressively affirming within all the company.

However, it is important to underline that many other factors – both internal and external – have affected and are continuing to affect the change in the I.V.V. institutional culture. Firstly, a role in this change has been also played by the new integrated information system itself. Its introduction and recurrent use by the members of the company for the execution of their tasks through time (*arrows f* and *g*) has contributed to the institutionalization of some of the rules, roles and routines embedded in it, among which are the management control ones (*arrow h*). For example, the recurrent use of the system for inputting costs, requiring workers to enter the cost centres, has helped them to know and to better understand the I.V.V. organizational structure, its cost accounting system and some of the management control logics which stand behind it, helping and reaffirming, at the same time, the diffusion of a new language based on management control terms.

Furthermore, the institutional context outside the organization has changed a lot during the last years, deeply influencing the firm: the increased competition of the East European and Asiatic countries, the changes in the distribution system, the economic recession after the 11th September 2001, the continuous variations on the euro/dollar exchange and the consequent alteration of the methane cost (the main I.V.V. cost) are all factors that have led – and that are still pushing – I.V.V. to a change of its beliefs and practices about conducting business and towards an increased attention to management control. In such a scenario, it is of paramount importance for the managers to rely on timely information about every aspect of the business in order to make well-timed and efficient decisions.

However, even after the adoption of the new integrated information system, it was difficult for the I.V.V. managers to receive this kind of information from the controller. The reproduction of the data from the system to the worksheets, their check and elaboration and the drawing up of the reports, requested him a lot of time. Consequently, it began to emerge the consciousness of the necessity to support the controller on his work. And the ICT could provide this help (*arrow i*).

Thus, at the beginning of 2003, two new functionalities were included to the information system to sustain the management control function. The decision to implement a computer application for the management of the budget had been taken at least 1 year before its actual implementation. Before adopting such functionality a great deal of work had to be done in order to make it more coherent with the I.V.V. budgeting process and, hence, to embed in it part of the existent management control rules, routines and roles (*dotted horizontal arrows between squared and oval boxes*).

The implementation of the two new functionalities represent another example of how the organizational culture may affect the ICT configuration (*arrow e*): their adoption could be interpreted also as a consequence of the diffusion of a new control culture within I.V.V.

All the aforementioned factors are still influencing the process of change on the management control function. The same influences, in fact, may explain the probable future implementation of a Balanced Scorecard and some changes that are currently taking place in the management control tasks. In particular, the introduction and continuous use of the new information system (*arrows f, g*) have progressively provided more reliable data and information. Thus, much information checking activity is no longer undertaken by the controller (only some random tests are conducted now) (*arrow j*). Then, the new functionalities recently implemented are supporting the controller in part of his routine jobs (*arrow f*). The time so saved may be assigned by the controller to provide more direct support to business managers to interpret the various financial and non-financial information with which they are faced and to assess both the operating and strategic consequences of alternative courses of action.

The increase on the relative weight of these activities (support to business managers) to detriment of the routine activities is not only a consequence of the adoption of the new computer applications. On the contrary, as mentioned before, it is especially due to the new I.V.V. institutional context (*arrow a*): the increased instability and competition that have to be faced required not only reliable and timely information about all the aspects of the business, but especially to be able to interpret them in order to made timely and efficient decisions. Thus, nowadays, I.V.V. managers are gradually turning more to the controller to ask for help to accomplish this interpretative task: a wider role for the controller is starting to emerge.

However, this particular process of change is still in its first phase: the main part of the controller's time is still devoted to accomplishing his routine tasks. Thus, although he is ready (and he hopes and would like) to cover this broader role, he is currently prevented from doing it: he does not have enough time to transform himself to "business support" or "internal business consultant" (see also Anastas, 1997; Scapens et al., 2003). Furthermore, the managers themselves need time to recognize this new figure: they still consider the controller mainly as a "bean-counter" or "score-keeper", so, they are disinclined to look to him for a support.

The case study described in this paper highlights the complexity of the relationship between ICT and management control processes of change. In particular, it shows that while the adoption of a new integrated information system within I.V.V. has facilitated changes in management control, it cannot be portrayed as the only driver of such transformation. The implementation of the new information system has only opened some opportunities. So far, only part of these opportunities have been exploited. To transform them into actual changes requires joint action of many other factors of both internal and external nature. Furthermore, it is necessary also a certain period of time in order to allow organizational members to find new mutually acceptable ways of working through a complex process of mediation.

Thus, many of the changes in management control in I.V.V., even if stimulated by the implementation of the new information system, cannot have been produced, for example, without the action of the controller who has believed in change and worked for it. However, the effort of the controller itself could have been vain if it were not sustained by the DA (about the role of the top manager in the evolution of the management control system see also: Fligstein, 1990; Euske and Riccaboni, 1999). And, at least in a first moment, it was so. But, as time went by, the aforementioned factors (recurrent use of the new information system, behaviour of the controller, etc.) jointly with other changes in the external institutional context (increased competition, economic recession, etc.) have led towards an increased attention on management control, facilitating its change.

In short, the management control change process in I.V.V. has been – and still is – the result of a continuous interplay of multiple factors of diverse nature (among which are the implementation of a new information system) and the outcome of a complex mediation between organizational members.

2.6 Conclusions

This paper seeks to offer further insight into the interrelationship between ICT and management control processes of change. Through the experience lived at I.V.V. we have had the opportunity to go into the nature of these processes of transformation and to explore them in more depth, and as a result we have developed an institutional framework to interpret *how* and *why* ICT and management control systems evolve across time.

> More specifically, there is mutual interdependence in the relationship between our theoretical framework and longitudinal fieldwork in I.V.V. While, on the one hand, the case research has contributed to our search for an institutional explanation of the evidence experienced and collected, on the other hand, the empirical data itself may be illuminated by the theoretical insights gained from the framework.

For this reason, as the research is still in progress, both the theoretical perspective and the case study will be further developed. In particular, a specific attention will be paid to trying to understand how the SMEs peculiarities and, moreover, the specific features of the cooperative firms could affect the ICT and management control processes of change.

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Part II
What is Next by Context: PMM in Collaborative Environments

Chapter 3
A Framework for Evaluating Enterprise Network Performances

Luca Cagnazzo, Lorenzo Tiacci, and Stefano Saetta

Abstract Globalization has entailed the necessity for small businesses to join skills and forces together in order to compete in the new economy. New industrial collaboration forms are evolving during last years, indicating with different degree of success the achievement of the first goal of the alliances: the competitiveness of the partners involved within. The necessity for new management methodologies for these new environments are nowadays strongly emerging. Among them, the performance measurement of the network businesses is still something not well discussed in literature. The deep understanding of the network results in terms of performance measurement is one of the most value adding activities within the collaborative environment. This article proposes an assessment of the network performances, through an auto-evaluation questionnaire submitted to the partners of a network with the Virtual Development Office (VDO) structure. First qualitative and quantitative results follow.

3.1 Introduction

In recent years the Enterprise Networks (ENs) have been considered as a solution especially, but not only, for the Small & Medium Enteprises (SMEs). The aim of the ENs are very ambitious: to increase efficiencies, reducing costs, govern the innovation process, increase the learning process. The development of ENs introduces new issues to be analyzed. One of the most relevant is that an EN, as the single companies, has to evaluate its business on respect of its performances. As a consequence of that, it is important to develop specific performance measurement frameworks to evaluate the Network Performances (NPs).

The article is structured as follows: a literature review on the topic of Business Performance Measurement and Management (BPMM) for ENs is presented; by understanding the state of art of the matter, the article presents a framework for

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evaluating NPs. The performances measurements should allow an holistic evaluation of this complex system. This framework is part of a larger research aiming to define BPMM models for ENs. As a consequence of that, this framework represents the preliminary result of this work. A questionnaire based on the framework dimensions has been furnished to the companies of a real network of 20 companies, namely Gruppo Poligrafico Tiberino (GPT), representing the case study for the research. First quantitative results from the questionnaire follow.

3.2 The Research Methodology

Although lot of material has been produced in literature about the Business Performance Measurement and Management (BPMM) for single companies (Taticchi et al., 2009), very few material is available extending the focus on Enterprise Networks (ENs). Due to the lack of academic publications on this topic, the research approach chosen by the authors has been to separately deepen the

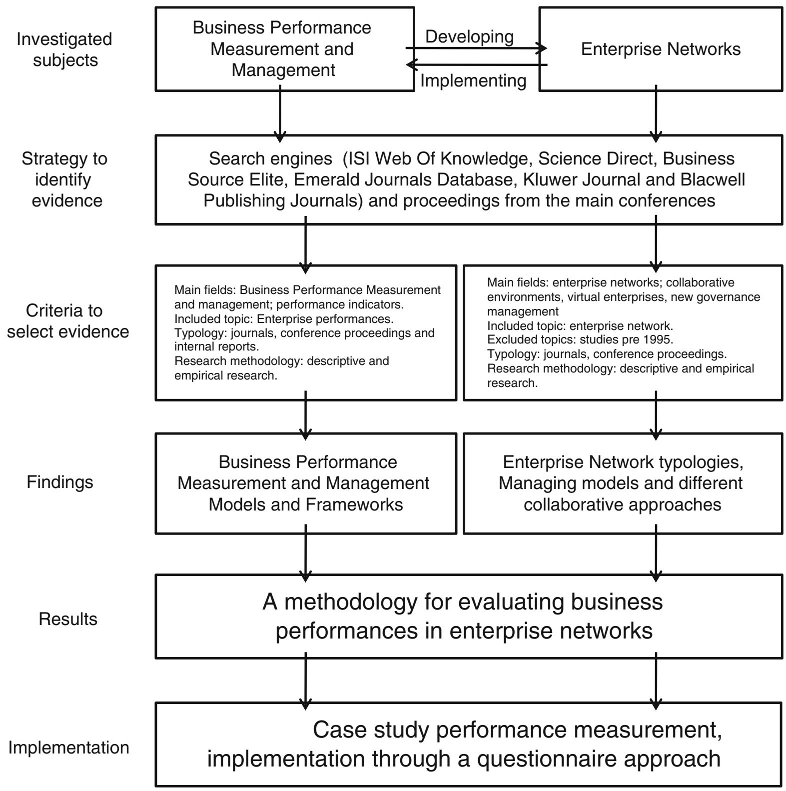

Fig. 3.1 Research methodology

knowledge on BPMM topic for single companies and on the other hand to investigate the EN environments in general. From these two different starting points, the authors have been able to identify the critical aspects of both the two worlds.

In order to review the existing body of knowledge about these two main subjects, the authors adapted the methodology proposed by Sign (2004) and Tranfield et al. (2003), as depicted in Fig. 3.1.

The investigation has been conducted for finding the articles of both the research topics in the main scientific databases, such as ISI Web of Knowledge, Science Direct and Emerald. The research is mainly extended to journal papers and conference proceedings. The findings represent the base to develop the new theory about the BPMM in ENs, as a merging of the two separated approaches. A new framework for evaluating the performance of the ENs is developed thanks to the literature investigation. Finally, a questionnaire is realized following the proposed framework dimensions; the questionnaire has been submitted to 20 companies of an EN belonging to the printing and packaging sector. The case study EN is characterized by a particular governance structure, i.e. the Virtual Development Office (VDO) (Botarelli et al., 2008), described in the fourth paragraph.

The literature review action and the main findings are discussed in the next paragraph.

3.3 Literature Review

As research findings, the authors have collected academic articles from the area of both the two investigated subjects, the Business Performance Measurement and Management (BPMM) and the Enterprise Network (EN).

Interest on BPMM has notably increased in the last 20 years. Particularly, it is important to note the evolution of focusing performance from a financial perspective to a non-financial perspective. Since the middle of 1980s, companies emphasized the growing need of controlling production business processes. Companies have understood that for competing in continuously changing environments, it is necessary to monitor and understand firm performances. Measurement has been recognized as a crucial element to improve business performance (Sharma et al., 2005). The complexity of performance measurement system (PMS) design is the explanation of the diversity of literature today available. Hundreds of works debate topics related to these subjects, numerous others focus their attention just on few aspects of the PMS design, such us the audit, the design of measures or the review-system; only a tenth of models address the problem in its entirety. From the literature available the authors picked up 25 models and frameworks that were recognized as relevant with the belief that each has different features that could be a significant contribute for PMS design. It is important to remark that such models have been developed for *large companies*. The overall list of models and frameworks analyzed is presented in Table 3.1:

Table 3.1 Main models and frameworks in literature

Name of the model/framework	Period of introduction
The ROI, ROE, ROCE and derivates	Before 80s
The Economic Value Added Model (EVA)	1980
The Activity Based Costing (ABC) – The Activity Based Management (ABM)	1988
The Strategic Measurement Analysis and Reporting Technique (SMART)	1988
The Supportive Performance Measures (SPA)	1989
The Customer Value Analysis (CVA)	1990
The Performance Measurement Questionnaire (PMQ)	1990
The Results and Determinants Framework (RDF)	1991
The Balanced Scorecard (BSC)	1992
The Service-Profit Chain (SPC)	1994
The Return on Quality Approach (ROQ)	1995
The Cambridge Performance Measurement Framework (CPMF)	1996
The Consistent Performance Measurement System (CPMS)	1996
The Integrated Performance Measurement System (IPMS)	1997
The Comparative Business Scorecard (CBS)	1998
The Integrated Performance Measurement Framework (IPMS)	1998
The Business Excellence Model (BEM)	1999
The Dynamic Performance Measurement System (DPMS)	2000
The Action-Profit Linkage Model (APL)	2001
The Manufacturing System Design Decomposition (MSDD)	2001
The Performance Prism (PP)	2001
The Performance Planning Value Chain (PPVC)	2004
The Capability Economic Value Intangible and Tangible Assets Model (CEVITAM)	2004
The Performance, Development, Growth Benchmarking System (PDGBS)	2006
The Unused Capacity Decomposition Framework (UCDF)	2007

As starting point to identify and select the most adaptable model for the scope of developing a methodology to measure performance for EN, the authors analyzed the literature in terms of article citations. The research dataset used has been constructed using the ISI Web of Science database. Every publication that contained the phrase “performance measurement” in its title, keywords or abstract has been identified and downloaded. This search identified 6,618 papers published in 546 different journals. The earliest paper included in the dataset was published in 1970 and the most recent in 2008 (Taticchi et al., 2009). The 6,618 papers included in the dataset provide some 115,547 citations, covering 88,959 works and drawing on

22,091 different lead authors.[1] The most frequently cited authors were: *R.S. (Bob) Kaplan* (552 citations), *Abraham Charnes* (271 citations), *Andy Neely* (249 citations), *Rajiv Banker* (226 citations). At a more detailed level, it is possible to explore the frequency of citations for individual pieces of work. Once again the pattern of citations is diverse, further supporting the suggestion that the field of performance measurement is immature with little consensus. Only 10 works are cited more than 30 times. As a result of this analysis, the Kaplan and Norton (1992, 1996) Balance Scorecard (BSC) is the most referred model in literature (260 citations), followed by Charnes et al. (1978) performance measurement model (135 citations), by Dixon et al. (1990) (63 citations) and Neely et al. (1992) (67 citations). The BSC approach is one of the best candidate for the scope of the article.

Regarding the second research topic, i.e. Enterprise Networks (ENs), literature is quickly growing. One of the first formal taxonomies of network associated to geographic concentration appears in the definition of industrial cluster provided by Czamanski and De Ablas (1979). Another geographically characterized network is the innovation systems (Chung, 2002). The current trend for globalization together with the advanced use of modern information and communication technology has fostered forms of collaboration between enterprises situated at geographically dispersed locations. In this situation, one of the emerging networking concepts is the extended enterprises (EE) (Jadjev and Browne, 1998); this form of collaboration is represented by the formation of mutually beneficial and formal links in terms of co-ordination in the design, development and costing between the co-operating and independent manufacturing enterprises. Particular forms of extended enterprises are the various forms of manufacturing chains, where principles of extended co-operation become more accepted by manufacturers, like supply chain (Sahin and Robinson, 2002) and value chain (Porter, 1985). Another emerging issue is the concept of Virtual Enterprise (VE), defined as a temporary organization of companies that come together to share costs and skills to address business opportunities that they could not undertake individually. Because of its dynamic features the virtual enterprise can be thought of as (Kochar and Zhang, 2002) “temporal case” of an extended enterprise. The term “virtual” derives from the fact that the enterprises involved in the VE seems to act as a single virtual entity. Other kind of network made up by a variety of entities (organizations and people) that are largely autonomous, geographically distributed and heterogeneous in terms of operative environment, culture, capital and goals is the Virtual Breeding Environment (VBE) (ECOLEAD Project, 2004). It is defined as a set of organizations and their support institutions, which participate in a long term cooperation agreement and adopt common operative principles and infrastructures, with the main aim of increasing their potentialities through the collaboration in possible VO (Virtual Organizations). The

[1] In the *Web of Science* database references are recorded using the name of the lead author. Hence the citation analysis is based only on lead authored papers. This is the reason why well-known co-authors, such as David Norton, do not appear in any of the tables.

governance structure in which the BPMM model has been applied, could generally be reported as a special case of the ECOLEAD EN model; it is explained in the next paragraph.

3.4 The Case Study Network: A Particular Structure

The Virtual Development Office (VDO) model has been developed within the Italian research project MIGEN,[2] during which the University of Perugia supported the development of an enterprise network from its first steps. The aim of the project was to define a conceptual organizational model for enterprise networks, in order to increase the competitiveness of the SMEs involved. The approach proposed is based on the creation of an independent subject, the VDO, GPT (Gruppo Poligrafico Tiberino) in the case study, which acts as a leading actor, and it has the role of creating, coordinating and managing a community of enterprises (Botarelli et al., 2008). Particularly, it should be the market intelligence of the network, continuously catching business opportunities in the market and positioning the network on it. Moreover, the VDO is the permanent interface to public institutions, financial institutions and research centres. A proactive collaboration with such subjects is a leverage factor in today business. The VDO activities presented above are "external" to the network. However, the VDO also has a crucial role inside the network life. First of all, it has the role of maintaining and consolidating the trust of companies involved in the network by generating and promoting a long-term alliance. By acting as a central player on respect of the "business ecosystem", it promotes both the willing of cooperation, both the readiness to collaborate each time a business opportunity, which for a network can be defined as a "collaboration opportunity" (CO) arises. From a value chain point of view, particularly interesting is the creation of the Virtual Enterprise (VE) or Virtual Organization (VO) for specific business opportunities, since the processes that constitute the value chain, i.e. those activities that represent the value proposition of the network and lead to customer satisfaction will be split amongst the members of the network that are participating in the collaborative opportunity. The scenario in which the first example of VDO was born is the district of paper products, printing and publishing in the Centre of Italy. Such a district, composed by over 160 enterprises, is characterized by a high technical-productive specialization due to an historical handicraft tradition in the mechanical and printing field. The competitive potential of the district is severely limited because it lacks the ability to spontaneously aggregate its activities, a situation exacerbated by the absence of leader firms capable of providing direction for the system as a whole. In this regard the Umbrian paper mill district can be

[2] MIGEN (the name comes from the Italian acronym for Innovative Models for Enterprises Network Management) is a research project supported by Italian government with the PRIN (Research Project of National Interest) program. The project involved the Universities of Perugia, Florence and Genoa and it focused on the development of specific models and tools for managing networks of enterprises.

seen to embody the problems of the Italian Small & Medium Enterprises (SME). In such a scenario, three firms (Pasqui, Litop and Litograf), characterized by a range of complementary products and by a partnership based on a solid personal knowledge of the entrepreneurs, decided to form a new company: G.P.T., acronym of "Gruppo Poligrafico Tiberino" (that will constitute what the authors introduced in the model with the concept of VDO), with the first intent of integrating the commercial and marketing functions. Since the early stage of its life, GPT perceived the need of expanding its own mission and activities. From 2005 to 2007 GPT grew from the 3 initial partners to the 20 actual members. Today, it is pushing interesting strategies for the consolidation of the Italian market and it now entering the South America and Northern Africa markets.

3.5 The Enterprise Network Balanced Scorecard

As performance measuring model, the authors adapted the classic Balance Scorecard (BSC) in the Enterprise Network Balanced Scorecard (ENBSC); as the Kaplan and Norton (1996) BSC approach, the ENBSC provides a technique to balance long-term and short-term objectives, financial and non-financial measures, leading and lagging indicators, and internal and external perspectives. The typical dimensions, i.e. customer, financial, internal business, and learning and growth, have been adapted in ENBSC to assess current state of networks' performance and evaluate the impact of initiatives in this area (Kankanhalli and Tan, 2004). In doing it, the authors adapted the classical BSC dimensions with five new measurement areas of interest, the most significantly related and influenced by the implementation of a Business Performance Measurement System (BPMS) in the collaborative environment.

The framework developed relies on five dimensions which have been identified as crucial for evaluating Network Performances (Fig. 3.2).

They are:

- Network's objective, as Fitzgerald et al. (1991) stated it can be investigate under the following two dimensions:
  - Financial Performance (McDermott, 2002; King and Ko, 2001; Laitamaki and Kordupleski, 1997);
  - Competitiveness (Holsapple and Wu, 2008);
- Cost reduction (Holsapple and Wu, 2008);
- Learning (Lee et al., 2005);
- Innovation (Johannessen, 2008; Lundvall and Nielsen, 2007; Park and Kim, 2006);
- Environment (Holt et al., 2004).

Each dimension is deeply investigated and discussed in the next sections.

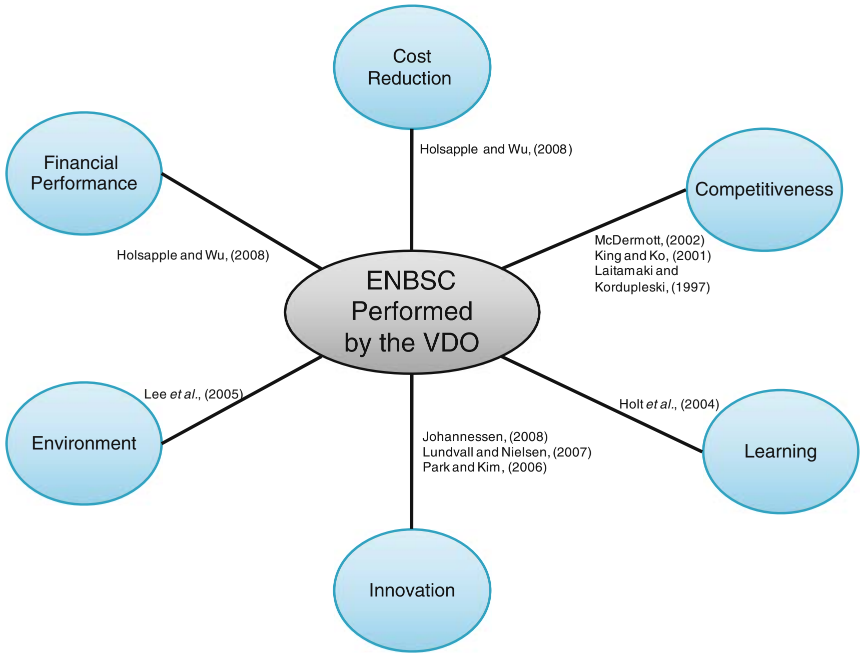

Fig. 3.2 ENBSC dimensions

3.5.1 Network's Objective

In last decades companies have become increasingly confused about corporate goals. The only goal that makes sense for companies is to earn a superior return on invested capital because that is the only goal that aligns with economic value. In addition in the case of SMEs, it's important, as "objective", the market gain and maintenance. This is strongly reflected in the network environment, mirroring the partners' objective. Therefore, the authors decided to adopt the objectives classification proposed by Fitzgerald et al. (1991), extending his vision from service sector to manufacturing sector. In particular the two dimensions identified are: financial performance and competitiveness (Fig. 3.2). Under the financial performance sub-dimension, the classical financial indicators are taken in consideration, such as ROI, ROE, ROS and EDIBTDA, evaluated in each single company of the network. Under the competitiveness dimension, a very important factor is the evaluation of the turnover created by the belonging to the network, and so developed thanks to the collaboration among partners. The voice "turnover" refers to the turnover generated by the single companies since their affiliation in the network. The "network effect" can means different things to companies, therefore it is important to analyze deeply this voice. In particular, the turnover created by the network, with reference to the single internal company, can be originated from "new customers" or from "existing customers". In this last case, the network effect is an enlargement of the turnover related to a specific customer. In the case of "new customers", a deeper analysis of turnover is yet possible: in example, it is possible to highlight if the new customer comes from a geographical market already served by the company or not. The same consideration can be done by referring to the sector of the "new customer". This dimension investigation permits important insight for understanding what the network affiliation brings effectively to the internal companies. It is possible in fact to understand if the "network effect" permits to achieve new customers, new markets or position the company offer in new sectors.

3.5.2 Cost Reduction

It is often cited in literature that enterprise networks can often lead to cost reduction for affiliated companies (Holsapple and Wu, 2008). This cost reduction can originate from different dimensions, such as the creation of network purchasing offices or the creation of specific cost reduction initiatives. Often companies affiliated to a network have special discounts in purchasing the products/services of other affiliated enterprises. Based on these considerations, authors have chosen to quantify the cost reduction effect and understand where it focuses. As a consequence of that, in the cost reduction dimension the following aspects are analyzed: cost reduction of manufacturing processes, internal processes cost reduction, product/service purchasing cost reduction, product/service commercialization cost reduction. Figure 3.3 summarizes the breakdown of the "cost reduction" dimension.

3.5.3 Learning

Similarly to humans that learn each other while grouped together, as companies do while organized in networks. Therefore, in this case, the "network effect" is a "learning effect" which in general has a positive effect on companies competitiveness. Based on these considerations, it has been chosen to quantify the learning effect and understand which areas it affects. As a consequence of that, in the learning dimension the following aspects are analyzed: increase of technological know-how related to manufacturing processes, increase of knowledge related to new product/service development, increase of knowledge of markets and customers, increase in the capability of attracting funding, knowledge circulation process. This last dimension, as suggested by Lee et al. (2005), is investigated under several subareas, such as knowledge creation, accumulation, sharing, utilization and internalization. Figure 3.4 summarizes the breakdown of the "learning" dimension.

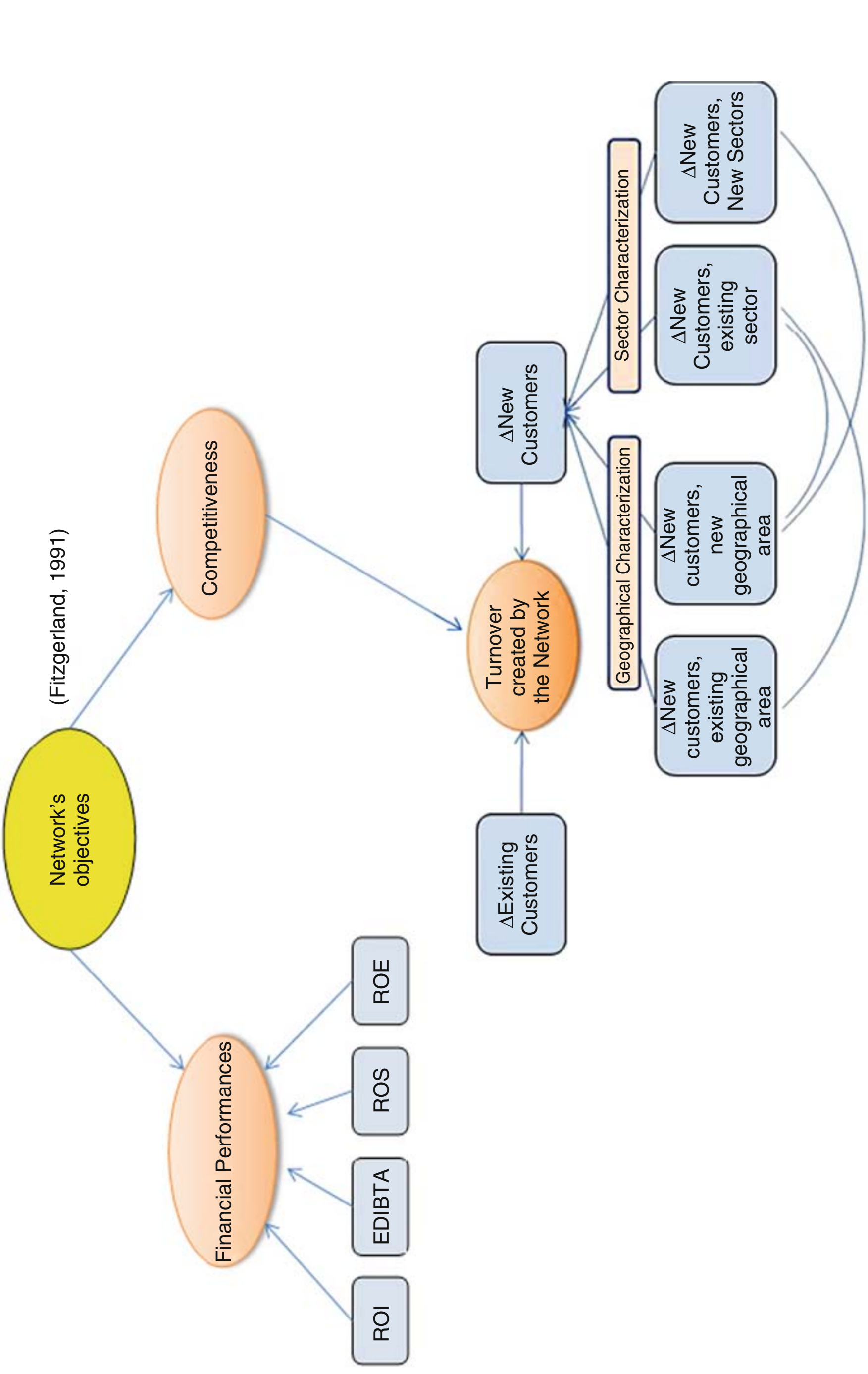

Fig. 3.3 The network's objective dimension

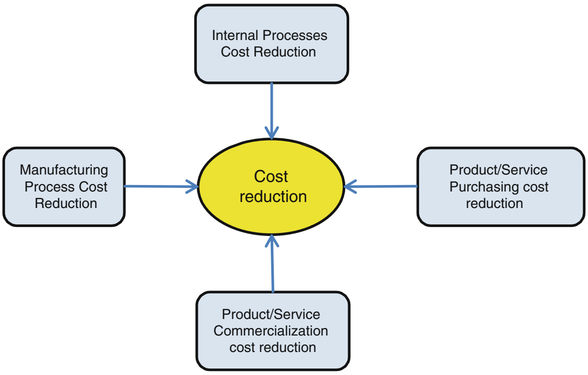

Fig. 3.4 The cost reduction dimension

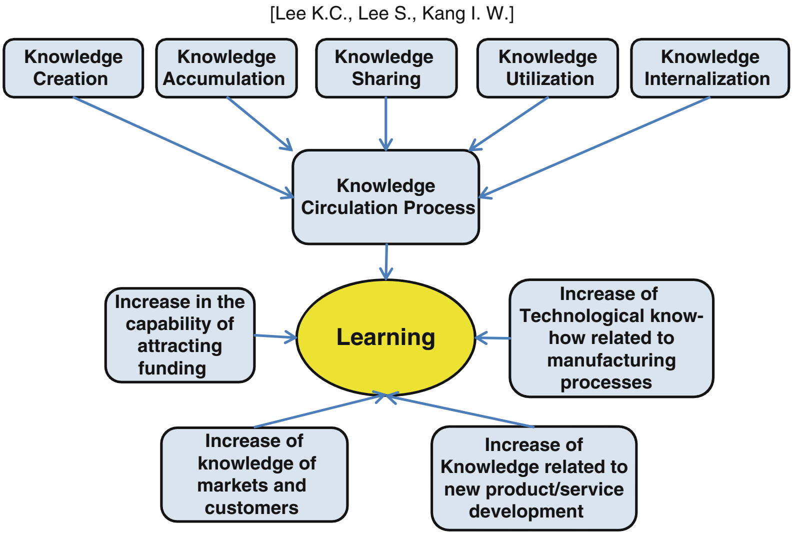

Fig. 3.5 The learning dimension

3.5.4 Innovation

Innovation is a key factor in all kind of businesses. Therefore, it should not being surprising that in literature (Johannessen, 2008; Lundvall and Nielsen, 2007; Park and Kim, 2006) innovation is one of the "network effects" more cited and attended. Within the proposed framework, authors decided to explore the innovation dimension in terms of: new products and services development, changes in business models and the drive of investments. In order to isolate the "network effect", it is therefore important to understand and quantify how the network affiliation affect such aspects. Figure 3.5 summarizes the breakdown of the "innovation" dimension.

3.5.5 Environment

Network relations, more then a performance parameter, represent a driver of performance. Moreover, to understand network relations it means to understand network dynamics and therefore being able to make simulations of how networks can evolve. Within the framework, it has been decided to focus the attention over particular aspects, such as the quality and intensity of the collaboration among companies, the potential network model development and the infrastructure degree of maturity. Figure 3.6 summarizes the breakdown of the "network relations" dimension.

To summarize the ENBSC model and in order to show the evolution from the classical Kaplan and Norton's BSC, the author's have reassumed the investigating dimensions in Table 3.2.

3.6 Data Analysis from the Questionnaire

Tables 3.3, 3.4, 3.5, 3.6, 3.7 and 3.8 show aggregate results from the questionnaire submitted to the 20 companies belonging to the GPT network. The following dimensions discussed in the previous section are considered: Competitiveness (Table 3.3), Cost Reduction (Table 3.4), Learning (Table 3.5), Innovation (Table 3.6), Environment (Table 3.7) and Financial Performance (Table 3.8).

Because results are reported in aggregated form, average values of ΔTurnover are still low. In effect, the collaboration opportunities created by the VDO have not still involved all the companies, because some of them joined the network only in recent times. However, the greater contribute to the turnover increase comes from new clients in new geographical areas and in new sectors.

Cost reduction comes especially from services and products procurement. It has been observed that services procurement (like IT services) discounts have been easily obtained even trough the collaborative procurement of companies belonging to

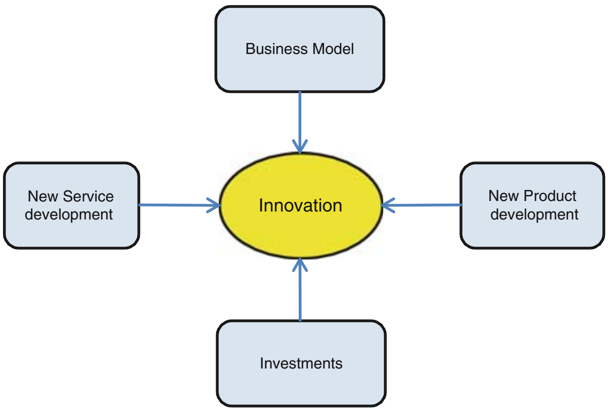

Fig. 3.6 The innovation dimension

Table 3.2 ENBSC dimensions

Classic BSC dimensions	ENBSC dimensions	Sub-dimensions		References
Financial	Cost reduction	Internal processes cost reduction Product/service purchasing cost reduction Product/service commercialization cost reduction Manufacturing process cost reduction		Holsapple and Wu, (2008)
	Network's objective: financial performance	ROI EDIBTA ROS ROE		McDermott, (2002), King and Ko, (2001) and Laitamaki and Kordupleski, (1997)
Internal business	Environment	Infrastructure	Network technology development Technology information share Support as vehicle for information sharing	Holt et al. (2004)
		Collaboration	Economical and market information Share projects with partners Commerce of goods New partner relationships	
		Network model	Network development General companies' relationships	
Learning and growth	Innovation	Business model New product development Investments New service development		Johannessen, (2008), Lundvall and Nielsen, (2007) and Park and Kim, (2006)
	Learning	Knowledge circulation process Increase of technological know-how related to manufacturing processes Increase of knowledge related to new product/service development Increase of knowledge of markets and customers Increase in the capability of attracting funding		Lee et al. (2005)
Customer	Network's objective: competitiveness	Turnover created by the network: Δ existing customers Turnover created by the network: Δ new customers		Holsapple and Wu, (2008)

Table 3.3 Network's objective: competitiveness

(%)	Δ Turnover pre-existing customers	Δ Turnover new clients, pre-existing geographical area	Δ Turnover new clients, new geographical area	Δ Turnover new clients, pre-existing sector	Δ Turnover new clients, new sector
0	x				
<1		x		x	
1–25			x		x
25–50					
50–75					
75–100					

Table 3.4 Cost reduction

(%)	Costs reduction in products and services procurement	Costs reduction in products/services trading	Costs reduction in the manufacturing production	Costs reduction in other internal processes
0				
<1		x	x	
1–25	x			x
25–50				
50–75				
75–100				

Table 3.5 Learning

(%)	Knowledge improvement on technological opportunities in manufacturing processes	Knowledge improvement on clients and markets	Increasing in the attracting funds capability	Knowledge circulation	Knowledge improvement related to innovation in products/processes/ services
0					
<1					
1–25	x	x			x
25–50			x	x	
50–75					
75–100					

Table 3.6 Innovation

	New products development	New services development	Investments	Business model
Suggested by internal company	x			
Suggested by supplier		x		
Suggested by client	x	x		
VDO	x	x	x	x
Other			x	

different sectors, while products procurement discount are favored for companies in the same sector (e.g. the purchasing of the same type of material).

The learning dimension is the one that shows highest improvements due to the network collaboration. New technological opportunities in manufacturing processes (e.g. printing machines renewal) have been caught thanks to the possibility to take advantage of public funding specifically addressed to companies aggregations. Furthermore, the capability of attracting funds from banks and credit institutions has also increased, thanks to the possibility to show in an aggregate form the financial statements of the companies.

From results regarding the innovation dimension, it is evident that companies adhering to the network recognize the fundamental role played by the VDO in stimulating all the innovation aspects. However, it also emerges that new products and services development has been promoted by internal companies, customers and suppliers.

In the questionnaire's table submitted relating to the network environment evaluation, each company has to indicate the other companies with which it has some form of relationships (products trading, technological and market related information exchanges, projects). Figure 3.7 shows aggregate results, in which relationships with the VDO are also represented. VDO is involved in almost all the network activities about projects and economic/market related information exchanges. A few products trading activities among companies are also observed

Since GPT is still a start-up, the financial performances are not so influenced by the belonging to the collaborative environment of the network. It is also important to underline that the parameters considered in the Table 3.8 are averaged values; this means that even if two companies have had a 1–25% score of ROI increasing, the other companies' low values decrease the total averaged score.

However, the Financial Performance perspective is one of the most important dimensions to take in consideration for further analysis, when also the financial parameters will be strongly increased by the network business. Several projects are starting on and this allows the authors to guess the financial parameters will be strongly influenced in the next years.

Table 3.7 Environment

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Company 8	Company 9	Company 10	Company 11	Company 12	Company 13	Company 14	Company 15	Company 16	Company 17	Company 18	Company 19	Company 20	VDO
Products trading	5	–	–	2	–	–	3	–	1	–	5	–	4	–	1	–	–	6	1	8	–
Technological information exchange	2	2	–	–	4	–	3	–	6	–	4	2	–	1	–	3	3	–	5	3	–
Economic/market related information exchange	6	8	5	5	3	4	4	3	8	7	1	5	6	3	4	4	3	4	3	1	18
Projects	–	3	–	2	–	4	4	–	–	–	2	–	4	–	4	4	–	2	3	3	12

Table 3.8 Network's objective: financial performances

(%)	ROI	EDIBTA	ROS	ROE
0				
<1	x	x	x	x
1–25				
25–50				
50–75				
75–100				

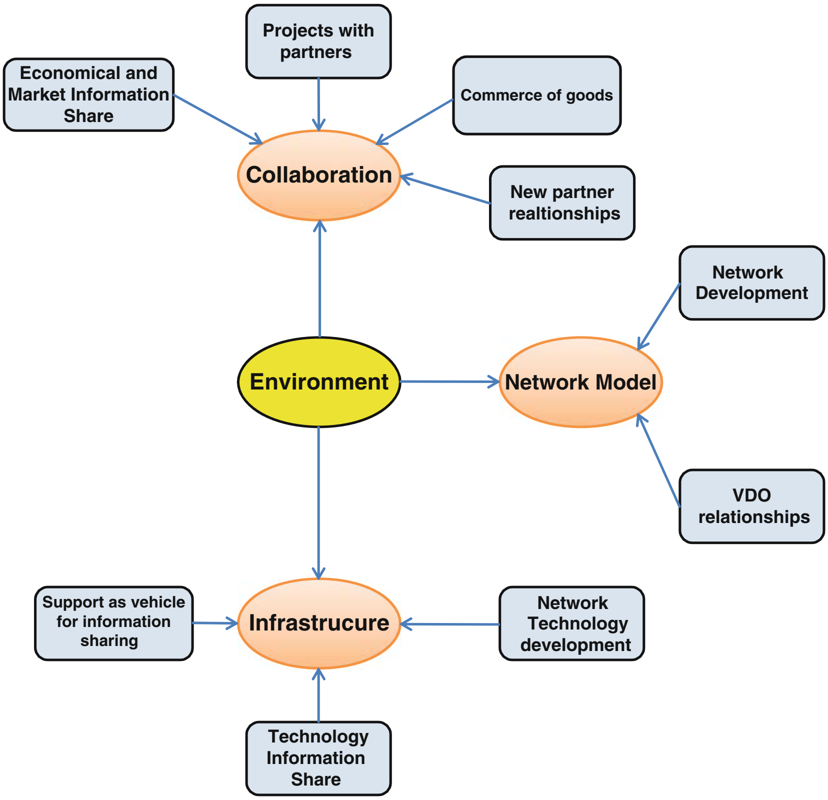

Fig. 3.7 The environment dimension

3.7 Conclusions

The Framework shown in the paper is a tool aimed in measuring the business performances of ENs. In synthesis EN performances take into account 6 dimensions: cost reduction, competitiveness, financial performance, innovation, environment.

Qualitive and quantitative parameters has been considered. For the competitiveness measurement, an analysis of company turnover has been proposed, in order to point out EN benefits. In learning the effect of learning circulation is considered while in innovation new products, new services developed within the EN.

Future directions in EN Business Performance Management could consider also benchmarking. EN could be compared to other competitor companies (for instance an EN of SMEs could be compared with one big company) in order to show the advantage of EN in terms, for instance, of flexibility and product variety.

Another aspect could be the measurement of the EN design. By the simulation of different EN designs it could be possible to measure the performance of one EN in respect to the others.

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Chapter 4
Performance Analysis of Rfid Applications in Cold Chain Management

Alessandra Rollo and Maria Grazia Gnoni

Abstract Cold chain management represents a focal activity in several industrial contexts from food to chemical chains (i.e. fresh food, vaccines or pharmaceutical products). It involves a network of temperature controlled processes and vehicles, which have to be strictly interconnected and monitored to assure product protection for both sanitary and economical reasons. All these factors could be managed by a more efficient system for improving visibility and traceability, based on Radio Frequency Identification (RFID) applications.

The paper aims to highlight a metric model for assessing effectively economic performances of an RFID application in a specific cold chain. The model could support the design and the control of the whole cold supply chain by evaluating technological and managerial implication of the RFID application.

4.1 Introduction

Cold chain management (CCM) usually represents a very complex activity: CCM affects perishable goods, which are characterized by a shelf life. According to the New International Dictionary of Refrigeration published by IIF, the term "cold chain" refers to "the continuity of resources used in sequence to ensure the preservation of low temperature of perishable products from the stage of production to final consumption."

Thus, all criticalities usually characterizing supply chains (e.g. demand volatility, quick response, information sharing, etc.) are increasing in these types of temperature-controlled chains. Main industrial sectors involved are traditionally food and pharmaceuticals. Thus, CCM represents a critical activity not only from an economic but also from an environmental (i.e. waste production) and social (i.e. food safety) points of views. One complexity factor is due to high variability

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of operating parameters (such as temperature, humidity, etc.), which usually vary according to type of products. An effective traceability system requires monitoring and recording temperatures during all production and storage phases in a cold chain as product shelf life is determined by temperature more than time. This issue is usually obligatory according to International Standard Legislation (such as Hazard Analysis Critical Control Points, HACCP); in several countries, cold chain management is regulated according to specific standards: in US shipment of temperature sensitive articles is regulated by the Food and Drug Administration (FDA).

Otherwise, research on this topic is limited; few papers are facing with an holistic approach on CCM. A recent review has been proposed by Zhang starting from 1995 to 2007. Growing attention about this issue is demonstrated by the increasing number of scientific papers proposed in the last 2 years as the outlined problem becomes critical issue in such a context. Cold chains are usually a capital intensive sector (Cano-Muñoz, 1991) mainly due to significant investments in technology (e.g. storage and transportation equipment) to maintain constant temperature in each stage of the chain. Then, a critical issue in cold chain management is represented by an effective real-time information systems. The availability of new tools based on emerging technologies, such as Radio Frequency Identification (RFID) technology, has now supplying new capabilities in cold chain management.

Radio Frequency Identification (RFID) technology could facilitate visibility in a cold chain of time-sensitive products by providing non-contact, real-time data collection and efficient interfacing with the management control system in the supply chain. RFID applications in cold chain management could contribute both to reduce risks associated with product safety and to increase product shelf life by creating transparent supply chain accountability.

The present paper proposes a critical analysis of cold chain management practices from an organization (i.e. problem connected to supply chain structure) and a technological (i.e. ICT tools for improving visibility) side aiming to assess key performance indicators, which could support the identification of weak links in specific cold chains, and, the subsequent corrective actions according to a more proactive approach. The paper consists of three main sections: first, an analysis of cold chain structures and criticalities has been proposed to assess fields of improvement (Sect. 4.2); Sect. 4.3 proposes a literature review about RFID applications in cold chain management by a managerial point of view; finally, in Sect. 4.4, a proposal of categories of key performance indicators in order to supply tools for effectively evaluating ICT investments in cold chain management.

4.2 A Critical Analysis of Typical Cold Chain Structures

A first cold chain classification could be defined according to type of products. Based on analysis proposed by Heat, cold chains could be divided in two main categories type according to product operative conditions:

- *Chilled item*: usually, this type of product (food, pharmaceutical or other) requires a temperature operative range about 0°C for both storage and production processes;
- *Frozen item*: operative conditions usually vary from –18 to –30°C.

Operative conditions under –30 °C could characterize specific product types (e.g. ultra frozen items) or manufacturing processes of such a product (e.g. frozen fish). These conditions affect usually several types of products from food to pharmaceutical contexts.

The proposed reference model for the cold chain structure is depicted in Fig. 4.1. As a typical supply chain, four main levels could be highlighted:

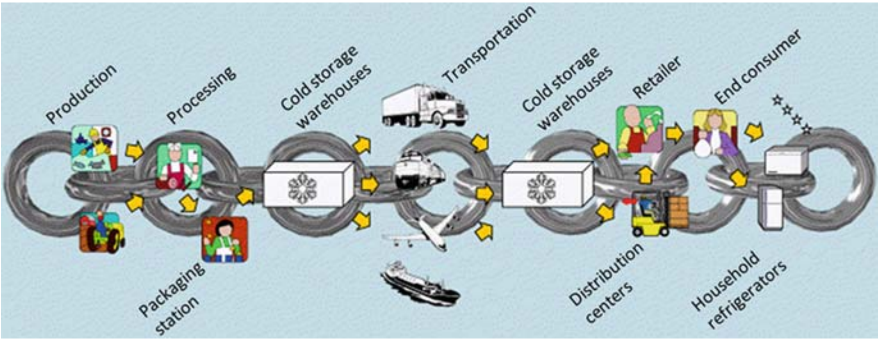

Fig. 4.1 The proposed reference model for a typical cold chain

- *Production/manufacturing level*: Several processes are involved at this tier level such as packaging and storage at production sites. Packaging represent one of the main source of alteration of a temperature-controlled products. Thus, information about interaction between item and its packaging (e.g. box, pallet,etc.) have to be maintained in each production step in order to guarantee product integrity in all production phases. Innovation in this field is now oriented in developing the so called "intelligent packaging" where time-temperature and freshness indicators are integrated in unique system. Another critical parameter is represented by the throughput of each product; it has to be traced both for economical aspects involved and, with more prescriptive value, for product guarantee aspects. Usually, this level is characterized by less variability than other levels (Bishara, 2005). The manufacturing environment is more static and consequently control activities are easier than in other tier levels.
- *Inter-operational storage level*: at transshipment points, one critical issue affects inventory management. Different factors contribute to its complexity: one issue is connected to the wide range of products usually managed at this level: high service level request to more flexibly respond to the consumer needs. Different products require different operational conditions (e.g. in terms of temperature, humidity, etc.); moreover, even if less variability affects this chain level due to

static condition of processes, it has to be considered temperature could vary greatly inside a storage room, and also inside each pallet (Hardgrave et al., 2008). This slight temperature variation affects the remaining shelf life of a product and, consequently it has to be effectively traced. Another key factor is due to the evaluation of inventory policies. More effective strategies have to be based with *FEFO – First Expired, First Out* – rather than traditional *FIFO – First In, First Out* – inventory logic in order to reduce high costs of perishable shrink, and consequently, operational costs.

- *Distribution level*: this category involves all transportation activities from each node of the cold chain (e.g. delivery to distribution centers and sales, transportation from points of sale to the place of consumption, etc.). One critical activity, usually neglected, is represented by reverse logistics, which affects the management of product flow from end consumers to retailer/producer (Kumar andBudin, 2006). In cold chains, transport type is heavily dependent on type of products, i.e. their operational conditions in terms of temperature ranges and commodity type (i.e. bulk versus retail) as proposes by Heap. At this level, main sources of variability are such points of origin and destination, article and container sensitivities to cold, accidental freezing or heat, transit mode (such as air, truck, sea, or combination), environmental conditions (time, weather and season) and carrier type. Another critical factor is represented by the outsourcing level: usually, due to the high investment requirements, third party provider represents a common solution in cold chain management. A critical variable is represented by the transit duration, which means the amount of time that a shipment remains in transit in the chain. For in-transit deliveries, a critical issue is represented by the tracing of temperature history of each trip within minutes of arrival. In this specific context, it has to be noted a lack of effectiveness of traditional tools developed for cold chain management; usually, ICT tools (based on wireless sensors, GPS technology, etc.) are focalized only in final distribution of products (e.g. from retailer to point of sales); innovative systems will be oriented to integrate information among the whole supply chain in order to optimize chain costs. As an example, customer refusals due to an improper handling at the first tier of the cold chain, have to be highlighted immediately as to not affect revenues of processors or distributors downstream.
- *End -consumer level*: at this level, temperature and resident times are more difficult to control because of the low dimensions of the actors involved and consequently the low intensity level of investment. Otherwise, this level requires an increasing attention mainly due to the reverse flow of products from customers to cold chain.

4.3 Rfid Applications in the Cold Chain

Managerial aspects in the Cold Chain Management (CCM) currently represents a relevant topic in this context. Cold chains are usually a capital intensive sector (Cano-Muñoz, 1991) mainly due to significant investments in technology (e.g.

storage and transportation equipment) to maintain constant temperature in each stage of the chain. Several industrial contexts are facing with CCM; main fields are:

- *Food context*: from several years, normative has defined a procedural system the well known HACCP system (CAC, 2001) in order to define standard for traceability procedures.
- *Pharmaceutical/chemical context*: several products (such as insulin, hemo-derivates, vaccines, etc.) are temperature-sensitive items. Traceability becomes essential for these type of products. Currently, all levels of cold chain are traced by a specific systems; many efforts could be oriented to integrate in real-time and standardized way information about the whole chain.

Then, a critical issue in cold chain management is represented by an effective real-time information systems. Research on this topic is limited; few papers are facing with an holistic approach on CCM; a recent review of Zhang (2007) starting from 1995 to 2007 has confirmed this issue; the author has also noted an increasing trend in the last few years.

Thus, in this chapter a review analysis is proposed: the review is focalized in evaluating how emerging technologies could contribute to improve effectiveness of cold chain management. As an emerging technology, Radio Frequency Identification (RFID) represents a greater opportunity for an effective and efficient traceability system in cold chains (Kelepouris et al., 2007). RFID is a multi-purpose technology, which applies radio waves for item identification; moreover, compared to traditional identification tools (i.e. barcodes), RFID could support a dynamic exchange of information stored al item level. It is based on a wireless microchip and an antenna in the tag that does not need physical contact or sight positioning (like barcodes) with the reader (Abad et al., 2009).

RFID applications in cold chain management could represent a unique identification of a product (developed by the Electronic Product Code, EPC) and a communication tool for storing and transmitting real-time environment data about items in a cold chain. These potential benefits have attracted industry and research interests. According to the literature review, a growing attention about these issues is demonstrated by the increasing number of scientific papers proposed from 2002 to 2009 as the outlined problem becomes critical issue. Results are depicted in Fig. 4.2: the research has been carried out by *Science Direct Engine*; a total amount of 23 papers is resulted

Following, papers are analyzed in order to evaluate how RFID technology could support more effective cold chain management procedures; the analysis is organized according to the specific industrial context (food and pharmaceutical/chemical).

4.3.1 Food Context

In this context, literature review results are focused on two main issues: the first issue affects the definition of general frameworks for implementing traceability

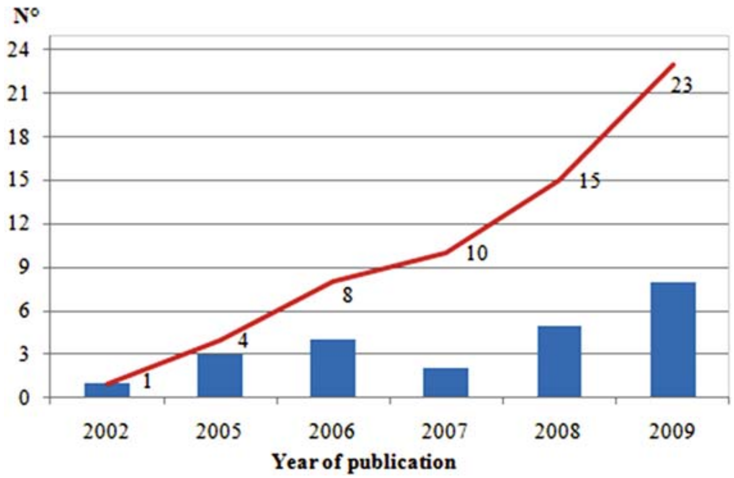

Fig. 4.2 Results obtained for the review process (2002–2009 years)

systems among the whole cold chain; a common purpose is to define procedures and software and hardware devices, which aim to integrate all tier of the chain. RFID could support a revolution in traceability systems by shifting environmental monitoring from the process equipment (i.e. warehouse, shipment, etc.) to individual item (such as pallet, box, product). The second issue concerns results obtained by experimental evidence about RFID applications in such a critical process in a cold chain.

According to the first issue, Thompson et al. (2005) propose an interesting analysis of traceability systems in the US seafood context. The analysis carries out both procedural organizations and technological features required for designing an effective traceability system. Authors outline how ICT tools could support a cost-effective traceability system, which could also support efficiencies in cold chain management. Similarly, McMeekin et al. (2006) propose an integration between RFID systems and food safety databases for improving current performances of such traceability system.

Folinas et al. (2006) by real example data outline requirements which could support in design phase of an integrated and shared traceability system. Authors identify two types of traceability levels: the logistics traceability, which affect the physical movement of an item (point of origin, destination, etc.), and the qualitative traceability, which supplies additional information to customer (internal or external) about product characteristics (e.g. pre-harvest conditions, etc.). The aim was to support a guideline for all actors and operators involved in a cold chain in the food sector.

Kelepouris et al. (2007) propose a comparison between traditional – usually based on barcodes – and RFID-enabled traceability systems. Authors highlight the capabilities of RFIDs in cold chain synchronization. Finally, an architecture for food traceability system is proposed based on the integration of distributed elements (located at each tier level) and a centralized information system, which could be managed by an internal supply chain member or outsourced to a service provider.

Regattieri et al. (2007) provide a brief analysis of potentiality of RFIDs in food traceability; results highlight as tag and infrastructure cost represents one critical issue in its diffusion. A general framework is proposed based on RFID technology for trace the Parmigiano Reggiano (the famous Italian cheese) production and process.

According to the second issue, several papers are focusing on managerial implications of RFID in cold chain management, especially inventory management optimization. Ngai et al. (2008) describe an application of a RFID-based system in a conveyor-belt sushi restaurant; main results obtained are in inventory control, responsive replenishment, food safety control activities; all these factors has contributed to improve the global service level supplied to end customers. Alfaro and Rabade, (2009) propose, starting from a case study in a Spanish vegetable industry, the evaluation of operational benefits of an on-line traceability by a quantitative and qualitative point of view. Chande et al. (2005) face with a critical managerial problem in cold chain management: the dynamic pricing evaluation of perishable products. An effective architecture based on RFID has supported optimal planning for discount offers and order quantity management in order to reduce operational cost of a cold chain. Another critical issue with both organizational and safety consequence is the product recall management. Kumar and Budin (2006) face the problem by a global exporter perspective: their analysis propose preventive procedures and intensive application of RFID to implement proactive procedures for managing this type of recalls. RFID application aiming to improve traceability in cold chain management are discussed in Bogataj et al. (2005) and Montanari (2008).

Moreover, several papers are facing with innovative technological solutions for improving performances of ICT devices in cold chain management. The aim of the study proposed by Abad et al. (2009) is to validate tag prototypes, which integrate temperature and relative humidity sensors with RFID communication capabilities. A test application is proposed for online monitoring a specific food chain, i.e. fresh fish chain from South Africa to Europe. Jedermann et al. (2006) present a sensor system prototype integrating hardware devices (i.e. RFID and wireless sensors) with software agents in order to estimate and track the actual state of agricultural products. The prototype allows traceability at pallet level; the real time communication with control software system allows the applications of more effective detection of weakness in the cold chain.

Amador et al. (2009) discussed results obtained by the application of RFID for the temperature mapping of pallets equipped by two different types of packaging: corrugated boxes and reusable plastic containers inside a container load. Laniel et al. (2009) propose a similar test case by comparing alternative tag types in monitoring marine container temperature at the pallet level.

Studies proposed by Mousavi et al. (2002), Kerry et al. (2006) and Shanahan et al. (2009) are focalized on traceability of the meat production processes. Mousavi et al. (2002) propose a prototype system, which integrates RFID on conveyor transportation for improving performances of material handling traceability system. On the other hand, Shanahan et al. (2009) describe a general framework for tracing the whole meat cold chain from farm to retailer level. Kerry et al. (2006) discuss the problem of intelligent packaging systems (i.e. based on RFID) in the context of meat production. Traditionally, the primary functionality of packaging is product protection; in cold chains, more sophisticated features could be required such as provide sufficient ventilation to allow product quality, etc. Intelligent packaging supplies a dynamic monitoring of product characteristics (e.g. freshness, integrity, etc.). Reverse logistics of reusable packaging problem is discussed by Martinez-Sala et al. (2009). The authors propose the application of active tags on returnable transport unit in order to manage direct product flows and the reverse packaging flow in cold chains.

4.3.2 Pharmaceutical/Chemical Context

Results show a less number of papers than in food context: several papers have been funded facing with the so called "pervasive healthcare" context, where ICT devices are wide spreading for improving service levels (Tu et al., 2009). This topic has revealed an increasing attention from public opinion (Katz and Rice (2009), but papers are not discussed in the present study as they do not affect cold chain management.

RFID technology applied for tracking and monitoring of blood temperature and of hemo-derivatives products is discussed in Abarca et al. (2009). Authors present a prototype system which supplies real-time information in the whole cold chain, i.e. from the extraction to the transfusion phase. The prototype could support a more effective inventory management of the blood reserves by a unique identification of such a parameter (blood type, date, etc.).

Otherwise, Uysal et al. (2008) investigate the application of RFID in a specific level of a cold chain: the distribution phase. The paper proposes the comparison of performances obtained by different types of RFID tags – such as passive High Frequency versus Ultra High Frequency tags- for the item level identification of pharmaceutical products throughout their distribution chain. The analysis does not consider economic point of view, but only technical performances. Innovative identification tool based on RFID is proposed by Wertheimer and Norris (2009) in order to control drug counterfeiting; the system proposed could also support more effective actions for brand loyalty and inventory tracking.

In Tzeng et al. (2008), the discussion about potentially of RFID is focused at a strategic level: based on an analysis of different case study regarding Taiwan healthcare context, authors highlight opportunities for creating business value in this context.

4.4 Performance Indicators for Rfid Applications in Cold Chain Management

Review analysis proposed in the previous section has highlighted several issues. First, traditional approaches in cold chain management are limited to small parts of the whole distribution chain. Thus, a growing interest is developing in evaluating tools and devices which affect performances of the whole chain from the source to the shelves at the retail store in order to study the impact of new emerging technologies, as RFID. Currently, an obstacle for RFID spreading in cold chain management is represented by its cost, especially in demonstrating its return on investment level. Thus, the evaluation of the long-term viability of RFID applications in cold chains require a more holistic approach; all partners in the cold chain need to work together to ensure product quality

In this section, a model[1] based on strategic Key Performance Indicators (KPI) is proposed to support cost-effective RFID adoption; the general structure is based on two main categories such as supply chain synchronization and traceability compliance.

These two categories are detailed following:

- *Traceability compliance:* one indicator category could affect the management of reverse flow of product recall which represents a critical issue perceived by end consumer. Such an indicator are efforts applied for managing product recall, the flexibility of each level in facing with data supplied by real-time traceability system, the tracing level (i.e. truck, pallet or item level) of environmental conditions of a temperature sensitive product, the integration level of information systems of each partner in the cold chain.
- *Supply chain synchronization*: cold chains are usually organized as a series of independent nodes that do not have the capability to interface dynamically. RFID could support the ability to identify each item (e.g. pallet, box, etc.), but also to sense environmental conditions, which could represent the actual value added. Identification could be improved as RFID allows to place sensors on each carton, not just on each pallet: this would enable monitoring of each carton through the whole supply chain including when item is separated from the pallet according to customer demand. One performance indicator about effectiveness of inventory policies could be average number of out-of –date stock at each level: this value supports an actual analysis of inventory management which represents a critical issue in cold chains. Such an indicator could be dependent on chain service level as the frequency fulfillment commitments missed for non accurate operative conditions in such a levels; the response time to change introduced by environmental variations at each level, etc.

[1] The model has been adapted from an analysis proposed by Industry Canada and Supply Chain and Logistics Canada in 2005.

Otherwise, RFID applications in cold chain are affected by several limits that could be overcome in order to assess Some concepts are related to accuracy of data supplied by RFID, lack of uniformity

Further development could be oriented in defining operational key performance indicators, which supply detailed information for developing investments evaluation of RFID in cold chains.

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Part III
What is Next by Context: PMM in Application to Special Sectors

Chapter 5
A Performance Measurement System for Racing Teams: An Exploratory Study in an Unresearched Context

Francesco Mastrandrea and Paolo Taticchi

Abstract Performance measurement and management is a topic of increasing interest both in the business and academic environment. The literature is today quite vast and particularly focused on the development of frameworks and metrics for large companies, and secondly for small and medium enterprises. This paper presents the topic of performance measurement in application to a particular business, such as that of racing teams. By relying on a deep comprehension of racing team processes and organization, a performance measurement system is presented based on the value chain scheme. This paper, based on an action research, explores the application of performance measurement in an unresearched context.

5.1 Introduction

The design of performance measurement (PM) systems is a topic of increasing interest both in the academic and managerial ambits.

Enterprises need to fix strategic directions, establish goals, execute decisions and monitor their state as they move towards their goals. Once a firm become large enough that a single manager can not sense the firm's current state alone, the firm must use a performance measurement and management system to replace the eyes and ears of the beleaguered manager (Kellen, 2003).

Therefore, it is evident today that PM systems play a crucial role in organizations, by revealing how well the organization is doing in respect of its objectives and pinpointing where improvements are required (Dixon et al., 1990).

Despite the large academic and industrial interest in performance measurement, only a tenth of models address the problem in its entirety, while large research has been carried out for covering specific PM issues. Few frameworks offer an integrated approach (Taticchi and Balachandran, 2008) such as the Balanced Scorecard

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(Kaplan and Norton, 1992) and the Performance Prism (Neely et al., 2001). Most of the frameworks available rely on a deep comprehension and analysis of business processes (Taticchi and Balachandran, 2008). As a consequence of that, the "Value Chain Scheme" proposed by the well know academic Porter (1985) is a good base for developing performance measurement systems with a focus on processes (Collier and Evans, 2007).

This article reports an action research conducted by the authors aiming to explore the theme of performance measurement in application to an unresearched context, that of racing teams. Particularly, the context of the action research was the Superbike (SBK) challenge. Achievement of the research is the design of a performance measurement system (PMS) for racing teams.

The article is developed through three sections. First, a thorough overview of racing team businesses characteristics and processes is proposed.

Second, a performance measurement system comprehensive of performance indicators is proposed by explaining the research methodology, the steps of design and discussing the results achieved. The final section draws the conclusions of the research.

5.2 Racing Teams: Organization and Processes

5.2.1 Racing Team Organization

From an organizational point of view, a SBK racing team is predominantly a functional organization, where employees are grouped hierarchically, managed through clear lines of authority, and reporting ultimately to one top person. Of from this description is the rider, which responds directly to more figures of the organization regarding different topics.

Moreover, it is important to remark the fact that in racing teams, each member of the team, independently of the role covered in the organization, is a very specialized professional. As a consequence of that, in racing teams there is a strong association between processes and team members (responsible of the process).

Therefore, in order to understand the processes of a team, a description of the processes/activities performed by each team member is shortly presented ahead.

Team owner: The team owner (TO) is the person that brings the capital to the team, and arranges for resources. Often, racing teams are directly related to motorbike-houses, and therefore the role of the team owner is covered by the motorbike-house CEO or Sport Manager. His participation to races is occasional.

From a task point of view, the TO is responsible for the financials of the team, the sponsors, the merchandising and the reward system. Moreover, it is responsible for the final rider and team's ranking.

Team manager: The team manager (TM) is the responsible for the team's operations, and responds directly to the TO. Specifically, his tasks cover the driver and employees' selection, and the overall management of the team.

Sport Director: The sport director (SD) is the right hand of the TM, to which responds directly. Specifically, his tasks cover relations with the challenge organizers, drivers and other managers. Moreover, he participate to the process of race-strategy definition and helps the TO in the sponsors' scouting activity. In small teams, such a figure is often carried out directly by the TO.

Technical Director: The technical director (TD) is the responsible for the research and development (R&D) activity and budget, suppliers' selection and management of team technicians. As well as the SD, he supports the TO in the sponsors' scouting activity. In small teams, such a figure is often carried out directly by the TO.

The TO, TM, SD and TD could be referred as the executives of the team, since their strong role in terms of decision making.

Press Agent: The press agent (PA) has the key task of managing public relations with sponsors and medias. His main tasks is to strength the team's brand, through official presentations and parties.

Track Engineer: The track engineer (TE) is responsible for the technical decisions regarding the bike setups. Specifically, his tasks cover bike geometry, suspensions, motor and electronics. Moreover, he is responsible for the generation of bike performance data.

Data can be objective, such as time lap, split time, average speed, etc.; or subjective, such as driver performance feeling or chief mechanic remarks.

Chief Mechanic: The chief mechanic (CM) is responsible for the bike management and maintenance. His tasks cover the management of mechanics, as well as suspension, tyre and motor consultants. Moreover, he tests new components or settings introduced by R&D; and cover the key role of psychologically support the driver during races.

Data Acquisition Engineer: The data acquisition engineer (DAE) is responsible for all the measurement systems (sensors, cables, etc.). Moreover, is tasks cover the setting of the junction box so as to implement TE and driver requests regarding power supply, brake effectiveness and traction control. Such tasks are very delicate, since they affect directly driver safety.

Mechanics: The activities carried out by mechanics are very delicate in terms of performance, since of accuracy and time constraints. Time for setting up a bike or changing a motor can be crucial in fact so as to determine the participation or not to a race.

Moreover, accuracy of mechanics' activities directly affects driver safety.

Tyre Mechanic: The tyre mechanic (TME) is responsible of many tasks, such as tyre supply, tyre quality control, tyre assembling and tyre heating. The complexity of his task is due to fact that for each racing day, drive can ask up to three tyres for dry conditions, two for water conditions and one for intermediate conditions, both for front and rear wheels.

Driver: The driver is doubtless the key element of a racing team. His tasks cover both the extreme bike drive so as to win races, as well as to give feedbacks to technicians for addressing bike improvement.

The TE, CM, DAE, mechanics, TME and driver could be referred as the worker of the team, since their role in operations and alignment to executives' strategies.

The organization chart further presented refers to a hierarchy that not always is applied in reality. In fact, shortness of time and extreme specialization of technicians leads often the workers to be the unique responsible of their activities. Moreover, it is important to remark the fact that in racing teams, each team member is essential for the execution of activities, and therefore absenteeism is not admitted at all.

Suspension Consultant: The suspension consultant (SC) is responsible for the supply of optimal suspension in relation to drivers' drive-style and bike settings. Often, the SC is not a real member of the racing team, but is the in-box representative of the suspension supplier.

Tyre Consultant: As well as the SC, the tyre consultant (TC) is the in-box representative of the tyre supplier.

Motor Consultant: The motor consultant (MC), often present in official racing teams, is the responsible of the development and optimization of the motor, which is the most complex element of the bike.

However, the presence of the consultants is related to the racing team budget.

The overall organization chart of a standard racing team is therefore presented in Fig. 5.1.

5.2.2 Racing Team Processes

In racing teams, it is possible to identify two classes of processes: the "*always running processes*" and "the *race processes*".

The *always running processes* include activities such as material procurement, research and development, team administration, sponsors' scouting, infrastructures' maintenance and logistics.

The *race processes* instead, are very detailed activities that are performed limitedly during racing days. A shot overview of such activities is presented ahead, based on the racing day.

Wednesday

- Circuit arrival;
- Bureaucracy procedures;
- Box assembling;
- Air, electricity and IT plant assembling.

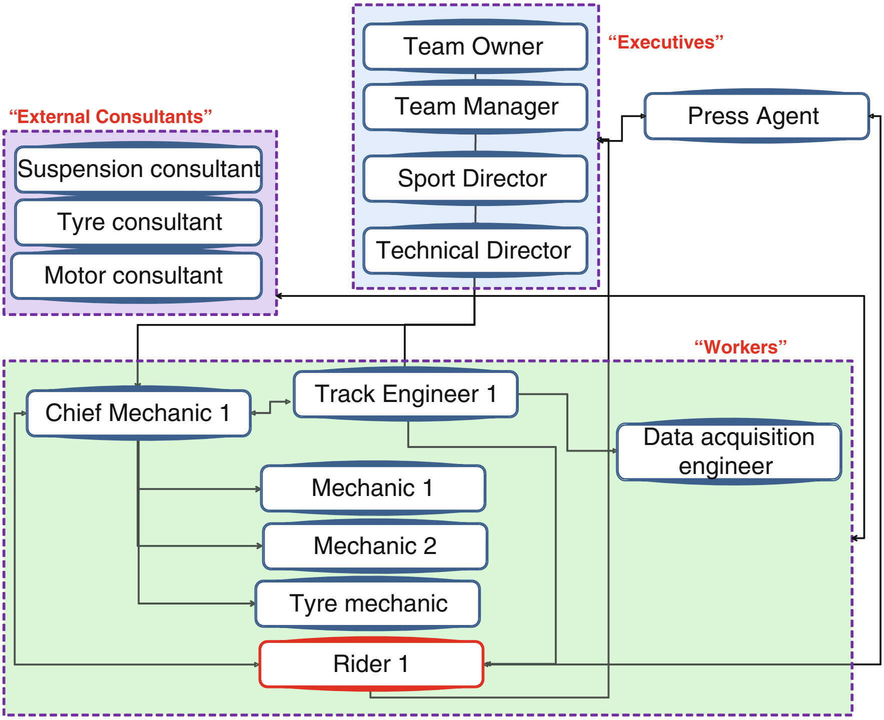

Fig. 5.1 Standard racing team organization chart

Thursday

- Bike checklist;
- Materials' checklist
- Briefing with drivers;
- Technical controls from the local organization;
- Briefing between TD, TME and TC for free practice 1 (FP1) tyre selection;
- Briefing between driver, TD, TE and CM for FP1 setups;
- Tyres' collection.

Friday

- Friday morning
  - Bike checklist;
  - Tyres' heating;
  - FP1;
  - Team briefing after FP1;
  - Performance data acquisition;

    - Evaluation of bike/driver performances;
    - Deep briefing between driver, TD, TE and CM for deciding next setups;
    - Bike optimization for qualifying practice 1 (QP1).

- Friday afternoon
    - Bike checklist;
    - Tyres' heating;
    - QP1;
    - Team briefing after QP1;
    - Performance data acquisition;
    - Evaluation of bike/driver performances;
    - Deep briefing between driver, TD, TE and CM for deciding next setups;
    - Bike optimization for qualifying practice 2 (QP2).

Saturday

1. Saturday morning
    - Bike checklist;
    - Tyres' heating;
    - QP2;
    - Team briefing after QP2;
    - Performance data acquisition;
    - Evaluation of bike/driver performances;
    - Deep briefing between driver, TD, TE and CM for deciding next setups;
    - Bike optimization for free practice 2 (FP2).
2. Saturday afternoon
    - Bike checklist;
    - Tyres' heating;
    - FP2;
    - Team briefing after FP2;
    - Performance data acquisition;
    - Evaluation of bike/driver performances;
    - Deep briefing between driver, TD, TE and CM for deciding next setups;
    - Bike optimization for time attack (TA)
    - TA (definition of starting order)

Sunday

- Sunday morning, first half
    - Bike checklist;
    - Tyres' heating;
    - Warm up (WU);
    - Team briefing after WU;

  - Performance data acquisition;
  - Evaluation of bike/driver performances;
  - Deep briefing between driver, TD, TE and CM for deciding next setups;
  - Bike optimization for Race 1 (R1)

- Sunday morning, second half

  - Bike checklist;
  - Tyres' heating;
  - R1;
  - Team briefing after R1;
  - Performance data acquisition;
  - Evaluation of bike/driver performances;
  - Deep briefing between driver, TD, TE and CM for deciding next setups;
  - Bike optimization for Race 2 (R2)

- Sunday afternoon

  - Bike checklist;
  - Tyres' heating;
  - R2;
  - Team briefing after R1;
  - Performance data acquisition;
  - Evaluation of bike/driver performances;
  - Deep briefing between driver, TD, TE and CM for evaluating team and driver performances, and decide future areas of improvement.

5.3 A Pms for Racing Teams

5.3.1 Research Methodology

To the knowledge of the authors no researches have been conducted in the field of PM applied to racing business. As a consequence of that, this research can be characterized as being exploratory in nature and longitudinal; the project took about 1 year to complete. During this extended period of study the authors grouped a number of key figures in racing teams, experienced the race days and preliminary preparation, explored the processes of the team and participated into the strategy definition, and above all, in the PMS design. Formal project management methods and a variety of data collection techniques were also utilized during this process, e.g. direct observation, surveys, as well as direct participation in joint meetings.

This kind of approach differs from the conventional case study methodology which typically relies on data gathered from key informants by interview or survey to provide a window on reality in that it allows researchers to gain a deeper knowledge of the case and its dynamics.

From this point of view our work might be further classified as action research as defined by Benbasat et al. (1987) since in this approach "The action researcher is not an independent observer, but becomes a participant, and the process of change becomes the subject of research".

5.3.2 Development of the PMS for Racing Teams

The development of the PMS for racing teams has followed the methodology proposed by Taticchi and Balachandran (2008) which identifies 4 milestones for PMS design, as in Fig. 5.2:

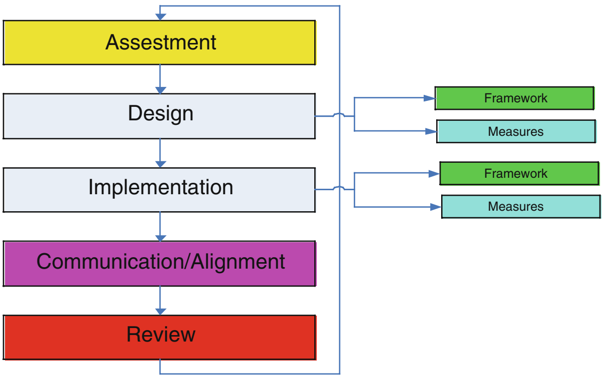

Fig. 5.2 Milestones for PMS design (Taticchi and Balachandran, 2008)

Since the PMS developed is currently under implementation/validation, exclusively the design features are presented in this paper.

Assessment/Audit Phase: In the first part of the action research, the authors carried out an audit in a number of "Superbike" racing teams (PSG-1 Corse, Team Pedercini, Ducati Xerox Team) with the objective of identifying if some measurement system were in place and more generally if some PM best practices were adopted.

Such a audit activity resulted that teams were missing a performance measurement system, even if they felt the need of it for better controlling and alignment. Particularly, the unique performance indicators used were the times and placements during race days that are lagging indicators. The audit phase highlighted as well the executives' desire of structuring a number of leading performance indicators so as to better predict and drive team results and create alignment between the various team members.

As a consequence of that, the authors decided to consider the context as a "scratch-context".

Framework/Measures Design: In order to design the PMS, the authors involved the technical directors (TDs) and team owners (TOs) of the teams so as to establish a learning process during the PMS development. Particularly, the involvement of the TDs was essential to identify the real drivers of performance, and therefore define best performance indicators.

Moreover, the participation of TDs was essential for the understanding PMSs objectives and set the bases for the implementation/validation of the model developed. The involvement of the TOs was essential as well, so as to create trust and commitment in a managerial initiative very innovative for the racing world.

In order to design the PMS, the authors introduced TDs and TOs to the theme of PM by presenting popular business frameworks, popular business metrics and popular best practices. After a brainstorming, the project team (PT; authors, TDs, TOs) decided that the design of the PMS should rely on two milestones:

1. It should be based on processes;
2. It should present strong linkages with teams' organization.

The decision above originates from the fact that racing teams manage a restricted number of processes, and often such processes are managed by single persons of the organization. As a consequence of that, the organization is very vertical, and performance of processes can be attributed directly to performance of people.

In order to design the PMS, the PT opted therefore for using as a reference scheme of the racing business the "Value Chain Scheme" proposed by M. Porter (1985), since its flexibility. The PMS is composed therefore by three sets of performance indicators, related to primary processes, secondary processes and financial indicators. Contrary to typical businesses, financial indicators are not the objective of the business (most of racing teams end years with losses instead margins), since the unique goal is the global racing classification. The performance indicators (PIs) composing the PMS are presented in Table 5.1:

Table 5.1 The performance measurement system for racing teams

Performance indicator	Metric	Measure unit	Frequency of measurement
Primary processes			
Inbound logistics			
• PI-1: Availability of components/materials	Stock-out events per year	Dimensionless	Daily
Operations			
• PI-2: Bike reliability	Breaks events per year	Dimensionless	Daily (race days)
• PI-3: Rider time improvement	Lap times	Milliseconds	Every lap (race days)
• PI-4: Rider performance	Rider performance	Dimensionless	Daily (race days)
• PI-5: Rider reliability A	Number of tumbles by himself	Dimensionless	Yearly
• PI-6: Rider reliability B	Number of tumbles due to others	Dimensionless	Yearly

Table 5.1 (continued)

Performance indicator	Metric	Measure unit	Frequency of measurement
• PI-7: TD performance	TD effectiveness in problem solving	Dimensionless	Monthly
• PI-8: CM performance	CM performance	Dimensionless	Monthly
• PI-9: TE performance	CM performance	Dimensionless	Monthly
• PI-10: Mechanics performances	Bike assembly times	Minutes	Monthly
• PI-11: DAE performance	Performance of setups and measurement	Dimensionless	Monthly
• PI-12: Calendar respect	Missed events per year	Dimensionless	Daily
• PI-13: Team alignment	Team alignment	Dimensionless	Monthly
• PI-14: Number of faults due to driver	N° of driver faults	Dimensionless	Daily (race days)
• PI-15: Number of faults due to team	N° of team faults	Dimensionless	Daily (race days)
Outbound logistics			
• PI-16: Delivery times	Average time of delivery	Days	Monthly
Service			
• PI-17: Customer satisfaction	Customer satisfaction	Dimensionless	Six-monthly
• PI-18: After sale efficiency	After sale – customer satisfaction	Dimensionless	Six-monthly
Secondary processes			
Firm infrastructure			
• PI-19: Time to build box	Time to build box	Hours	Every race
• PI-20: Energy availability	Energy stock-out events	Dimensionless	Every race
Technology development			
• PI-21: Number of tests	Number of tests per year	Dimensionless	Six-monthly
• PI-22: Positive tests	Number of positive tests per year which cause change	Dimensionless	Six-monthly
Procurement			
• PI-23: Quality of purchases	Percentage of purchases with defects	Dimensionless	Weekly
• PI-24: Delivery times	Percentages of deliveries on time	Dimensionless	Weekly
Human resource management			
• PI-25: Cost of HR	Total cost of HR	Monetary	Yearly

Table 5.1 (continued)

Performance indicator	Metric	Measure unit	Frequency of measurement
Financial indicators			
• PI-26: Budget from sponsors	Budget from sponsors	Monetary	Yearly
• PI-27: Cash flow	Cash flow	Monetary	Monthly
• PI-28: Profits	Profits	Monetary	Yearly
Key performance indicators			
KPI	Metric	Measure unit	Frequency of measurement
• KPI-1: Number of successful races	Number of successful races	Dimensionless	Daily (race days)

Communication/Alignment: The aim of achieving business goal and strategy alignment should be accomplished with clear guidelines to effectively communicate performances inside the organization (Taticchi et al., 2008). Several solutions on this communicational aspect has been proposed such as the use of a single indicator to facilitate common comprehension, the use of dashboards for managers or the use of icons and smiles with employees (Taticchi and Balachandran, 2008). In this particular case, the PT opted for creating two levels of communication: a detailed level of communication for "team executives" (team owner, team manager, sport manager, technical director) with the use of structured reports composed by tables and graphs; and a sample level of communication for "team workers" (telemetrist, track engineer, mechanics and rider) based on visual management techniques (e.g., status of performance indicators identified by smiles stick on box walls).

Review: A PMS should be dynamic and including a system for periodic reviewing measures and objectives so as to ensure reactivity to changes in terms of strategy or business environment. The context of racing teams doesn't change significantly over time in terms both of strategy and environment, and therefore the structure of the PMS is less subjective to changes. However, it is important that the PMS should be tailored to the real need of racing teams, and therefore implementation and validation phase represent a crucial moment of PMS effectiveness review.

5.3.3 Discussion

At the base of the PMS development there was a process of learning of both the authors and racing people; this is typical of action research. The authors, played an essential role in terms of providing the right methodologies for developing the framework, as well as the racing people that explored and analyzed the process and characteristics of such a particular business. The indicators defined above have been designed by the PT by using standard nominal group techniques.

The PMS obtained reflects the peculiarities of the racing context, and could appear very weird to a reader used to deal with traditional business frameworks. As a consequence of that, a number of characteristics need to be highlighted:

1. *Key performance indicators (KPIs)* – Only a KPI is present in the PMS, and it is related to the number of successful races. Such a parameter, could differ from team to team (e.g., certain teams consider successful placements only in the podium, while others consider successful placement in the first ten) and it is remarkable the fact that is not a financial indicators. This characteristic reflect the main difference respect traditional business.
2. *Lagging and leading indicators* – The assessment phase of the projects resulted no best practices in term of performance measurement in the racing teams. Particularly, they seem to rely exclusively on race results, which represents a lagging indicators. The PMS developed, based on the team executives indications, is composed by a large number of leading indicators (e.g., bike reliability, rider performance, team alignment or number of tests) which drive and determine the overall performance of the racing team. It is not an easy task to start measuring all these indicators, but the effort is paid by a greater understanding of processes dynamics ad well a major capability of predicting future performance.
3. *Quantitative and qualitative indicators* – Some of the performance indicators identified by the PT are not directly measurable in a quantitative way. As a consequence of that, the PMS is composed both by quantitative indicators (e.g., availability of components, customer satisfaction or number of tests) and qualitative indicators (e.g., rider performance, TD performance or team alignment). Qualitative indicators are "quantified" through the use of nominal group techniques which present good results in this kind of applications.
4. *Financial and not financial indicators* – In the PMS developed, financial indicators represent only 10% of the global set of indicators. Such a characteristic is peculiarity of the racing business, where costs and profits are secondary issues, often not an issue at all. Moreover, since the primary goal is represented by the success on races, which is not a financial goal, the large use of not financial indicators is predictable in this context.
5. *Measurement unit* – Another peculiarity of the PMS obtained is the fact that the majority of the measurement units are dimensionless, while few are monetary and none is physical.

The PMS is currently under implementation in a number of racing teams, so as to evaluate its effectiveness and obtain important feedbacks for design optimization.

5.4 Conclusions

This paper has explored the characteristics and processes of racing teams in order to present a performance measurement system that has been particularly developed for these kind of businesses.

Based on action research, the PMS obtained relies on the value chain scheme, and reflects both the processes and organization of racing teams. The set of indicators defined highlights the presence of leading indicators, a remarkable achievement in a context which typically rely exclusively on lagging indicators. The value of this paper is that it explore the topic of performance measurement in application to an unresearched context, that of racing teams.

Likely, such a exploratory research will draw the attention of other researchers, that could bring their contribute in this field.

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Chapter 6
How Small Firms in the High Quality Food Sector Can Improve Their Business Performance: The Ligurian Oil Case Study

Giorgio Locatelli and Mauro Mancini

Abstract This paper proposes a methodology to create market value in the high quality food sector. The research starts from the consumer's opinion about the attributes characterizing a high quality food, then a market research shows which are the attributes able to increase the good value in the different distribution channels. The paper shows how attributes are market and channel dependent, therefore attribute able to create value in certain markets and channels are uninflected in others.

The methodology proposed is concretely applied on a case study: the Italian Extra virgin olive oil sector with a particular focus on the Ligurian olive oil, one of the most appreciated Italian oil. Likewise the methodology can be implemented form many other high quality food.

6.1 Introduction

The Ligurian extra virgin olive oil (from here called "Ligurian oil" or "oil") is a potential high quality oil because is composed from specific types of cultivar, such as "Taggiasca" and "Lavagnina". These varieties, that over the centuries have adapted to the Ligurian climate, are able to produce in that area an oil with low acidity, little yield, but a sweet flavour that makes it special and highly appreciated (Casale et al., 2007). The types of cultivar are not the only parameter to achieve the best quality, it is also necessary an accurate olive processing that include less than 24 h between harvesting and milling, a controlled olive and oil storage and so on. Unfortunately the Ligurian region is characterized by hills that reduce the possibility to mechanize the harvesting, and reduce the number of plants in a hectare and the overall production, in fact the Ligurian region accounts for about the 1% of olive

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and oil production in Italy. Moreover the average dimension for each farm is much smaller than the most productive Italian region and other countries. Therefore, considering the morphology and farm size, the production cost for the Ligurian oil is greater than in the other regions.

If the production cost and the intrinsic and extrinsic quality are greater it is expected that the final price for the customer will be grater. The purpose of this article is, starting from the consumers' opinions, to assess how the different attributes of the oil and the sales channel concur to make the price. In this way is possible to understand how is possible to "create the value" necessary to pay back the production cost and to create gain for the farmers.

6.2 Method

Like previously indicated the Ligurian oil has, compared to the other Italian oil, both a greater production cost and premium quality features. In order to reap a premium price from the market is important to determine the main actions to increase the sale price without decrease the market share. To obtain this information a series of interviews and market researches have been performed to assess which elements are able to create value. Finding these elements means to understand which are the attributes receiving a premium price from the customers. Examples of these elements, attributes, are: physical features (acidity, cultivars), certifications, packaging feature etc. Since different consumers have different sensibilities coming from their education, age, incomes (Saba and Messina, 2003) they are willing to pay more for different attributes. Allowing that oil with the appropriate attributes is available for the customer willing to pay for them means "create the value" (Fig. 6.1).

To create value in this food sector it is possible to pursue the methodology here exposed. In this paragraph the methodology is theoretically explained, whereas in

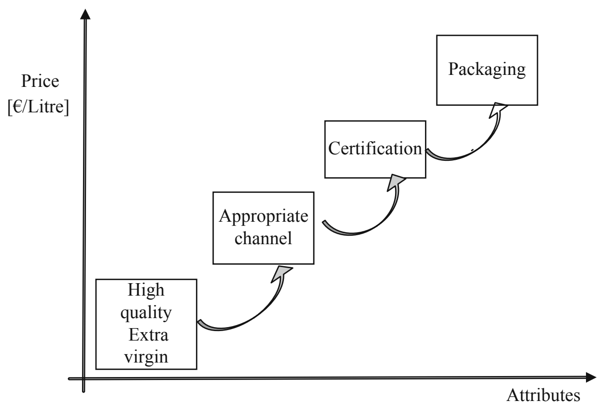

Fig. 6.1 How is possible to create value in the market oil

the following sections there is an example of implementation with the Olive oil Case.

Enforcing the methodology is important to keep in mind that it is possible to classify attributes in two basic classes:

1. Attributes for which the consumer are consciously willing to pay more, for example food characterized by health benefit (Bower et al., 2003);
2. Attributes for which the consumer are not direct consciously willing to pay more but that receives a premium price, for example the packaging.

The common approach to explore the first class of attribute is by a well structured questionnaire, while for the second class by a focused Market analysis.

Customers are able to understand the intrinsic and extrinsic attributes (Roosen et al., 2007) for a certain product by different ways; so they can be ranked:

1. Personal advice: the customer receives information from the grocery or wine shop owner (or shop assistant) that considering the customer needs and desires can suggest an appropriate oil
2. Physical contact and the physical characteristics: the customer can appreciate the packaging and all the attributes by looking and touching the bottle
3. Brands and certificates; they can guarantee certain attributes (for example that the oil is organic)
4. Advertisements from mass media, friends and so on

In order to analyse this food sector the following methodology has been designed and developed.

The main steps can be listened as follow:

1. Comprehend the most important attributes of the product that can be used as a strengthen point respect to other similar goods. In this area the right information can be correctly arisen only by expert and qualified persons like: international literature, producers and sellers
2. Asses the consumers' conscious attitude toward the product asking with direct interview designed to define costumers' feeling of the product, the most important characteristics, the preferred distribution channel and so on.
3. Introduce possible new attribute with creative tools developed in the quality management field like brainstorming, SWOT analysis, relation diagrams, fishbone diagrams and so on trying to define the bigger amount of statistical data related to the attributes emerged.
4. Compare the list of attributes emerged in step 2 with those emerged in step 3 in order to define optimal combination of best "product attribute" with "consumer willing to pay for them" and related distribution channel

Section 6.3 summarises the results of the interviews to the consumers and Sect. 6.4 summarises the results from the market analysis. To assess how the value is created in the market we listed the most important attributes of an oil. A statistical analysis indicates the correlation between the attributes (for example the DOP[1] certification) and the price. To define which subtype of oil should go to a specific sales channel the market analysis is subdivided in the three main channels (physical, Italian on line, US online).

6.3 The Consumers' Interviews

6.3.1 Method

It has been decided to perform the interview at food exhibitions because the consumers in this contest look for high quality food and manifest a proactive attitude. To concretely assess the conscious consumers' attitude toward the oil, a questionnaire, prepared from the Polytechnic of Milan research group, has been submitted. The one page questionnaire was composed by open and closed questions whose results are showed in Sect. 6.3.2. The typical situation was that each questionnaire was fulfilled by married couple or singles (representing the type of decision maker in the mass goods sectors).

6.3.2 Results

Analysing the answers to the proposed questionnaire the consumers' attitude toward the olive oil and its preferred attributes can be defined. Consumers give value to well defined attributes, most related to the "origin of the product"; this is consistent with the literature (Siret and Issanchou, 2000).

Considering the Fig. 6.2 it is possible to recognize the attributes related to the origin are:

- Guaranteed origin: 25%
- DOP: 17%
- Supply chain traceability: 12%

The sum of this attributes is equal to 54% and also "the traditional food processing (23%)", that is related to this aspect, can be added. This is a fundamental indication: to increase the value of an oil is necessary to show the strong link with its territory. This has been recognised also in the market research. These interviews explain also that a number of attributes important for the producers do not create value for the consumers. An example is the acidity that seems does not create value in the interviews and in the physical market either.

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[1] DOP is the acronym of "Denominazione di Origine Protetta", the Italian langue version of PDO (Protected designation of origin).

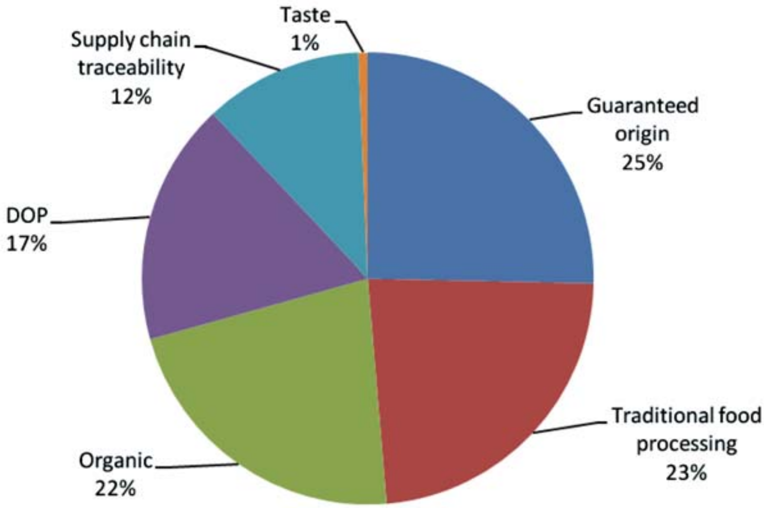

Fig. 6.2 Characteristic for a high quality oil

After this main consideration coming from the field survey a market research has been conducted to analyse overall data distinguishing different distribution market used.

6.4 Market Analysis

6.4.1 Method

After having considered the consumers' opinions in this section will be exposed how the market is able to create value for the consumers. In order to understand how the value is created in the oil market a statistical analysis based on 1,085 collected records will be performed in the following paragraphs. In this way is possible to quantify also the attribute that consumers are not consciously willing to pay for them and how the attribute create value in the different channels.

The main difference emerged is the analysis is among physical and web based channel in fact the overall records have been broken down as follow:

- Physical channels (471 records)
- On-line channels (614 records)
  - Italia-n Web-sites (361 records)
  - United States web site (253 records)

Considering the literature, the producers and the specific characteristic of each channel is possible to write a list of attribute just to be sure to consider all the important attribute In order to suggest the best approach to apply the proposed methodology to other food sectors is useful to prepare a draft of the attributes list and start with the market research to realize if the list is appropriate and, in case it is not, update the list with new factors.

6.4.2 Results

6.4.2.1 Sales Channels

Physical Channels

Physical shops have been visited in the North of Italy (mainly in big cities) in order to control the price of the oil sold. As a general comment is important to consider that the mean price are characterized by a great variance due to the type of shop providing the oil, in particular the average price for oil in a Wine shop or a Grocery (22 [€/Litre]) is three or four time the price of an oil sold in a supermarket (6 [€/Litre], therefore in case of a market strategy that wants to increase the final price of the oil these channels represent the best environment.

On Line Channels: Italian Web Sites

After the physical channels also the on-line channels has been investigated. It is important to recall how in this channel there are great opportunities, due to a global exposition and is potential growth. (Politecnico di Milano, 2006). Moreover in a web site it is easy putting videos (about, for example, the olive grove and the olive pressing), pictures and texts showing the feature of the product and, how emerges from the interviews, the link between the product and the territory. Moreover in literature how consumers are willing to pay more for:

- traditional foods;
- food characterized by health benefit (Bower et al., 2003), (Rossen et al., 2007);
- organic products (Crescimanno, 2002).

It is important to notice that a web site can provide more information than a label also because the web site is not subject to the rigid legislation that controls the labels. Considering that the investment necessary to enter in the channel are supportable by any farm, it is important to assess its potentiality. Also in this channel the average price for oil in a Wine shop or a Grocery is three or four time the price of other bottles of oil (usually sold by olive pressers or olive millers).

On Line Channels US Web Sites

To enhance the assessment of the on line channel also the US on line oil market has been also investigated. Considering that the object of the investigation is the Italian Olive oil the retailers in the US market do not include the typical players involved in the production: Olive presses, farms, oil mills. Moreover the typical players in this market are the groceries and the generalist sellers.

The average value 33.90 [€/Litre] represents a very important valorisation of the product, but the most important result is that the value in this channel is obtained by different attributes compared to the Italian on line channels, like showed in the following paragraphs.

6.4.2.2 The Influence of the Product Origin: The Regionality and the Region of Origin

The first characteristic of the oil that will be analyzed is it origin, the most important characteristic emerged from the interviews (Sect. 6.3.2). The Italian law provides that the label shows where the oil has been bottled. These information, if are alone, do not indicate where is the origin of the olives and either where the olives have been milled. Nevertheless it is possible to know, in some case, the origin of the olives, by some certification (like DOP) or by voluntaries indication on the label, for example: "made with 100% Italian olives".

In the physical channel is rare to find where the olives used to make the oil come from., therefore from the data analysis is possible to draw the following consideration:

- if the origin of the oil is indicated and referred to a specific region the price increases, usually doubles. This situation is coherent with the literature and the interviews because when the region is indicated the oil gain the attribute of "typicality",
- inside the oil with the know region the Ligurian attribute doesn't increase the price, in fact the price of the Ligurian oil is close to the price of the other regional oil.

This information is useful to plan an effective market strategy, focused on the link between the product and the territory.

6.4.2.3 The Influence of the Oil Characteristics

After analyzing how the origin influences the price it is important to note that the two main intrinsic features (acidity and cultivars) don't concur to create value in the physical channel, but create value in the on-line market.

As regards the acidity within the analysis is possible to recognize how in the physical channels the low acidity oil (≤ 0.5 and ≤ 0.3) are sold at a price lower than the average of the channel. This situation can be explained considering that many oils sold by international brand in the supermarkets have a price lower than 8 €/Litre and it is very rare that an oil sold in the wine shop (the most profitable channel) show the value of acidity (only 2 cases out of 84), therefore is possible to conclude that the acidity level is used by cheap oil to increase their value. Superior quality oils don't need to indicate their acidity level. As regards the cultivar factor an oil Mono cultivar is sold at a price greater than an oil made with a blend independently by the distribution channel and the cultivar Taggiasca (typical cultivar for an Ligurian oil) is mainly valorised in the Italian on line channel. This fact is crucial because it show how to direct the sale efforts, therefore the first market for this type of oil is the Italian on line channel, the others channels may represent only a makeshift.

6.4.3 The External Recognitions Influence

In the oil market (considering the made in Italy product) there are a number of different certifications (like DOP or BIO[2]) or prizes provided by national or international organization (public or private companies). One of the analysis's scopes is to assess how these recognitions are able to form the value in the different channels.

6.4.3.1 The DOP Certification

The most important certification in the olive oil market is the DOP. Researches (Fotopoulos and Krystallis, 2003; Fandos and Flavián, 2006) shows how consumers have a favourable attitude toward the DOP and they are willing to pay a premium price for it. Our analysis shows that in the physical channels the DOP is able to increases the value for the 40%.

On the other hand in the Italian online channel the DOP certification is, in general, unable to create value; the same situation is for the USA market where the DOP certification is quite unknown.

The Ligurian oil has a slightly different behaviour, in fact, in the Italian online channel, the DOP certification seems to create value for a Ligurian olive oil. This could be due to the fact that the Ligurian attribute is able to create value and the DOP certificate secures that the oil considered is really made in Liguria, therefore the consumers are willing to pay for this certification.

6.4.3.2 The BIO Certification

The other certification in the oil market is the Organic (BIO) label analysed in the following tables.

In Italy, the price for organic oil is very close to a non organic one. Analogously to what has been stated about the acidity it is possible to recognize also in this case how the organic oil in the physical channel is sold mainly in the supermarkets, whit a price close to the mean, 9.22 [€/Litre], and is a rare attribute. In the online channel the situation is similar, although there are a greater percentage of bottles with this attribute. Quite the reverse is the result for the US market, in fact, in this market an organic oil bottle gains an average of 6 euro of premium price; this is due to the different attitude of the US consumers. In fact in the USA there is, for a certain

[2] BIO is the Italian certification for the organic food.

market segment, a deep appreciation for the organic food (Govindasamy and Italia, 1999). Considering all this results it makes sense to structure the supply chain to direct the organic oil in the US market.

6.4.3.3 Prizes Won

In addition to the certification it is important to consider how prizes and appreciations (such as citations in some important guide or being finalist in some important competition) influence the value. This information is not showed on the label of an oil bottle, but is often included in the oil's card in the web site; therefore the analysis is limited to the web site only. From our analysis the advantage of selling in the USA market is evident probably because of in a foreign country the prizes can guarantee the quality of a certain product.

6.4.4 The Packaging Influence

Changing the intrinsic oil quality or obtaining external recognitions could require an important effort: receiving a DOP or BIO certification is a long process and to change the cultivar mix can take many years. Completely different is the effort needed to change the size, the shape and the capacity for a bottle sold in a certain channel and so next paragraphs show how the various packaging features are able to create value in the different channels.

6.4.4.1 The Bottle Capacity

The most important packaging attribute is certainly the bottle capacity. The analysis indicates that in the physical channel there is a strong correlation between increasing the price and reducing the size, furthermore the results shows how the wine shops and the gastronomies use a small sized bottle (0.5 and 0.75 l) to increase the value, whereas in the supermarkets the most common size is 1 l.

Using the same criteria of classification used for the physical channel is interesting to note that considering in particular the US online channel the 0.5 l format is the most common and the most valorised, therefore it seems obvious choosing the 0.5 like the default size to enter in the US market.

6.4.4.2 The Label Tied to the Bottle Neck

After the capacity another important attribute in the packaging for the oil market is the label tied to the bottle neck. That label (can be a card or a booklet) provide different information about the oil characteristics, productive modalities and so on, the value of this information will be quantified in the next chapter, the scope of these analysis is to assess how the label itself is able to increases the sale price leaving the information provided out of consideration. The results show how in the physical and online Italian channel this attribute do not change the sale price, whereas, it is able to increase the value in the US market.

6.4.5 The Information Value

It is well known in literature that to provide information during the selling process about a certain product can increase its value (Bower et al., 2003; Di Monaco et al., 2005). The scope on this section is to assess and quantify this differential value for the oil bottles in the different channels. In this case there is deep difference between the physical and the online market, in fact in the physical market the information are provided by the label, and must respect rigorous laws. In the online channel there is more freedom and it is possible to present the bottle giving a large number of information.

The most common characteristic reported for the oil bottles is the taste. The statistical analysis shows how, in the physical channel, the taste description do not create value but, even decrease the value. This situation can be explained considering that many oils sold by international brand in the supermarket at price lesser than 6 €/l provides information about the taste. Also in the Wine shop this attribute do no create value, since in that location the information are mainly provided by the shop assistant and a design without this type of information might be more elegant. In the online channel, in particular in the US market, this information is able to create value, whereas it is influent in the Italian online market.

Another analysis can be made considering each type of information provided in addition to the information that the law obliges to write on the label, example of "voluntary" information are: taste, acidity, production methods etc. The results in this case are analogues to the results provided for the taste description.

6.5 Final Results of the Statistical Analysis

Beside the already reported factors many other have been analysed. Table 6.1 summarises the impact of the most relevant.

With these information is possible to increase the value of a certain oil in two steps.

First step: to find the right market for the characteristics of the oil. The characteristics here considered are those "constant" such as: place of origin, Acidity, Prize won. When the channel as been select is possible to implement the step two, that is, the fine tuning of the characteristic "easy to change". In this step the characteristics such as "Bottle coated" or "label tied to the bottle neck" are chose according to the market.

The table can be used as a tool also to improve the performance in the actual market position by adding the factors able to increase the value. For instance for the DOP sold in the low value channel is valuable to create a bottle with a peculiar

Table 6.1 Results of the statistical analysis

		Physical channels			On line channel			
			Low value channel		Italy			
		High value channel	DOP oil	Not a DOP oil	Global	DOP oil	Not DOP oil	USA
Specificities	Olive origin (general)		++		++	++	++	++
	Olive origin (region)	++	++	++	++	++	++	++
	Monocultivar			+	++	++	++	
	Acidity	– –	N.O.		++	+	++	
	Taste	– –				+		+
Certifications	DOP certification		Not applicable		++	Not applicable		– –
	Organic (BIO) certification	N.O.		++	N.O.	N.O	N.O	++
	Other certification (IGP. . .)		N.O.	+		N.O		– –
Packaging	Bottle capacity	++	++	++	++	++	++	++
	Bottle shape	N.O.	++	N.O.	N.O.	N.O.	N.O.	N.O.
	Characteristic description			++				
	Bottle coated				++		++	
	Label tied to the bottle neck	++			N.O.	N.O.	N.O.	++
Internet related	Prizes won	Not applicable			– –		++	
	Link sponsored					++		N.O.
	Type of vendors				++	+	++	++
	Olive origin (specific)						++	

+ = weak significance in increase the value (5% <P value ≤10%)
– = weak significance in decrease the value (5% <P value ≤10%)
++ = strong significance in increase the value (P value ≤5%)
– – = strong significance in decrease the value (P value ≤5%)
N.O. = not enough data (not significant P value)

shape, whereas for an oil sold in gastronomies or wine shops is value to add a label tied to the bottle neck.

6.6 Conclusions

The methodology exposed in this paper try to merge the information gained from a field survey with those coming for database analysis in order to define some suggestions to increase the value of the olive oil to the eye of the costumers. The analysis showed that there is a strong difference between the attribute considered important in an interview with those paid more by the consumers, and this could bring to the idea that there is a lack of information in this sector. Moreover the paper stresses the importance of the right channel to increase the value of certain oil (like gastronomies and wine shops). Another channel able to place a higher price on the oil is the on-line channel. Although the market share of this channel is not yet important it is going to increase. Moreover there are many correlations in he combination of characteristic of the oil and related best distribution channel (for example the DOP certification allows to gain value in the Italian market and not in the US market where is quite unknown). On the other hand the BIO certification creates value in the USA where there is a grater sensibility thought the organic food and not in Italy.

Last element is that although is not consciously recognized from the consumers the packaging plays a fundamental role. It is well recognized how reducing the size increases the value, but there are still examples of high quality oil sold in large bottle. It seems obvious that a good design study in the bottle conformation will allow to increase the value, in a way simpler than, for example, getting a DOP certification.

It is important to remark how the methodology here exposed about the oil market is applicable to a broad range of goods, in particular high quality food characterized by well defined attributes.

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Chapter 7
How to Use Different Measures for Different Purposes: A Holistic Performance Management Model for Public Organizations

Francesco Sole and Giovanni Schiuma

Abstract One of the main challenges in the field of performance measurement and management is about how to use and manage performance measures in an effective way in order to fully integrate them into the organizational management system. This paper draws upon this need and proposes a holistic performance management model aimed to highlight the linkages among measurement systems and the effective use of performance measures for improving decision making, performance and accountability, in the public sector.

7.1 Introduction

In the last 20 years, the academic and practitioner attention on performance measurement and management systems in public sector is increased. Moreover, even if conceptions, designs, and methodologies for performance measurement and management systems continue to evolve, a single, central purpose of these initiatives has been unchanging: to improve public management and program outcomes.

Recent review of public management identified performance measurement as a trend transforming government because of its potential to improve government performance and accountability (Abramson et al., 2006).

Furthermore, as highlighted by Yang and Holzer (2006) "performance measurement and its public reporting have value beyond use in the budget and planning process. They have the capability of restoring citizen trust in government by making its activities, service, efforts and accomplishments more transparent, open to public scrutiny, and demonstrative of real value to taxpayers".

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In order to study more in depth the role and the value of performance measurement and management systems in the public sector we need first of all to distinguish the concepts of performance measurement and performance management.

In this respect, Nathan (2009) has emphasized that performance measurement should not be confused with performance management. Measuring performance is a necessary but not sufficient condition for performance management.

According to Bititci et al. (1997), "performance measurement system is the information system which is at the heart of the performance management process and it is of critical importance to the effective and efficient functioning of the performance management system. Performance management is the management processes and the behaviours management uses/adopts to manage the performance of an organisation".

Therefore, performance measurement systems should be not stand-alone systems, but rather essential systems to support or operationalize other management and decision-making processes, such as planning, budgeting, process improvement and so on.

Poister (2003) has argued that performance measures are monitored and used most effectively through performance measurement systems that track selected performance measures at regular time intervals so as to assess performance and enhance programmatic or organizational decision making and accountability.

In particular, performance measurement systems serve a variety of purposes in public organizations, therefore with respect to the measurement system itself, management needs to clarify its purpose and make sure that it is designed to serve the intended uses.

To summarize, producing reliable and valid reports of government performance is no end in itself. All of the reliable and valid data about performance is of little use to public managers if they lack a clear idea about how to use them or if the data are not appropriate for this particular use.

In such a propsect, the following questions represent some of the main challenges in the field of performance measurement and management in public sector: what are the appropriate performance dimensions for better supporting the management processes in public organizations? How to use and manage performance measures in an effective way in order to fully integrate them into the organizational management system?

This paper draws upon this need and starting from the insights of the literature review, proposes a holistic performance management model suitable to support public organizations in developing and implementing an effective performance measurement and management system.

The paper is organised as follows. In the second section, the evolution of performance dimensions in public organizations is briefly described. Then, in the third section, the use of performance measures in public sector management systems is addressed. Afterward the holistic performance management model is presented in the fourth section. Finally, in the last section, conclusions and suggestions for future research are provided.

7.2 The Evolution of Performance Dimensions in Public Organizations

Public sector management is closely connected both with public policy, policy-making and policy implementation that is, as well as with public administration. It is impossible to make a sharp separation between managerial action, policies and administration in the public sector. Public sector management embraces objectives and decision-making, as in policy-making, but it also takes into account how institutions constrain the employment of resources, as in administration (Lane, 2000).

From a performance measurement perspective, in 1980s public organizations have fosused the attention more on the legitimacy of public expenditures than on customers and citizens. Therefore public administrations' performances have been defined mainly with regard to the observance of the legislators' rules.

In the 1990s New Public Management (NPM) (Mwita, 2000; Hoque, 2004; Halachmi, 2005) has become increasingly popular with public sector accounting research and thus overlaps with many aspects of performance measurement and management. It is one of the main theoretical models that have dominated these disciplines in the twentieth century. From a performance measurement perspective, according to NPM, public organizations reassessed the role of the customers and focused the attention not only on financial measures but also on efficiency and output quality.

In the mid-1990s the concept of public value creation (Moore, 1995) has emerged. It has addressed the attention of politicians and executive managers on the performance results in terms of outcomes for the communities and citizens. In particular, the model proposed by Moore highlights two main elements for the success of public governance: the role of customers, citizens and others internal and external stakeholders in supporting and legitimating the public action by providing financial resources and approval; the public organizations' capacity of creating value for all stakeholders.

Other researchers (Neely et al., 2001; Kennerley and Neely, 2002) have also emphasized the centrally role of stakeholders within the context of public sector performance management as an important issue in the academic discussion.

In particular, according to Poister (2003), many stakeholders have an interest in the use of performance measures, including legislative bodies, politicians and other elected officials, customers and constituents, citizens and community, labor unions, chief executive, managers, and employees.

In generic terms, Battalino et al. (1996) have summarized the evolution of performance measurement systems in the last 20 years as the focus change from public interest to results that citizens value; from efficiency to quality and value; from a justify-costs mentality to a deliver-value mentality; from functions, authority, and structure to identifying a mission, services, customers, and outcomes.

To conclude, as the literature review has highlighted, in order to satisfy internal and external stakeholders' needs performance measurement systems in public sector must necessarily include multidimensional performance indicators, based on a mix of outcomes, output, effectiveness and efficiency measures.

7.3 The Use of Performance Measures in Public Sector Management Systems

In the previous paragraph, the evolution of performance dimensions in public organizations has been described and the importance among others of outcome measures has been stressed. Now the next question is: how to use them (outcomes, output quality, efficiency, productivity, and other key performance dimensions) in an effectice way?

Many experiences in public sector have highlighted that performance measures are often perceived as not useful due to the lack of meaningful contributions to decision making. Nathan (2009) has argued that "what gets counted counts, in the sense of making a difference, only if the reports are reviewed and used in making decisions".

A substantial amount of skepticism remains about both the feasibility and the utility of measurement systems, and numerous fallacies and misperceptions about the efficacy of performance measurement still prevail in the field (Ammons, 2002; Hatry, 2002).

After all, according to Behn (2003) neither the act of measuring performance nor the resulting data accomplishes anything itself; only when someone uses these measures in some way do they accomplish something. He has stressed that performance measurement is not an end in itself and as part of their overall performance management system, public managers can use performance measures in several ways: to evaluate, control, budget, motivate, promote, celebrate, learn, and improve.

Poister (2003) has affirmed that performance measurement is intended to produce objective, relevant information on program or organizational performance that can be used to strengthen management and inform decision making, achieve results and improve overall performance, and increase accountability.

According to Sanger (2008), performance measurement has many functions, but accountability to citizens and managing for results are two prized outcomes that have been expected from its expansion over the last decade. In particular she has stressed that "transparency and public reporting of performance are key elements of a successful public organization. The sharing of data produces visibility for the governmental or organizational unit and builds internal pride and incentives for continual improvement. Public reporting also builds trust and goodwill from authorizers, citizens, customers, and other stakeholders".

To summarize, about the use of performance measures in public sector, the literature review has highlighted that an effective performance-based management system requires the following essential elements: implementing multidimensional performance masurement systems with a reasonable level of agreement among key stakeholders and using performance information to strengthen accountability and improve policy effectiveness by supporting decision making.

7.4 An Integrated Performance Management Model for Public Organizations

Based on the results of the literature review, we propose the following holistic performance management model (see Fig. 7.1) aimed to address public organizations in improving performance and creating value for all stakeholders by managing performance measures in an effective way.

The proposed model is aimed both to analyze more in depth the fundamental components of a performance-based management system and to integrate them in an effective management process.

The model is based on the assumption that the main goals of a performance management system implemented in a public organization are: (1) assure transparency to stakeholders through a sistematic internal and external accountability process; (2) achieve outcomes objectives by improving performance day by day.

To better understand the model, a separate description of the three organizational levels (strategic level, operational level and team and individual level) included in Fig. 7.1 is provided. The description is aimed to analyze: the performance dimensions at each one organizational level, the stakeholders involved in accountability activities and the decision making processes the available performance data should be used for.

We want to stress that the model is a flexible tool therefore public managers can use it by adding or removing specific performance dimensions, key stakeholders or decision making processes according to need.

Finally a brief analysis and explanation of the dynamics in terms of information flows which characterize the model is carried out.

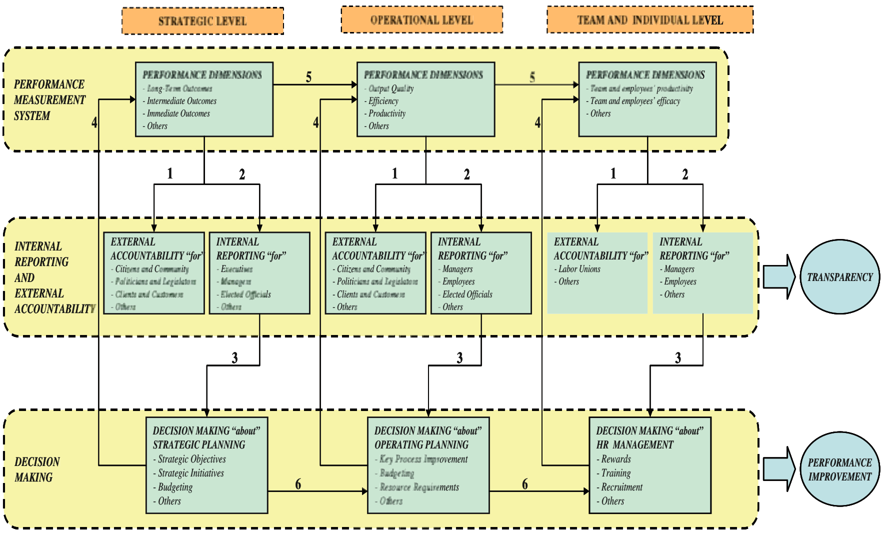

Fig. 7.1 The integrated performance management model for public organizations

7.4.1 Strategic Level

According to Poister (2003), the model identifies outcome measures (immediate outcomes, intermediate outcomes and long-term outcomes) as the most important strategic performances. Outcomes measures are essential for monitoring progress in implementing strategic initiatives and assessing their effectiveness in producing the desired results.

In addition, outcome measures allow politicians and elected officials to learn how well services are delivered, how well they meet the needs of their constituents, and whether they reflect the political demands they are elected to fulfill. Usually, strategic performance indicators also tend to be observed over longer time frames, more commonly providing annual or possibly semiannual or quarterly data.

Because strategic planning is concerned ultimately with maintaining and improving organizational effectiveness, we have identified also immediate outcomes (very closely in time to output measures) as important performance measures in order to address this issue.

As the proposed model shows, from an accountability perspective, outcome measures have significant value among others to the following stakeholders: citizens and community, customers, politicians and legislators.

Of course to communicate performance effectively, managers and staff should to take into account both the nature of the performance data and the stakeholders' needs for the data. Then managers should report and display the data in a way that maximizes the audience's ability to easily, accurately, and quickly understand what the data represent (Poister, 2003). These rules are valid both for internal and external accountability, at all decisional levels.

Finally, in order to address the integration of strategic measures in decision making processes, the model highlights the fundamental role those measures play in successful strategic planning efforts.

However, as Pollit (2000) has argued, "decisions regarding strategies, priorities, goals, objectives and strategic budgets are often made in heavily politicized contexts characterized by competing interests at different levels, forceful personalities, and the abandonment of principle in favor of compromise. Thus, although the purpose of measurement systems is to help improve performance through influencing decisions, they cannot be expected to control or dictate what those decisions will be".

7.4.2 Operating Level

At this level the model presents performance dimensions very closely related to internal operating efficiency (i.e. input and output measures) and efficacy (i.e. service quality and customer service indicators).

As compared with performance measurement systems that are intended to support strategic management and work with annual data, for example, systems designed to monitor quality and productivity tend to focus on more detailed indicators of performance at the operating level, and often very frequently, perhaps on a monthly, weekly, or even daily basis.

The data reporting about operational performances could be very useful both for external stakeholders like citizens, customers and legislators and internal users like executives and managers.

In particular by using these measures in internal decision making processes managers can judge the success of their operations and their improvement over time and allocate resources more effectively (Ammons, 1995; Behn, 2003).

7.4.3 Team and Individual Level

The performance dimensions included at this level are focused on the results of the single employee or team in terms of productivity and efficacy indicators. Providing feedback by using internal accountability to employees on their performance is a central element of effective approaches to human resource management, and this feedback is frequently provided by performance measures.

These measures should be used in decision making related to the processes of directing and controlling employees and work units in an organization and motivating them to perform at higher levels. In other words, these measures are fundamental for planning human resource management initiatives.

Poister (2003) have stressed that the importance of the measurement system based on team and individual performances is predicated on the idea that people's intentions, decisions, behavior, and performance will be influenced by the performance data and how they are used.

7.4.4 The Model "Step by Step"

In the previous paragraphs we have described all the elements included in the model excepting the arrows which connecting them. These arrows both horizontal and vertical are aimed to integrate the elements within the framework of the holistic performance management model. They highlight how public managers should implement and use a performance management system in an effective way by adopting a step by step approach.

In the following a brief description of these steps in the form of guidelines is provided. The step number one (see Fig. 7.1) is to connect, at all organizational levels, the performance measurement systems to the external accountability systems in order to make stakeholders certain of transparency.

Afterward, the step number two is to connect, again at all organizational levels, the performance measurement systems to the related internal reporting systems and then (step number three) develop systematic procedures aimed to ensure the use of the report system's information within the related decision making processes.

The step number four is to plan specific meetings just after the implementation of the decision making processes in order to review and update the performance measurement systems.

As a result of the updating of the performance measurement system at strategic level, the step number five is to align the performance measurement systems both at operational level and team and individual level. Finally, the step number six is to check and ensure the systematic alignment of decision making processes related to strategic initiatives, operational initiatives and human resource management initiatives.

By integrating these steps in the performance management system of their organizations, public executives and managers can use performance measures in a more effective way and as a consequence (see Fig. 7.1) can both increase the external accountability and transparency and improve the organizational performances.

7.5 Conclusions

According to Poister (2003) performance measurement systems can make a difference in government. Good performance measures, particularly outcome measures, signal what the real priorities are, and they motivate people to work harder and smarter to accomplish organizational objectives.

Measurement systems could provide managers and decision makers with information regarding performance that they use to manage agencies and programs more effectively, redirecting resources and making adjustments in operations and service delivery systems to produce better results.

However, as the literature review has highlighted, it must always be understood that performance measurement is a necessary but insufficient condition for results-oriented management or results oriented government.

For measurement to be useful, it must be effectively linked to other management and decision-making processes. Without strong linkages to such vital management and decision-making processes, performance measurement systems may generate information that is "nice to know," but they will not lead to better decisions, improved performance, or more effective accountability and control.

In such a prospect, starting from the analysis of the literature of performance measurement and management systems in public sector, we have developed a holistic performance management model aimed to highlight the linkages between measurement systems and the effective use of performance measures for improving decision making, performance and accountability, in the public sector.

The model we have proposed could be useful in order to address public managers at all levels implement and use effective measurement systems as components that are carefully integrated into processes for strategic planning and management, operational planning, budgeting, quality and productivity improvement, human resource management and other purposes.

Clearly, the proposed model is seen as open for future extension and development. Therefore further research is needed in order to test the conceptual model, by examining the robustness and consistency as evaluated in practice by public managers, politicians and of course external stakeholders.

We want to conclude this paper reporting a statement provided by Poister (2003) that highlights some restrictions related to the use of performance measures in public management (above all, measures are indicators only).

He has affirmed that “although measures can be invaluable in enabling managers and others to track the performance of agencies and programs, they cannot tell the whole story by themselves. Rather, they are intended to serve as one additional source of information on performance; the data they generate are purely descriptive in nature and provide only a surface-level view of how well or poorly programs are actually doing. Thus, managers should learn to use performance data effectively and interpret the results within the fuller context of what they already know or can find out about a program’s performance, but they should not let measures themselves dictate actions”.

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Part IV
What is Next by Theme: PMM and Sustainability Management

Chapter 8
Using Qualitative System Dynamics to Enhance the Performance Measurement of Sustainability

Cristiana Parisi

Abstract This paper aims to propose the adoption of qualitative system dynamics frameworks in order to improve the so called "second generation" performance measurement models with regards to the social and environmental dimensions of business performance. The said models address the issue of connecting financial and non financial indicators by using strategy or success maps. Some authors suggested the use of system dynamics approaches to improve them by taking into account the dynamic nature of performance and the transformation processes linking objectives and resources.

Based on a system thinking approach this paper specifically focuses on the performance measurement of sustainability, suggesting the adoption of qualitative system dynamic frameworks in order to better identify objectives and in support of a correct process of selection of indicators.

8.1 Introduction

Non financial performance measurement systems are becoming an increasingly important part of organisational life (Townley et al., 2003). Whether we are talking about balanced scorecard, quality management, or triple bottom line these new management technologies all have in common that they move beyond traditional financial accounting models to include new issues such as customer satisfaction, product quality, community relations, and pollution control (Abdel-Maksoud et al., 2005; Chatterji and Levine, 2006). Some sees the non financial performance measurement systems as a reflection of a disillusion with existing management control systems, others as a representation of the instrumental rationalisation of organisations, and still others as a response to overall societal changes that increase

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the need to manage intangible assets (Townley et al., 2003; Kaplan and Norton, 1996).

Whatever the perspective, there seem to be some consensus that the new performance measurement systems may stimulate organisational changes, albeit not always in the way that was originally intended. Proponents believe that “what gets measured gets done” and that non financial indicators can potentially be a source of competitive advantage, whereas more sceptical voices argue that these systems have a more symbolic character and are only loosely coupled to organisational decision-making and behaviour (Corvellec, 2006).

In a recent paper Neely et al. (2003) introduced the concept of performance measurement systems generations. According to their theorization, the Balanced Scorecard (BSC) (Kaplan and Norton, 2006), Skandia Navigator (Edvinsson and Malone, 1997) and the Performance Prism (Neely et al., 2002) can be considered the first generation performance measurement frameworks. The examples of second generation frameworks are Strategy Maps (Kaplan and Norton, 2000), success and risk maps (Neely et al., 2002; Marr et al., 2004) and the IC-navigator model developed by Goran Roos (Roos and Roos, 1997). The authors, in the same article specify that the first generation frameworks supplement the traditional financial metrics with non financial indicators, whereas the second-generation models are designed to allow for a visualization of the linkage between firm’s assets and business value.

The second generation of performance measurement systems is consistent with the systemic thinking approach to business management and performance measurement (Warren, 2007). Those frameworks describe managerial perception about the structure of the business system and the performance measurement related to them should capture the essential of the system behavior.

However, in the literature some problems and limitations of those models can be found. Nørreklit (2000, 2003) provide a critical examination of the Balanced Scorecard assumptions and concepts. In particular the inadequate definition and utilization of performance indicators has been pointed out as a main cause for failure of the BSC adoption also by other authors (e.g. Stivers et al., 1998; Ittner and Larcker, 1998; Ittner et al., 2003; Olve et al., 1999). Part of the literature (Schoeneborn, 2003; Narayanan Vijay, 2005) suggest the adoption of a qualitative and quantitative System Dynamics methodology to support the second generation performance measurement systems in general and the Balanced Scorecard in particular.

To the author’s knowledge theoretical or empirical research on the limitations of the performance measurement systems belonging to the second generation, with a particular focus on social and environmental resources is still scarce (Parisi and Hockerts, 2008). Given the peculiar process of accumulation of the social and environmental resources (Orsato and Renato, 2009), the present contribution suggests the inadequacy of a quantitative System Dynamic approach and propose the use of a qualitative methodology in order to improve the selection of indicators to be included in the performance measurement frameworks. The present paper provides theoretical evidences to support the hypothesized improvement of managerial decision effectiveness and the quality of the implemented performance measurement system.

8.2 The System Theory Approach

According to the system theory literature (Forrester, 1961; Senge, 1990; Sternman John, 2000) mental models are conceptual representations of the structure of an external system formed by individuals. Mental models can be used to describe and explain system behavior and to predict its future evolution (Doyle and Ford, 1998).

Managerial mental models or perceptions of the business system they are embedded in, is reflected by the decisions they assume and the indices they consider central for the measurement of firm's performance. Experimental research suggested that decision makers perform better if the structure of their mental models resembles the structure of the external system they represent (Wyman and Randel, 1998; Ritchie-Dunham, 2001).

The organizational outcomes in terms of financial performance and competitive advantage are reflections of managers' values and cognitive biases. In other words, firms can be viewed as top management mental models (an interpretist view of business) transformed into real organisations (a functional view of business). Kaplan and Norton (1996, p. 17) affirm that a properly constructed Balanced Scorecard should articulate the theory of the business. In other words, the Balanced Scorecard as well as the other performance management systems should reflect the dominant logic (Prahalad and Bettis, 1986) of the top management team since it represents the top management team's conceptualisation of the business and it is used as an administrative tool to accomplish managers' goals and make decisions to achieve this conceptualisation.

However, cognitive limitations can influence the potential for strategic performance by limiting managers' understanding about the real business system (Senge, 1990). Cognitive limitations are related to the bounded rationality of human decision making processes. According to Simon (1957) "the capacity of human mind for formulating and solving complex problems is very small compared with the size of the problem whose solution is required for objectively rational behavior in the real world or even for a reasonable approximation to such objective reality". Due to limitations of cognitive capabilities, the mental models managers use to make their decisions are deficient (Sterman John, 2000). Even when managers form adequate mental models, they are unable to correctly infer the dynamic behavior of the business system (Sterman John, 2000).

Decision making processes are the result of applying decision rules and policies that are in turn governed by managers' mental models (Sterman John, 2000). Therefore many performance management systems of the second generation are affected by managerial cognitive limitation, so the perceived causal relations upon which decision making processes are based can be described as finality rather that causality (Nørreklit, 2000) or may be affected by the cognitive limitations.

Empirical research suggests that decision makers tend to avoid the use of feedback loops when describing the reality and implementing decision making processes based on their analysis (Axelrod, 1976; Doyle and Ford, 1998). Decision makers tend to build “tree shaped” decisional structures, in which the causal chain is unidirectional. Similar studies suggest (e.g. Wyman and Randel, 1998) that individuals tend to assume that each event derives from a single cause and when a causal event is identified the analysis in considered concluded.

The heuristic scheme that is generally implemented leads to the construction of mental models and performance measurement systems that tend to avoid elements such as feedback loops, multiple connections, non linear hypotheses, and temporal delays. The managers’ mental model is also affected by the limitation of changing according to the moment in time when the analysis is developed. Some authors highlighted that individuals’ perception of causal linkages tends to be relevant only in case of spatial and temporal proximity of the analysed phenomena (Sterman John, 2000).

The said analysis underlines the complexity for decision makers to analyse accurately complex systems, in which causes and effects can be distant in time and space, in which actions can have multiple effects and can have consequences that are more complex than expected. Therefore the analysis of the impact of investments in social and environmental resources, which are generally only loosely coupled to firm’s financial performance and produce effects mainly in the long run, presents particular difficulties.

8.3 Qualitative System Dynamics: The Construction of Causal Maps

Within the system theory approach managerial perceptions can be described by feedback loops (Forrester, 1961). In the single loop approach to learning and decision making (Argyris, 1999), managers compare information about the situation of real system compared to goals, perceive deviations between desired and actual states, and make the decision they believe will move the system towards the desired state. In this process the information about the system state is the only input decision making.

However the single loop decision making and learning process does not change managers’ mental models. In the double loop approach (Argyris, 1999), information about the business system is not only used to make decisions within the context of existing frames, but also tends to improve managerial perceptions and mental models (Sterman John, 2000). The adoption of imperfect approaches causes the managers to have an incorrect perception about the impact of their decision, and so they are unable to build their mental models accurately (Sterman John, 2000). Therefore performance measurement systems shuold be defined in order to minimize these barriers. In the present paper the adoption of the causal maps model, within the qualitaitative system dynamic approach, is suggested in order to overcome the said limitations.

A wealth of methods for mapping out managerial cognition has been developed by many scholars, from causal mapping to mind mapping (Ackerman and Eden, 2004). Each of these tools aims to capture not only the concepts (or nodes) but also ways in which they are connected together (interrelationships). In performance measurement systems, these tools enable people in the organisation to understand how they contribute to the overall direction giving them a sense of purpose of their actions and how different performance measures impact on one another (Ackerman and Eden, 2004; Akkermans and van Oorschot, 2005).

The importance of causal maps in supporting strategy formulation and strategic control has been consistently proved by a vast range of literature (e.g. Eden and Ackerman, 2001). Numerous methodologies for constructing aggregated causal maps have been proposed, but only a few attempts are present in literature on the use of the causal mapping technique for finding indicators (Akkermans and vaan Oorschot, 2005).

Causal maps were originally devised to elicit mental models for individuals (Axelrod, 1976). A number of researchers (Langfield-Smith, 1992; Bougon, 1992; Weick and Bougon, 1986; Schneider and Angelman, 1993; Nicolini, 1999; Laukkanen, 1994; Lant and Shapira, 2001) then extended the application of the concept. The three common methods found in the literature for constructing collective mental models are aggregate, congregate and workshop mapping (Vo et al., 2005).

The first method aims to represent all individual maps as completely as possible in the collective map. This can result in a complex, aggregate causal map, but at the same time provides the most complete representation of a social system, allowing for all views to be represented.

The congregate mapping approach centres on the identification of key causal loops that drive system dynamics (Bougon, 1992). This methodology stresses the cause-and-effect relationship. These maps are simpler than the sum of individual maps, so that all possible conflicting views of the social system are not fully represented. Lastly, the workshop mapping approach focuses on a consensual model built at group level. Workshops, or group meetings, are where the model is built by all participants, aided by the facilitator (the researcher) whose role is central for the success of the session. This methodology cannot be employed by large groups or organizations and presents a limit of subjectivity in the elicitation of the model.

8.3.1 The Use of System Dynamic Approaches to Improve Performance Measurement Systems

System theory approaches have been suggested by the literature in order to overcome the limitations of the second generation performance measurement systems. While those systems are designed to handle the complexity of the strategy through many variables, which generates detail complexity, organisations abound in dynamic complexity because cause and effect relationships of managerial interventions are not easily identified immediately but they appear over time.

Dynamic complexity makes difficult to assert the causality between performance indicators making invalid the assumptions about cause-and-effect relationships used in the performance measurement systems. Systems thinking aims to identify the dynamic complexity existing in organisations by looking at multiple cause-and-effect relationships over time (Senge, 1990).

Measurement and assessment of organisational performance influence both the decision-making process and the people involved in strategic decision making and strategy implementation (Tapinos and Dyson, 2007). Causal relationships described in the Balanced Scorecard literature between performance measures follow a linear logic, and do not consider the information feedback processes where the outcome performance measures (effects) are used to change processes captured in the leading performance indicators (causes).

Thus, the information in the second generation performance measurement systems is not neutral to the process of decision-making and can affect the future value of the performance indicators leading to a circular process, from cause to effects and to causes again. The design of the causal relationships should consider the feedback processes existing between the information given by the performance indicators and the likely intervention in the organisation to correct deviations. Causal loop diagrams can illustrate the feedback processes existing between performance indicators and related organisational processes.

The complex nature of organisations makes the design of a set of performance measures very complicated. Nørreklit (2000) suggests it may be more useful to establish coherence between performance measurements, given the aim of obtaining certain results from organisational activities, than trying to establish causal relationships in a Balanced Scorecard. However, the ability to judge coherence and predict results depends on knowledge of both means and ends over time (Nørreklit, 2000) but it is difficult to judge coherence in managers' actions since organisations are complex systems where cause and effect are often separated both in time and space (Sterman John, 2000). Systems thinking is a methodology designed, in most of the cases in conjunction with simulation, to address all the issues related to judging coherence in strategic decision making and performance measurement systems (Akkermans and van Oorschot, 2005).

The use of System Dynamics in order to overcome the limitations of the second generation performance measurement system. A two stages approach is generally followed (Kunk, 2008; Akkermans and van Oorschot, 2005). In the first stage qualitative mental models of managerial perceived interrelationships are using causal loop diagramming, resulting in a refined version of a "strategy" or "success" maps.

Causal loop diagrams are then translated into a quantified simulation model, that describes the dynamic evolution of socks and flows of firm's assets. The model is calibrated using key company data. The distinction between qualitative and quantitative modelling is common in the SD literature and is considered the best way to introduce system dynamic models to support performance measurement systems in organizations (Senge, 1990; Vennix, 1996; Sterman John, 2000). In this paper we argue that given the peculiar characteristics of sustainability resources a qualitative approach is preferable in order to elicit key performance indicators and assign targets to improve the performance measurement systems.

8.4 The Performance Measurement of Sustainability

Corporate Social Responsibility is becoming an increasingly important part of organizational life (Orsato, 2009). There is the felt need to move beyond traditional financial accounting models to include new issues such as customer satisfaction, product quality, community relations, and pollution control (Abdel-Maksoud et al., 2005; Chatterji and Levine, 2006). Some sees the sustainability performance measurement systems as a reflection of a disillusion with existing frameworks (Perrini and Tencati, 2006), others as a response to overall societal changes that increase the need to manage those intangible assets (Yongvanich and Guthrie, 2006).

Whatever the perspective, there seem to be some consensus that the adoption of sustainability performance measurement systems may lead to organizational changes, although not always in the way that was originally intended. It is believed that those models can potentially be a source of competitive advantage, whereas more skeptical voices argue that these systems have a more symbolic character and are only loosely coupled to organisational decision-making and behaviour. The said situation often results in the adoption of normative approaches to investments in sustainability by companies (Orsato, 2009).

However, the most important performance measurement systems for sustainability are the balanced Scorecard, and the EFQM model, that belong to the second generation of performance measurement tools.

8.4.1 The Balanced Scorecard Model for Measurement of Social and Environmental Performance

In the area of strategically oriented performance measurement, the Balanced Scorecard (BSC) has been one of the most debated suggestions for developing a framework for performance measurement and management (Kaplan and Norton, 1996). The tool was first developed as a new approach to performance measurement, due to problems of short-termism and past orientation in management accounting. The concept of the Balanced Scorecard is based on the assumption that the financial indicators are not as capable of evaluating all determinants of competitive advantage as other "soft" factors, such as intangible assets and relational capital, referred to by the authors as customer orientation (Kaplan and Norton, 2004).

The new framework focuses on corporate strategy, which is divided into four perspectives, i.e. financial, customers, internal processes and learning and growth, in order to evaluate and manage the contribution of soft factors to the overall performance of the company. Cause and effect relationships are expressed in the BSC through the "strategy maps", tools created to describe the path of value creation in the process of implementing corporate strategy. Strategy maps contain hypotheses or predictions about how organizational processes drive corporate performances, which are measured against targets in the BSC. The relationship between performance indicators connect the four perspectives, creating a hypothetical description of the internal process of value creation, that leads to financial results and has to be validated by confronting targets with the company's actual performances (Hellström and Husted, 2005).

Indicators are distinguished between "lagging" indicators, which are ex-post measures of the achievement of objectives in the four dimensions, and "leading" indicators, which reflect the strategic hypothesis of each specific firm that creates them, and represent how results, expressed by lagging indicators, should be achieved.

According to scholars and practitioners studying sustainable development, this tool is very significant for many reasons. In fact, it claims that qualitative indicators, among which environmental and social ones, are of strategic importance. Moreover, since it forces managers to reach an agreement on the definition of corporate strategy, it is an effective platform to evaluate and communicate the value added by sustainability, that can be defined more clearly when creating the strategy map. In fact, to build the tool allows the firm to define more easily the business case for environmental and social activities. It also widens the horizon of performance measurements, including long-term determinants of value creation which are crucial for sustainable investments (Olve and Sjöstrand, 2002).

On the basis of said considerations, academics have concluded that this tool is meaningful in that it aligns the process of value creation of environmental and social strategic themes to the corporate strategy. More specifically, academic literature has come up with three basic possibilities to integrate sustainable aspects in the BSC. Environmental and social issues can be integrated in the existing four standard perspectives; alternatively, an additional perspective, whether (Olve et al., 1999), or not market-related (Figge et al., 2002) can be added to take those aspects into consideration; and finally, a specific environmental and/or social scorecard can be created (Epstein and Roy, 2003). The third approach to integrating environmental and social aspects into the BSC consists of the deduction of a sustainability scorecard. This variant cannot be considered as an alternative to the first two models, but rather as an extension thereof, since a derived environmental and social scorecard is developed in conjunction with the BSC created for the company as a whole (Parisi and Hockerts, 2008).

It draws its contents from an existing BSC system and is therefore used to coordinate, organize, and further differentiate environmental and social aspects once their strategic relevance and position in the cause-and-effect chains has been identified by the previous approaches, so it can be used to clarify the relationship between a shared service unit and the main scorecard. Therefore, it can be said that this approach is tailored to a given structure of the firm that is more popular in Anglo-Saxon culture – which the BSC was created in – than in most European countries (Epstein and Roy, 2007).

As for the first two approaches – subsumption and addiction of a new perspective – these refer to an existing core Balanced Scorecard system. The main shortcoming of such an approach, is the limited capacity of the existing four traditional perspectives of the BSC of dealing with sustainability and the stakeholders' approach in general (Neely et al., 2002).

The extreme rigidity of the structure of this management framework is unable to efficiently include socially related dimensions.

Those gaps are visible; in fact, the first attempt to include other stakeholders' concerns, such as local communities, the impacts of products and services made by the company or the difference in working conditions found in large multinational companies, in the internal processes perspective under the name of "governmental and societal" processes (Kaplan and Norton, 2004), somewhat disrupts the entire system. This is due to the different time dimension required by the management of the different processes described, and the lack of connection between stakeholders' interests and the other perspectives. Those issues are only related to long-term financial perspective, therefore the causal linkage described by the Authors is not respected. In their last work, Kaplan and Norton (Kaplan and Norton, 2006) simply do not consider those issues in their model.

The given example may demonstrate why the structure of the BSC and the related Strategy Maps cannot be considered sufficient in this context. Although companies are currently keen on reporting their positive impacts on local communities, the negative ones are more difficult to measure. Therefore, there is a high degree of subjectivity, the so-called "judgmental effect" (Lipe and Salterio, 2000), that relates to the impact of managers' evaluation of the most important strategic themes in the act of strategy formation. The current structure of the BSC does not help managers to formulate a strategy that takes external stakeholders and sustainable development into adequate consideration. Therefore, we believe that a new model is required in order to eliminate the shortcomings of the tool in the process of strategy formation when dealing with social and environmental strategy.

8.4.2 The EFQM Excellence Model and Sustainability

The past decade has witnessed the forceful emergence of the quality culture movement on the business scene. Its impact was at first limited to the industrial sector; over the years, however, these initiatives have spread and become more popular, reaching almost all economic sectors: financial services, education, social services, health care, etc. The rise of Quality Management (QM) in the business world is generally associated with the implementation of Quality Systems based on the ISO 9000 international standards and, in Europe, of the Excellence Model of the European Foundation for Quality Management (EFQM), one of the international models for establishing Total Quality Management (TQM) systems within companies (Avlonas).

The EFQM Excellence model is a non-prescriptive framework based on nine criteria, that can be used to assess an organization's progress toward excellence.

The model acknowledges the existence of many approaches to achieving sustainable excellence in all aspects of performance, and is based on the premise that excellent results with respect to Performances, Customers, People and Society are achieved through Leadership driving Policy and Strategy, that is delivered through People, Partnerships and Resources and Processes.

The dynamic nature of the model is shown by the connections between the said areas, which show how innovation and learning help to improve enablers which, in turn, lead to improved results. The terms "Enablers" and "Results" are used to designate two categories of criteria. Enablers criteria are concerned with how the organization undertakes key activities, while Results criteria are concerned with what kind of results are achieved. The "Enablers" contain the conditions needed for successful change: incorporation in policy and strategy, management dedication, people integration, an adequate supply and utilization of resources and partners and incorporation in key processes. The "Enablers" achieve results for the organization and also for its key target groups (customers, employees and society). On a second level, these nine criteria are further specified in thirty-two criterion parts (Van Aken, 2005).

This method was initially applied to the analysis of questions related to education, public administration or other economic and business issues. It has now been adapted in order to incorporate corporate social responsibility aspects. The wish is for corporate social responsibility to be adopted within established TQM systems as a tactic to advance understanding and acceptance of a more ethically anchored approach to quality management.

As for the evaluation of this model, most studies on QM are quantitative and are based on surveys directed at managers; and most surveys have been specifically addressed to managers and/or staff in charge of quality management (Cragg, 2005).

To the author's opinion, these researches are potentially limited and methodologically distorted, since they are grounded only on opinions about the effects of the process of company managers who have participated in implementing quality systems. As a result of this possible bias, the use of commercial economic and financial databases as sources of information to verify the impact of QM models on company results has grown in recent years. Even so, these studies are very limited when establishing the cause of relationships, as is all too well-known and emphasized in the studies.

Though the analysis of the effect of the implementation of EFQM models on business among practitioners shows a high degree of consensus, the degree of consensus achieved among the experts significantly decreases with regard to the impact of the application of the EFQM model on the quality of products and services offered by companies (Saizarbitoria, 2006).

In fact, the model improves the quality of products or services offered to the extent that "it is fully aimed at satisfying the client", while not taking into consideration a balanced approach to the interests of the company's many stakeholders. Its failure to focus on specific areas in which performances are relevant, can lead to an inadequate assessment of performances, as well as to a lack of control on the number of variables considered. In fact, scholars and practitioners have underlined that too many indicators have often been considered when implementing the tool.

8.5 The Characteristics of Social and Environmental Resources

Numerous empirical studies have been conducted in order to verify the existence of a business case for good corporate behaviour and to test the relationship between Corporate Social Performance (CSP) and Corporate Financial Performance (CFP), (Aupperle et al., 1985; Blacconiere and Patten, 1994; Klassen and Whybark, 1999; Margolis and Walsh, 2001, 2003).

The results of the empirical test suggest a positive association between CSP and CFP, and reveal a bidirectional self-enforcing relationship. Moreover, the so-called "trust capital" is found to be an important mediator in the relationship (Orlitzky et al., 2003).

Notwithstanding the numerous studies investigating the CSP-CFP relationship, only a limited number of these studies try to disclose the competitiveness linked to CRS related intangibles (Dyllick, 1999; Reinhardt, 2000;). Furthermore, none of the aforementioned studies try to define a model from which to derive indicators to support the measurement of CSR actions.

In order to analyze the possible methodologies for the performance measurement of firms' social and financial performance the main characteristics of sustainability resources have to be outlined. In order to argue, qualitatively, the existence of a business case, many authors hypothesised correlation between CSR and the company's reputation, access to financing, employee motivation, better risk assessment, increased competitiveness, improved operational efficiency and the possibility to be granted the licence to operate. (Baumol, 1970; Burke and Logsdon, 1996; Davis, 1973; Dyllick, 1999; Hart, 1995; Orsato, 2009; WBCSD, 2002). The intangible nature of social and environmental resources, is related to specific characteristic such as non rivalry, networks effects and a specific processes of accumulation.

Physical, human, and financial assets are rival assets in the sense that alternative uses compete for the services of these assets. In particular, a specific deployment of rival assets precludes them from simultaneously being used elsewhere. Such rivalry leads to positive opportunity costs for rival assets, where the cost is the opportunity forgone, namely the benefit from deploying the asset in the next-best alternative.

In contrast, social and environmental resources are, in general, non rival; they can be deployed at the same time in multiple uses, where a given deployment does not detract from the usefulness of the asset in other deployments. Accordingly, many intangible inputs have zero or negligible opportunity costs beyond the original investment.

A major contributor to the non rivalry of CSR assets is the fact that these assets are generally characterized by large fixed (sunk) cost and negligible marginal (incremental) cost. Many such investments are not subject to the diminishing returns characteristic of physical assets. The positive reputation related to firm's CSR investment requires large initial investments and limited marginal costs, but the ability to use such assets in simultaneous diminishing returns to scale typical and repetitive applications of physical assets.

Moreover the intangible assets benefit form the economics of networks, that can be succinctly summarized as "One's benefit from being part of a network increases with the number of other persons or enterprises connected to it" (Shapiro and Varian, 1999). The fact that benefits in network markets increase with the size of the network often creates positive feedback, in which success begets success. This is the case of the relational capital (Mouritsen et al., 2005) generated by the investments in social and environmental asset by the company.

The expected long term returns on investments related to the effects of non rivaltry and the uncertainty related to the quantification of network effects causes the difficulty in defining effective indicators and largerly explains the normative approach generally adopted by companies deciding investements in social and environmental assets. The said characteristics also result in the different process of accumulation of sustainability, reputational assets, is compared to tangible ones, therefore a traditional qualitative and quantitative system dynamic approach might be inapplicable to measure these specific assets.

Since the existent performance measurement systems of sustainability can be considered part of the second generation (Neely et al., 2003), as they present the same attributes and shortcomings as the said frameworks. However, to the author's opinion the traditional system dynamic approach cannot be implemented in order to overcome them, but can contribute to the definition of correct indicators to support the performance measurement of social and environmental performance.

To the author's belief the process, in order to promote the measurement of CSR action's performance the existent models adopted by companies should be complemented by a specific framework able to structure coherent causal relations between those resources and firm's overall process of value creation. The qualitative system dynamics approach can be adopted in order to clarify the correct causal chain that describes the contribution of those asset to firms' internal processes. It could be used to overcome the limitations related to management's cognitive boundaries. However, to the authors's opinion the nodes and connections created should not be used to compute stocks and flows of materials, as in the traditional system dynamic approach, but to highlight the indicators.

The causal maps within the qualitative system dynamic approach can be used to support the mission statement into a series of strategies which indicate the intention to focus the thinking and strategic actions related to CSR actions, that are not likely to be achieved in the short term. Supporting them the causal map will show a number of interrelated strategic objectives providing a more detailed picture of how the division is to attain the strategies.

The peculiar framework described can be used to derive more efficient indicators, that complement the existent performance measurement system, to concentrate efforts an them whilst maintaining a direction in accordance to the main strategies. The said indices will be dealt with each year in order to perform a double loop strategic feedback that will improve and correct the strategic assumptions and the chosen indicators.

8.6 Concluding Remarks

Literature on system dynamics describes the role of congregate maps in supporting performance measurement systems, improving the causal relations of the model and selecting better indicators following a positivistic approach (Schoeneborn, 2003; Othman, 2006).

Even though the objective is apparently similar, a different approach is considered applicable for the measurement and management of sustainability strategies. The mapping process described produce a qualitative record of the company's strategy. This strategic direction can be developed as a network of statements with regard to the company's intentions, their importance and how they are to be achieved. The resulting map expresses the assumptions about interrelationships between elements and the coherence of the strategy, providing, in turn, a coherent rationality.

The aim of this paper was to improve social and environmental the second generation performance measurement systems using a system thinking approach. The causal maps built following a qualitative system dynamic approach can overcome management cognitive biases regarding the contribution of social and environmental resources to the overall process of value creation.

The said approach can be the first used to describe the strategies adopted by the firm as a consequence of the perceived competitive advantages related to CSR, then to provide a more detailed picture of the strategic programmes and actions through which the company is to attain strategies; and lastly a set of indicators can be defined in order to evaluate the performance of the company in implementing them.

The indicators drawn from the causal maps constitute one step in the building of a performance measurement model that incorporate preference information on acceptable trade-offs between performances on different dimensions. This attempts to solve the problems related to discrepancies between stakeholders' evaluation of costs and benefits deriving from company's actions. The continuous process of revising the strategy and the indicators based on the results of corporate management (Kaplan and Norton, 2008) is expected to improve the precision of the model.

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Chapter 9
Operationalising Sustainability: How Small and Medium Sized Enterprises Translate Social and Environmental Issues into Practice

Cristiana Parisi and Maria Pia Maraghini

Abstract Drawing on a survey of Italian SMEs from the Tuscan area, this study aims to explore if and how SMEs integrate sustainability in their strategy and management systems, in particular in the performance measurement system. By combining theoretical and empirical findings, the study provides insights on how performance measurement systems could be improved to better operationalise sustainability strategies in SMEs. Moreover, the paper aspires to contribute to the existent sustainability literature by focusing on the processes of translating social and environmental issues into practice within SMEs.

The research is part of the activities of the Sustainability & Management Lab (S&M Lab), an international research group whose aim is to explore how social and environmental issues can be effectively integrated into companies' traditional strategic planning, organizational structures, accounting and performance measurement systems.

9.1 Introduction

Today, sustainability issues can be found in the web-site of more than 80% of Fortune 500 companies (Bhattacharya and Sen, 2004). However, statements of sustainability do not reveal much about actual practices. According to the former EU social affairs commissioner, Anna Diamantopoulou, 90% of major USA corporations make sustainability commitments, but only 35% of them are able to prove that they follow their principles.

In consequence, it is not surprising that scholars and practitioners have addressed the need for sustainability to move from being a peripheral add-on activity to become better integrated in the all core business functions and activities (Busco

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et al., 2007). The new focus on mainstreaming sustainability implies that much of the debate has changed from being about "whether" to do sustainability to "how". More attention has therefore been directed toward the issues of translating overall sustainability strategies into everyday business practices and of improving management systems accordingly.

However, despite this shift in the literature's concern, little attention is still given to small and medium sized enterprises (SMEs). Moreover large scale analyses of the process of implementing sustainability in companies of this size seem to be lacking.

Drawing on a survey of Italian SMEs from the Tuscan area, this study aims to explore if and how SMEs integrate sustainability in their strategy and management systems, in particular performance measurement system.

By combining theoretical and empirical findings, the study provides insights on how performance measurement systems could be improved to better operationalise sustainability strategies in SMEs. Moreover, the paper aspires to contribute to the existent sustainability literature by focusing on the processes of translating social and environmental issues into practice within SMEs.

The research is part of the activities of the Sustainability & Management Lab (S&M Lab), an international research group with the aim to explore how social and environmental issues can be effectively integrated into conventional strategic planning, organizational structures, accounting and performance measurement systems.

Numerous authors suggest that there exists no one universally accepted definition of the term "sustainability" (see Votaw, 1973; Whitehouse, 2003). While academics continue to debate the content and meaning of sustainability or "corporate social responsibility" (CSR) (see, for example, Carroll, 2001; Waddock, 2001; Wood, 1991), however, many large companies appear to have found common ground upon which they have constructed elaborate sustainability policies and practices. Whitehouse suggests that sustainability reveals itself among large companies not as a uniform concept but as a variety of conceptions. For some companies, sustainability derives from and is closely related to pre-established concepts such as stakeholding. For others, it concerns the manner in which they operate all aspects of their business and the extent to which that behaviour impacts upon the environment, their stakeholders and society generally (2006, p. 293).

As we targeted SMEs, we have deliberately chosen the term ''sustainability'', over "corporate social responsibility". While, within the study she reports on, ''corporate social responsibility'' was the most common phrase, it was not seen as the most appropriate and ''sustainability" was a reasonably popular alternative. But this is not necessarily to argue that this is the best term, merely one that avoids ''corporate'' and ''social'', neither of which are very appropriate to SMEs (Southwell, 2005). Other authors (e.g. Tilley, 2003) while dealing with SMEs prefer to adopt the term "sustainability".

The World Business Council for Sustainable Development (WBCSD) defines sustainability as "the commitment of business to contribute to sustainable economic development, working with employees, their families, the local community and society at large to improve their quality of life". The concept of sustainability is underpinned by the idea that corporations can no longer act as isolated economic entities operating in detachment from broader society, neither focus their value only on the financial dimension. Consequently, traditional views about competitiveness, survival and profitability are being swept away. Sustainability promotes a vision of business accountability and responsibility to a wide range of stakeholders, besides the usual shareholders and investors. Key areas of concern are environmental protection and the wellbeing of employees, the community and civil society in general, both now and in the future, showing thus a strong link with Sustainable Development dimensions: Economic Prosperity, Social Equality and Environmental Safeguarding (this is known as the Triple Bottom Line – the TBL – of Sustainability).

The increased prevalence of sustainability as a feature of corporate policy and practice during the last decade is made evident by a review of the literature of some of both the largest companies and SMEs (Gadenne et al., 2009; Spence, 1999; Spence and Rutherfoord, 2003; Spence and Schmidpeter, 2003; Spence et al., 2003).

The inclusion of a few paragraphs within the annual report dealing with the non-financial aspects of the business has been replaced by the publication of glossy reports and a high profile presence on corporate websites of "sustainability" issues. The popularity of sustainability among European firms reflects to some extent the approach adopted by companies within the US where sustainability has been a feature of corporate practice since the 1960s. As Esrock and Leichty's analysis of a random sample of Fortune 500 companies revealed, ''90% had web pages and 82% of the sites addressed at least one corporate social responsibility issue'' (1998, p. 305).

This ability to implement policies founded upon a concept that remains ambiguous raises a number of questions regarding the definition employed by those who profess a commitment to sustainability, why they have chosen to implement sustainability policies, how they develop those policies and their value in terms of reducing the adverse impact of corporate activity.

Within the described context, researchers and practitioners are still working to improve the knowledge base supporting the link between theory and practice in sustainability. In recent years, theory has evolved suggesting what could drive sustainable behaviour within firms (Fassin, 2008; Perrini et al., 2007; Gadenne et al., 2009; Russo and Tencati, 2008) but knowledge gaps still exist affecting the sustainable managerial best practices (Perrini, 2006). In other words managers do not possess all the information and frameworks necessary to implement sustainability strategies, and this problem is even more visible when it comes to distinguishing between large corporations and small and medium sized enterprises. In particular, much work remains to develop a better knowledge on sustainability tools for SMEs and to connect new theories to small firm practice (Tilley, 2000; p. 39). In the words of Moore and Spence "from a policy perspective, there remains the impression that we need still more examples to show that responsible business practice can be carried out in SMEs in order to inspire others".

Given the high degree of interrelation between SMEs and their environment or communities in which they operate, it is natural to focus on a limited geographical area when dealing with firms of this size (Thompson and Smith, 1991). For this reason the present contribution aims at contributing to the said debate by examining how a representative sample of Italian SMEs of the region Tuscany deal with sustainability, namely the main motivation for the adoption of sustainable practices, the integration of sustainability within firms' overall strategy, the managerial actions and the main drivers and barriers faced by firms.

The paper is organized as follows. First a brief review of the existing literature on corporate practices in respect of sustainability with a particular focus on SMEs is presented. This is followed by an account of the methodology employed in obtaining the data that forms the basis of this work. Then and analysis of the findings of the empirical survey is presented, the chronological track of the process of sustainability policy development is kept. On the basis of the findings of the empirical survey, conclusions are drawn and suggestions for further development are presented.

9.2 Translating Sustainability into Everyday Business Practices by Small and Medium Sized Enterprises: A Literature Review

9.2.1 Small and Medium Sized Enterprises and Sustainability

The literature available in respect of the concept of sustainability is substantial (see, for example, Andriof et al., 2002; Carroll, 1991, 2001) but it is not the aim of this paper to offer a review of current thinking in respect of the concept; that task has been undertaken by other writers (see, for example, Garriga and Mele,´2004). Rather, in seeking to offer a unique insight into the formation and implementation of sustainability policies by some of the small and medium size enterprises, this paper seeks to complement the findings of the existing literature on sustainability in practice by highlighting and, in later sections, addressing questions that remain unanswered.

To date, the existing literature has tended to focus on larger companies (Jenkins, 2004). Yet it is recognised that SMEs, which are firms with fewer than 250 employees and with a turnover of less than €50 millions or a balance sheet total of less than €43 millions (EC Recommendation 2003/361/EC) can practice sustainability.

Therefore while, as Moore and Spence point out, there is no area of research into responsible business practice and SMEs which could be considered well addressed (2006, p. 220), there are only some areas which have been investigated to some extent. For example the issue of employment practices and relations in small firms has been fairly well addressed in the small business and human resource management field. It is perhaps the keen awareness of the employees' reliance on the employer for their livelihood that is different from the larger firm, where decision makers will not normally have personal contact with the individuals who are affected.

The focus of the present work is, however, more on a meso-level, according to the definition of Spence (1999, p. 201). Outside of the strictly academic literature the emphasis in policy circles has been on identifying good practice examples, primarily to encourage more SMEs to act socially responsibly. This clearly presupposes that SMEs are not operating in a responsible manner.

At a European level, the Enterprise Directorate General of the European Commission has produced a document with 17 case examples from across Europe illustrating good practice in the broad areas of marketplace, workplace, community, and the environment. From a policy perspective, there remains the impression that we need still more examples to show that responsible business practice can be carried out in SMEs in order to inspire others. Meanwhile, a further batch of publications supports the notion that responsible business practice is perfectly evident in small firms, but not easily identifiable as such due to the inapplicability of sustainability theory and traditional business ethics approaches in the small firm context (Jenkins, 2004; Spence, 2000; Vyakarnam et al., 1997).

At the most basic level, it has been found that competitors are often treated as (moral) stakeholders rather than just adversaries in the marketplace. This is because they are different in nature, not just in size, from large firms (see Goffee and Scase, 1995) and are unlikely to adopt marketing tools, or strategic approaches using ''management speak''. Most are product focused not having the time or necessarily the skills to think about functional and organisational issues like responsible business practice. That does not mean that they are acting irresponsibly, or that they are less capable of fulfilling sustainability than large corporations however (Thompson and Smith, 1991), just that what they do is not codified in the way it might be in a large firm.

An additional reason for the difficulty of identifying small business behaviour as in keeping with other sustainability approaches is the major one of the lack of use of recognisable terminology (Southwell, 2005; Spence, 2000). Formal environmental management systems are not found to be readily adopted by small firms which tend to take more of an ad hoc and reactive approach to environmental issues, again reflecting the lack of formalised strategic controls.

While popular (largely unfounded) opinion may well be that small firms are less ethical than larger firms (Thompson and Smith, 1991), there is a basic acceptance that SMEs have good relations with local communities.

Some research supports this notion of SME embeddness in the local community, such as that by Besser and Miller (2001), Southwell (2005), Spence and Schmidpeter (2003) and Spence et al. (2003). However, SME researchers have also been rather more skeptical, with Curran and Blackburn (1994) identifying the isolated "fortress enterprise", and Curran et al. (2000) identifying a characteristic of non-participation in local economic development by small firms.

Here, there is an issue of the impact of "moral proximity" for some types of small firms. Jones (1991) argues that proximity is one of the factors that increase the likelihood of moral behavior. While those who draw their customers from a close geographical group (e.g. garages) are perhaps more likely to feel that moral proximity acutely, others may be relatively unattached to their surroundings (e.g. web designers) and readily enjoy the independence which is a common motivation for starting one's own small business (Goffee and Scase, 1995).

While policy-makers are especially keen either to export large firm sustainability tools to small firms or develop new tools for SMEs, there remains little scholarly work which really addresses the usefulness of either of these approaches. Exceptions are Graafland et al.'s (2003) work comparing instruments used in large and small firms (finding, unsurprisingly, that smaller firms are far less likely to strategise responsible business practice than large firms) and Tencati et al.'s (2004) efforts to identify appropriate tools to foster responsible business practice for smaller firms.

While it has been well, though inconclusively, covered in terms of large firms (Perrini, 2006), an equal area of concern for those trying to influence responsible business practice is whether such approaches are financially advantageous for SMEs. Tentative positive conclusions are found by Kramer et al. (2005) in looking at Danish SMEs. However, such perspectives are in danger of rather missing the nature of SMEs with, as noted above, most not being driven by financial perspectives alone (Goffee and Scase, 1995; Spence and Rutherfoord, 2001).

It has been also suggested that there is a generalized lack of understanding on causal drivers of SMEs sustainable behaviour. Therefore there's a growing recognition that we need to improve the understanding of those firms' sustainable practices so that more theoretical conceptualizations of sustainability can be developed (Fassin, 2008; Russo and Tencati, 2008).

Bansal and Roth (2000) argue that an explanation of business responsiveness is needed for two reasons. The first of these is that it would help organizational theorists to understand the factors that induce sustainable practices. The second, and perhaps the more significant reason is that it would shed a light on the mechanisms that foster sustainable organizations. This would allow "researchers, managers, and policy makers to determine the relative efficacy of command and control mechanisms, market measures, and voluntary measures" (p. 717).

9.2.2 SMEs in Europe and Italy

A specific investigation of sustainability within SMEs in an European and Italian context can be considered relevant due to those enterprises' impact on the overall economic context. In fact according to the Observatory of European SMEs small and medium-sized enterprises constitute 99% of all business in the EU and are responsible for 66% of total employment and half of the total value added in the EU (2003). Their impact on society appears therefore underestimated (Lepoutre and Heene, 2006) and ignoring SMEs in research is "in fact totally inappropriate".

However, given the high degree of interrelation between SMEs and the communities in which the often also act as benefactors or local activist, when undertaking a study on the sustainability practices of SMEs there is a need to focus the research in a specific geographical area (Murillo and Lozano, 2006). Moreover there is a logical homogeneity between SMEs operating in the same area, given their being subject to the market dynamics determined by large enterprises operating within the area, which in many cases they supply (Enderle, 2004).

The Italian context was chosen for its remarkable attention to social relationships, due to the predominance of SMEs who are strictly involved in local districts (Perrini, 2006).

Regarding the predominance of SMEs, a comparison with the average size of European enterprises shows the peculiarity of the Italian system. In fact Italian SMEs employ an average of 61% workers, compared to 40% in the EU in general and e.g. 20% in Germany, 30% in France, 40% in the United Kingdom, 20% in Sweden and 10% in Denmark (European Commission, 2003). Moreover 80.3% of Italian industrial enterprises have less than 250 employees while the EU equivalent statistic is 66%.

Moreover Italian companies seem particularly involved into sustainability issues, as Italy holds a leading position in acquiring the SA8000 Standard, and companies are beginning to circulate their first corporate social audit and ethical codes. Initially, the relative investment was made above all by large companies (e.g. Eni, Agip, Coop), but is now spreading to SMEs. In the study conducted by Longo et al. 10 percent of SMEs in the region Emilia Romagna produce a social audit and one of the companies also holds the SA8000 certificate (2005).

Italian industrial district are located all over the country, more specifically in North and Central Italy, along the Adriatic coast and in a few areas of the South, however the literature has focused more on the overall Italian context (Perrini, 2006; Perrini et al., 2007; Russo and Tencati, 2008) or the North of the Country (Longo et al., 2005). There is the felt need for in an depth analysis of other specific areas within the Italian context, that are specifically relevant for their attention to sustainability issues. Following the aforementioned argument, the present paper focuses on a sample of SMEs based in Central Italy, and more specifically in the region Toscana.

9.3 Translating Sustainability into Everyday Business Practices by Small and Medium Sized Enterprises: An Empirical Survey

9.3.1 Methodology

The quantitative data presented in the paper was obtained during a survey involving representatives of more than two hundred Italian companies (essentially SMEs) of the region Toscana. The aim of the survey was to acquire information relating to the practical implementation of sustainability and in particular, the views of those at the forefront of corporate policy development.

In deciding which companies to contact, the aim was to obtain data on sustainability polices that had the potential to impact upon the greatest number of stakeholders across a range of sectors. The decision was taken, therefore, to approach companies who professed a commitment to sustainability. On this basis, only companies who implemented SA8000 were chosen.

SA8000 is the first auditable standard to monitor businesses' social responsibility. The worldwide-recognized certification to the SA8000 standard involves the development and auditing of management systems that promote socially acceptable working practices, bringing benefits to the complete supply chain.

The SA8000 standard was chosen to broaden the sample as much as possible. In fact, more than two hundred Tuscany companies has obtained the SA8000 certification (exactly n. 252), also motivated by the specific tax benefits that the region has linked to such a certification. As a result, the region Toscana is the leading region within the Italian context for the adoption of the SA8000 standard (Fig. 9.2).

Firms were contacted via e-mail and could answer the survey posited on dedicated sections of the Region Toscana (www.fabricaethica.it) and Sustainability & Management Lab (www.semlab.unisi.it) websites.

The questionnaire has been filled in by the 22.22% of the companies of the sample (n. 56 companies). The companies interviewed are essentially micro, small and medium-sized enterprises considering the EU SME definition. They have obtained the SA8000 certification mainly in the last 5 years.

9.3.2 The Findings of the Empirical Survey: Data and Discussion

Consistently with the choice of the sample, all interviewed companies have foreseen appropriate sustainability strategies. However, such strategies do not always result formalized in appropriate planning documents: only the 85.71% of people interviewed admits the existence of such documents. Moreover, an ad hoc strategic plan on social and environmental themes is rarely drawn up. On the contrary, the formalization of sustainability strategies is applied in the general strategic plan (75%) or in other type of documents (25%) such as the reports that Business Managers draw up after the examination of the social Balance or the integrated Manual of social responsibility and quality system.

The inclusion of sustainability strategies within a general strategic plan may seem obvious, in virtue of their desirable integration with business strategies (Porter and Kramer, 2006). However, only a little more than the half of people interviewed (57.4%) states that, within their company, sustainability strategies are integrate with business strategies. Moreover, also when strategies are integrated, integration occurs only in the substance: strategies instead of being defined following a shared strategy and formalized in only one document (as in the 62.5% of analysed cases) are formulated according to processes that include sharing moments (remaining 37.5%).

Focusing the attention on which are the main reasons that drove to a greater attention on social and environmental matters, the survey underlines how companies interviewed have been lead by a moral issue (Fig. 9.1). Sustainability remains a

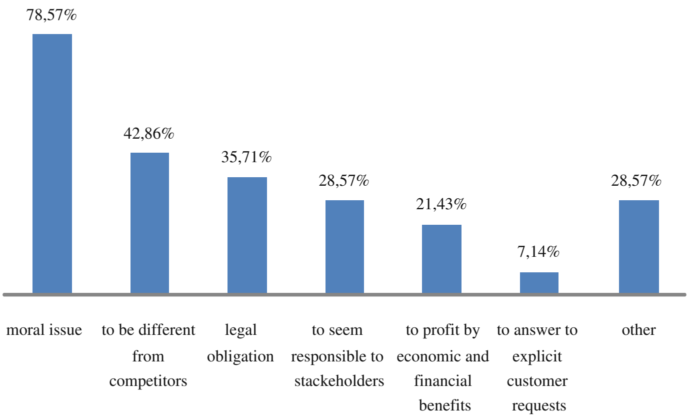

Fig. 9.1 Why has the sustainability concept been introduced in the company?

facultative choice connected to personal sensibility of those who lead the company and sometimes to specific normative and prescriptive obligations. A sensibility that, only in few cases derives from the external environment, that is to say driven by explicit or implicit requests, by stakeholders or by "isomorphism" – in other words by the necessity of conforming to values, rules and organizational "myths" present in the institutional scenario of reference (Meyer and Rowan, 1977).

However, the 42.68% of people interviewed considers sustainability as a strategy of competitive advantage, particularly useful to be different from competitors. The 21.43% admits that the choice of being more careful about social and environmental matters is also connected to benefits that derive to the company in economic and financial terms. In those cases, sustainability is connected to the business strategies that it contributes to pursue.

The companies that consider sustainability like a strategy of competitive advantage are those more recently certified, that is to say those that have been coping with those matters for a short period of time. If companies are listed according to the year in which obtained the certification SA8000 a clear separation can be identified: all the companies that obtained the certification after 2006 marked the option in object differently from all other companies.

It seems that a great business consciousness concerning the potentiality of sustainability for the whole organizational development is extending in the business world. In other terms, the analysis seems to underline how companies implement sustainable policies not only as an answer to moral duties, but also because they are aware of the advantages that such strategies can bring into business activities. Above mentioned considerations underline how, in literature of business economics and in the practice, in recent years, contributions aiming at underlining potential positive effects about the implementation of sustainable activities within companies have been proliferated not only with reference to their social and environmental context but also with reference to the pursuit of their mission (Porter and Kramer, 2007).

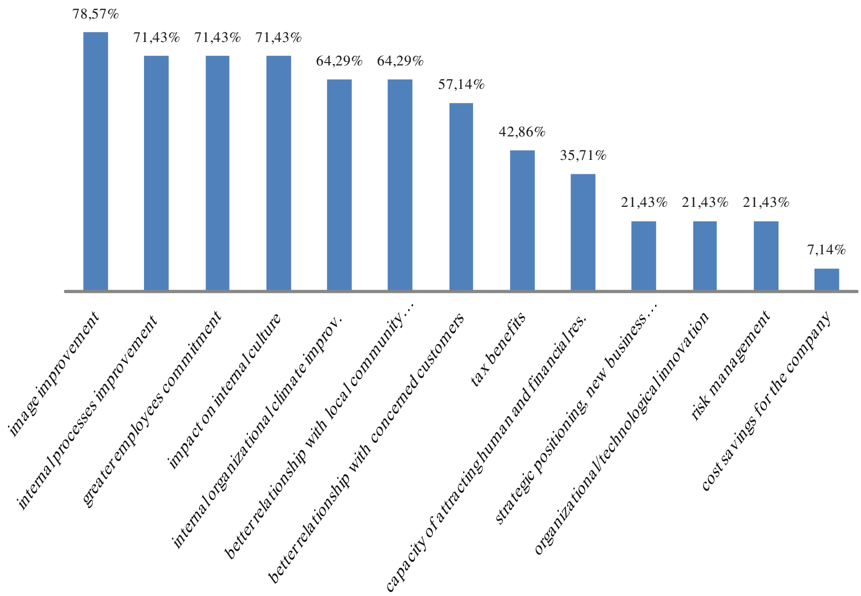

Fig. 9.2 Which are the principal (perceived) benefits related to the implementation of a sustainability strategy?

Also this analysis underlines several benefits connected to the implementation of sustainable strategies of examined companies. They state how such implementation determined the production of positive effects both regarding their relationship with the external environment (improvement of the business image) and within the business perimeter (improvement of internal processes) (Fig. 9.2).

The positive impact that such strategies have on the internal culture, on the organizational climate – thanks also to a greater interest, commitment and/or involvement of employees – and on the relationship with external stakeholder is particularly underlined. Positive feed-back are reported by local communities (57.14% of interviewed people), suppliers (42.86%), customers (28.57%), credit institutions and labor market in general (both have been indicated in 21.43% of cases) (Fig. 9).

With reference to those consideration, it should be underlined the particular composition of the sample: it is composed by certified companies at least regarding the prescription SA8000 that concerns company protection of human rights and of working conditions. The composition of the sample explains the high percentage of those that connect the implementation of sustainable strategies to the pursuit of certain fiscal benefits (42.68%).

The advantages that can be obtained in strategic terms are still not very clear, at least for the companies that form part of the analysed sample: the Fig. 8 shows how lower percentages are associated to answers that indicated a better strategic position, business opportunities and competitiveness of products/services, the incentive to processes of technological and/or organizational and/or managerial innovation or a more efficient risk management as consequent benefits of the implementation of sustainability strategies. It should be underlined that the implementation of sustainable policies does not prevent to undertake new business projects: none of the people interviewed indicates such implementation as a limiting factor for business projects.

In the business world, on the one hand, a greater consciousness regarding sustainability potentiality for an overall organizational development seems to be more and more widespread; on the other hand lower obviousness regarding the actual evidence of such potentialities can be surveyed. For the latter point, the spending of a longer period of time is needed.

Generally speaking, no cost savings connected to sustainable policies are reported. On the contrary, the increase of the cost is indicated as the main disadvantage came out after the implementation of sustainable strategies (Fig. 9.3).

Other negative effects recorded concern the increasing complexity of internal reports and of documental flows (underlined by the 64.29% of people interviewed) and the extra organizational work (57.14%). The specific managerial and operative actions that companies interviewed state to carry out in favour of sustainability are numerous and various, whereas the percentage of companies that develop products and/or services environmentally compatible or with a low environmental impact are modest, but this factor mainly depends on the activity carried out by the company.

With reference to the number of the managerial and operative actions that companies interviewed state to carry out in favour of sustainability, it is interesting to notice the particular allotment of this information depending on the period in which the companies obtained the certificate SA8000, that indicates in some ways the time in which the company pays attention to the matters in object. Observing the percentage of companies that state to carry out more actions than average for each of the three temporal segments identified at the beginning of this paragraph, progressively decreasing values have been recorded. Therefore, time and the consequent

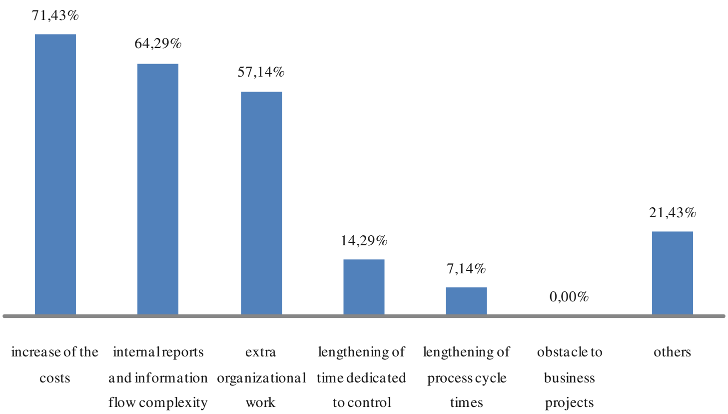

Fig. 9.3 Which are the major (perceived) problems and/or the main shortcomings emerged due to the implementation of a sustainability strategy?

experience have a positive effect on company willingness to carry out "sustainable" projects: such factors are useful for the constitution of a general agreement and of an appropriate confidence regarding activities carried out in order to guarantee a better efficiency of single projects, their development and their integration.

Among the problems met during the implementation of sustainable strategies are mentioned the initial mistrust of employees, the difficulties in the management of the relationship with suppliers and the lack of an appropriate culture and knowledge concerning real opportunities connected to a greater attention to social and environmental matters. A lower significance is assigned to lengthening of time dedicated to control (indicated by 14.29% of interviewed people) or produce products (7.14%).

It is interesting to notice how companies interviewed indicate, as elements that facilitate the implementation process of sustainability strategies, the control system and the support of external companies (both have been specified by the 57.14% of people interviewed). In this case, the answer is connected to small and medium enterprises interviewed, that often do not have at their disposal necessary competences and, consequently, need an external support (Fig. 9.4).

A central role is assigned to the control system. It has been changed by the implementation of social and/or environmental strategies in the 92.86% of companies. Such companies integrated their programming and monitoring system of business performance with the following actions:

- separation and specification of social and environmental strategies in annual aims to be pursued (30.77%)
- the drawing up of an appropriate action plan (84.62%);
- individuation of specific KPIs (social and environmental key indicators) and identification of values to be pursued (53.85%);
- monitoring of the achieving degree of foreseen aims, that is to say monitoring of the actual development of indicated actions or the actual achievement of target values specified for various key indicators (76.92%);
- other (15.38%).

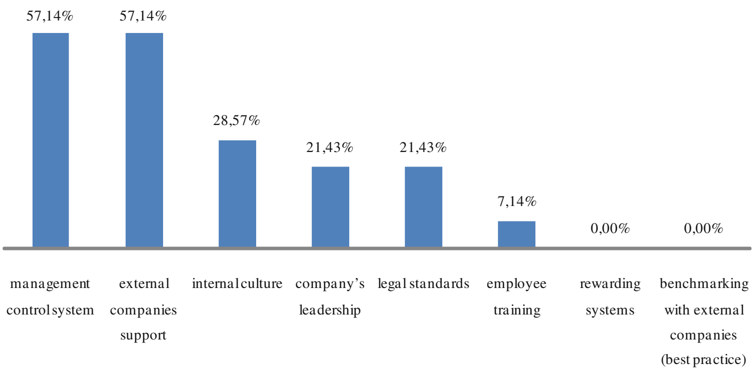

Fig. 9.4 Which are the main (perceived) elements that have facilitated the implementation of a sustainability strategy?

The analysis carried out demonstrates how the attention to sustainable strategy is not only limited to the definition of social and/or environmental strategies, but it is also focused on the definition of projects that should be undertaken and whose development is subjected to monitoring – 81.82% of cases. The SA8000 prescription itself establishes that the company controls "continuously activities and results in order to demonstrate the efficiency of systems implemented in accordance with business policy and prescription requirements". However, if above mentioned information is integrated with the quite high percentage of those that individualize also specific KPIs (social and environmental key indicators) and with the identification of relative values to be reached – whose actual achievement is monitored in 71.43% of cases – it is possible to state that the standard procedure of analyzing periodically the appropriateness, the suitability and the continuous efficiency of sustainability strategies, of procedures and of achieved results does not take place only in compliance with requirements foreseen by the SA8000 prescription and other prescriptions established by the company, but constitutes also a voluntary practice established by business managers.

The definition of initiatives to be undertaken and/or the indicators of results to be achieved only in 30.77% cases derives from the separation and specification of social and environmental strategies in annual aims to be pursued. In few cases, such actions and/or indicators result the natural and immediate origin of a punctual and structured planning process. Moreover, all companies that marked the option are those that consider sustainability as a strategy of competitive advantage (apart from a limited number, that is to say those that have faced with the problem a little bit later).

According to above mentioned considerations, the definition and the implementation of a structured and punctual system of planning and control of sustainable aims does not derive from appropriate law requirements but from the awareness of the strategic importance of the concrete and correct implementation of social and environmental policies. The repeated use of procedures and instruments aiming to guarantee a greater business sustainability does not seem capable of modifying the relative "culture", of imposing its relevance to achieve and improve business aims. On the contrary, it seems to strengthen initial use and motivations to guarantee the actual passage from the "formal" to the "substantial" in the implementation of sustainability strategies. Therefore, it is necessary to intervene on the culture of the company, guaranteeing a spread awareness regarding its strategic value.

Taking into consideration the possible integration of the sustainability performance appraisals and information with financial performance measurement, the analysis carried out demonstrates that such an integration is asserted by the 61.54% of the companies interviewed. Approximately a half of companies limits such integration to the drawing up of a scorecard where indicators of economical, financial, social and environmental performances are recorded. Only the 12.50% defines strategic maps and Balanced Scorecard for sustainability.

Parameters of economic and financial nature and of another nature (social and/or environmental) are employed for the assumption of responsibilities of single organizational units by the 85.71% of involved companies. In the 23.08% of cases, information and measurements obtained according to social and environmental performance are explicitly connected to the incentive system. They are communicated in the annual report: the 85.71% of companies interviewed draw up a social balance, a social and environmental balance or sustainable balance.

In analysing collected answers regarding elements that facilitate the implementation process of sustainability strategies, further useful conditions are connected to the internal culture (28.5%) and to business leadership (21.43%). The leadership is considered as a body involved in the processes through which social and environmental strategies are defined in the 78.57% of cases, whereas in no case it results extraneous to such projects. The leadership is less involved in the implementation processes of above mentioned strategies (71.43%). Generally speaking, all people interviewed recognize a real interest and engagement of the leadership in the analyzed matters even if such strategies are not demonstrated and communicated to employees through examples but by means of traditional practices such as the drawing up and the spread of ethic and conduct codes (92.86%), the training on such themes (92.86%) and the organization of appropriate sensibilisation programs (57.14%). More particular activities such as the selection of innovative ideas (35.71%), the definition of rules for career progresses (28.5%) or the team building (14.29%) are defined more rarely.

The role covered in the context of processes for the planning of sustainability strategies by the person in charge to the management control is particularly relevant: he is considered the main actor by the 42.68% of companies interviewed. He is always involved in those processes and usually supports his role with other actors. Also in this case the percentages above mentioned decrease according to the participation of the controller in implementation processes of above mentioned strategies: he is considered the main actor by the 28.57% of companies interviewed.

On the one hand, if in a company there is a figure/function responsible for the control of results of business management, it results also responsible for the implementation of sustainability strategies and of their control (30.00%). On the other hand, because of particular dimensions of analysed companies, the control of results in no cases results to be the only area of responsibility of the figure/function in charge for it.

Similar considerations can be obtained by the analysis of received answers according to the existence of an appropriate business function for the implementation of sustainable strategies and of their following control. In the 28.57% of cases the General Manager of the company has such responsibility; on the contrary, if such responsibility is relied upon a specific subject, it constitutes his unique responsibility area (20.00%). The 90.00% of companies involved in the survey states that such person is continuously in contact with other business bodies; the remaining 10.00% has the necessary authority to manage the realization and the control of what established.

In this sense, the survey underlines a strong "closeness", and in some cases the correspondence among various people in charge for planning and implementing sustainability strategies, and those in charge for business activities and the existence of an intense dialogue among them. In spite of these factors, only the 57.14% of involved companies admits an actual integration between above mentioned strategies. Consequently, it is possible to deduce that the intensity of the strategic dialogue is not sufficient to guarantee also effectiveness. On the contrary, it seems to be more directly connected to motivations at the base of the same dialogue.

9.4 Conclusions and Issues for Further Research

In this paper we have presented an empirical investigation of small and medium-sized enterprises' sustainability practices. Based on a significant sample of Italian enterprises of the region Toscana, this study suggests that sustainability practices with a significant impact on the bottom line (e.g. environmental protection, attention to employee working conditions). Moreover SMEs support initiatives that encourage stakeholder engagement, which can be seen to exemplify their attempt to secure a license to operate in the communities.

The main motivation for the adoption of sustainability practices appears to be related to the ethical standards of the entrepreneurs. This result appears in line with the previous research on the topic (e.g. Longo et al., 2005), however and interesting result of the present study is related to evolution in the perception of the so called "business case" for sustainability. While companies that obtained the SA8000 Standard before year 2006 implemented sustainability strategy for moral reasons, the companies that adopted the Standard more recently are aware of the possible financial returns of their choice.

However the study reveals how SMEs strategies are not embedded into the formal strategy and control systems of enterprises. In line with the previous literature (Perrini, 2006; Russo and Tencati, 2008), we found that little attention was paid to the integration of sustainability objectives into enterprises strategy and that decisions are often are informally. It is possible for an organization to remain in this phase for a long period, especially if it remains relatively small and external pressures do not force it to develop more defined organizational procedures, specific managerial tools and formal control systems.

The said observation could also affect the business case for sustainability, as the implementation of formal management control systems leads to an improved perception of the financial returns of sustainability practices. From that perspective it is to be considered positively that more than half of the sample analysed integrates sustainability objectives within the financial overall goals of the enterprise. Part of the SMEs also declares to have implemented an advanced control management framework such as the balanced scorecard.

In brief the results highlight a growing awareness of sustainability by Italian SMEs, even if the formalised sustainability strategies aimed at improving the financial returns of sustainable practices is seldom implemented.

However the present study present several limitation, among which the low response rate to the survey, that is typical of these studies (Thompson and Smith, 1991), the possibility of misinterpretation and biasing by respondents given the limited knowledge of formal managerial language that often characterizes the SMEs

(Kotey and Slade, 2005) and the limitation in the extension of the geographic area object of analysis.

The present study, as well as the majority of the existent literature focuses on a regional scale analysis. It could be interesting, as Moore and Spence suggest, to compare the results obtained within the said area with the one obtainable in different geographical contexts, extending from local/regional to national, transnational and global (2006, p. 219).

Moreover future research appears necessary to better define the differences and similarities among firms of different size with a focus new issues associated with sustainability practices. In fact, although the sustainability issues can be easily associated with large companies, researchers should carefully consider that small and medium-sized enterprises are becoming increasingly aware of their responsible behaviour, but more work is needed to transform such awareness into opportunities for SMEs.

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Chapter 10
Supplier Performance Evaluation for Green Supply Chain Management

Roberto Maria Grisi, Luigi Guerra, and Giuseppe Naviglio

Abstract Environmental protection and effective operations management are no longer considered incompatible goals to be achieved rather they are merged to represent a strategic performance parameter of a company: the eco-efficiency. This is one of the reasons which led to Green Supply Chains (GSCs) development. To make GSCs more efficient and more effective a careful supplier performance analysis is needed considering both traditional parameters (economic efficiency) and environmental ones. In this paper an in-depth review of the performance parameters for suppliers selection is presented which provided the basis for the implementation of a Fuzzy-AHP model for "green" suppliers evaluation.

10.1 Introduction

In recent decades, the environmental issue has become ever more present, insomuch as interesting and inspiring the same economic enterprise.

In fact, companies have initially considered this merely as an additional cost compared to ordinary management but under the impulse of more restrictive laws and the new awareness of the public, they have actively addressed the problem being able to grasp the countless opportunities (cost reductions resulting from energy conservation, improvement of business, etc...).

From this point of view, it is therefore necessary to review the processes and products, evolving the classic concept of *Supply Chain* in the *Green Supply Chain*, where management systems are supported and integrated with the new environmental requirements. Environmental protection and management, therefore, are no longer considered incompatible goals, but on the contrary, they can be merged to create an important way of measuring corporate performance: the *eco-efficiency*.

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For the implementation of a Green Supply Chain the same set of policies, actions and reports relating to the phase of supply should be revised in a new light. In regards to this, the selection of suppliers, having identified a particular model to use, it's necessary to make the choice of criteria whereby assessing performance. Downstream of a thorough analysis of existing literature on the subject, aimed at identifying the most significant criteria for ranking, it seemed evident that the environmental performance of suppliers begin to form discriminating parameters only at the beginning of the 90s.

The indexing on mentioned parameters were also used as the basis for the preliminary design of a system for evaluating the performance of suppliers based on methods for comparison (*Analytic Hierarchy Process*, AHP).

The use of these models, however, immediately raised the question of interpretation of assessments and evaluations often expressed verbally, and therefore unlikely to be converted into numerical terms. To address the problem of uncertainty inherent in expression of a subjective assessment, *Fuzzy Logic* has been chosen for the extension of the model, by introducing fuzzy numbers in the allocation of assessments and the weights of the criteria.

The work is to be considered a preliminary study to the design of an *Extended Fuzzy AHP* model that will be adopted and which will cover the logic of design and operation.

10.2 Green Supply Chain Management

In literature it cannot be found a universally recognized definition of the term *Green Supply Chain Management* (GSCM).

The GSCM, however, may be interpreted as the set of policies for management of the supply chain (from suppliers to consumers and vice versa) taking into account questions related to company-environment relations, with particular attention to the characteristics of the product, recycling, management of materials and toxic waste (Dal Ben, 2006).

Klassen and McLaughlin argue, more specifically, of *Environmental Management*, defined as the totality of efforts supported by a company to minimize the environmental impact resulting from their products and production processes (Klassen and McLaughlin, 1996).

Gupta (1995) interprets the *Environment Management System* as a tool to prevent adverse effects on the environment arising from industrial and environmental performance through appropriate strategies while in (Klassen and Angel, 1998) it is proposed the *Environment Management Posture* that is all set of objectives, plans and management systems that determine the position of the company and its level of responsibility towards the environment. Finally, Narasimhan and Carter provide for the involvement of the purchasing function in activities that include waste reduction, recycling, reuse and replacement of materials, linking the concept of GSCM only phase supply. This definition is taken from (Carter et al., 1999) in which the concept of *Environmental Purchasing* is proposed.

In any case, irrespective of the definition considered, the GSCM poses two key challenges:

- compared to traditional networks, the economic objectives have expanded to include environmental ones. You must consider the two types of requirement to avoid problems of local optimization. This implies an increase in the complexity of the logistics network and sometimes incompatibility, although often apparent, between economic and environmental needs;
- specific resources are required to respond to the economic and environmental objectives. These resources, as well as the actors belonging to different entities, are not necessarily the same as in conventional networks. A little careful planning of resources is often the cause of the failure in the structuring of a GSC.

All things considered, there are three key aspects that can influence the efficiency of a GSC: green purchasing, customer communications and choice of suppliers.

10.2.1 Models and Performance Criteria for Selecting Suppliers

In one of his first books on issues relating to the selection of suppliers Howed Lewis writes: "*...of all the responsibilities that fall to the leaders in the field of buying, probably, there is not any more important than the selection of its resources...*" (Weber et al., 1991).

There are many factors which, over time, led to increased difficulties in the choice of their suppliers and, at the same time, have made this choice critical to the success of a supply chain (de Boer et al., 2001):

- globalization of the market and spread of the Internet that led to the sudden availability on increased geography scale of potential suppliers;
- demand for greater transparency in corporate decision-making processes;
- specifically designed supplying functions;
- changing customer requirements.

The criteria traditionally used for the selection of suppliers were not very effective for a selection that actually takes into account the points mentioned above. Indeed, the use of suitable criteria for selecting suppliers may increase the effectiveness of the purchasing function, helping managers to consider a wider portfolio of alternatives and to incorporate into decision-making models used also intangible factors (efficiency of decisions). The nature of mathematical models used in regards to it, has often been considered incompatible with many intuitive and emotional issues that often contribute to the formulation of a decision. In fact, many were the works in literature that have stressed the usefulness of a systemic approach to the evaluation of suppliers (Zhu et al., 2008).

Wanting to create a grouping of the methods for selection of suppliers available in the literature (Fig. 10.1), it is possible to distinguish between *combined models*

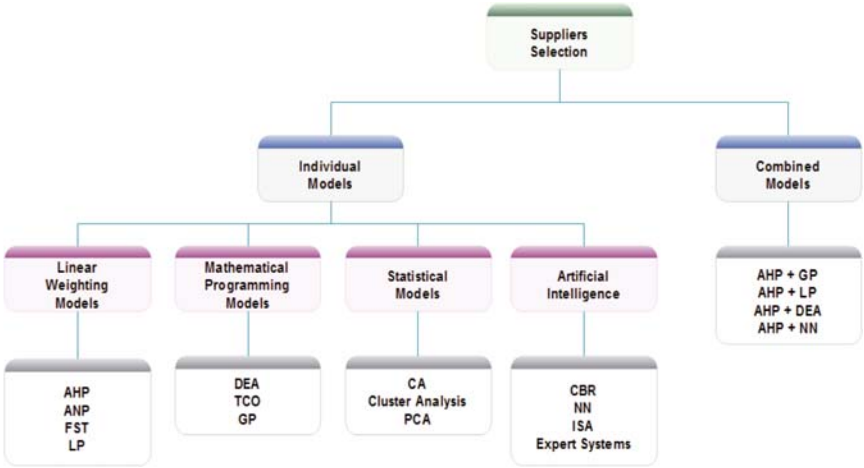

Fig. 10.1 Classification of methods for selecting suppliers in literature

and *individual models*, the latter further subdivided into linear models for relative comparison, models based on mathematical programming, statistical models and models based on artificial intelligence (Sung and Krishnan, 2008).

Regardless of the particular model used, it is necessary to identify the criteria that allow the comparison between potential suppliers and, in one way rather than another, they will be combined in the model. The characterization of this set of methods showed itself to be essential for a proper selection procedure but in any case it's difficult to determine in advance what criteria have to be used and which can be removed without compromising their choices.

In regards to this, starting from what has been proposed in (Weber et al., 1991) a thorough analysis has been carried of the present literature, considering sources that refer to traditional selection criteria and selection criteria that emphasize environmental issues and that aim, then, to the "green" management of the supply chain (Humphreys et al., 2003; Noci, 1997).

Tables 10.1 and 10.2 (Part I and Part II) provide, respectively, the different criteria used in the literature for the selection of suppliers and the reference to sources where it can be found their effective use. Based on the collection made, wanting to propose a relative weight for each of the criteria identified, it can be concluded that the price (78%), quality of delivery (61%), quality of services provided in general (57%) are the traditional selection criteria considered most significant. If you want to make a comprehensive selection of suppliers you need to combine the mentioned criteria that take environmental aspects into account, among which the most important are: the environmental (72%), the use of environmental management systems (64%), the image that the supplier proposes to himself (62%) and environmental impact on existing processes and products.

Table 10.1 Criteria as stated in the literature for the evaluation of suppliers

1	Quality	16	Labor relation records
2	Delivery	17	Geographical location
3	Performance history	18	Training aids
4	Production facilities and capacity	19	Reciprocal arrangements
5	Price	20	Green image
6	Technical capabilities	21	Environmental planning/designing
7	Financial position	22	Green management systems
8	Procedural compliance	23	Environmental capabilities
9	Communication system	24	Cost for environmental improvement
10	Reputation and position in industry	25	Life cycle cost minimization
11	Management and organization	26	Laws complying
12	Operating controls	27	Present environmental impact
13	Repair services	28	Environmental efficiency
14	Attitude	29	Environmental flexibility
15	Packaging abilities		

10.3 A Feahp Model for Suppliers Selection

Referring to the aforementioned analysis, it is possible to propose a model for evaluating the performance of suppliers who consider economic factors and the compatibility of economic efficiency, based on a comparison of the relative and weighted criteria and the alternatives available. Taking into account the uncertainty inherently contained in the expression of opinions by experts, usually in the form of quality, allowing the comparison, the model will be structured through a multi-logic (Extended Fuzzy AHP, FEAHP) (Chan and Kumar, 2007).

The AHP method (Wang et al., 2007) widely used in literature to solve multicriterial problems, is unable by itself to capture the uncertainties and ambiguities that arise in setting the priorities of different attributes when you make use of expressions of a qualitative type, mainly due to the use of a numerical scale of interpretation of predetermined size (the Saaty discrete scale). Although this solution involves clear advantages in terms of simplicity and immediacy of use, the hierarchy of decision-making variables that are the subject of the comparison in pairs could not be satisfactorily defined in (Lee et al., 2008; Entani et al., 2005). So, since some of the criteria of evaluation are inherently subjective and qualitative, to express preferences using exact numerical values could not facilitate the task that the experts called into question.

The use of a FEAHP type model allows better management of data incoherence involved in the global decision, allowing the use and integration of quantitative and qualitative data provides the necessary flexibility for the analysis of problems of an industrial character and facilitates tasks of verification of the robustness of the decisions taken.

The following sections proposed the logical path to be adopted in the structuring of the model that will be proposed (Chan and Kumar, 2007).

Table 10.2 Factors used in the literature for the selection of suppliers (*Part I*)

Author	*Year*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*
Abratt	1986					1					1			1	1															
Ansari et al.	1986	1	1			1									1			1												
Ansari et al.	1988	1	1			1									1	1		1												
Anthony et al.	1987		1			1																								
Azzone et al.	1996																				1				1			1		1
Banerjee	1986		1			1																								
Banerjee	1986					1																								
Bender et al.	1985	1	1		1	1																								
Benton et al.	1990	1	1											1																
Bernard	1989	1	1									1		1																
Billesbach et al.	1991	1	1			1																								
Browning et al.	1983		1		1	1	1																							
Buffa et al.	1983	1	1	1		1																								
Burton	1988	1	1		1	1	1					1	1			1		1	1											
Chakravarty	1988					1																								
Chapman	1989	1	1		1																									
Chapman et al.	1990	1	1																											
Chen	2005																						1	1	1		1	1		
Croell	1980	1	1																											
Dada et al.	1987					1																								
Frazier et al.	1988	1	1			1	1					1																		
Ghodsypour and Brien	1998	1	1			1																								
Goyal	1987					1																								
Gregory	1986	1	1		1	1	1										1													
Hahn et al.	1986	1	1		1	1	1										1													
Handfield et al.	2002																				1	1	1						1	
Handfield, et al.	1997																				1		1	1		1	1			
Ho et al.	2008	1	1			1					10																			

Table 10.2 (continued)

Author	*Year*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*
Ho et al.	1988				1																									
Humphreys et al.	2003																				1	1	1	1						
Hwang et al.	1990					1																								
Jacobson et al.	1987	1																												
Jordan	1987					1																								
Kingsman	1986					1																								
Kraljic	1983	1	1		1		1																							
Laforge	1985					1																								
Lamm et al.	1988					1																								
Lamming, et al.	1996																				1	1	1	1	1	1	1	1	1	
Lee et al.	1986					1																								
Markowski	1988					1																								
Mazurak et al.	1985	1	1			1	1																							
Minn et al.	1999	1	1			1																								
Monahan	1984					1																								
Monczka et al.	1981	1	1	1	1	1		1			1		1					1												
Narasimhan et al.	1986				1	1																								
Nawrocka and Parker	2009																				1		1	1				1		
Newman	1988	1																												
Newman	1988	1	1		1	1	1									1		1												
Newman et al.	1988																													
Noci	1997																				1			1		1		1		
Pan	1989	1	1			1																								
Preuss	2002																						1	1			1		1	
Ronen et al.	1988		1			1																								
Sarkis et al.	1996																					1	1			1		1		1
Segev et al.	1998						1																							
Sharma et al.	1990	1	1			1																								

Table 10.2 (continued)

Author	*Year*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*
Shore	1981	1	1			1																								
Soukup	1987	1	1		1	1	1	1				1			1			1												
Srivastava	2007																					1			1				1	
Stavropolous	2000					1																								
Timmerman	1986	1	1	1		1	1																							
Treleven	1987	1	1		1	1																								
Turner	1988				1	1																								
Wagner et al.	1989	1	1			1					1			1				1												
Weber et al.	1991	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1										

10.3.1 Constructing the Hierarchical Structure

The first step is to create a hierarchical structure or a network of the problem and then compare in pairs the hierarchical elements to establish relationships within the existing structure.

The main advantage of a hierarchical structure is that it allows a detailed decomposition, structured and systematic analysis of the general problem in its core and its interdependencies with a large degree of flexibility.

At the first level of the hierarchy there is, of course, the target of the analysis and at the second level there are the general criteria for the assessment and the criteria are placed in the third and final level (Fig. 10.2).

In regards to this, the preliminary analysis of the literature on the subject has allowed the identification of the mostly used criteria for the evaluation of suppliers. With this in mind we have focused on the criteria considered to be of particular importance on the basis of this research.

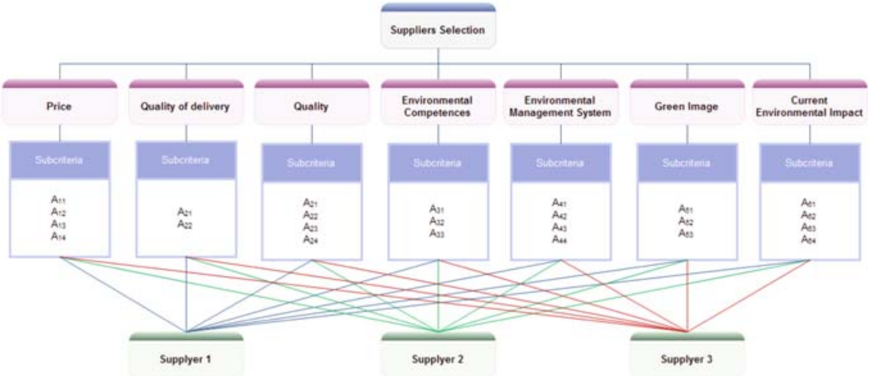

Fig. 10.2 The Hierarchical Structure for Suppliers Selection

10.3.1.1 Price

It is the most commonly criterion used in the assessment of global suppliers because it substantially determines the cost of supply and, therefore, significantly affect the process of minimizing the total cost of ownership. The analysis should consider, however, the overall cost that refers to the costs resulting from product management and those arising from environmental consequences (Chan and Kumar, 2007). One can make reference to the following sub-criteria:

- *Price of goods* (A_{11});
- *Shipping costs* (A_{12});
- *Costs of pollution effects* (A_{13}). This category is made up of several rates. The costs for the disposal of solid waste (processing and transport costs), the costs

for the disposal of waste and toxic chemicals, costs for minimizing the concentration of pollutants before entry into the environment, costs for wastewater treatment and slurry, costs for the energy absorbed in the production of the products.
- Rates and customs taxes (A_{14}).

10.3.1.2 Quality of Delivery

The selection process will have to assess the ability of the provider in ensuring quality of delivery in terms of (Chan and Kumar, 2007):

- *Response to specific requests of the company* (A_{21}). Namely the supplier's ability to provide adequate responses to the needs of delivery from time to time may be required;
- *Timeliness* (A_{22}). That is respect of the established delivery date.

10.3.1.3 Quality

Another factor is the quality of the product offered to the customer. In this respect, the quality of the product may be partly affected by problems that are more or less directly linked to their suppliers:

- *Increased rate of return of the product* depending on factors that may relate to suppliers (A_{31});
- *Increased average waiting time* depending on factors that may relate to suppliers (A_{32});
- *Processes for internal audit quality* (A_{33}). One shall ensure that the supplier will make a reasonable number of audits on the quality level offered and is certified to ensure a minimum level of quality to prevent possible failures;
- Quality issues recovery procedures (A_{34}).

10.3.1.4 Environmental Competences

For environmental competences we mean the sum of qualitative factors which reflect the ability of the suppliers to implement a process of gradual reduction of the environmental impact due to their production processes, to design components that optimize the use of natural resources and which are in agreement with the environmental management dictated by the laws and the company (Noci, 1997). The environmental skills of the supplier may be expressed in terms of:

- *Availability of "clean" technologies* (A_{41});
- *Use of ecological materials* (Materials that make up the component or part provided, A_{42});
- Ability to respond adequately and in a short timeframe to change of product/process to reduce the environmental impact (A_{43}).

10.3.1.5 Environmental Management System

The Environmental Management System, which is properly integrated within the management system of the enterprise, provides among other things, procedures for the verification of environmental conscious behaviours compliance that are divided into different stages, periodically repeated and which overall aim to the continuous improvement of the environmental performance. The indicators for the analysis of an Environmental Management System are:

- *Environmental policies* (A_{51});
- *Environmental Planning* (A_{52});
- *Implementation and operation* (A_{53});
- *ISO 14001* (A_{54}).

10.3.1.6 Green Image

In relation to the image that the supplier projects of himself as regards the sensitivity to environmental issues, it is possible to use quantitative and qualitative factors to assess:

- *Segment of green customers* that purchase components from the supplier (A_{61});
- *Type of relationship* between the supplier under consideration and its shareholders (A_{62});
- Customers fidelization (A_{63}).

10.3.1.7 Current Environmental Impact

To assess the current environmental impact of the supplier it is necessary to analyze the production process in terms of:

- *Immission of air pollution* (A_{71});
- *Substances discharged into the sewer*. In terms of sludges and effluents (A_{72})
- *Solid waste* produced (A_{73});
- *Power consumption* (A_{74}).

10.3.2 Constructing the Pairwise Comparison Matrices

In this phase the different criteria are initially compared and thereafter for each of these the alternatives are considered. From a mathematical point of view this is to build some double-entry matrices that will allow comparing the criteria (Entani et al., 2005). So, the above mentioned criteria will be arranged in structures like the following one:

$$\tilde{A} = [\tilde{a}_{ij}] = \begin{pmatrix} 1 & \cdots & \tilde{a} \\ \vdots & \ddots & \\ \tilde{a}_{n1} & \cdots & \vdots \end{pmatrix} \tag{10.1}$$

where a_{ij} represents the importance of criterion i compared to criterion j.

10.3.3 Consistency Analysis

The determination of priorities among the elements of the matrix can be obtained by calculating the eigenvalues and eigenvectors of the matrix:

$$CI = \frac{\lambda \max - n}{n-1}; CR \tag{10.2}$$

where w is the eigenvector of the matrix A, and $\lambda_{\max}$ is the largest eigenvalue of A.

The consistency of the matrix are checked to ensure the consistency of judgments in the pairwise comparison. The consistency index (CI) and consistency ratio (CR) are defined as (Saaty, 1980):

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n-1}; \mathrm{CR} = \tag{10.3}$$

where n is the number of criteria which constitutes the matrix, and RI is the average consistency index of a pairwise comparison matrix of the same order and randomly generated (Table 10.3).

Table 10.3 Random index (Saaty, 1980)

N	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.19	1.51	1.48	1.56	1.57	1.59

10.3.4 Fuzzy Numbers and Fuzzy Pairwise Comparison Matrix

At this stage there's the definition of fuzzy numbers and the subsequent *fuzzification* of the values expressing the relative importance of each criterion and sub-matrix, in order to highlight the uncertainty of assessments derived from the pairwise comparison.

Triangular shaped fuzzy numbers will be adopted as suggested in the literature (Lee et al., 2008). This stage is critical because the proper definition of the number scale and thus the subsequent size of the "overlapping" area may significantly affect the results. In this respect, in order to make the model sufficiently robust, a thorough sensitivity analysis will be made (Fig. 10.3).

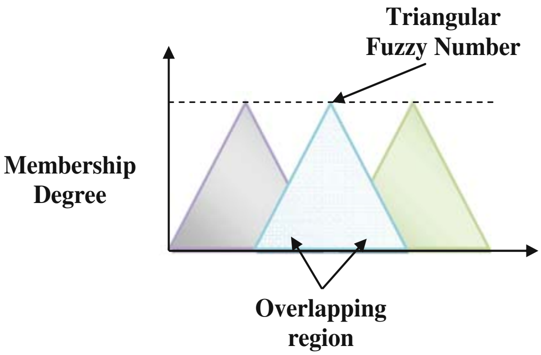

Fig. 10.3 Fuzzy numbers definition

This will allow the construction of a new pairwise comparison matrix with fuzzy values (Entani et al., 2005):

$$\tilde{A} = [\tilde{a}_{ij}] = \begin{pmatrix} 1 & \cdots & \tilde{a} \\ \vdots & \ddots & \\ \tilde{a}_{n1} & \cdots & \vdots \end{pmatrix} \tag{10.4}$$

where $\tilde{a}_{ij}$ is a fuzzy number representing the priority of the criterion i with respect to criterion j.

Mathematically, the number will probably be represented in parametric form (ac_{ij}, ad_{ij}) where ac_{ij} and ad_{ij} are the centre and width of the number. Such a representation is extremely compact and it enables obvious savings in terms of computational resources.

10.3.5 Defining Weights and Priorities

In this phase the most suitable weights will be assigned to each criterion for each supplier (Chan and Kumar, 2007). Also in defining this weights it is useful to use as many matrices as are the criteria, reporting on the columns the sub-criteria for each criterion and on the lines the alternatives, that is the different suppliers (Table 10.4).

Table 10.4 Comparison between criteria and alternatives

Criterion i	Sub-criterion$_{i1}$	Sub-criterion$_{i2}$	....	Sub-criterion$_{in}$
Supplier 1				
Supplier 2				
....				
Supplier n				

10.3.6 Defuzzification

Since the weights of all evaluation criteria were fuzzy values, it was necessary to compute a non-fuzzy value by the process of defuzzification. This can be done in different ways (Wang et al., 2007):

- Centroid Average (CA);
- Maximum Center Average (MCA);
- Mean of Maximum (MOM);
- Smallest of Maximum (SOM);
- Largest of Maximum (LOM).

10.3.7 Normalization

In order to effectively compare the relative importance among evaluation criteria, we normalized the obtained weights.

10.3.8 Synthesis of Hierarchy and Final Choice

The weight of each individual evaluation criterion at bottom level can be obtained by the implementation of step 1 through step 7. And the weights of criteria or sub-criteria at upper level were the synthesis of the weights of their subordinations. Hence, the weights of all criteria at every level of hierarchy can be obtained.

10.4 Conclusions

Following extensive research regarding the various methods whether for suppliers selection or for their performance evaluation and given the increasing importance of the Supply Chain, a "global" selection model has been proposed to take into account, in the assessment process, both the green and the traditional criteria. In short it deals with the use of an extended Fuzzy-AHP model, in which Fuzzy Logic is adopted in order to overcome the uncertainty arising from human qualitative judgments. In this paper we presented the in-depth review of the performance parameters for suppliers selection which provided the basis for the implementation of the Fuzzy-AHP model for "green" suppliers evaluation. The validation of this model will be presented when data on real industrial cases will be collected.

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Part V
What is next by theme: PMM and Project/HR/Risk Management

Chapter 11
A Synthetic Measure for the Assessment of the Project Performance

Antonella Certa, Mario Enea, and Antonio Giallanza

Abstract The present paper aims to offer a synthetic project performance indicator (PPI) that aggregates two input parameters obtained by the Earned Value Analysis. The PPI is calculated by using a Fuzzy Inference System (FIS) able to single out a measure based on the input parameters, instead of formulating a mathematical model that could be a troublesome task whenever complex relations among the input variables exist. The purpose is to communicate the project performance to the stakeholders in a clear and complete way, for example, describing the PPI by means of contour lines.

11.1 Introduction

Suitable performance measures are surely key factors in ensuring the project success which is in its turn sensitive to the chosen metrics. Many researches tried to individuate some project success factors and attempted to measure the whole project success (Munns and Bjeirmi, 1996; Freeman and Beale, 1992). The choice of appropriate performance measures implies numerous critical phases concerning the identification of opportune criteria and metrics for the evaluation. Several models and metrics have been developed to assess the project success during the execution phase, mostly founded on the Earned Value Analysis (EVA). The EVA is a useful tool which allows the project risk control and also representing a valid support in predicting final cost and duration. It provides information that integrate cost, schedule and technical performance.

The basic principle of the EVA has been described in details in the Practice Standard for Earned Value Management (Project Management Institute, 2005), in

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Cantamessa et al. (2007), Fleming and Koppleman (2000), Meredith and Mantel (1995) and Anbari (2003).

Several recent researches handle with new measures of project performance based on the EVA.

Vandevoorde and Vanhoucke (2006) provide an overview of the state of art of the EVA, mainly focusing on proposed performance indicators for estimating the total project duration. Moreover, the Authors present a generic schedule forecasting formula usable in different project situations.

Lipke et al. (2009) propose a method to improve the capability of project managers for making informed decisions by providing a reliable assessment of the final cost and duration. They provide the results for predicting project outcome taking into account the information regarding the values for the high and low bounds for both cost and schedule obtained from statistical computation. The Authors apply the proposed method to a small sample data but they emphasize the general applicability of the specific method.

In order to offer a significant practical contribution to the management of information system implementation, Plaza (2008) develops a decision support model to determine both the learning curve coefficient and the project duration during the early stages of a project. In particular, the research introduces some formulas to forecast the project duration and a model in which the learning curve is fully integrated with the EVA.

The EVA is a project management tool having numerous meaningful managerial benefits, by identifying project deliverables, to be presented to specific group. However, results would be easier to communicate and to understand. Cioffi (2006) highlights that the last aspect is fundamental to make the EVA more operable. To fulfill this object, Cioffi introduces a new notation for the EVA that he defines consistent, mnemonic and compact.

In this paper a synthetic indicator that aggregates parameters obtained by the Earned Value Analysis is presented. It gives a global measure of the project performance during the execution phase. The possible values taken by the indicator, depending on the input parameters, are described by means of contour lines. Thus, besides assessing the project performance, it is possible to forecast the project success with relation to several scenarios of cost and duration and, at the same time, to supply the results of project control to the stakeholders in a clear and complete way.

The information necessary to estimate the value of the EVA indicators are often characterized by vagueness and uncertainty. That being so, it is proposed a decision support system which employs the Fuzzy Inference System (FIS) to handle this type of information that can not be managed with traditional (crisp) mathematical models. One advantage in using the FIS is that it helps to reflect a given situation in reality and provides solutions, instead of trying to build mathematical models, a task almost impossible when complex phenomena are under study. Experts' knowledge may in fact efficiently be represented in the form of rules when fuzzy logic is employed. The FISs are useful tools, which have been successfully applied in many fields like control (Carlsson, 2002; Klir and Yuan, 1995), and decision support (Bojadziev and Bojadziev, 1999). Their success is mainly due to their closeness to human perception and reasoning, as well as to their intuitive handling and simplicity, which are important factors for systems acceptance and usability. Specific applications of fuzzy logic in project management are relatively few in comparison with other application areas.

Dweiri and Kablan (2006) propose a fuzzy decision making system (FDMS) for the evaluation of the project management internal efficiency. The proposed evaluation criteria are the project cost, the project time and the project quality. They combine the impact of each criterion on the global score efficiency with its weight by means of IF – THEN rules. In particular, the Authors suggest the Analytic Hierarchy Process to find the relative weights of criteria. The authors also propose this approach to evaluate the performance of project team.

Fasanghari and Roudsari (2008) develop a fuzzy system to select the best ICT project by the fuzzy set theory and fuzzy integer linear programming optimization. Assuming all projects are independent of one another, the proposed model uses two parameters, the investment cost and the expected profit, to estimate the financial feasibility of projects. Hence, the goal is to maximize the total return on investment, simultaneously satisfying the budget limits. The fuzzy inference engine constructs the fuzzy rules based on two fuzzy parameters, the project strength and the project attractiveness, to get the fuzzy project rank.

The remainder of this paper is organized as follows. Section 11.2 is dedicated to the description of the Fuzzy Inference System. The input parameters descriptions, the individuation and formulation of the synthetic parameter are further supplied. A numerical application is reported in Sect. 11.3 and the final conclusions are summarized.

11.2 Project Performance Indicator

11.2.1 Fuzzy Inference System

As before mentioned, a fuzzy inference system is herein proposed to find out a global score expressing the project performance.

As it is well known, a basic fuzzy logic system is constituted by four components: a rules set, a fuzzifier, an inference engine and a defuzzifier. The core of a FIS is its knowledge base, which is expressed in terms of fuzzy rules allowing the approximate reasoning (Czogala and Leski, 2000). The fuzzy logic system here applied is a Multi Input–Single Output System (MISO), using the Mamdani implication (Mamdani and Assilian, 1975) and the center of area method (COA) as defuzzifier.

At the first step of the inference process, it is needed to define the fuzzy set to represent the crisp input values, that is the fuzzification process, which consists in assigning fuzzy linguistic variables in the universe of discourse of each input value. In particular, in this paper each input parameter is described by triangular and trapezoidal fuzzy numbers. Triangular fuzzy numbers are widely used for their simplicity and solid theoretical basis (Pedrycz, 1994). The membership function of a triangular fuzzy number A is μ_A: R $\rightarrow$ [0, 1] and it can be represented by the set of Eq. 11.1, where $l < m < u$. Consequently, a triangular fuzzy number is fully characterized by three real numbers (l, m, u). The parameter m corresponds to the maximum grade of $\mu_A(x)$ that is equal to 1, whereas l and u are the lower and upper bounds of the definition interval. Similarly (Eq. 11.2), a trapezoidal fuzzy number is fully characterized by four real numbers (l, m, n, u). The parameters m and n give the maximum grade of $\mu_B(x)$.

$$\mu_A(x) = \left\{ \begin{array}{cc} \dfrac{x-l}{m-l} & \text{when } x \in [l, m] \\ \dfrac{u-x}{u-m} & \text{when } x \in [m, u] \\ 0 & \text{otherwise} \end{array} \right\} \tag{11.1}$$

where $l < m < u$.

$$\mu_B(x) = \left\{ \begin{array}{cc} \dfrac{x-l}{m-l} & \text{when } x \in [l, m] \\ 1 & \text{when } x \in [m, n] \\ \dfrac{u-x}{u-n} & \text{when } x \in [n, u] \\ 0 & \text{otherwise} \end{array} \right\} \tag{11.2}$$

where $l < m < n < u$.

In particular, in this paper each input parameter has eight linguistic variables described by triangular and trapezoidal fuzzy numbers. Instead, the output parameter has seven linguistic variables. The boundaries of each number have to be chosen by the project organization experts so that to model the problem in according their cognitions.

Since the assessment parameters values are crisp, the fuzzifier maps the input crisp numbers into the fuzzy set to obtain their degrees of membership.

For example, let consider the membership for *SI*. The variable fuzzification is shown in Fig. 11.1. The SI value (–70) is fuzzified into two fuzzy numbers: high – negative and medium – negative with a degree of membership equal to 0.65 and 0.35, respectively.

The next step in the fuzzy logic system is to define the possible rules arising from combining the fuzzy inputs. Rules are usually provided by a team of experts in the form of IF – THEN sentences and are introduced into the FIS. By means of the rules the approximate reasoning of the decision maker is reflected.

Hence, each rule is formulated as a sentence in which the experts state their judgments. For example, in such a case the rule can be expressed like the following one: If CI is high AND SI is medium then PPI is high.

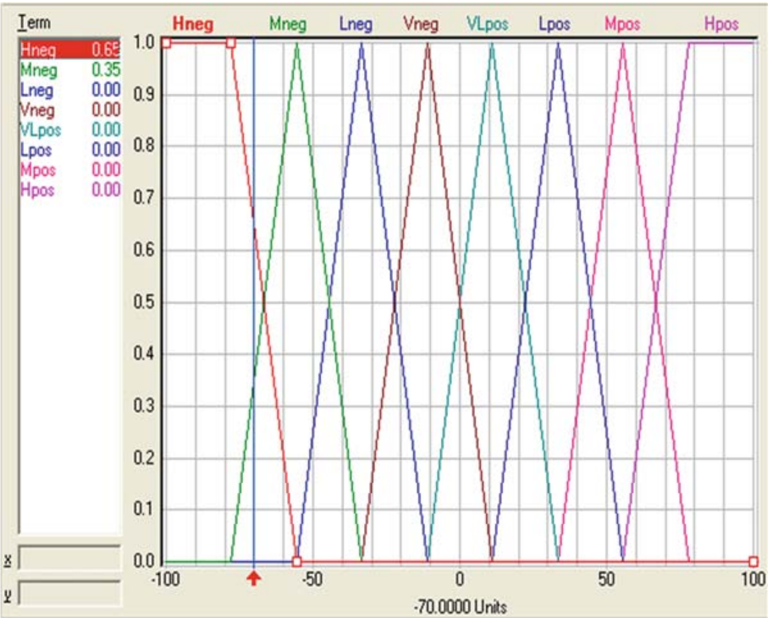

Fig. 11.1 Fuzzification process for SI

In this research the use of the FIS is proposed to evaluate the project performance in a multi-criteria context and thus the implication of each rule also expresses the combined importance assigned to the input parameters, representing in such a case the evaluation criteria. The latter is a key factor in the process assessment since evaluating the weights of criteria could be very hard, especially whenever an interdependence exists among them. The problem of the interdependence among the decisional elements is tackled in other decisional methods proposed in literature, as The Analytic Network Process (Saaty, 2001). Thus, the rules formulation is an important phase that can help to derive the influence of the factors that characterize the evaluation.

The inference engine of the FIS maps the antecedent fuzzy set (IF part) into the consequent fuzzy set (THEN part) taking into account the already stated rules. The inference process determines the fuzzy subset of the output variable for each rule by using the MIN (Mamdani operator) as implication operator. If more than one rule produces the same consequence, an operator must aggregate the results of these rules. In particular, the MAX operator is used.

Finally, the defuzzifier maps the fuzzy output into a crisp number, which becomes the output of the FIS, that is, in the case here considered, the final score project performance indicator (PPI). As mentioned before, in this case the COA method is applied being the latter the most used defuzzification methods (Sugeno, 1985; Lee, 1990). The Fig. 11.2 represents the inference process.

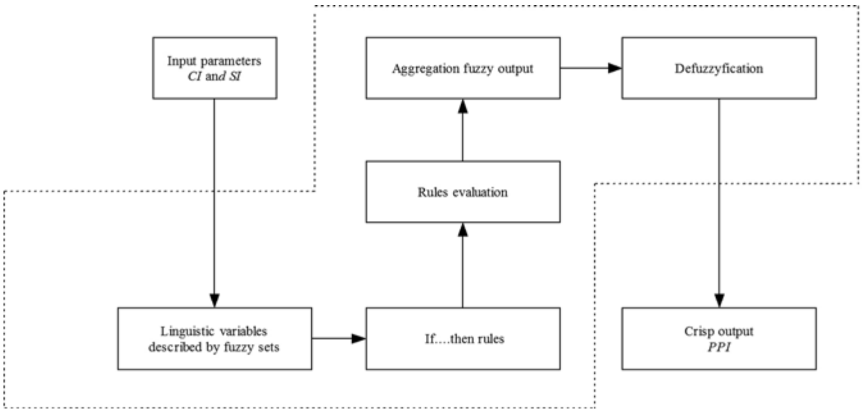

Fig. 11.2 Block diagram of Fuzzy inference procedure Input parameters

11.2.2 Input Parameters

The following terms are used in this subsection:

EVA = Earned Value Analysis.
EV = Earned Value.
PV = Planned Value.
AC = Actual Cost.
CI = Cost Indicator.
SI = Schedule Indicator.
PPI = Project Performance Indicator.

The project performance measure here proposed is based on EVA. In particular, two indicators are proposed for measuring the cost performance (CI) and the schedule performance (SI), respectively. The first one, the CI, belonging to the range [–100; 100], depends on the EV and the AC parameters and it is evaluated by the Eq. (11.3).

$$\mathrm{CI} = \left\{ \begin{array}{cc} -100 & \text{if } \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} \le a \\ \dfrac{-100}{a}\cdot\dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} & \text{if } a < \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} < 0 \\ \dfrac{+100}{b}\cdot\dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} & \text{if } 0 \le \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} < b \\ +100 & \text{if } \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} \ge b \end{array} \right\} \tag{11.3}$$

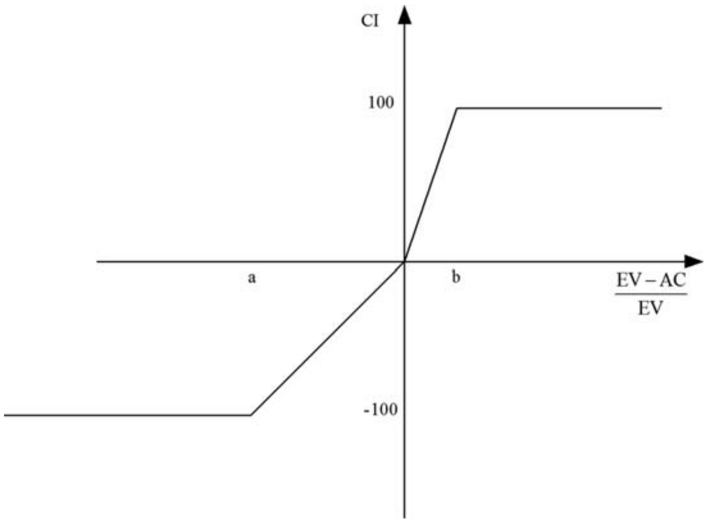

Fig. 11.3 CI function

As it is possible to figure out from the Fig. 11.3, the CI takes the maximum and minimum values out the range [*a, b*]. The identified bounds could correspond with the extreme values, positive and negative, which a project may give rise during the execution phase. In the worst hypothesis, most likely a project can fall into a 90% cost inefficiency, that is a equal to (–0.9). The best value that $\frac{\mathrm{EV}-\mathrm{AC}}{\mathrm{EV}}$ may presumably take is 0.3, related to a cost efficiency of 30%. Furthermore, a and b can respectively represent a nadir point and a target point of the rating $\frac{\mathrm{EV}-\mathrm{AC}}{\mathrm{EV}}$ for the project manager. That is, with relation to these values the project manager feels the maximum efficiency and inefficiency of the project performance cost. However, the a and b values herein described are just reported to give an example; they are absolutely subjective.

Similarly to the CI the schedule performance indicator SI has been formulated (See Fig. 11.4). It depends on the EV and PV parameters and it is evaluated by the Eq. (11.4).

$$\mathrm{CI} = \left\{ \begin{array}{cc} -100 & \text{if } \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} \leq a \\ \dfrac{-100}{a} \cdot \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} & \text{if } a < \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} < 0 \\ \dfrac{+100}{b} \cdot \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} & \text{if } 0 \leq \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} < b \\ +100 & \text{if } \dfrac{\mathrm{EV}-\mathrm{PV}}{\mathrm{PV}} \geq b \end{array} \right\} \tag{11.4}$$

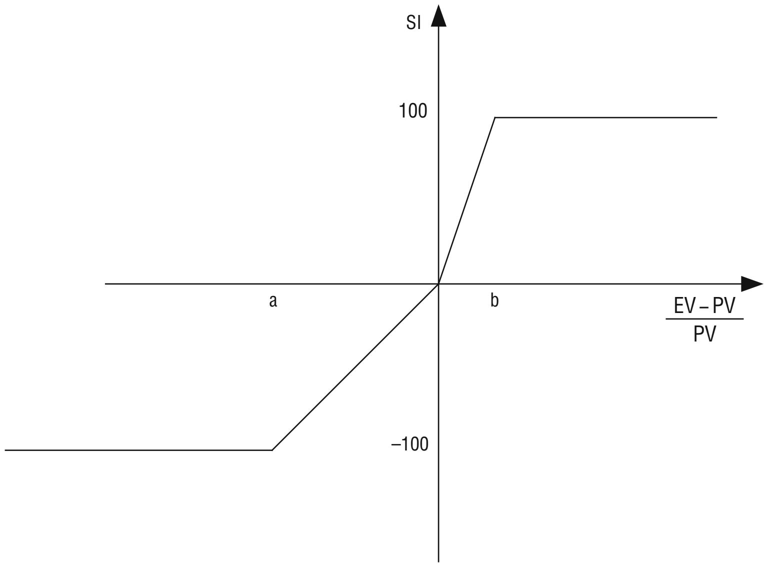

Fig. 11.4 SI function

The considerations made regarding the CI have to be repeated with relation to the *a* and *b* values for the SI indicator.

11.2.3 PPI Contour Lines

As mentioned before, the communication tools chosen to make the stakeholders aware of projects performance, are the contour lines. Other than trying to improve the EVA by providing a synthetic indicator, to better detect the variances from the cost baseline, the aim of this research also is to make the understanding of the analysis results easier, thus aiding to make the proper decisions about changes to put to use.

By means of the contour lines, the project manager may be conscious of the project evolution, namely to predict the efficiencies (inefficiencies) that the variances can bring.

The contour lines (see Fig. 11.8) split the possible value of the PPI, chosen here as belonging to the range [0; 50], into classes expressing a specific range of efficiency (inefficiency).

11.3 Numerical Application

The proposed procedure is here applied to a simulated cases. The inference process is carried out by the Informs software package Fuzzy Tech.

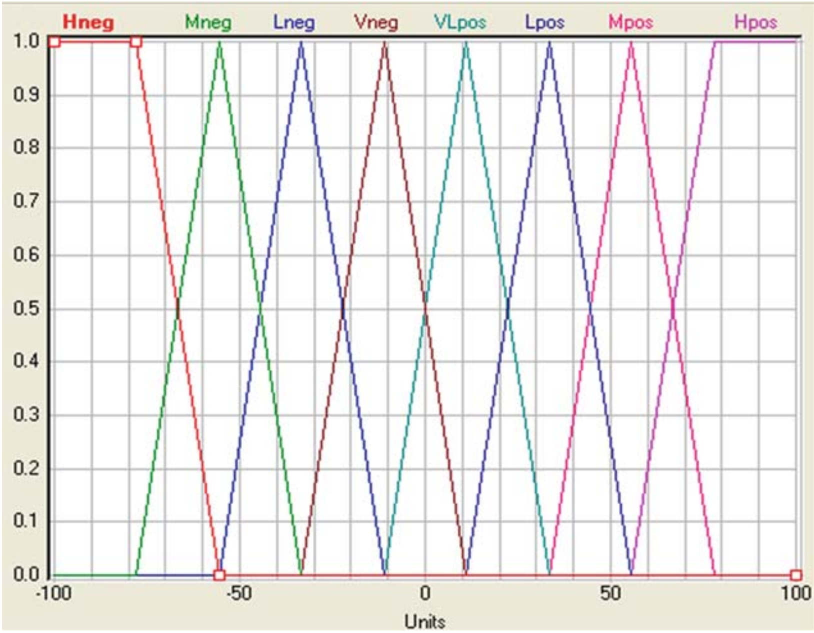

Fig. 11.5 CI membership

As said in the previous section, the two input parameters have eight linguistic variables described by triangular and trapezoidal fuzzy numbers, as shown in Figs. 11.5 and 11.6. Their crisp values, as explained in Sect. 11.2, may take both positive and negative values.

Instead, the PPI, described by seven linguistic variables reported in Fig. 11.7, is defined belonging to a positive range. Obviously, other scales may be defined according to the specific perceptions of decision makers.

An experimental design of 121 applications, related to the rules set in Table 11.1, have been carried out. The values of input parameters are those in Table 11.2. The Fig. 11.8 shows the contour lines and classes of PPI generated taking into account the CI and SI values of Table 11.2.

As it possible to note from Fig. 11.8, the PPI provides the project performance values following the combined importance of evaluation criteria expressed by the project manager. Furthermore, these preferences are implicitly stated by means of the IF – THEN rules – set (see Table 11.1). The simulated application is related to a case in which the decision maker assigns a greater priority to the CI criterion. In fact, symmetrical couples of values (CI, SI) give different values of PPI and the evaluation is mainly influenced by the cost performance. For example, the two extreme points (–100, 100) and (100, –100) or again (60, –40) (–40, 60) fall into different classes.

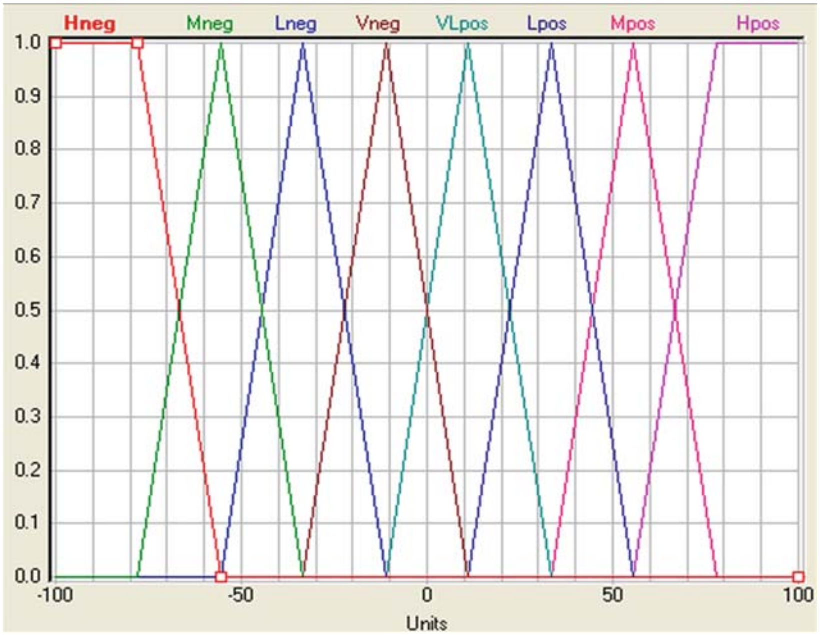

Fig. 11.6 SI membership

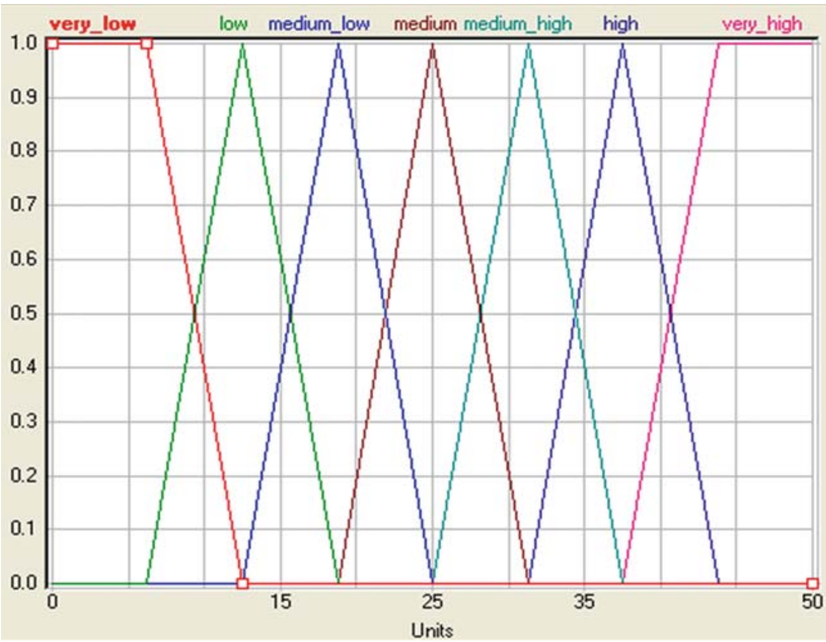

Fig. 11.7 PPI membership

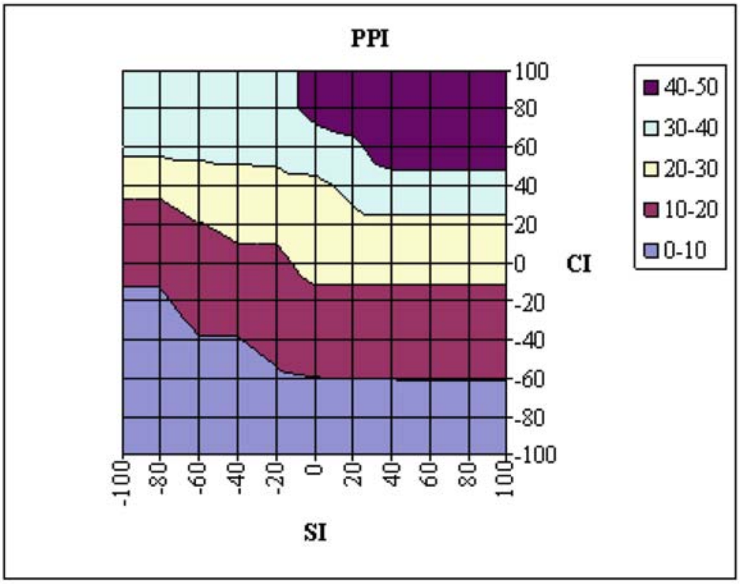

Fig. 11.8 PPI contour lines

Table 11.1 Set of IF – THEN rules for the FIS

	IF		THEN
# rule	CI	SI	PPI
1	High-negative	High-negative	Very-low
2	High-negative	Medium-negative	Very-low
3	High-negative	Low-negative	Very-low
4	High-negative	Very low-negative	Very-low
5	High-negative	Very low-positive	Very-low
6	High-negative	Low-positive	Very-low
7	High-negative	Medium-positive	Very-low
8	High-negative	High-positive	Very-low
9	Medium-negative	High-negative	Very-low
10	Medium-negative	Medium-negative	Very-low
11	Medium-negative	Low-negative	Very-low
12	Medium-negative	Very low-negative	Low
13	Medium-negative	Very low-positive	Low
14	Medium-negative	Low-positive	Low
15	Medium-negative	Medium-positive	Low
16	Medium-negative	High-positive	Low
17	Low-negative	High-negative	Very-low
18	Low-negative	Medium-negative	Low
19	Low-negative	Low-negative	Low
20	Low-negative	Very low-negative	Medium-low

Table 11.1 (continued)

	IF		THEN
# rule	CI	SI	PPI
21	Low-negative	Very low-positive	Medium-low
22	Low-negative	Low-positive	Medium-low
23	Low-negative	Medium-positive	Medium-low
24	Low-negative	High-positive	Medium-low
25	Very low-negative	High-negative	Low
26	Very low-negative	Medium-negative	Medium-low
27	Very low-negative	Low-negative	Medium-low
28	Very low-negative	Very low-negative	Medium-low
29	Very low-negative	Very low-positive	Medium-low
30	Very low-negative	Low-positive	Medium-low
31	Very low-negative	Medium-positive	Medium-low
32	Very low-negative	High-positive	Medium-low
33	Very low-positive	High-negative	Low
34	Very low-positive	Medium-negative	Medium-low
35	Very low-positive	Low-negative	Medium-low
36	Very low-positive	Very low-negative	Medium-low
37	Very low-positive	Very low-positive	Medium
38	Very low-positive	Low-positive	Medium
39	Very low-positive	Medium-positive	Medium
40	Very low-positive	High-positive	Medium
41	Low-positive	High-negative	Medium-low
42	Low-positive	Medium-negative	Medium
43	Low-positive	Low-negative	Medium
44	Low-positive	Very low-negative	Medium
45	Low-positive	Very low-positive	Medium
46	Low-positive	Low-positive	Medium-high
47	Low-positive	Medium-positive	Medium-high
48	Low-positive	High-positive	Medium-high
49	Medium-positive	High-negative	Medium-high
50	Medium-positive	Medium-negative	Medium-high
51	Medium-positive	Low-negative	Medium-high
52	Medium-positive	Very low-negative	Medium-high
53	Medium-positive	Very low-positive	Medium-high
54	Medium-positive	Low-positive	Very-high
55	Medium-positive	Medium-positive	Very-high
56	Medium-positive	High-positive	Very-high
57	High-positive	High-negative	High
58	High-positive	Medium-negative	High
59	High-positive	Low-negative	High
60	High-positive	Very low-negative	High
61	High-positive	Very low-positive	Very-high
62	High-positive	Low-positive	Very-high
63	High-positive	Medium-positive	Very-high
64	High-positive	High-positive	Very-high

Table 11.2 – Input parameters to the FIS

	SI										
CI	–100	–80	–60	–40	–20	0	20	40	60	80	100
–100	5	5	5	5	5	5	5	5	5	5	5
–80	5	5	5	5	5	5	5	5	5	5	5
–60	5	5	5	5	9	10	10	10	10	10	10
–40	5	5	10	10	13	16	17	17	17	17	17
–20	9	9	14	16	16	19	19	19	19	19	19
0	12	12	17	19	19	22	22	22	22	22	22
20	15	15	20	21	21	22	28	28	28	28	28
40	22	22	26	27	27	27	33	37	37	37	37
60	33	33	33	33	3	37	38	45	45	45	45
80	38	38	38	38	38	42	45	45	45	45	45
100	38	38	38	38	38	42	45	45	45	45	45

11.4 Conclusions

The measures formulation for the project performance assessment has positive and significant impact on the project success. This study focuses on the Earned Value Analysis, by defining a synthetic indicator based on the classical parameters EV, PV and AC to support the project manager or the project board in monitoring project cost and duration performance. Since the assessment of these parameters requires information often affected by uncertainty and vagueness, the tool chosen to carry out the synthetic indicator is a Fuzzy Inference System. Moreover an expert decision support system based upon IF – THEN rules allows to take into account experts' experience and company strategic objectives in the evaluation judgments, their preference about the criteria evaluation and to emulate their decision process. Therefore, the representation of this indicator is supplied by means of contour lines that delimit classes of possible value of PPI allowing to predict also the project development. The numerical application shows that the presented methodology may be efficiently employed to support in the decision process providing a meaningful score of the project performance, thus confirming the effectiveness of fuzzy inference systems in decision analysis.

Since the key factors for the project success may be identified in project time, project cost and project quality, further development can regard the formulation of an indicator that handles the PPI here proposed with a measure of the quality performance to get an overall score about how well the project was managed and executed.

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Chapter 12
A Project Manager Suitability Parameter in Project Accomplishment

Antonella Certa, Mario Enea, Giacomo Galante, and Manuela La Fata

Abstract One the most critical aspect in project management is how to assign the project managers (PMs) to projects, especially whenever the PMs can lead more than one project. The present paper proposes a parameter (PME) to evaluate the PM in accomplishing a specific project useful for a next phase of assignment. The PME takes into account the technical skills, the leadership behavior and the relationships with project's stakeholders. These parameters are aggregated by a Fuzzy Inference System (FIS) that well emulates the decision process of the experts by means of a rule-based inference engine. Moreover, to better define the PME, a procedure, based on the discordance concept, is proposed to compare the PM skills with those required by the project.

12.1 Introduction

In every organization the process of evaluating the PMs (project managers) performance should be appropriately done in according to the projects portfolio since a right matching between PMs (project managers) and projects definitely positively affect the project's performance and the organization's success. Hence, an appropriate choice of parameters and decision process on the base of assessing the PM with respect to every project in the business portfolio are necessary.

In order to properly assign the PMs to projects, a multi-criteria evaluation procedure taken into account some meaningful parameters also contrasting one each other, is proposed. In particular, it defines the suitability of project manager candidate in accomplishing each project on the base of different parameters.

Diverse researches have been conducted to individuate the parameters with relation to appraise and successively select the PM. Such parameters characterizing

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the PM do not have to involve the technical skills only, that are, for example, the knowledge and the analytical ability in using the tools and the techniques of the specific discipline, but even those factors influencing his/her performance like relationship and communication capability.

El-Sabaa (2001) proposed a study investigating a group of managers and he found that the human skills have a greater influence on project management practices than technical skills and organizational/conceptual skills.

The leadership behavior of project manager is a relevant human factor which strongly influences the project's success so it makes sense to suggest it as a parameter on the base of evaluating the PM's suitability in order to carry out a specific project. In particular, the leadership behavior depends on the project's size, for example whenever a lot of human resources are involved into the project, particularly for a large one, the project manager has generally to show a strong leadership behavior. The leadership feature implies a capability in developing a vision and strategy, and in motivating people to achieve the vision and strategy (PM BOK, 2004). Kotter (1990) stated that leadership involves:

- Establishing direction: developing both a vision of the future and strategies for producing the changes needed to achieve the vision.
- Aligning people: communicating the vision by words and deeds to all those whose cooperation may needed to achieve the vision.
- Motivating and inspiring: helping people energize themselves to overcome political, bureaucratic, and resource barriers to change.

The leadership feature also depends on project type. Müller and Turner (2007) analyzed the interaction of the project manager leadership with the project type and their combined impact on project's success. The latter is measured by different criteria like project team satisfaction, stakeholders satisfaction, client satisfaction with relation to the project results, etc. The project manager's leadership feature involves intellectual, emotional and manager competences. The authors undertook a web based questionnaire research, by interviewing several projects managers from different companies, and they finally concluded that the project manager's leadership influences project's success and different leadership styles are appropriate for different types of project. Lin et al. (2007) showed that there is a positive correlation between the project manager's leadership and the project's performance. The authors individuated some variables that characterise the project manager's leadership (communication skills, authorization abilities) and performance of the project (project progress, customer satisfaction degree, economics benefits of project, work efficiency, etc..) respectively. Subsequently, they structured a model to express the relationship between the two kind of variables to analyze the data collected by a questionnaire. In order to accomplish the analysis, about a hundred of project managers, from different enterprises, were investigated. Chen and Lee (2007) proposed a model to evaluate project managers, on the base of managerial practices. This model incorporates leadership behavior that influences the managerial practices (planning, consulting, delegating, monitoring, etc.). In particular, the authors used the Analytic Network Process (ANP) to calculate the relative importance of factors included in leadership behavior (influencing people, making decisions, building relationship, etc.) and also the relative importance of factors that affect the leadership behavior. They supposed that some interdependencies between the aforementioned factors occur and stated that the project manager performance is not only associated with his/her capability of acquiring profit but also dependent on whether he/she can effectively and efficiently implement the managerial practices of the leadership behavior.

Bi and Zhang (2006) applied a fuzzy analytical hierarchy process (FAHP) based on triangular fuzzy numbers to evaluate the project manager's ability. The evaluation system by which the overall project manager's ability is estimated includes four characteristics: knowledge, capability, character, and body. Furthermore, each of the aforementioned characteristics have several sub-criteria, i.e. capability includes leadership, while knowledge includes management knowledge, etc.

A problem that frequently arises when designing an evaluation support procedure is to represent the vagueness and uncertainty that typically affects information which cannot be handled with traditional (crisp) mathematical models. The proposed approach takes into account such vagueness and uncertainty by means of fuzzy set and emulates the decision process of a human expert by means of a rule-based inference engine. In fact, experts' knowledge may efficiently be represented by rules when fuzzy logic is employed. Rule-based expert systems use human expert knowledge to solve real-world problems that normally would require human intelligence. Fuzzy Inference Systems are popular computing frameworks based on the concepts of fuzzy set theory, which have been successfully applied in many fields like control (Carlsson and Fuller, 2002; Klir and Yuan, 1995), and decision support (Bojadziev and Bojadziev, 1999). Their success is mainly due to their closeness to human perception and reasoning, as well as to their intuitive handling and simplicity, which are important factors for acceptance and usability of the systems. Specific applications of fuzzy logic in project management are relatively few in comparison with other application areas. Dweiri and Kablan (2006) proposed a fuzzy decision making system (FDMS) for the project management internal efficiency evaluation. The proposed evaluation criteria are project cost, project time and project quality. The authors also proposed this approach to appraise the performance of projects team. Fasanghari and Roudsari (2008) developed a fuzzy system to select the best ICT project by the fuzzy set theory and fuzzy integer linear programming optimization. Assuming all projects are independent one another, the proposed model uses two parameters, the investment cost and the expected profit, to estimate the financial feasibility of projects. Hence, the goal is to maximize the total return on investment, simultaneously satisfying the budget constraints. The fuzzy inference engine is characterized by a rule-set based on two fuzzy parameters, the project strength and the project attractiveness, to get the fuzzy project rank.

A FIS is herein proposed to obtain a synthetic measure of each candidate to the PM role. It gives an evaluation of the candidate suitability in playing the role of project manager for a specific project, on the base of their technical skills and features behavior. Therefore, it is proposed a non compensative evaluation procedure to assess the congruency among the technical skills owned by every candidate with those required by each project.

The paper structure includes a section regarding the description of the evaluation criteria, one for the definition of the synthetic parameter and a section dedicated to a numerical example to show the efficiency of the Fuzzy Inference System on the decision analysis area and in particular in project management. The conclusions are finally drawn.

12.2 Input Parameters

12.2.1 Individuated Evaluation Criteria

As stated before, several parameters that influence the process evaluation should be considered. Anyway, this paper aims at presenting a methodology rather than formalizing the complete decision framework, therefore only three representative parameters have been proposed. A synthetic parameter is here determined by aggregating the decision maker evaluation with relation to different parameters like: the technical skills, the leadership behavior and the relationships with project's stakeholders.

About the first one called g_{ji}, explained in the next subsection, a measure based on the discordance concept is proposed in order to better express the congruency among the technical skills owned by every candidate j with those required by each project i.

The second criterion in appraising the PM candidate is his/her leadership behavior with relation to the project's complexity in term of team size and duration. This factor is indicated as l_{ji}. The last criterion s_{ji} expresses the relationship that each candidate has with the project's stakeholders and, in particular, with the functional managers with which the PM will share the human resources and with the project sponsors which interests may positively or negatively affect the project's success. Different methods can be used to evaluate the two previous factors but for the sake of shortness are here not analyzed.

12.2.2 Technical Skills Evaluation

In this context, it is supposed the lower the gap is between the skill owned and that required, more suitable the candidate is for a project. Obviously, if a candidate is too less skilled with respect to the required value, he/she is not appropriate for the project but the opposite is still true. In fact, it could not be convenient to evaluate the candidate j as suitable to carry out the project i, with relation to the specific skill k, if his/her skill value overcomes that required by the project of a fixed amount. That arises from the consideration that a PM candidate having a larger skill value than the amount effectively needed by the project, has a greater potential for being selected to participate in other projects. The parameter employed to evaluate the candidate with relation to each project, concerning the first criterion, is defined as:

$$g_{ji} = \min\left\{\sum_k \frac{a_{jik}}{K}\ ;10 - \max_{k \in K*} d_{jik} \rightarrow \forall j,i\right. \tag{12.1}$$

that depends on the two parameters a_{jik} and d_{jik}, belonging to the range [0; 10], evaluated by the Eqs. 12.2 and 12.3 respectively on the base of the difference $\Delta_{jik} = -[c_{jk} - c'_{jk}]$. The parameter c_{jk} is the evaluation of the candidate j with respect to the skill k and c'_{jk} represents how important is the required skill k in accomplishing the specific project i.

$$a_{jik} = \begin{cases} 0 & \text{if } \Delta_{jik} < S_k^+ \\ 10 \cdot \frac{\Delta_{jik} - S_k^+}{I_k^+ - S_k^+} & \text{if } S_k^+ \leq \Delta_{jik} < I_k^+ \\ 10 & \text{if } I_k^+ \leq \Delta_{jik} \leq I_k^- \quad \rightarrow \forall j,i,k \\ 10 \cdot \frac{\Delta_{jik} - S_k^-}{I_k^- - S_k^-} & \text{if } I_k^- < \Delta_{jik} \leq S_k^- \\ 0 & \text{if } \Delta_{jik} > S_k^- \end{cases} \tag{12.2}$$

$$d_{jik} = \begin{cases} 0 & \text{if } \Delta_{jik} < S_k^- \\ 10 \cdot \frac{\Delta_{jik} - S_k^-}{V_k - S_k^-} & \text{if } S_k^- \leq \Delta_{jik} \leq V_k \quad \rightarrow \forall j,i,k \in K^* \\ 10 & \text{if } \Delta_{jik} > V_k \end{cases} \tag{12.3}$$

The Fig. 12.1 graphically represents the previous equations. The thresholds $S_k{}^+$, $I_k{}^+$, $I_k{}^-$, $S_k{}^-$ and V_k enables the decision maker to express the degree with which he/she agrees or disagrees with the suitability of the candidate to the project in a fuzzy way.

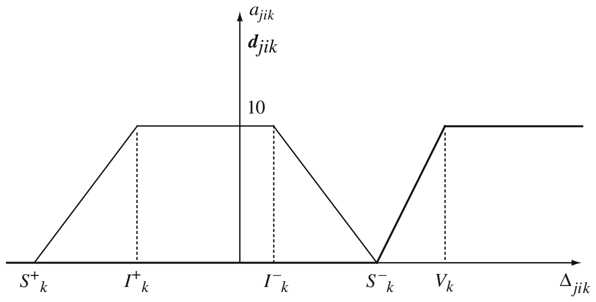

Fig. 12.1 a_{jik} and d_{jik} parameters

The parameter a_{jik} states the degree with which the decision maker agrees in believing the candidate as suitable with relation to each project and skill. Contrasting the hypothesis formulated for the first parameter a_{jik}, the second one d_{jik} is a measure to explain how the decision maker disagrees in considering the candidate as fit for the project. It is only determined for the keys and fundamental skills on project's success. The skills thought as fundamental in carrying out the project i are identified like those having a

$$\mu_B(x) = \begin{cases} \dfrac{x-l}{m-l} & \text{when } x \in [l,m] \\ 1 & \text{when } x \in [m,n] \\ \dfrac{u-x}{u-n} & \text{when } x \in [n,u] \\ 0 & \text{otherwise} \end{cases}$$

greater than a fixed value

$$\begin{matrix} \dfrac{x-l}{m-l} & \text{when } x \in [l,m] \\ \dfrac{u-x}{u-m} & \text{when } x \in [m,u] \\ 0 & \text{otherwise} \end{matrix}$$

$c'_{jk}*$. The set of all fundamental skills has been indicated as K^*. It is supposed that if a candidate j is positively evaluated on some skills with relation to the project i and, on the contrary, considered unsuitable on at least one of the fundamental skill k, i.e. the difference Δ_{jik} is higher than the threshold value V_k and the value of g_{ji} is equal to zero, the candidate has to be discarded for the PM role of the specific project. For the same reason, in this case the final score of candidate j with relation to project i is forced to take the value zero.

The just explained concept is the non compensative aggregation based on the discordance, that is a key factor of the outranking methods like ELECTRE (Roy, 1990).

12.3 Synthetic Evaluation Parameter

12.3.1 Fuzzy Inference System

To evaluate the global suitability of the candidate to play the role of project manager in accomplishing a specific project, on the base of the different parameters previously described, it is proposed a fuzzy logic inference approach.

As it is well known, a basic fuzzy logic system is constituted by four components: a rules set, a fuzzifier, an inference engine and a defuzzifier. The core of a FIS is its knowledge base, which is expressed in terms of fuzzy rules allowing the approximate reasoning (Czogala and Leski, 2000). The fuzzy logic system here used is a Multi Input – Single Output System (MISO), using the Mamdani implication (Mamdani and Assilian, 1975) and the center of area method (COA) as defuzzifier.

At the first step of the inference process, it is needed to define the fuzzy set to represent the crisp input values, that is the fuzzification process, which consists in assigning fuzzy linguistic variables in the universe of discourse of each input value. In particular, in this paper each input parameter is described by triangular and trapezoidal fuzzy numbers. Triangular fuzzy numbers are widely used for their simplicity and solid theoretical basis (Pedrycz, 1994). The membership function of a triangular fuzzy number A is μ_A: R $\rightarrow$ [0, 1] and it can be represented by the set of Eq. 12.4, where $l < m < u$. Consequently, a triangular fuzzy number is fully characterized by three real numbers (l, m, u). The parameter m corresponds to the maximum grade of $\mu_A(x)$ that is equal to 1, whereas l and u are respectively the lower and upper bounds of the definition interval. Similarly (Eq. 12.5), a trapezoidal fuzzy number B is fully characterized by four real numbers (l, m, n, u). The parameters m and n give the maximum grade of $\mu_B(x)$.

$$\mu_A(x) = \begin{cases} \dfrac{x-l}{m-l} & \text{when } x \in [l,m] \\ \dfrac{u-x}{u-m} & \text{when } x \in [m,u] \\ 0 & \text{otherwise} \end{cases} \tag{12.4}$$

where $l < m < u$.

$$\mu_B(x) = \begin{cases} \dfrac{x-l}{m-l} & \text{when } x \in [l,m] \\ 1 & \text{when } x \in [m,n] \\ \dfrac{u-x}{u-n} & \text{when } x \in [n,u] \\ 0 & \text{otherwise} \end{cases} \tag{12.5}$$

where $l < m < n < u$.

In particular, in this paper each input parameter has three linguistic variables (low, medium and high) described by triangular and trapezoidal fuzzy number, as shown in the Fig. 12.2. Instead, the output parameter has five linguistic variables (very low, low, medium, high and very high) as shown in the Fig.12.3.

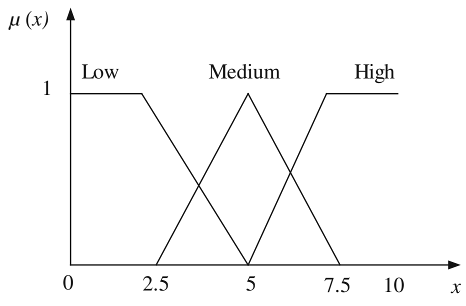

Fig. 12.2 Fuzzy set for the input variables

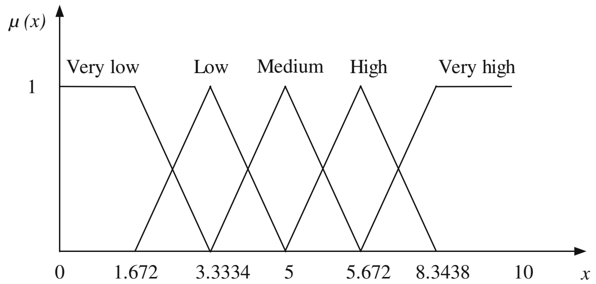

Fig. 12.3 Fuzzy set for the output parameter

The next step in the fuzzy logic system is to define the possible rules arising from combining the fuzzy inputs. Rules are usually provided by a team of experts in the form of IF – THEN sentences and are introduced into the FIS. Later, since the values of the assessment parameters are crisp, the fuzzifier maps the input crisp numbers into the fuzzy set to obtain their degrees of membership. The inference engine of the FIS maps the antecedent fuzzy (IF part) set into consequent fuzzy set (THEN part) taking into account the already stated rules. The inference process determines the fuzzy subset of the output variable for each rule by using the MIN (Mamdani operator) as implication operator. If more than one rule produces the same consequence, an operator must aggregate the results of these rules. In particular, the MAX operator is used. The inference fuzzy model does not consider the cases in which the parameter g_{ji} takes the value zero because in this case it is thought to be not opportune assigning the candidate j to the project i, as previously explained.

Finally, the defuzzifier maps the fuzzy output into a crisp number, which becomes the output of the FIS, that is, in the case here considered, the final score e_{ji} of each candidate with relation to each project. As before mentioned in this case the COA method is applied being the latter the most used defuzzification method (Sugeno, 1985; Lee, 1990). The Fig. 12.4 represents the inference process.

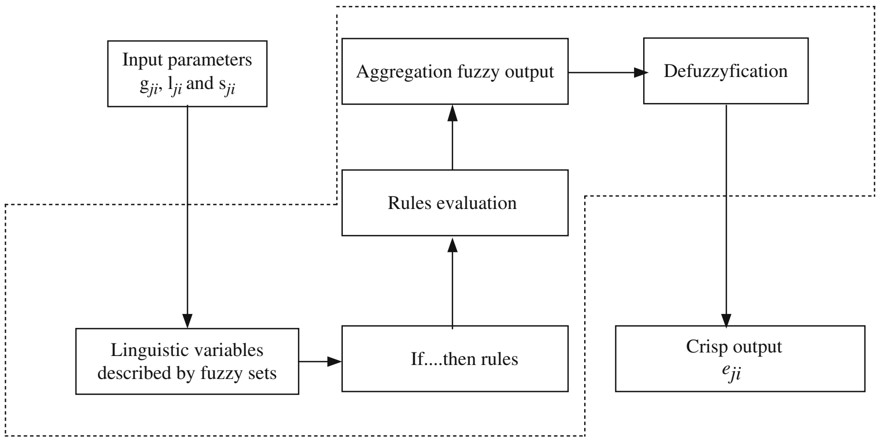

Fig. 12.4 Block diagram of fuzzy inference procedure

12.4 Numerical Application

The proposed approach has been applied to a simulated case including five candidates, ten projects and five technical skills. The set of individuated rules are those reported in Table 12.1. The input data are reported in Tables 12.2, 12.3, 12.4, 12.5 and 12.6. For the sake of simplicity, it is assumed the same thresholds for each

Table 12.1 Set of rules for the FIS

	IF			THEN
Rule	g_{ji}	l_{ji}	s_{ji}	e_{ji}
1	Low	Low	Low	Very low
2	Low	Low	Medium	Very low
3	Low	Low	High	Low
4	Low	Medium	Low	Very low
5	Low	Medium	Medium	Low
6	Low	Medium	High	Low
7	Low	High	Low	Low
8	Low	High	Medium	Medium
9	Low	High	High	Medium
10	Medium	Low	Low	Low
11	Medium	Low	Medium	Low
12	Medium	Low	High	Medium
13	Medium	Medium	Low	Medium
14	Medium	Medium	Medium	Medium
15	Medium	Medium	High	High
16	Medium	High	Low	Medium
17	Medium	High	Medium	High
18	Medium	High	High	High
19	High	Low	Low	Medium
20	High	Low	Medium	High
21	High	Low	High	High
22	High	Medium	Low	High
23	High	Medium	Medium	High
24	High	Medium	High	Very high
25	High	High	Low	Very high
26	High	High	Medium	Very high
27	High	High	High	Very high

Table 12.2 Values of c_{jk}

	k				
j	1	2	3	4	5
1	5	3.5	6.5	8	4.5
2	8	6	10	4.5	3.5
3	7	10	4.5	3.5	6
4	4.5	5	7	10	4.5
5	4.5	3.5	3.5	7	9

skill k (Table 12.4) and the value of $c'_{jk}*$ is also stated to be equal for every project and skill and in particular equal to 8. The parameters g_{ji}, calculated by the procedure described in Sect. 12.2, are shown in Table 12.7. The output parameters e_{ji} of the FIS, obtained by the Informs software package Fuzzy Tech, are summarized in Table 12.8.

Table 12.3 Value of c'_{jk}

	k				
i	1	2	3	4	5
1	5	5	3	6	7
2	2	5	9	3	6
3	4	1	7	4	6
4	6	3	7	10	9
5	5	7	2	8	6
6	7	9	4	5	2
7	3	9	10	2	4
8	9	6	6	1	10
9	10	9	5	7	7
10	9	4	5	7	1

Table 12.4 Threshold value

S^+	I^+	I^-	S^-	V
–6	–3	1	4	6

Table 12.5 Value of l_{ji}

	j				
i	1	2	3	4	5
1	4	5.5	10	6.5	3
2	8	3	2	6	7.5
3	7.5	1	6	5.5	4
4	4.5	2	6.5	8	7
5	6	7	4.5	1.5	2.5
6	8	9	7	3	5
7	3.5	6.5	3.5	9.5	9
8	3	7	8	3	8
9	6.5	5.5	5	9	4
10	4	3	2	10	2

Table 12.6 Value of s_{ji}

	j				
i	1	2	3	4	5
1	3.5	8.5	5	2	4.5
2	7	7.5	2	7	5
3	5	2	2	9	4
4	3.5	5	2	3	6
5	7	8.5	4	2	9
6	2.5	8	8	7	6
7	8	7	6	8	2
8	7	3	5.5	4	8.5
9	9	5.5	3	7	9
10	3	4.5	5	6	8

Table 12.7 Value of g_{ji}

	j				
i	1	2	3	4	5
1	8.33	6	7.67	7.67	9.67
2	7	7	5.33	7	2.5
3	9	7	7	7	8.33
4	7.33	2.5	0	8	6.67
5	7	5.33	7.5	7.67	8.33
6	2.5	6.67	9	5.67	2.5
7	2.5	7.33	2.5	4.67	0
8	2.5	0	6.33	2.5	4
9	2.5	4	7	2.5	2.5
10	7.67	7.67	4.33	7.5	5.67

Table 12.8 Fuzzy inference output e_{ji}

	j				
i	1	2	3	4	5
1	6	7.69	8.7	8.08	6.33
2	8.41	6.88	3.55	7.82	5
3	8.7	4.67	7.3	8.41	6
4	6.02	1.3	0	8.7	7.71
5	7.82	7.07	6.25	5	6.67
6	3.33	8.2	8.70	5.82	3.33
7	3.33	8.14	1.92	6.45	0
8	2.78	0	7.95	1.67	6
9	4.33	4.72	6.33	5	3.33
10	6	6.33	2.61	8.7	5.45

The e_{ji} parameter value of Table 12.8 expresses the suitability of each candidate in accomplishing the specific project in a synthetic and numerical way by synthesizing the decision makers preference and the experience. As aforementioned the values zero mean that the candidate will bediscarded for the PM role. In opposite, high values fulfill the tree criteria evaluation.

12.5 Conclusions

In the present paper a synthetic parameter expressing the PM performance in performing a specific project is proposed. Information regarding this type of evaluation can be hardly formalized by means of traditional (crisp) mathematical models, due to its vagueness and uncertainty, whereas such characteristics can be efficiently taken into account using approximate reasoning. That being so, an expert decision support system based upon a fuzzy inference engine is presented, which allows to involve the experts' experience in the evaluation judgments.

The procedure to appraise the individual suitability to play the PM role considers three criteria: the technical skills, the leadership behavior and the relationship with the project's stakeholders. In particular, with relation to the technical skills owned by each candidate, a non compensative approach is proposed expressing concordance and discordance judgments typical of the outranking methods. The evaluations regarding the three criteria are later aggregated into a single parameter by a fuzzy inference process. In this way it is possible to employ the classical mono-objective mathematical programming to assign the most suitable PM to each project by taking into account the proposed synthetic parameter.

The numerical application shows that the methodology presented may efficiently be employed to support the decision maker in the evaluation process providing a global score that summarizes different judgments with relation to different criteria also contrasting one another, thus confirming the effectiveness of fuzzy inference systems in decision analysis.

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Chapter 13
The Dilemma of Performance Appraisal

Peter Prowse and Julie Prowse

Abstract This paper deals with the dilemma of managing performance using performance appraisal. The authors will evaluate the historical development of appraisals and argue that the critical area of line management development that was been identified as a critical success factor in appraisals has been ignored in the later literature evaluating the effectiveness of performance through appraisals. This paper will evaluate the aims and methods of appraisal, the difficulties encountered in the appraisal process. It also re-evaluates the lack of theoretical development in appraisal and moves from the psychological approaches of analysis to a more critical realisation of approaches before re-evaluating the challenge to remove subjectivity and bias in judgement of appraisal.

13.1 Introduction

This paper will define and outline performance management and appraisal. It will start by evaluating what form of performance is evaluated, then develop links to the development of different performance traditions (Psychological tradition, Management by Objectives, Motivation and Development). It will outline the historical development of performance management then evaluate high performance strategies using performance appraisal. It will evaluate the continuing issue of subjectivity and ethical dilemmas regarding measurement and assessment of performance. The paper will then examine how organisations measure performance before evaluation of research on some recent trends in performance appraisal.

This chapter will evaluate the historical development of performance appraisal from management by objectives (MBO) literature before evaluating the debates between linkages between performance management and appraisal. It will outline

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the development of individual performance before linking to performance management in organizations. The outcomes of techniques to increase organizational commitment, increase job satisfaction will be critically evaluated. It will further examine the transatlantic debates between literature on efficiency and effectiveness in the North American and the United Kingdom) evidence to evaluate the HRM development and contribution of performance appraisal to individual and organizational performance.

13.2 What is Performance Management?

The first issue to discuss is the difficulty of definition of Performance Management. Armstrong and Barron (1998:8) define performance management as:

> A strategic and integrated approach to delivering sustained success to organisations by improving performance of people who work in them by developing the capabilities of teams and individual performance.

13.2.1 Performance Appraisal

Appraisal potentially is a key tool in making the most of an organisation's human resources. The use of appraisal is widespread estimated that 80–90% of organizations in the USA and UK were using appraisal and an increase from 69 to 87% of organisations between 1998 and 2004 reported a formal performance management system (Armstrong and Baron, 1998:200). There has been little evidence of the evaluation of the effectiveness of appraisal but more on the development in its use. Between 1998 and 2004 a sample from the Chartered Institute of Personnel and Development (CIPD, 2007) of 562 firms found 506 were using performance appraisal in UK. What is also vital to emphasise is the rising use of performance

Table 13.1 Use of performance appraisals in United Kingdom

Workplace size	Any non-managerial employees (%)	60% or more non-managerial employees (%)
10–24 employees	73	64
25–49 employees	65	60
50–99 employees	81	72
100–199 employees	82	75
200–499 employees	89	74
500 or more employees	91	81
Sector ownership		
Private sector	68	62
Public sector	86	77

Source: Adapted from Table 4.5 Kersley et al. (2006) page 83.

appraisal feedback beyond performance for professionals and managers to nearly 95% of workplaces in the 2004 WERS survey (see Table 13.1). Clearly the use of Appraisals has been the development and extension of appraisals to cover a large proportion of the UK workforce and the coverage of non managerial occupations and the extended use in private and public sectors.

13.2.2 The Purpose of Appraisals

The critical issue is what is the purpose of appraisals and how effective is it researched and used in practice throughout organizations?

The purpose of appraisals needs to be clearly identified.

Firstly their purpose. Randell (1994) states they are a systematic evaluation of individual performance linked to workplace behaviour and/or specific criteria. Appraisals often take the form of an appraisal interview, usually annual, supported by standardised forms/paperwork. The key objective of appraisal is to provide feedback for performance is provided by the line manager. The three key questions for quality of feedback:

1. What and how are observations on performance made?
2. Why and how are they discussed?
3. What determines the level of performance in the job?

It has been argued by one school of thought that these process cannot be performed effectively unless the line manager of person providing feedback has the interpersonal interviewing skills to provide that feedback to people being appraised. This has been defined as the "Bradford Approach" which places a high priority on appraisal skills development (Randell, 1994). This approach is outlined in Fig. 13.1 which identifies the linkages between involving, developing, rewarding and valuing people at work.

13.2.3 Historical Development of Appraisal

The historical development of performance feedback has developed from a range of approaches. Formal observation of individual work performance was reported in Robert Owens's Scottish factory in New Lanark in the early 1800s (Cole, 1925). Owen hung over machines a piece of coloured wood over machines to indicate the superintendent's assessment of the previous day's conduct (white for excellent, yellow, blue and then black for poor performance). The twentieth century led to F.W. Taylor and his measured performance and the scientific management movement (Taylor, 1964). The 1930s Traits Approaches identified personality and performance and used feedback using graphic rating scales, a mixed standard of performance scales noting behaviour in likert scale ratings. This was used to recruit and identify

Fig. 13.1 Performance management and the critical factors (Adapted from Randell, 1994)

management potential in the field of selection. Later developments to prevent a middle scale from 5 scales then developed into a forced-choice scale which forced the judgement to avoid central ratings. The evaluation also included narrative statements and comments to support the ratings (Mair, 1958).

In the 1940s Behavioural Methods were developed. These included Behavioural Anchored Rating Scales (BARS); Behavioural Observation Scales (BOS); Behavioural Evaluation Scales (BES); critical incident; job simulation. All these judgements were used to determine the specific levels of performance criteria to specific issues such as customer service and rated in factors such as excellent, average or needs to improve or poor. These ratings are assigned numerical values and added to a statement or narrative comment by the assessor. It would also lead to identify any potential need for training and more importantly to identify talent for careers in line management supervision and future managerial potential.

Post 1945 developed into the Results-oriented approaches and led to the development of management by objectives (MBO). This provided aims and specific targets to be achieved and within time frames such a specific sales, profitability, and deadlines with feedback on previous performance (Wherry, 1957). The deadlines may have required alteration and led to specific performance rankings of staff. It also provided a forced distribution of rankings of comparative performance and paired comparison ranking of performance and setting and achieving objectives.

In the 1960s the development of Self-appraisal by discussion led to specific time and opportunity for the appraisee to reflectively evaluate their performance in the discussion and the interview developed into a conversation on a range of topics that the appraise needed to discuss in the interview. Until this period the success of the appraisal was dependent on skill of interviewer. In the 1990s the development of 360-degree appraisal developed where information was sought from a wider range of sources and the feedback was no longer dependent on the manager-subordinate power relationship but included groups appraising the performance of line managers and peer feedback from peer groups on individual performance (Redman and Snape, 1992). The final development of appraisal interviews developed in the 1990s with the emphasis on the linking performance with financial reward which will be discussed later in the paper.

13.2.4 Measures of Performance

The dilemma of appraisal has always to develop performance measures and the use of appraisal is the key part of this process. Quantitative measure of performance communicated as standards in the business and industry level standards translated to individual performance. The introduction of techniques such as the balanced scorecard developed by Kaplan and Norton (1992). Performance measures and evaluation included financial, customer evaluation, feedback on internal processes and Learning and Growth. Performance standards also included qualitative measures which argue that there is an over emphasis on metrics of quantitative approach above the definitions of quality services and total quality management. In terms of performance measures there has been a transformation in literature and a move in the 1990s to the financial rewards linked to the level of performance. The debates will be discussed later in the paper.

13.3 Criticism of Appraisals

Critiques of appraisal have continued as appraisals have increased in use and scope across sectors and occupations. The dominant critique is the management framework using appraisal as an *orthodox* technique that seeks to remedy the weakness and propose of appraisals as a system to develop performance.

This "orthodox" approach argues there are conflicting purposes of appraisal (Strebler et al, 2001). Appraisal can motivate staff by clarifying objectives and setting clear future objectives with provision for training and development needs to establish the performance objective. These conflicts with assessing past performance and distribution of rewards based on past performance (Bach, 2005:301). Employees are reluctant to confide any limitations and concerns on their current performance as this could impact on their merit related reward or promotion opportunities (Newton and Findley, 1996:43). This conflicts with performance as a continuum as appraisers are challenged with differing roles as both monitors and judges of performance but an understanding counsellor which Randell (1994) argues few managers have not received the raining to perform. Appraisal Manager's reluctance to criticise also stems from classic evidence from McGregor that managers are reluctant to make a negative judgement on an individual's performance as it could be demotivating, lead to accusations of their own support and contribution to individual poor performance and to also avoid interpersonal conflict (McGregor, 1957).

One consequence of this avoidance of conflict is to rate all criterion as central and avoid any conflict known as the *central tendency*. In a study of senior managers by Longnecker et al. (1987), they found organisational politics influenced ratings of 60 senior executives. The findings were that politics involved deliberate attempts by individuals to enhance or protect self-interests when conflicting courses of action are possible and that ratings and decisions were affected by potential sources of bias or inaccuracy in their appraisal ratings (Longenecker et al., 1987). There are methods of further bias beyond Longenecker's evidence. The political judgements and they have been distorted further by over rating some clear competencies in performance rather than being critical across all rated competencies known as the *halo effect* and if some competencies are lower they may prejudice the judgment across the positive reviews known as the *horns effect* (ACAS, 1996).

Some ratings may only include recent events and these are known as the *recency effects*. In this case only recent events are noted compared to managers gathering and using data throughout the appraisal period. A particular concern is the equity of appraisal for ratings which may be distorted by gender, ethnicity and the ratings of appraisers themselves. A range of studies in both the US and UK have highlighted subjectivity in terms of gender (Alimo-Metcalf, 1991; White, 1999) and ethnicity of the appraise and appraiser (Geddes and Konrad, 2003). Suggestions and solutions on resolving bias will be reviewed later.

The second analysis is the *radical critique* of appraisal. This is the more critical management literature that argues that appraisal and performance management are about management control (Newton and Findley, 1996; Townley, 1993). It argues that tighter management control over employee behaviour can be achieved by the extension of appraisal to manual workers, professional as means to control. This develops the literature of Foucault using power and surveillance. This literature uses cases in examples of public service control on professionals such a teachers (Healy, 1997) and University professionals (Townley, 1990). This evidence argues the increased control of public services using appraisal as a method of control and that the outcome of managerial objectives ignores the developmental role of appraisal and ratings are awarded for people who accept and embrace the culture and organisational values. However, this literature ignores the employee resistance and the use of professional unions to challenge the attempts to exert control over professionals and staff in the appraisal process (Bach, 2005:306).

One of the different issues of removing bias was the use of the *test metaphor* (Folger et al., 1992). This was based on the assumption that appraisal ratings were a technical question of assessing "true" performance and there needed to be increased reliability and validity of appraisal as an instrument to develop motivation and performance. The sources of rater bias and errors can be resolved by improved organisational justice and increasing reliability of appraiser's judgement.

However there were problems such as an assumption that you can state job requirements clearly and the organisation is "rational" with objectives that reflect values and that the judgment by appraisers' are value free from political agendas and personal objectives. Secondly there is the second issue of subjectivity if appraisal ratings where decisions on appraisal are rated by a "political metaphor" (Hartle, 1995). This "political view" argues that aappraisal is often done badly because there is a lack of training for appraisers and appraisers may see the appraisal as a waste of time. This becomes a process which managers have to perform and not as a potential to improve employee performance. Organisations in this context are "political" and the appraisers seek to maintain performance from subordinates and view appraises as internal customers to satisfy. This means managers use appraisal to avoid interpersonal conflict and develop strategies for their own personal advancement and seek a quiet life by avoiding censure from higher managers. This perception means managers also see appraisee seeks good rating and genuine feedback and career development by seeking evidence of combining employee promotion and pay rise. This means appraisal ratings become political judgements and seek to avoid interpersonal conflicts. The approaches of the "test" and "political" metaphors of appraisal are inaccurate and lack objectivity and judgement of employee performance is inaccurate and accuracy is avoided. The issue is how can organisations resolve this lack of objectivity?

13.3.1 Solutions to Lack of Objectivity of Appraisal

Grint (1993) argues that the solutions to objectivity lies in part with McGregor's (1957) classic critique by retraining and removal of "top down" ratings by managers and replacement with multiple rater evaluation which removes bias and the objectivity by upward performance appraisal. The validity of upward appraisal means the removal of subjective appraisal ratings. This approach is also suggested to remove gender bias in appraisal ratings against women in appraisals (Fletcher, 1999). The solution of multiple reporting (internal colleagues, customers and recipients of services) will reduce subjectivity and inequity of appraisal ratings. This argument develops further by the rise in the need to evaluate project teams and increasing levels of teamwork to include peer assessment. The solutions also in theory mean increased closer contact with individual manager and appraises and increasing services linked to customer facing evaluations.

However, negative feedback still demotivates and plenty of feedback and explanation by manager who collates feedback rather than judges performance and fail to summarise evaluations. There are however still problems with accuracy of appraisal objectivity as Walker and Smither (1999) 5 year study of 252 managers over 5 year period still identified issues with subjective ratings in 360 degree appraisals. There are still issues on the subjectivity of appraisals beyond the areas of lack of training.

The contribution of appraisal is strongly related to employee attitudes and strong relationships with job satisfaction (Fletcher and Williams, 1996). The evidence on appraisal still remains positive in terms of reinvigorating social relationships at work (Townley, 1993) and the widespread adoption in large public services in the UK such as the national health Service (NHS) is the valuable contribution to line managers discussion with staff on their past performance, discussing personal development plans and training and development as positive issues. One further concern is the openness of appraisal related to employee reward which we now discuss.

13.3.2 Linking Appraisals with Reward Management

Appraisal and performance management have been inextricably linked to employee reward since the development of strategic human resource management in the 1980s. The early literature on appraisal linked appraisal with employee control (Randell, 1994; Grint, 1993; Townley, 1993, 1999) and discussed the use of performance related reward to appraisals. However the recent literature has substituted the chapter titles employee "appraisal" with "performance management" (Bach, 2005; Storey, 2007) and moved the focus on performance and performance pay and the limits of employee appraisal. The appraisal and performance pay link has developed into debates to three key issues: The first issue is has performance pay related to appraisal grown in use? The second issue is what type of performance do we reward? and the final issue is who judges management standards?

The first discussion on influences of growth of performance pay schemes is the assumption that increasing linkage between individual effort and financial reward increases performance levels. This linkage between effort and financial reward increasing levels of performance has proved an increasing trend in the public and private sector (Bevan and Thompson, 1992; Armstrong and Baron, 1998). The drive to increase public sector performance effort and setting of targets may even be inconsistent in the experiences of some organizational settings aimed at achieving long-term targets (Kessler and Purcell, 1992; Marsden, 2007). The development of merit based pay based on performance assessed by a manager is rising in the UK Marsden (2007) reported that the:

> Use of performance appraisals as a basis for merit pay are used in 65 per cent of public sector and 69 per cent of the private sector employees where appraisal covered all non-managerial staff (p.109).

Merit pay has also grown in use as in 1998 20% of workplaces used performance related schemes compared to 32% in the same organizations 2004 (Kersley et al., 2006:191). The achievements of satisfactory ratings or above satisfactory performance averages were used as evidence to reward individual performance ratings in the UK Civil Service (Marsden, 2007). Table 13.2 outlines the extent of merit pay in 2004.

The second issue is what forms of performance is rewarded. The use of past appraisal ratings as evidence of achieving merit-related payments linked to achieving higher performance was the predominant factor developed in the public services. The evidence on Setting performance targets have been as Kessler (2000:280) reported "inconsistent within organizations and problematic for certain professional or less skilled occupations where goals have not been easily formulated". There has been inconclusive evidence from organizations on the impact of performance

Table 13.2 Establishments reporting use of "merit pay" for some employees (% of establishments in sector declaring use of merit pay)

	Private % merit pay	Public % merit pay	Private % merit pay	Public % merit pay	Private N(all establish)	Public N(all establish)
Weights	Establishment	Establishment	Employment	Employment	Establishment	Establishment
Manufacturing	13	–	27	–	210	–
Electricity, gas and water	–	–	–	–		–
Construction	11	–	18	–	92	–
Wholesale and retail	13		22		461	–
Hotels and restaurants	17	–	20	–	161	–
Transport and communications	9	29	25	21	70	50
Financial services	29	–	43	–	95	–
Other business services	19	0	33	0	274	17
Public administration	–	6	–	28	–	97
Education	1	10	8	19	15	179
Health	11	11	9	22	105	156
Other community services	31	3	20	12	72	70
Total	16	10	26	21	1557	589

pay and its effectiveness in improving performance. Evidence from a number of individual performance pay schemes report organizations suspending or reviewing them on the grounds that individual performance reward has produced no effect in performance or even demotivates staff (Kessler, 2000:281). More in-depth studies setting performance goals followed by appraisal on how well they were resulted in loss of motivation whilst maintaining productivity and achieved managers using imposing increased performance standards (Marsden and Richardson, 1994). As Randell (1994) had highlighted earlier, the potential objectivity and self-criticism in appraisal reviews become areas that appraisees refuse to acknowledge as weaknesses with appraisers if this leads to a reduction in their merit pay. Objectivity and self reflection for development becomes a weakness that appraises fail to acknowledge as a developmental issue if it reduces their chances of a reduced evaluation that will reduce their merit reward. The review of civil service merit pay (Makinson, 2000) reported from 4 major UK Civil Service Agencies and the National Health Service concluded that existing forms of performance pay and performance management had failed to motivate many staff.

The conclusions were that that employees found individual performance pay divisive and led to reduced willingness to co-operate with management, citing managerial favorites and manipulation of appraisal scores to lower ratings to save paying rewards to staff (Marsden and French, 1998). This has clear implications on the relationship between line managers and appraises and the demotivational consequences and reduced commitment provide clear evidence of the danger to linking individual performance appraisal to reward in the public services. Employees focus on the issues that gain key performance focus by focusing on specific objectives related to key performance indicators rather than all personal objectives. A study of banking performance pay by Lewis (1998) highlighted imposed targets which were unattainable with a range of 20 performance targets with narrow short term financial orientatated goals. The narrow focus on key targets and neglect of other performance aspects leads to tasks not being delivered.

This final issue of judging management standards has already highlighted issues of inequity and bias based on gender (Beyer, 1990; Chen and DiTomasio, 1996; Fletcher, 1999). The suggested solutions to resolve discrimination have been proposed as enhanced interpersonal skills training are increased equitable use of 360 degree appraisal as a method to evaluate feedback from colleagues as this reduces the use of the "political metaphor" (Randell, 1994; Fletcher, 1999).

On measures linking performance to improvement require a wider approach to enhanced work design and motivation to develop and enhance employee job satisfaction and the design of linkages between effort and performance are significant in the private sector and feedback and awareness in the public sector (Fletcher and Williams, 1996:176). Where rises be in pay were determined by achieving critical rated appraisal objectives, employees are less self critical and open to any developmental needs in a performance review.

13.4 Conclusion

As performance appraisal provides a major potential for employee feedback that could link strongly to increasing motivation, and a opportunity to clarify goals and achieve long term individual performance and career development why does it still suffers from what Randell describes as a muddle and confusion which still surrounds the theory and practice?

There are key issues that require resolution and a great deal depends on the extent to which you have a good relationship with your line manager. Barlow (1989) argued `if you get off badly with your first two managers, you may just as well forget it (p. 515). The evidence on the continued practice of appraisals is that they are still institutionally elaborated systems of management appraisal and development is significant rhetoric in the apparatus of bureaucratic control by managers (Barlow, 1989). In reality the companies create, review, change and even abolish appraisals if they fail to develop and enhance organisational performance (Kessler, 2000). Despite all the criticism and evidence the critics have failed to suggest an alternative for a process that can provide feedback, develop motivation, identify training and potential and evidence that can justify potential career development and justify reward (Hartle, 1997).

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Chapter 14
Risk in Supply Networks: The Case of Aeronautical Firms

Roberto Maria Grisi, Teresa Murino, and Pasquale Zoppoli

Abstract Companies linked in a modern supply network are affected by tight interdependences which cause remarkable risk levels. This paper suggests a method to select risk factors and sources providing the management with a functional tool to hold in check related risks. Particularly, aeronautical firms are considered in the practical application of the method: some strategic goals of the network are selected and a dashboard of indexes is adopted to establish specific control points. A variation in one, or more, indicator/s will allow to promptly investigate on the interested part of the network which could negatively affect its overall performance.

14.1 Introduction

The aim of this work is the development of a risk investigation methodology that weighs against a supply chain, making difficult the achievement of the goals on which the whole supply chain is based on. At the beginning the supply chain will be analyzed as an area of risk analysis, describing the most significant aims and approaches to risk management within the supply chain. A classification of risks will be performed in the supply network and the issue of identification and measurement of risk will be discussed and presented before the survey methodology, based on a dashboard of "key" indicators.

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14.2 A Review on Supply Chain Risk Management

14.2.1 Classification of Risks in a Typical Supply Chain

Risk-sharing through joint ventures, supply chain and other organizational structures has justified the trend towards wider supply chains but at the same time it has risen a certain number of problems about the risks and their control (Crouhy et al., 2001). Individual companies are working with lowering quantities of goods in stock and they depend more and more on the careful coordination of the complex network of partners in the supply chain (Dailun, 2004). Furthermore, the increase in outsourcing has not only made companies more dependent on others, but it also made the survey and the reaction to risk events much more difficult (Svensson, 2002).

Examining a company in the supply chain in which it is inserted, we can refer to the classification proposed in Fig. 14.1 where we identify five wide categories with related risk factors *(drivers)* that can generate them, as illustrated in Table 14.1 (Costantinoet al., 2007).

In particular, it is possible to distinguish among:

- operational risk;
- external risks;
- strategic risks;
- externalities of risk (consequences).

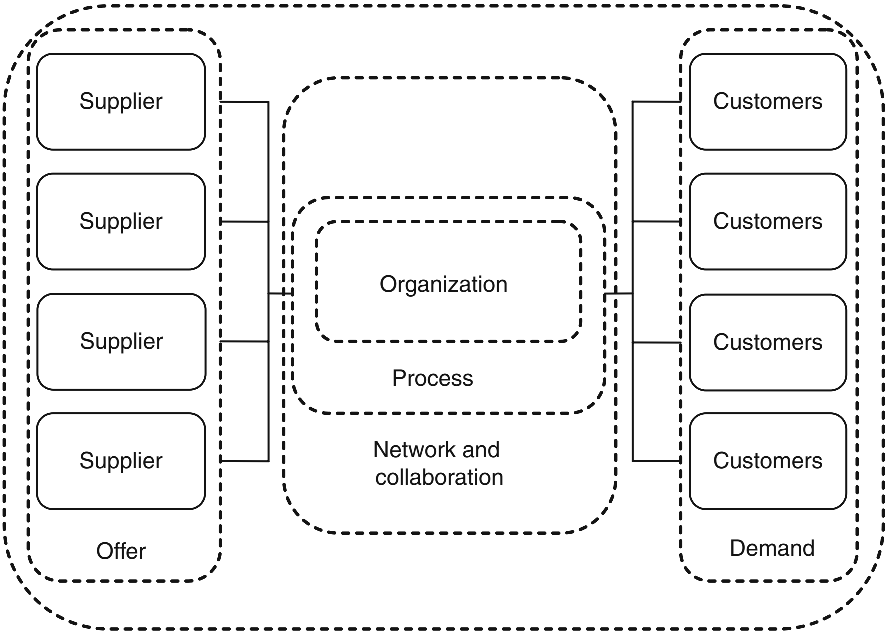


Fig. 14.1 Risks classes in a supply chain

Table 14.1 Classes and drivers of risks in a supply chain

Risk category	Risk drivers
Demand	• Changes in volume of orders and frequency • Changes to orders • Seasonality and promotional effects • Forecasting methods • Warehouses and linked supply • Time and method of payment for customers • Retention rate
Offer	• Quality Level and performance • Level of flexibility and elasticity • Duration and variability of lead time • Length and transfer terms • Just-in-time approaches or lean production • Outsourcing • Internationalization • Supply interruption
Process	• Flexibility of production and distribution systems • Variability in the processes management • Variability of the performance of processes • Productivity level • Production capacity • Material handling procedures • Operational and functional damages • Level of personalization of the product
Network and cooperation	• Trust and interdependence between the partners • Level of collaboration • Design and development of relations • Level of integration • Opportunism and informative asymmetry in transactions • Bargaining power • Strategic goals and mission • Corporate culture • Business logic • Relationship and involvement of stakeholders • Social and administrative responsibility • Availability and reliability of information systems
Environment	• Level of regulation • Policies • Laws • Taxes • Currency • Strikes • Natural and catastrophic disasters

Table 14.2 illustrates some of the risks present in each category (Kogan and Tapiero, 2007).

Operational risks concern the adverse consequences, direct and indirect, of results and events related to operations and services that are not justified, badly managed or badly organized. They can be induced both internally and externally.

Table 14.2 Example of risks

Operational risk	External risks	Strategic risks	Externalities of risks
Risk of late delivery; Synchronization Risks; Inventory risks; Quality risks;	Political risks; Regulatory risks; Risk measurement;	Dependence; Outsourcing; Moral hazards; Adverse selection; Non-transparency	Environmental risks; Regulatory risks; Ethical risk; Social risks;

The internal causes are the result of failures in operations and services management while in the second case, they derive from uncontrollable external events that were difficult to face.

The *external risks (external risks)* derive from events on which the companies have not much control within the supply chain.

Strategic risks. The supply chains are based on exchange and cooperation. The first aspect implies that the profits of a company that is part of a SC, must be at least more than a company that "works by itself". Consequently the risks arise when companies carry out some exchanges with other companies, whose motivations can differ from the company's aims. In such circumstances, the mere fact that companies decide to have supply chain collaborative relationships, leads to a different risk than the one arising from companies operating individually.

Asymmetries of information and bargain power make possible the control by few influential players towards the multitude of companies in the supply network. The consequences of this problem are the so-called "*adverse selection risks*" and "*moral hazard risks.*"

In the "*adverse selection*", there is an asymmetry of information. Because of it the quality evaluation is not well defined because of the risks that exists between the buyer and the seller (who has better information).

The "*moral hazard problem*" implies that a quality that can not be observed determines a risk to the customer. There is the possibility that the supplier uses this situation to his advantage and does not supply the right level of quality. It is for this reason that an index of performances is crucial and necessary to minimize the risks.

External effects (consequence of the risk) are a cost or a profit that is incurred by someone who is not part of the transaction which produces it. Negative external effects are a sustained cost while positive external effects are a profit (Ait-Sahalia and Lo, 2000), (Brun et al., 2006).

14.2.2 Risk Analysis

In order to acquire an overview of the risks related to the different business areas and to protect the company from risks that may threaten the corporate image *(reputational risk)* and/or cause the interruption of business activities *(business interruption)* the most common applications of risk management within the SC are addressed to the top management. Rarely these measurements are intended to improve performance and support the achievement of the aims towards which the processes are oriented (Akella et al., 2002). Measurements of risks must come after the analysis of characteristics of the referred company and supply chain organization environment. It is appropriate to define the factors and the sources of risk that characterize the environment, leading to an analysis that can be divided into two phases:

- *Analysis of context*, namely the analysis of the environment where the companies that are part of a supply chain work;
- *Analysis of focus*, namely the risk analysis through the structuring of a map of quantitative indicators to be measured and monitored during time (Gaudenzi, 2006).

In both analysis the observer must be identified and should not change along the supply chain, which means that the SCRM analysis must be conducted, or at most start, from a single company inside the supply chain. Every company has a subjective perception of the chain (identification of partners upstream and downstream, considering the nature of the relationship) and the characteristics of the reference environment (Svensson, 2000). The perception of risk can depend only on the individual perspective and in particular on the following elements:

- specific competitive position of the firm and its individual aims
- specific propensity to take risks.

The aim of *the context analysis* (see Fig. 14.2) is to define the risk of the considered supply chain. This is a qualitative survey of the environment that influences the performance of the supply chain. In particular, we consider:

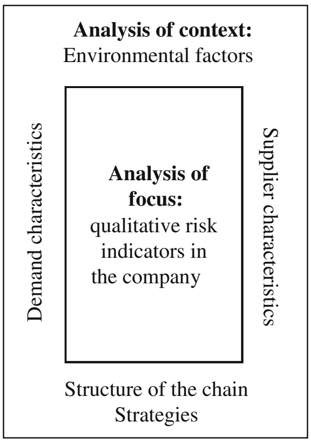


Fig. 14.2 Context and focus analysis

- Environmental characteristics;
- SC structural characteristics;
- Demand structural characteristics;
- Supply sources structural characteristics;
- Implications of strategic choices.

The characteristics of environmental risk factors are those not directly controllable by the company, but that may generate risks having an impact on supply chain management.

The structural elements of the supply chain can be real drivers of risk. In particular:

- Scarce reliability of suppliers and/or key customers;
- Lack of informative integration and/or visibility among the partners;
- Limited number of suppliers and/or key customers;
- High stock (in quantity or value) present in the supply chain;
- A very long lead time in the chain;
- Lack of a common performance system of measurement among firms.

With regard to the structural characteristics of the application we can find elements as risk drivers:

- a poorly predictable nature of the application;
- low rate of customer loyalty;
- inability to handle the variety and the service level requested by the application;
- low customers reliability.

The risk factors, on the structural characteristics of the suppliers, are the following:

- Insufficient reliability of suppliers in terms of quality, efficiency and service;
- lack of substitutability of suppliers;

Finally, the risk factors most related to the implications of some strategic choices, are the following:

- the combination of a high interdependence between business and the maintenance of productive strategies such as “lean” can lead to a significant increase in vulnerabilities in the supply chain;
- the globalization of supply chain;
- the choice of outsourcing involves two risks: a control reduction and a potential growth of cost sustained to manage relations;
- the use of production centres or a centralized distribution.

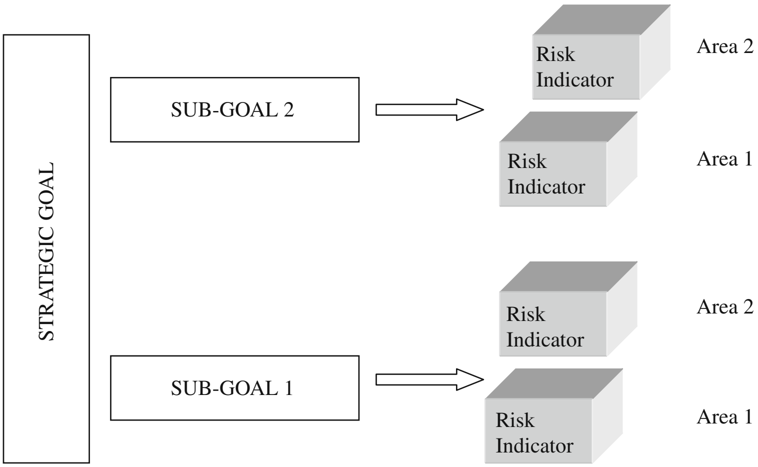


Fig. 14.3 Areas and targets in the focus analysis

The focus analysis consists of investigating the business risks (see Fig. 14.3), flows or processes of SCM, made from the perspective of a single firm of SC *(business focus)*. The goal is to identify those risk factors that threaten an effective and efficient management of the SC, in order to identify and select useful indicators for risk management (Timidei andBorghesi, 1998).

This analysis can be performed using different approaches that are based on qualitative and quantitative risk indicators (Hauser, 2003).

One approach is based on the selection of risk areas in the following categories (see Table 14.3):

- risks associated with suppliers;
- product liability;
- risks related to manufacturing;
- risks related to transportation.

In this approach the identification of risks is done by selecting the areas of risk that can be divided into five categories:

- transportation/distribution;
- production process;
- cycle of the order;
- warehouse;
- supply

Table 14.3 Risk areas

Risks related to suppliers	Product liability	Risks related to manufacturing	Risks associated with the transportation
Dependence on few suppliers; Attribution of contractual liability; Level of proximity to suppliers; Level of exposure to crisis or interruption of business;	Respect for quality programs; Exposure to the contamination of products; Importance of the recalled products (reverse logistic); Level of quality control on products;	Level of outsourcing; Compliance with regulations and scheduling; Rigidity and uniqueness of the processes; Employee exposed to risks related to production;	Dependence on few carriers; Level of stocks; Bargain power and index of carriers cost; Types of customer requests;

14.3 Risk Measurement

14.3.1 Research Method

A risk investigation method in the supply chain, based on a set of indicators, can be developed into two "macro phases" (see Fig. 14.4).

The first phase consisting of the following activities:

1. identifying the areas in which the supply chain is divided;
2. identifying the SCM goals and defining the criteria by which to assign a ranking to each goal to enable a more effective interpretation of the indicators.

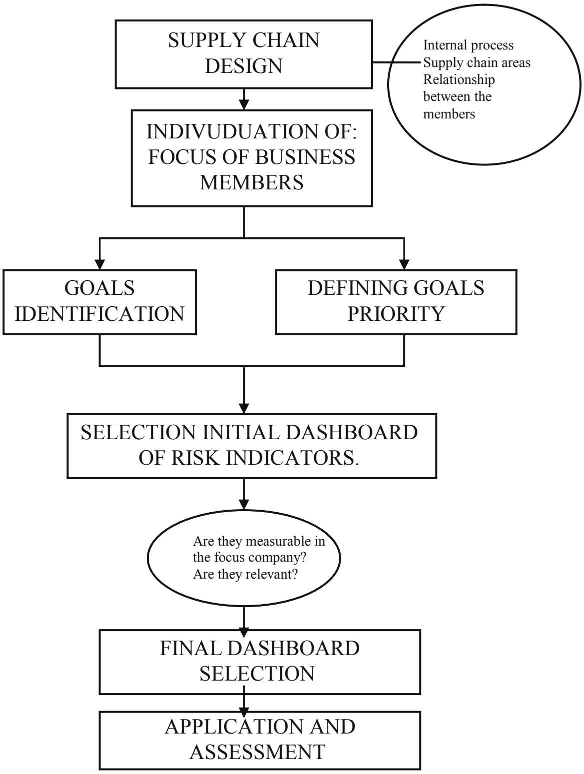
The second phase, that is the process used for defining the indicators dashboard, is the heart of the investigation method, and it consists of the following activities:

1. Identification of risk drivers;
2. Selection of initial dashboard of *risk indicators*;
3. Final dashboard selection;
4. Assessment of risk indicators.

The areas of the supply chain can be divided into five categories:

1. transport/distribution;
2. production process;
3. order cycle;
4. warehouse;
5. supplying

Fig. 14.4 A method to investigate risks in a supply chain



14.3.2 Goals and Priorities: The Analytic Hierarchy Process Method

Each area is characterized by several risk factors related to different goals and, therefore, it's necessary to:

1. identify the specific risks that threaten the fulfilment of individual goals;
2. assess the potential impact of these risks in relation to the different priorities given to goals.

It is not sufficient to attribute to every target a particular level of importance, but it is necessary to take into account the correlation between multiple goals.

In order to build a goal priority hierarchy it is possible to adopt an AHP *(Analytic Hierarchy Process)* method, a *decision making* technique founded in 1970 and subsequently developed in many areas of decision making.

The implementation is developed in four phases:

- create the hierarchical structure;
- compare the attributes and alternatives;
- convert the comparisons into "weights";
- reprocess the data obtained.

The first step is to break down the decision into a hierarchy of sub-problems that are easily understood, each of them can be analyzed separately. Once built the hierarchy we have to gather all the information necessary to define the importance of different factors, and to compare them to each other giving them a "preference index" (phase 2). The aim is to establish, inside the appropriate matrix, how each factor/goal is more important than another, according to a scale of preference. In making such comparisons the managers can use data or personal opinions. In the third phase some weights are assigned to each factor/goal, considering the comparisons and verifying that the requirement of consistency and significance is also satisfied in the judgment expressed by "preference index", which usually ranges from 1 to 5. The assignment of these weights allows a rational and consistent comparison between different elements, often not quantifiable.

In the final phase the data resulting from previous phases are reprocessing, coming to a final evaluation (Saaty, 2008).

We consider as the main goal the *creation of value for customer*. In particular, the level of service that companies should offer to the customer can be defined and measured by four components of the "perfect order". Typical indexes:

$$\text{PUNCTUALITY} = \frac{\text{Orders\_dispatched\_in\_time}}{\text{Tot.\_orders\_received}} * 100$$

$$\text{COMPLETENESS} = \frac{\text{Completed\_dispatched\_orders}}{\text{Tot.\_dispatched\_orders}} * 100$$

$$\text{CORRECTNESS} = \frac{\text{Correctly\_dispatched\_orders}}{\text{Tot.\_dispatched\_orders}} * 100$$

$$\text{LACK OF DAMAGES/DEFECTS} = \frac{\text{No\_defects\_on\_dispatched\_orders}}{\text{Tot.\_dispatched\_orders}} * 100$$

Based on the weight analysis and on the importance of these critical factors, the persons in charge must express an opinion on the importance they think to assign to the different goals. The process of assessing goals expects to make comparisons between two goals simultaneously.

The research into the goal priorities must be performed inside a company in the supply chain, but the assessments must extend to the goals of the whole supply chain and it is not necessarily the case that the individual firm must have internally the same priorities characterizing the entire supply chain. In order to avoid the appearance of such discrepancy it would be better that the focus company in the analysis represents the main firm in the supply chain.

Table 14.4 Goals comparison

	GOAL A	
	Comparison judgement	Explanation
GOAL B	= (equal importance)	The two goals have equal weight. The risk factors which affect the two goals, could have the same gravity.
	+ (more important)	The goal A is considered more important than that goal B.
	– (less important)	The goal A is considered less important than the goal B

14.3.3 Risk Indicators

The process of defining the dashboard of risk indicators to be applied to the firm under analysis is divided into the following phases:

1. identification, within each area of the supply chain, of the risk drivers that threaten the fulfilment of goals previously defined;
2. establishment of a dashboard of potential risk indicators that measure quantitatively the importance of the risk factors described above;
3. selection of risk indicators considered to be measurable and definition of the dashboard of indicators to be subjected to survey and evaluation.

With reference to *the punctuality goal*, it's possible to consider the risk factors listed below.

- *Unforeseen events that may affect processes*: such as sudden interruptions along the processes or operations which may cause unpredictable delays.
- *Concatenation of the stages along the processes*: the more the connections and causal relationships between the phases of the processes and activities of the chain, the greater the risk that any delay at the source would be reflected afterwards.
- *Nature of demand*: in every supply chain the demand can have different characteristics, depending on the type of product, sector, and the market.
- *Poor reliability of the order cycle*: an appropriate degree of computerization of the order cycle generally reduces time and errors in processing orders and promotes a greater sharing of information on in a company and among them.
- *Lack of integration with suppliers*: indicators of non-punctuality are not calculable only regarding to the provision of service to the end market, but also as indicators of the level of "non-service" received from its suppliers. If the supply sources show they are not systematically capable to provide good performance,

these indicators would represent the risk of a future manifestation of the same inefficiency.
- *Exposure to the risks of interruption of activities*, with particular reference to physical activities, typical of the warehouses and production plants.

The risk of *non-completeness* should be carefully considered in relation to two hypotheses: the voluntary non-completeness of the dispatch orders and the involuntary non-completeness.

It's possible to select two risk factors:

- *delays or errors attributable to one or more areas of supply chain*
- *Errors caused by the order cycle*.

Often this risk factor seems not to be relevant because of a computerized management of the order cycle.

With respect to the *correctness goal,* the risk areas are:

- *The order cycle* that can generate wrong orders;
- *transport*

Compared to *the delivery with no damage or defects aim*, risk factors may be related to two aspects:

- *presence of defects in the products*
- *damage caused by materials handling and transfer of goods* (Cavinato, 2004).

The selection of risk indicators in each area continues in two phases:

1. selection of risk factors considered measurable;
2. selection, among the identified indicators, of those that allow the definition of a system for measuring performance.

Indicators should relate directly to a process considered focus of analysis and must be simple and easy to be used. It's important to choose non-financial indicators because of their incapability to express the "causes" of a lacking performance or any corrective action to implement.

Indicators must provide a quick feed-back.

Finally, the indicators need to support continuous improvement, rather than simply monitoring: this principle is particularly useful in the risk measurement because the goal of the investigation method is not only to monitor the risks in the process, but to check the aptitude of the processes to achieve their goals. The risk factors are considered as potential causes of non-achievement goals.

The indicators vary according to "special circumstances": for this reason, the selection done by the management of few indicators considered to be significant should facilitate the monitoring in the course of time.

Indicators should represent trends or structural situations and not exceptional ones.

After selecting and measuring indicators, management needs to dedicate itself to evaluations. It is necessary to estimate the potential impact of direct and indirect risk factors described by the indicators.

14.4 Risk Analysis in the Aeronautical Field

14.4.1 An Aeronautical Supply Chain

The aviation industry is composed of three subsectors:

- *cell*, which includes companies engaged in the construction of the aircraft structure;
- *propellers*, whose companies are responsible for the design and implementation of the propulsive system;
- *equipment and avionics*, which includes both equipment manufacturers and instrumentations suppliers.

The organization of production also includes a final assembly area in which the parts are assembled from the three sub-sectors. Each of them represents a small supply chain structured on different levels.

The exchange relationships of this complex network of companies rotates around the circulation of information, often confidential, on very restrictive technology and quality standards, so the relationships between companies can't be occasional but they must last in the course of time and based on a mutual understanding, on reliability and on the same production philosophy (Cavalieri and Pinto, 2007).

The aerospace supply chain is therefore a structure already characterized by the external integration, where companies and the activities of each level are closely linked with relationships based on trust, cooperation and confidentiality of information.

In the aeronautic sector each product/service must have a high level of reliability and defined in advance, so each process and/or component can be a source of risk.

The goal of risk management is to assess the risk for all areas/activities related to the program, to manage any adverse events occurred, defining and implementing all measures to avoid or minimize the effects (Raj et al., 2004).

14.4.2 Building a Dashboard of Indicators

The main phases characterizing the methodology identified are:

1. identify areas that characterize the focus company;
2. identify the SCM goals and assign a priority order;

3. identification and definition of the dashboard of indicators;
4. assessment of indicators.

The areas involved in the risk analysis are:

- supplying;
- warehouses;
- production process;
- transportation/distribution;
- order cycle.

For aviation companies one of the main goals is to supply service to the customer. It is clear that the customer changes according to the firm for which the analysis is done.

This clarification is essential to highlight that the analysis can not be carried out by reference to the general aviation sector, but it is necessary to identify the individual observer. Each company has a subjective perception of the supply chain and of the characteristics of the environment in which it operates.

The goal labeled *service supplied to the customer* has been further subdivided into four sub-goals:

- punctuality;
- completeness;
- correctness;
- the absence of damage and/or defects.

In order to make the classification of priorities among the goals it is possible to adopt the AHP method, first by building a hierarchy of "critical factors" that may hinder the achievement of the goal.

Figure 14.5 shows the risk factors characterizing these goals.

Through the analysis of weight and the importance of these critical factors, it is possible to judge the importance to be assigned to different goals. The process of defining goal priorities primarily provides a comparison of the same goals.

Table 14.5 was constructed on the basis of considerations about the full responsibility of the aircraft manufacturer and its suppliers for discrepancies and errors that could lead to the *grounding* condition of the aircraft, namely the interruption of the activities because of the defects.

In the aviation field, thanks to the particularity of materials produced, it is assumable that rarely the correctness and completeness goals are not satisfied. This assertion is especially true for companies acting as suppliers. With regard to the completeness goal, it's unusual that a non-completeness is caused by errors in the order cycle, whereas errors or delays attributable to one or more areas of the supply chain could determine the non-achievement of that goal.

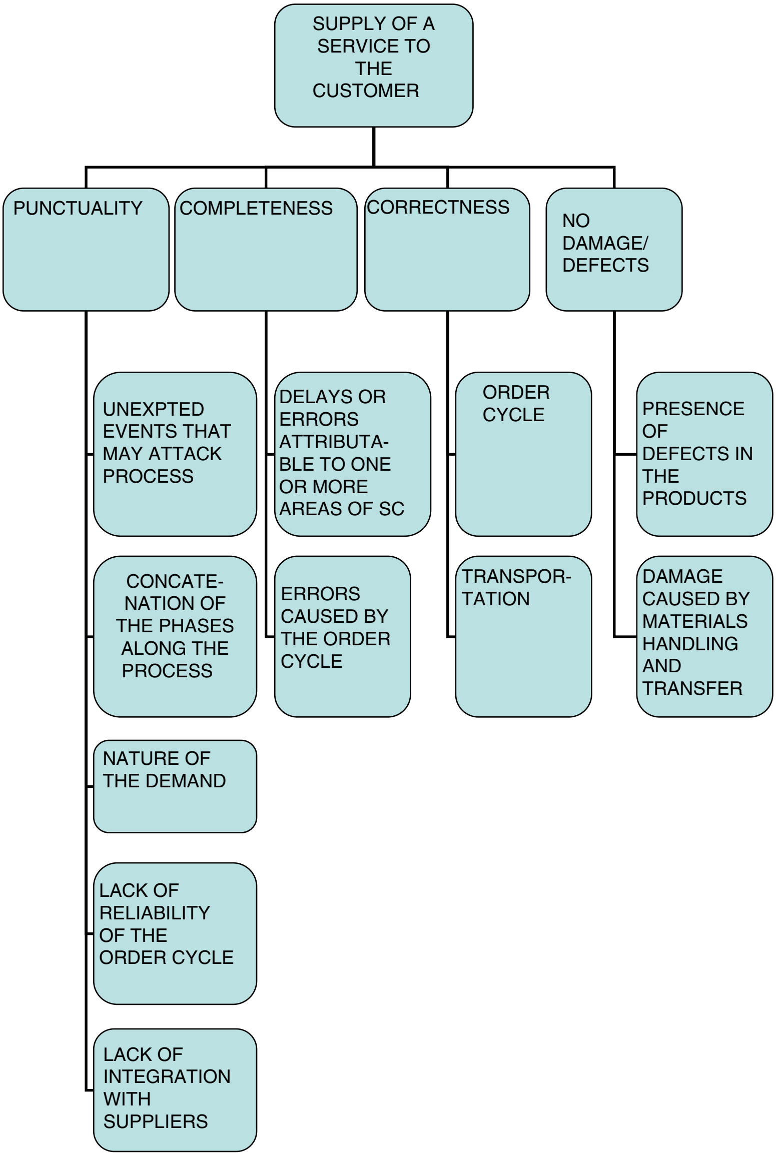


Fig. 14.5 Risk factors structure

Ultimately, through a simplified application of the AHP technique it has been possible to make an assessment of the priority goals considering as priority the following elements:

- punctuality;
- no damage/defects.

Table 14.5 Goals comparison

	PUNCTUA LITY	COMPLETE NESS	CORRECT NESS	NO DAMAGE/ DEFECTS
PUNCTUA LITY		–	–	=
COMPLETE NESS	+		=	+
CORRECT NESS	+	=		+
NO DAMAGE/ DEFECTS	=	–	–	

+→ The goal in column has a bigger weight compared with the correspondent in a row;

=→ The two goals have the same weight. For this reason the risk factors that affect the two aims could have the same seriousness ;

–→ The goal in column has a minor weight compared with the correspondent in a row.

Once having defined the goals it's possible to select the most significant indicators, achieving the final dashboard of indicators (see Table 14.6).

It is clear that in order to select the indicators to be measured, the choice of the focus company is crucial. Stages of processing in the aviation industry are particularly related to each other. This concatenation thus exposes companies to the risk of manifestation of "chain" effects. The indicator number 4 will be characterized by a value that is very close to the unit, which means that a delay or a processing problem will strike with an amplified effect on other phases.

The high number of quality checks done to ensure the absence of damage/defects, which, as repeatedly emphasized, is typical of the aviation sector, represents a risk of further slowdown.

It is also important to stress that it is necessary to choose a reference time horizon that depends on the period of time of the most important orders received by the company. Once it has been completed, the methodology must be applied again to verify the effectiveness of the corrective actions taken and/or identify new critical situations. The correct application of the proposed methodology does not end with the first quantification of the numerical indicators, but the value derives from the observations on their possible variations during the completion of the job order.

Table 14.6 Final dashboard

Area	Num	Risk indicator	Description
Transport/ distribution	1	$\frac{\text{Number of Delayed Deliveries}}{\text{TOT. Deliveries}}$	The delay is calculated considering the time agreed with the customer.
	2	$\frac{\text{Delays due to Unexpected Events}}{\text{Total Delays}}$	The non-predictability of delays is a lack of control and it increases the risk of delay.
Production process	3	$\frac{\text{Num. Non Scheduled Stopped Machines}}{\text{TOT. Number Stopped Machine}}$	The indicator represents the risk of incurring in unexpected and unscheduled down time. This index allows to indirectly assess the adequacy of the plan of maintenance scheduled
	4	$\frac{\text{N. Concatenated Processing Steps}}{\text{Tot. Number Processing Stages}}$	This indicator expresses the risk of "chain" effects. For this reason delays or processing problems can have repercussions on other stages
	5	$1 - \frac{\text{Monitored Processing Steps}}{\text{Tot. Number Processing Steps}}$	The monitoring of the stages supports the process control. This helps to avoid delays/problems of production and/or to react promptly to avoid prolonged interruption. The phases subjected to monitoring and control must coincide with those considered most critical and therefore more exposed to the risk of interruption
	6	$1 - \frac{\text{Quantity of Monitored components or materials}}{\text{Tot. Number of Components or materials}}$	Such monitoring could include both the individual stages of the production flow manufacturing and the flows related to specific materials or components, whose critical points can be studied.
Order cycle	7	$\frac{\text{Delayed orders}}{\text{Tot. Orders}}$	This indicator expresses the risk of not being punctual because of the order cycle.
	8	$\frac{PD_f}{QC_f}$	The integration helps to avoid any delay or to shorten the time of order processing: the further integration of information technology in the management of the order cycle is a speed indicator and its complementary represents an additional potential source of risk

Table 14.6 (continued)

Area	Num	Risk indicator	Description
Warehouse	9		The indicator measures the number of stopped machines that, during the production, are due to lack of materials in the warehouse and it allows to measure the disruption or inefficiencies that can have consequences on the manufacturing flux.
Supplying	10	$1 - \frac{\text{Punctual Orders}}{\text{Tot. Numberof dispatched orders bythesupplier}}$	This indicator represents the risk of not punctuality resulting from the supplying. It depends on the level of service offered by the supplier.
	11	$\frac{\text{Numberof Urgent Orders}}{\text{Tot. Numberof dispatched orders bythesupplier}}$	The higher the percentage of urgent orders sent to suppliers, the greater the relevance of non-scheduled performances.
	12	$\frac{\text{Numberof New Suppliers}}{\text{Tot. Numberof Suppliers}}$	In some types of supply chains a high rate of substitution of suppliers or use of new suppliers represents a lack of integration and collaboration: this situation is associated with a condition of exposure to the risk of not being timely.
	13	$1 - \frac{\text{Amount of Information exchanged electronically}}{\text{Tot. exchanged Information}}$	The amount of electronic information exchanged with suppliers is an expression of coordination between the actors. So its absence may be seen as a potential source of risk.
	14	$\frac{PD_{i,f}}{QC_{i,f}}$	This index expresses the number of defective parts found in the analysis on a material code provided by the supplier compared with the quantity tested.
	15	$\frac{PD_f}{QC_f}$	Number of defective parts supplied by the supplier compared with the quantity tested.

14.5 Conclusions

This article proposes a simple methodology for analyzing the risks present in a modern supply network. The basic idea is to give a panel of indicators to the managers of the companies involved. These panels have to be monitored during the evolution of a job order. Observing any variation from the values obtained at the beginning, it will be possible to deduce which area of the network requires a review and more control.

This methodology has been used in the aeronautical sector, but it could be applied in all sectors in which production is organized in articulated supply networks.

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Part VI
What is next by challenge: PMM Models' Evolution

Chapter 15
A Framework for Performance Measurement and Management Based on Axiomatic Design and Analytical Hierarchy Process

Paolo Taticchi, Luca Cagnazzo, Marco Santantonio, and Flavio Tonelli

Abstract Performance measurement and management (PMM) is a key practice to drive modern businesses. The literature available in this field highlights a certain maturity regarding performance measurement systems, while few frameworks have been proposed for PMM, which is today target. This paper presents a new framework for PMM, namely Business System Design Decomposition (BSDD), based on the strengths of the Axiomatic Design (AD) and the Analytic Hierarchy Process (AHP) techniques. The BSDD framework, offers a holistic approach to PMM, identifies cause-effects relationships in business processes, measures the performance versus stakeholders and offers interlinking between performance indicators. The result, is a deep understanding of the business environment and a real step forward PMM.

15.1 Introduction

In order to survive and succeed, companies need to set strategic directions, establish goals, execute decisions and monitor their state and behavior as they move towards their goals (Taticchi, 2008). As a consequence of that, firms need to use performance indicators (PIs) and performance measurement (PM) systems. But measurement and evaluation is just one of the components within the process of improving results through effective management. In fact, the complexity of today businesses requires the comprehension of cause-effect relationships so as to effectively support decision making processes (Taticchi and Balachandran, 2008). Only by considering these relationships, it is possible to move from PM to performance measurement and management (PMM).

Unfortunately, enterprise complexity makes it difficult because cause-effect relationships are not always known in terms of events or KPIs. As a consequence of that,

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there is need of performance measurement and management frameworks (PMFs) able to understand the processes of value creation, the drivers of activities, the relations between PIs in order to effectively support managerial decisions and fulfil the "*knowing-doing*" *gap* (Cohen, 1998).

The "*knowing-doing*" *gap* expresses the difficulty of companies in effectively translating information coming from the measurement of processes into effective tasks. This difficulty is not caused by the impossibility of models in finding a right set of KPIs for monitoring enterprises' processes. Instead, it depends on the scarce comprehension of cause-effect relationships the value of each indicator is based on. Success Maps (Neely et al., 2002) and Strategy Maps (Kaplan and Norton, 2004) approaches, and the logic the MSDD model (Cochran et al., 2001) is based on have contributed to define guidelines to effectively deal with "knowing-doing" gap-related troubles.

Purpose of this paper is to present a business PMF able to drive decision making processes, identify and understand relations between processes, quantify relations between performance indicators. Such a PMF, namely the Business System Design Decomposition (BSDD), relies on the strengths of the Axiomatic Design (AD) (Suh, 2000), MSDD model (Cochran et al., 2001), as well as the Analytical Hierarchy Process (AHP) technique (Saaty, 1980).

In the first section of the paper, AD, MSDD and AHP approached are introduced; section two presents the BSDD framework; section three draws the conclusions of this research.

15.2 AD, MSDD and AHP Techniques

15.2.1 Introduction to AD

Axiomatic design was developed in order to provide a scientific approach for the generation and selection of good design solutions (Beam, 1990). While there are many steps in the design process, axiomatic design theory focuses on the generation of requirements and the selection of means for achieving them (Tonelli et al., 2005). In fact, one of the most central ideas of axiomatic design is the importance of distinguishing between what is to be achieved and how it will be achieved. In axiomatic design terminology, the objectives of the design (known as functional requirements, or FR's) are expressed in the functional domain and the solutions (known as design parameters, or DP's) are expressed in the physical domain.

In axiomatic design, the functional and physical domains are connected by means of design matrices. That is, a vector of functional requirements can be related to its associated vector of DP's according to the equation:

$$\{\text{FR's}\} = [\text{A}]\{\text{DP's}\} \tag{15.1}$$

The elements of the design matrix indicate the effects of changes of the DP's on the FR's. In cases where the design parameters and functional requirements can be related mathematically, the matrix A can be constructed as a set of partial derivatives. However, in the case of the MSDD and BSDD presented here, most FR's and DP's are more conceptual in nature and mathematical relations between them are difficult if not impossible to define. In such cases, the design matrix concept can still be applied. The elements of the matrix cannot be quantified as partial derivatives; instead the entries in the matrix show simply whether or not some relationship exists between implementing the associated DP and achieving the associated FR. As an example, consider the design equation shown below.

$$\begin{Bmatrix} \mathrm{FR}_1 \\ \mathrm{FR}_2 \\ \mathrm{FR}_3 \end{Bmatrix} = \begin{bmatrix} X & 0 & 0 \\ X & X & 0 \\ X & 0 & X \end{bmatrix} \begin{Bmatrix} \mathrm{DP}_1 \\ \mathrm{DP}_2 \\ \mathrm{DP}_3 \end{Bmatrix} \tag{15.2}$$

The elements of the design matrix, expressed as X's and 0's, indicate the presence or absence of a relationship between the FR's and DP's. X's should always be present along the diagonal, meaning that each DP affects its associated FR (e.g., a11=X indicates that DP1 affects FR1). The X at a21 shows that DP1 also affects FR2. The following section will describe how the design matrix can be used to evaluate potential designs.

The information these matrices contain can also be represented graphically, as shown in Fig. 15.1.

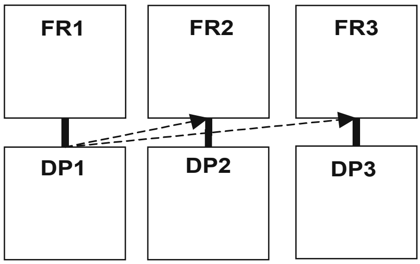

Fig. 15.1 Graphical representation of design matrix

An arrow from a DP to an FR indicates the presence of a non-zero off-diagonal element in the design matrix. For example, the figure below shows the graphical representation for the design matrix shown in equation.

When dealing with abstract FR's and DP's, is it not always clear what it means for a DP to "affect" an FR. In the case of the MSDD and BSDD, the following questions were used to determine the appropriate value for an element a_{ij} of a design matrix:

- Does this choice for DP_j affect system performance in terms of FR_i?
- Would failing to implement DP_j impede the system's ability to satisfy FR_i?

The two axioms of axiomatic design (*Indipendence Axiom* and *Information Axiom*) are used to select the best set of possible design parameters (Suh, 2000).

The first axiom states that when multiple FR's exist, the design solution must be such that each FR can be satisfied without affecting the other FR's. When this is achieved, the design matrix will be diagonal, as each DP will affect only its associated FR with no coupling occurring in the off-diagonal elements. Such a design is said to be uncoupled. In cases where independence is not achieved, two possibilities arise. In one case, the design will be partially coupled, meaning that the rows and columns of the design matrix can be rearranged such that the matrix is upper or lower triangular. When off-diagonal elements exist and the matrix cannot be rearranged to a triangular state, the design is said to be coupled.

The information axiom states simply that simpler designs are better. The two axioms can be used to select the best possible set of DP's when multiple options have been developed. Ideally, one would like to find a set of DP's that maintains functional independence (i.e., avoids coupling) while maintaining minimal complexity.

Once a set of DP's has been settled upon, the next step is to determine whether or not further decomposition is necessary. As discussed previously, this would normally be done by determining whether or not the current design contained sufficient information to be operational. If so, further decomposition is not needed. In the case of the MSDD and BSDD, decomposition proceeded for as long as it was possible to do so without beginning to limit the usefulness or range of applicability of the decomposition. When further decomposition is needed, the next step is to develop the next level of FR's.

To recap, axiomatic design provides a structured approach for the decomposition of high-level requirements and design concepts into a more detailed state, as in Fig. 15.2:

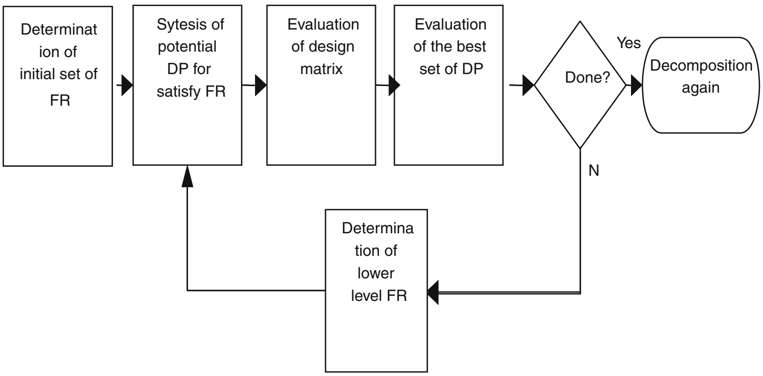

Fig. 15.2 The process of axiomatic design

15.2.2 Introduction to MSDD

The objective of the Manufacturing System Design Decomposition approach (Cochran et al., 2001) is to formalize a structure to relate low-level activities to high-level objectives, in order to understand the interrelations of the elements of a complex system, and to communicate this information to the personnel involved in the design of new manufacturing or production systems. MSDD was developed based on the "*Axiomatic Design*" (Suh, 2000).

The MSDD consists of six major branches. It starts from the functional requirement (FR) of "maximize long-term return on investment (ROI)," which is very general managerial objective of a company. The corresponding Design Parameter (DP) is manufacturing system design. The zigzagging principle of the Axiomatic Design ensures that the characteristics of the lower level FRs and DPs are confined to manufacturing issues (see Fig. 15.3).

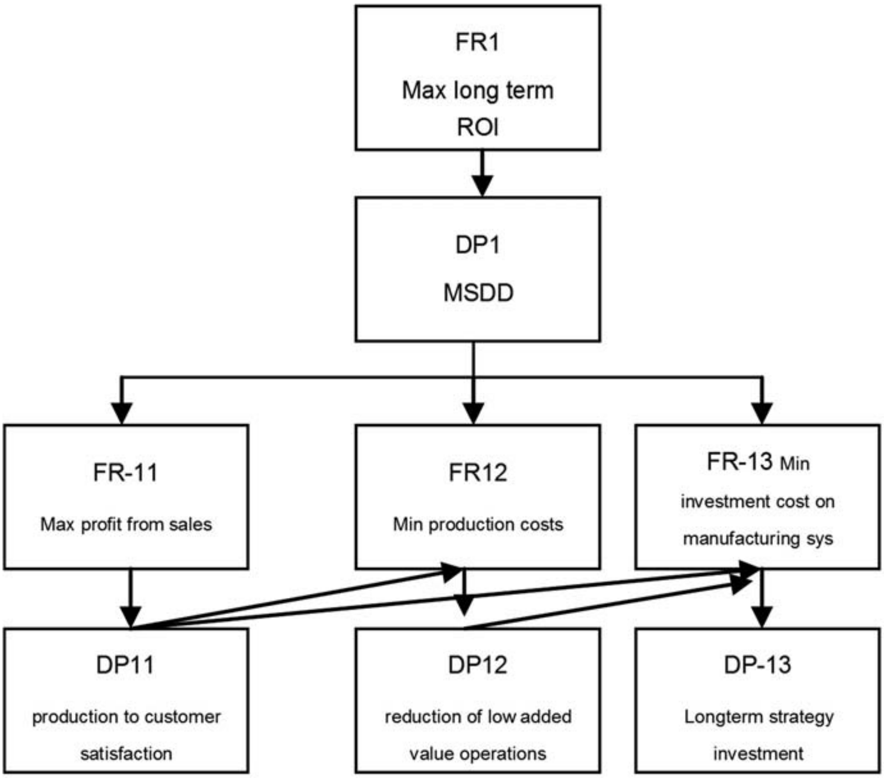

Fig. 15.3 MSDD framework, first two levels

The first level FR is further decomposed into three sub-FRs of:

- FR_{11}: maximize sales revenue;
- FR_{12}: minimize production costs;
- FR_{13}: minimize investment over the production system life cycle.

The aforementioned sub-FRs are derived from the ROI formula. These FRs are satisfied by the following DPs respectively:

- DP_{11}: production to maximize customer satisfaction;
- DP_{12}: elimination of non-value adding sources of cost;
- DP_{13}: investment based on a long-term system strategy;
- DP_s that synthesize the well known lean philosophy.

The design matrix that governs the relationship between the FR-DP pairs is an inferior triangular matrix between FR11-FR12-FR13 and DP11-DP12-DP13. The rationale behind the design matrix is that if the produced product failed to satisfy the customer, the product would not be sold very well and thus, cause unnecessary costs and investment. Therefore, DP11 affects FR12 and FR13 as well as FR11. In addition, the elimination of non-value adding sources of cost may require a certain amount of investment. Consequently DP12 affects FR13 along with FR12. It can be argued that DP12 may affect FR11. However, FR11 may be satisfied without eliminating non-value adding sources of cost and thus, DP12 would not affect FR11. With the term of non-value adding sources of cost, it is implicitly assumed that the eliminating cost drivers does not affect producing customer-satisfactory products. As is described above, production to maximize customer satisfaction (DP11) is chosen as a design parameter to achieve the FR11, maximize sales revenue. The decomposition procedure continues in different branches with a hierarchical scheme as shown in Fig. 15.4. The most important aspect is the tendency to multi-level integration, in the system studied, of needs and objectives (Tonelli et al., 2005).

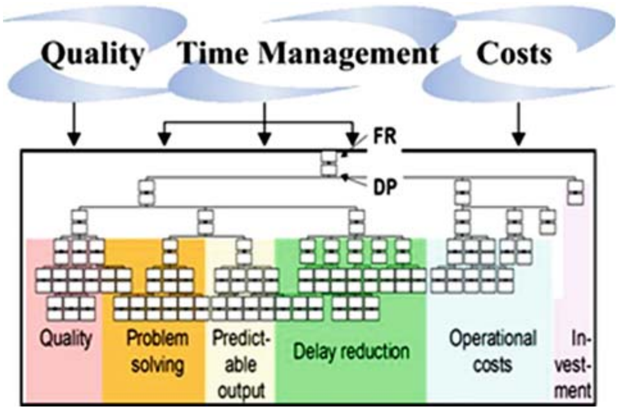

Fig. 15.4 MSDD framework

15.2.3 Introduction to AHP

The Analytic Hierarchy Process (AHP) is a structured technique for the treatment of complex decisions. On the basis of mathematics and psychology, was developed by Saaty (1980) in the late 70's and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring the decision problem for the representation and quantification of its components, to report the general objectives, and evaluate alternative solutions. It is used worldwide in a wide range of decision situations, in areas such as government, business, industry, health and education. Several software companies have used to help the process.

As a first step, the users of AHP decompose the decision problem into a hierarchy of more easily understandable sub-problems, each of which can be analyzed independently. The elements of the hierarchy may include any aspect of the decision, the problems tangible or intangible, accurately measured or estimated. Once the hierarchy is built, the leaders systematically evaluate its elements by comparing one with another two at a time. In making comparisons, the leaders can use data about the elements, or may use their decisions on its meaning and importance. AHP assessments converts numeric values that can be processed and compared within the entire range of problems. A numerical weight or priority is derived for each element of the hierarchy, allowing different and often incommensurable elements to be compared with each other in a rational and coherent manner. This ability distinguishes the AHP from other decision-making techniques. In the final stage of the process, the numerical priorities are calculated for each of the alternative decisions. These numbers represent the relative ability of alternatives to achieve the objective decision, in order to allow a simple examination of the various courses of action.

In order to build PMFs, relations between PIs need to be identified and quantified. Such a task is very complex, since often relation between PIs are not clear, and just qualitative hypotheses can be formulated. Sale and Sale, (2005) have demonstrated that AHP can be used by managers to quantify qualitative relations between PIs, without concern that the results will be judged to be unsubstantiated and overly subjective.

15.3 Business System Design Decomposition

The Business System Design Decomposition (BSDD) is a framework for performance measurement and management, which has been developed for overcoming the shortcomings of previous models and fulfilling the "*knowing-doing" gap*. The BSDD framework relies on the AD, MSDD and AHP techniques introduced in the previous paragraphs.

Particularly, the BSDD can be considered an evolution of the MSDD, which limits is focus on manufacturing and bases its structure on the ROI three (therefore a financial goal). The BSDD framework overcomes such shortcomings by bringing a holistic approach to the overall business, based on the design and decomposition of three perspectives:

- strategy;
- stakeholders;
- operations.

The BSDD framework starts from the functional requirement (FR) of “business excellence”, which is the general goal of the company. The corresponding design parameter (DP) is the “performance measurement and management system”, which is the system enabling the optimization of all processes in alignment with strategy and goals.

The decompositions process follows, and three additional functional requirements (FR) are identified (strategy, stakeholders and operations), and coherently the design parameters (DP). The BSDD framework assumes therefore the structure presented in Fig. 15.5:

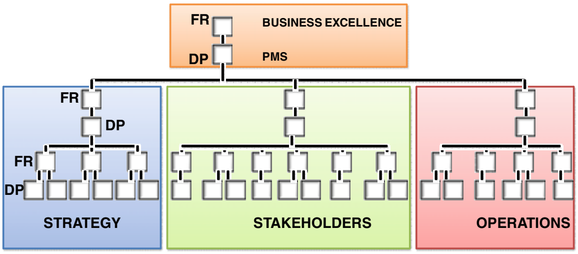

Fig. 15.5 Structure of the BSDD framework

The decomposition of strategy is based through the methodology proposed by Lunghi and Taticchi (2007), which affirms that two parameters are needed in order to completely identify a strategy, respectively a “*positioning choice*” and a “*strategic leverage*”. Positioning choices concern the market and the product; while the four strategic leverages are identified in: cost, quality, innovation and marketing.

The mix of Positioning choices and Strategic Leverages utilized by a company allows identifying 16 different typology of strategies that are therefore properly decomposed in terms of FRs and DPs, as depicted in Fig. 15.6. While strategy represents the FR of the highest level of decomposition, alignment to strategy is the related DP.

The decomposition of the stakeholders’ perspective is based on the suggestions of Taticchi (2008), which highlights the importance of monitoring performance versus six categories of stakeholders, that are: suppliers, customers, investors, legislators, partners and employees. In correspondence to these stakeholders that represents the FRs of the system, thirty-three DPs are identified. While stakeholders represent the FR of the highest level of decomposition, stakeholders’ satisfaction is the related DP.

Finally, the decomposition of the operations perspectives is carried out based on the value chain scheme of Porter (1985), which identifies the following primary and secondary processes: logistics, operations, marketing & sales, service, procurement, technology development, human resource management, firm infrastructure

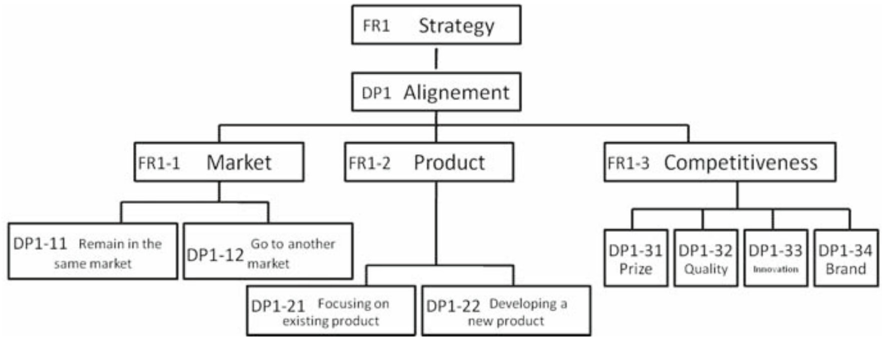

Fig. 15.6 Decomposition of the BSDD strategy perspective

and value creation (financial goals); which represent the FRs of the system. In correspondence of these FRs, thirty-six DPs are identified. While operations represent the FR of the highest level of decomposition, operations excellence is the related DP.

Based on the decompositions described above, the overall BSDD framework is presented in Fig. 15.7. However, companies adopting the BSDD framework, will not have all the branches of the three, but just a number of selected ones. The selection, is carried out through the use of a questionnaire that has been specifically developed,

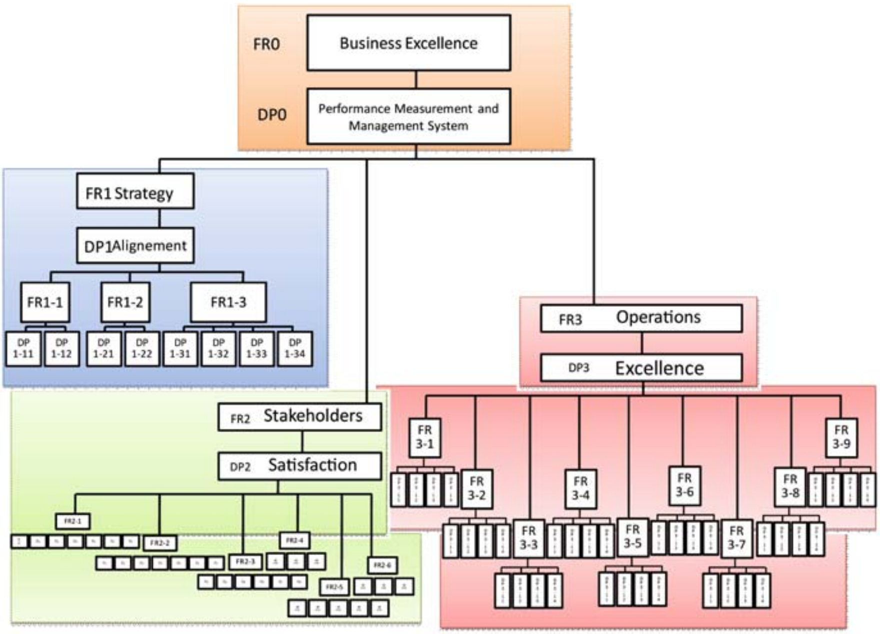

Fig. 15.7 The BSDD framework

and permits to assess the right FRs and DPs (the proper branches of the BSDD three), so as to tailor the BSDD framework on the company strategy, stakeholders and operations peculiarities.

15.3.1 AHP Application to BSDD for Quantitative Identification of PIs Relations and Effects

The BSDD framework offers the opportunity of building a performance measurement and management system (PMS), based on a real understanding of company strategy, stakeholders and processes.

In order to enhance the effectiveness of such framework, a methodology for quantifying the relations and effects between PIs of the system is needed. As highlighted in Sect. 15.2.3, the AHP methodology has proofed positively in overcoming this issue. Moreover, the BSDD framework has been designed for being integrated with AHP.

In fact, the first requirement of the AHP methodology is to structure the problem as a hierarchical problem. The BSDD framework is already a hierarchical structure, and therefore hierarchies between PIs (DPs) are known a priori. Then, a company team of managers (evaluation team) should carry out pair-wise comparisons so as to evaluate the relations and effect between PIs. If the relations being compared are objective, the numeric values are compared. Otherwise, if the relations are wholly or partially subjective, the comparison are made based on the basis of relative preference between the two on a scale of one to ten where one indicates no relation, and ten total influence of the PI to the upper PI. Then, a mathematical process follows, so as to validate the results and identify the PI relations, therefore the "weights" of the system". For a more complete discussion of the mathematical process and theory, see Saaty (1980).

The application of the AHP to the BSDD framework, in example for the strategy branch, results in something similar to what depicted in Fig. 15.8:

The numbers reported in Fig. 15.8 constitute the weights of the PIs in the PMS. This information is definitely valuable, since determinant for decision-making processes and for highlighting areas of improvement.

15.4 Conclusions

Performance measurement is an increasing area of research, since its importance for the corporate and industrial ambits. Research today focuses on the shift from performance measurement to performance measurement and management, so as to fulfill the *"kowing-doing" gap*, which expresses the difficulty of companies in effectively translating information coming from the measurement of processes into effective tasks.

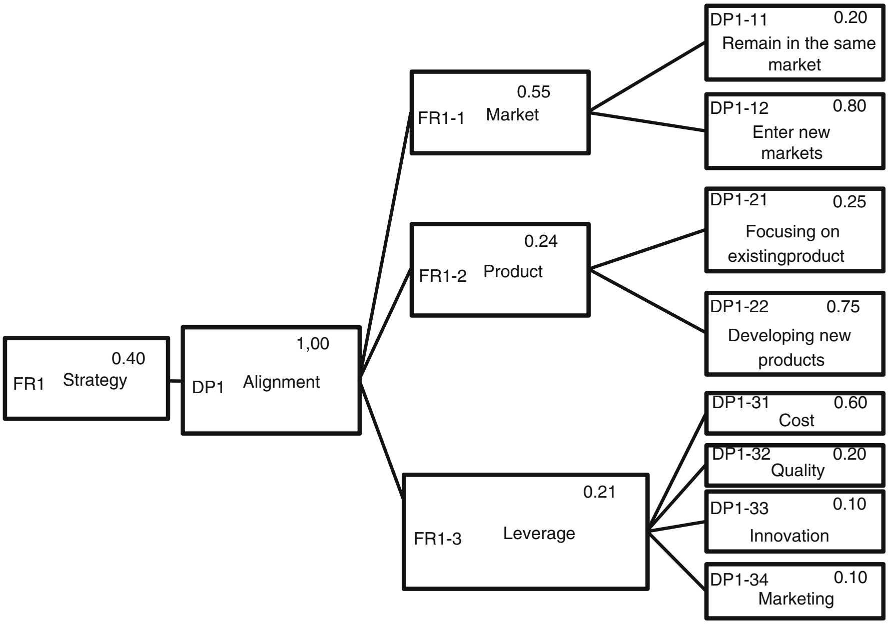

Fig. 15.8 Example of AHP application to BSDD – strategy branch

In this paper a framework for performance measurement and management was presented, based on *axiomatic design*, *manufacturing system design decomposition* and *analytic hierarchy process techniques*.

The framework relies on the strengths of previous framework developed in literature, offers an holistic approach to PMM, identifies cause-effects relationships in business processes, measures the performance versus stakeholders and offers interlinking between performance indicators.

As a consequence of that, the framework presented is a real step forward performance measurement and management, and the fulfillment of the *"knowing-doing" gap*.

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Chapter 16
Designing and Implementing Performance Management Systems

Veronika Packová and Peter Karácsóny

Abstract Design and implementation of performance measurement and management system are especially risky and complex processes that have to be well managed in order to ensure the proper integration into the company's structures and processes.

The first step – and in many aspects the most important one – is analysis, which sets the fundaments for the next phase. During design the expectations of management and real-life limitations face each other until a solution in a form of concept or model arises. Before the actual implementation, the design is usually tested in a proof of concept, which has a limited scope. Implementation follows with enlarging the initial concept into a full scale system that finally helps the management to run an organization.

16.1 Introduction

Performance measurements and management systems can't be designated as new or revolutionary business or strategic approaches in management of organizations anymore. Nevertheless, with its increasing popularity and utilization, the numerous terminology used can occur as confusing. So before moving on to the complexity of the design and implementation processes of performance management systems, this article will clarify some basic characteristics of the terms linked to performance measurement and management.

Indeed, design and implementation of performance management systems is a crucial business decision towards gaining competitive advantages and overall company's success. Magnified by the current ominous global economic and financial situation, increased competition and toughened business environment conditions,

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the matter of performance management is becoming a point of interest of companies from all sectors. Though, to launch and sustain a successful performance measurement and management system is challenging, especially it is complicated to move from a measurement system to a performance management system.

The purpose of this article is to describe a performance management concept for a successful design and implementation of performance management system, based on recent literature and exercise. The article has two sections; the first introduces some basic performance measurement and management terminology. The second section focuses on the design and implementation of performance measurement systems, covering the overall process of performance management.

16.2 Introduction to Performance Management

The most recent trend in performance management is incorporation of a result-focus (Pulakos, 2008). Organizations increasingly focus on achieving results, not just driving effective behaviors. Employees should strive to achieve results that contribute to the achievement of organizational goals. Thus it is necessary to assess both the results employees achieve as well as how they went about achieving these, so their job behavior (Pulakos, 2009).

So performance management is how organizations communicate expectations and drive behavior to achieve organization's goals; it's also how organizations identify ineffective performers for development programs or other personnel actions (Pulakos, 2009). Performance management is a system, thus consisting of specific steps and principles, which interact and work together in an interdependent way to achieve specified objectives. Nevertheless, there is no exact or right way nor recipe on how to set performance management systems, since each organization has different needs, habits, structures and models and the system must respect all those, thus its design and implementation varies from company to company. Some basic steps and principles of performance management systems will be discussed in the next section of this article.

Performance measurement consists of targets and indicators linked through reports in the organization. "It is the process of quantifying action, where measurement is the process of quantification and action leads to performance" (Neely et al., 2005).

Another expression is Performance appraisal, or evaluation. Performance appraisal isn't performance management, but it is one part of a performance management system. Performance appraisal is the process by which an individual's work performance is assessed and evaluated (Bacal, 1998).

A refreshing term is Business performance management (BPM), initially known as Corporate performance management (CPM). However, the abbreviation CPM in the business vocabulary can be easily exchanged with the algorithm analysis used in project management Critical path method, from the early 50s. Thus Business performance management is gaining a meaningful position in the customization of performance model presence in organizations. Business performance management has a broader meaning, since to measure the performance of your business, you must measure the performance of individuals, who perform their tasks and try to achieve goals. So the company must measure results and behaviors and these at all organizational levels and correlated with different organizational systems. This approach will be discussed further in the next section.

Business performance management "adds value to the business by focusing on how an organization develops, implements and monitors strategic plans. This strategic focus is kept throughout all management processes, right down to the contribution individual budget holders make. It is about the execution of the strategic plan" (Coveney, 2003). A BPM application enables executives to communicate and drive strategy down throughout the entire organization in a way that helps people act and make decisions that support the strategic goals. Finally, it helps members of the organization focus on key issues and critical data, rather than on all the data and events that are possible. It delivers the right information to the right people at the right time in the right context (Coveney, 2003).

Generally, when speaking about performance measurement, managers think or from the financial point of view, or from the human resources perspective. Naturally, it is essential to guide people in the organization to achieve results which contribute to the achievement of overall organizational goals. Financial metrics are the most accurate measurable indicators. But when speaking about performance management, it requires much more then coaching staff and developing measures. Performance measurement affects the planning system, processes and strategic objectives. The business performance management system must respect, support and incorporate goals and decisions at all organizational levels. It is linked to all business areas and is considered as a strategic tool. There follows the next term – Strategic performance management.

Performance indicators must be intentionally linked to organization's vision and strategy. The system must effectively tie up the vision and strategy with indicators, which determine it's achievement a thus require its managing. Critical success indicators are being measured by key performance indicators (KPIs), which are influenced by the organization's external and internal environment forces and must be in accord with the overall strategic direction of the organization. All changes in KPIs, threatening the achievement of the strategy, must be communicated in the system and lead to measures within the change management (Papula, 2008). Figure 16.1 illustrates the flow and linkage between the organization's strategy and performance indicators and the process of the KPIs identification.

16.3 Design and Implementation of Performance Management Process

Being able to constitute a successful performance management system, it is essential to understand and specify first what type of performance should be measured (skills/competencies, behaviors or results) and second how to make a reliable and

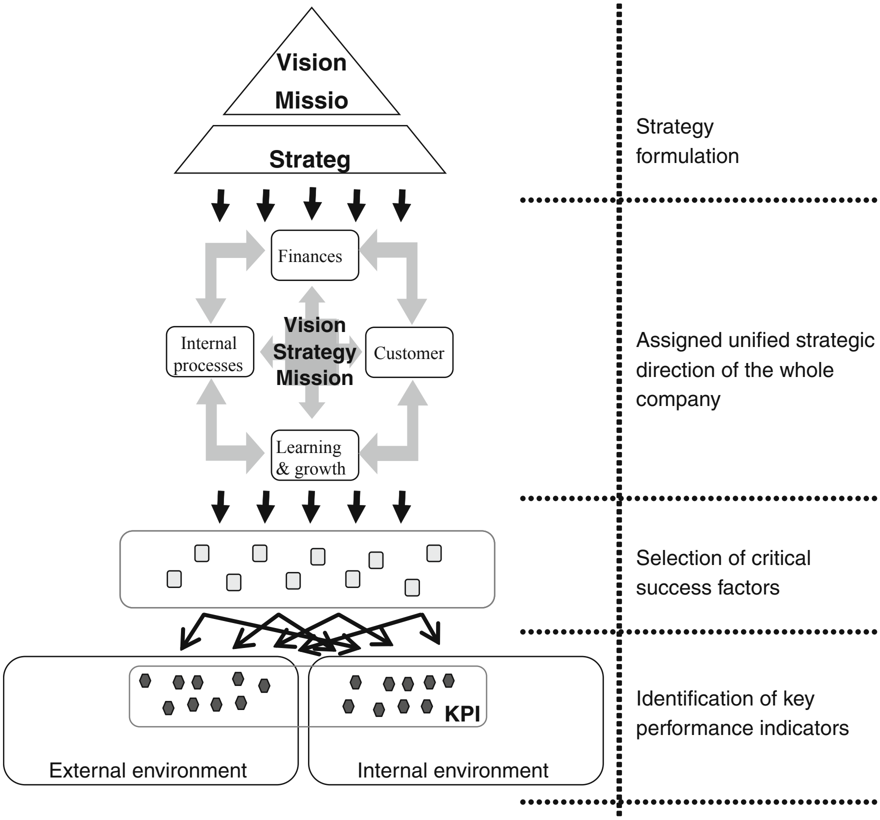

Fig. 16.1 Identification of key performance indicators (Papula, 2008)

precise performance measurement. The design and implementation of performance management systems are particularly risky and complex processes that have to be well managed in order to ensure the proper integration into the company's structures and processes. There are plenty instructions on how to design and implement a performance management system. It could be generalized, that there are three basic steps, which can be summarized as analysis, design and implementation.

16.3.1 Analysis

Analysis is a very significant step in the process of developing performance management systems and it sets the fundamentals for the next phase. In order to design a successful model for performance management, it is necessary to analyze and interpret several aspects that have influence on the organization. To start with, company's environments like the external and internal environment, the industry and the interactive environment should be analyzed to understand all factors and forces that can have an influence on the organization.

Emphasis should be stressed on company's structures, processes and activities. Organizational structures must support the implementation of a performance measurement system or otherwise companies would fail to implement BPM systems.

Processes should be analyzed by defining activities and related drivers so as to provide a comprehensive understanding of the company business. Companies must identify the company value chain, and all the detailed company processes, activities and related drivers. The identification of company's processes is so important because performance systems measure processes and other parameters (key performance indicators, KPIs) (Taticchi and Balachandran, 2008).

The company culture must be open towards innovative systems. Managers must be able, be prepared and ready to direct performance management and employees must be willing to accept the company's system and understand that it helps them to perform better. Sometimes employees fight against a new system, because they often don't understand the point of performance management or don't see it as something meaningful to them. Often this can be based on bad experience with performance management in the past. Further, if the system is not executed well, employees consider performance measurement simply as receiving critics – and no one likes to be criticized. But also managers often feel aversion against performance management, because they may consider some procedures laid down by the company as a non sense, find the very excuse of not having enough time, or they are not capable of doing observations and coaching, or even fear confrontation with their subordinates.

Another crucial issue is analysis of goals throughout the company. Goals should be established in a hierarchical – cascading way, meaning that goals at each organizational level should support goals directly relevant to the next level. This way all accomplished work fits together and supports the overall strategic direction of the company (Pulakos, 2009).

Attention must be paid also to the decision, whether the company wants to direct the performance outcomes to decisions (as about the payment) or the development of employees. Both decisions cover some pitfalls and must be considered very carefully.

16.3.2 Design

After the identification of all relevant and indispensable factors, the design of a performance management system can be developed. Some common steps of the design phase are planning, motivation and goal setting, preparing staff, setting rating standards and review.

Performance planning is a process of defining what needs to be done, how is it going to be measured and how barriers can be overcome. A very positive and motivating effect can be achieved by involving employees into the planning phase.

Emphasis should be put on motivation and goal setting. Ambitious yet realistic goals should be set and a plan of motivation and inspiration should be planned.

Inspiration by a leader often plays a major role spurring people on to maximum performance (Woolfe, 2002).

Staff should be prepared in order to the introduction of a new system, so that reluctance of employees can be minimized. The new strategy must be communicated in an easy understandable way, so everyone knows their contribution of the new system and their position in it.

During design rating standards are set according to what needs to be measured. Measures must be based on job-relevant factors and be measurable. Goals set standards, which employees are expected to achieve. So those objectives must be specified in detail, so they are clear to everybody and so results can be measured according to them. It is important that objectives for individuals at certain levels are set at a similar difficulty and complexity, to assure that they respond to the assigned standards. “Performance standards help employees understand what is expected from them and provide common standards for managers to use in evaluating employees, thereby increasing consistency, transparency, and fairness” (Pulakos 2009).

Before the implementation, components of the system and design usually undergo a pilot test, to ensure that they meet organizational needs and to revise the system if necessary.

According to Pulakos (2009) the performance management process consists of the following steps:

Step 1. Leaders set organization, division, and department goals
Step 2. Managers and employees set objectives and discuss behavioral expectations
Step 3. Managers and employees hold ongoing performance discussions
Step 4. Employees provide input on own perceptions or performance
Step 5. Knowledgeable rating sources provide input on employee performance
Step 6. Managers rate performance
Step 7. Managers and employees hold formal review sessions
Step 8. HR decisions are made – pay, promotions, training, etc.

This model shows some similar evidence of what has been described above, yet includes features from the design and also implementation phase as well. Top managers must set interrelated goals; managers set objectives and communicate them with employees that are involved in the process of goal setting and further evaluation. Important is communication and ongoing feedback that have a significant role. Rates are set and measured and performance and results are being reviewed to improve performance and the system. Last but not least results should be linked to decisions.

An important fact is that a good PM system should not only be limited to a list of KPIs, but should identify relations between them and their level of impact over the business (Taticchi and Balachandran, 2008).

Taticchi and Balachandran (2008) propose a new framework for a performance management system. They developed a system that integrates the PM system with other systems in the firm and creates an interrelationship among them. They propose an interaction of the performance system, cost system, capability evaluation system, benchmarking system and planning system, all based on the analysis of the value chain (processes) and company's goals and strategies. In their opinion, this very integration process represents a step in moving from performance measurement to performance management.

16.3.3 Implementation

To have an effective performance management design it is necessary, but not sufficient to guarantee a successful performance management. The execution is therefore essential, depending on managers and employees. After designing the process of performance measurement, it is necessary to assign several steps for implementation. According to Pulakos (2009) these steps include:

- automating the tools and processes to the extent possible,
- pilot testing,
- training employees and managers on using the system,
- evaluating and improving the system based on the evaluation results.

Automation is possible since mature information technology companies offer solutions – platforms and user interfaces that integrate also performance management functions. Automated systems "decrease workload, ensure widespread access, and provide a standardized format for collecting, storing, and reporting performance data" (Pulakos, 2009).

A pilot test of the new system should be done before implementing the system on a wide scale. Pilot testing consumes plenty of time and resources, which companies generally don't have for wasting. But the top management must understand that damage or losses from a wrong design or failure of implementation can be immense and are irrevocable. Pilot testing diagnoses the system and reveals the need for change, adjustments and further need. "Pilot testing should include all aspects of the system – the automated system, performance management content, written materials, training programs, and the assignment and analysis of ratings" (Pulakos, 2009).

Staff must be capable of conducting performance management effectively. Moreover, emphasizing on training shows the importance of the new system and employees and managers are more willing to show acceptance and interest when they see leadership's commitment to performance management coming from the top management.

Evaluation and improvement of the performance management system should be a continuous process. Evaluation should consider for example the interrelation of performance results and decisions or satisfaction of staff with the system.

One of the pillars of a successful performance management system is ongoing communication. Communication is important at all stages of the performance management process. "Ongoing performance communication is the process by which manager and employee work together to share information about work progress, potential barriers and problems, possible solutions to problems, and how the manager can help the employee. It's a dialogue that links planning and appraisal. Its importance lies in its power to identify and address difficulties before they grow" (Bacal, 1998).

The communication process should be set up in a way that it doesn't put on more work load then necessary. Companies and managers can choose between different types of communication forms, like one-to-one meetings, team meetings or written reporting, supported by informal communication processes. The amount of information gained should be managed properly, because it is challenging to gather the right information in the extent needed and not get overloaded with information that neither helps the manager nor the employee to accomplish any tasks. The communication must be documented, as well as gathering data and doing other observations are needed to make decisions.

In compliance with the performance management proposed by Pulakos (2009), managers must be able to rate performance. They must consider "both job behavior and results using defined performance standards as a basis for making ratings" (Pulakos, 2009). To make performance ratings, managers review the employee results, the information obtained from knowledgeable rating sources, employee's perceptions, and the performance standards for the employee's job and level (Pulakos, 2009). When using rating systems to rate performance, managers should be careful to write some additional comment or report, to prevent vague evaluations based on general impressions.

The next step of the implementation phase is holding formal review sessions. Feedback should be done regularly. Review sessions should be just a recapitulation of what has happened during the rating period and it should be forward-looking and developmentally focused (Pulakos, 2009).

Companies can link performance to some administrative actions – decisions mostly about pay, but also promotions, development and training needs, pay reductions and terminations. To relate performance to pay can be very motivating, but it is also very difficult to set up a well working pay-for-performance system. Further, the dependence on performance can firstly stimulate on the side of employees to better performances and secondly to a thorough execution of performance management processes of managers. On the other hand, when it comes to pay, there is always a risk of a negative effect based on proving a feeling of pressure and dissatisfaction, having a reverse effect of demotivation and lower performance. The process of transforming performance into pay must be transparent and standardized, to halt any doubt and uncertainty.

Coming back to the model of Taticchi and Balachandran, (2008), where performance management must be integrated with other systems in the organization, it must be remarked, that all factors of the design and implementation phase must be adapted to this interdependence. The value chain identifying activities, drivers and processes is evaluated by the performance system. The performance system together with cost system and evaluated capabilities must correspond with company's goals and strategy. The level of the benchmarking system brings in external factors that must be considered and comprised in the overall business strategic planning. Causal relations between those systems should be identified, driven and controlled. The approach of designing and implementing a performance management system is thus moving from specific interpersonal needs to a very strategic level of managing performance management systems within the company. The correlation between mentioned systems or others should be proven and their impact should be measured further.

16.4 Conclusion

Designing and implementing performance measurement and management systems hides many challenges that must be faced by organizations if they want to be successful and gain competitive advantages. There is no common recipe on how to design and implement a performance management system. This article lists and discusses some basic steps and principles that a performance management system must regard.

As Taticchi and Balachandran, 2008) state, it is necessary if not essential to integrate the performance system with other systems in the organization in order to be successful in having a performance measurement and management system. This fact must be comprised in the design and implementation process of performance management.

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Chapter 17
The Three-Stage Evolution of Full Cost Accounting in Business Economics

Fabio Santini

Abstract This paper analyzes the evolution of the concept and usage of full cost configurations in European and north-American enterprises by examining three different periods: the old period, characterized by a "traditional approach" beginning at the end of the nighteenth century and finishing in the 1970s; the transactional period that began in the 1970s and continued until the end of 1980, and the modern period that is still in progress. The research, developed with a quality Contingency theory approach, proposes a model for understanding the change in cost accounting and analysis, in particular regarding the role of overheads.

17.1 First Stage: The Traditional Approach

Only from the end of the eighteenth century a particular interest in the accepted accounting practices of allocation of manufacturing overheads to products developed in business literature. Before that period, in fact, a measured variety of production together with typically artisanal technical processes entailing a substantial identity between variable and full product cost, in many cases, made said practice superfluous (Garner, 1988).

The Industrial Revolution hastened a drastic rethinking of instrumental accounting practices in the computation of manufacturing costs. Beginning in that period, the progressive mechanization of industrial activities and the consequent conversion of the artisanal and industrial processes imposed substantial investments in durable factors of production that had the two-fold effect of transforming a large part of variable costs into fixed costs (the substitution of manual labour for machines), and direct costs with respect to the products in indirect costs (substitution of the cost of direct work with the indirect costs of supervision). The change in total cost mix ratio in favour of an increased incidence of indirect costs rendered recourse to the

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computation of the full product cost (in form of manufacturing cost of the product) in function of diverse cognitive objectives unavoidable (From the end of the nighteenth century on, we witnessed the proliferation of texts dedicated to the treatment of overhead costs: Metcalfe, 1885; Garcke and Fells, 1893; Church, 1901).

The extreme expression of the modifications that were introduced in the productive context by the mechanization process was represented by the system of mass production that characterized the western economy between the end of the nighteenthth century and the mid-twentieth century (Littleton, 1933).

Mass production became concrete reality in a virtuous circle to the extent that the growth in work productivity and the technical efficiency of plants determined the progressive contraction of average unit cost making the reduction of sales prices possible; that reduction in turn, created the premises for an ulterior increment in demand (Sibilio Parri, 2000). Even though that mechanism found fertile ground in contexts characteristic of a particular breadth of outlet markets (USA), in generalizing it is possible to identify some common traits of European an north-American businesses operating in that period in which a market demand oriented towards mass products was hardly differentiated and a demand that was generally superior to supply, had the consequence having little difficulty in the selling of goods on the market.

The characteristics of the external environment can be considered as determinants of the internal conditions of the corporate environment, so much so that in whole or in part, the same characteristics can still be compared today to industrial realities operating in mature, ample and protected markets:

i. orientation towards maximization of the revenue period as the only go-between of techno-productive efficiency (deriving from the lack of difficulty in the selling of the goods);
ii. stable availability of technology for extended periods of time and limited range of products with long life cycles (deriving from the stability of market conditions);
iii. raw materials and direct labour as predominant factors of production (deriving from the technical characteristics of the conversion processes carried out).

The socio-economic context that framed the mass production system represented the starting point from which accounting techniques of cost accounting and analysis (generally defined as traditional) were developed and perfected. Such techniques constituted a point of reference for enterprises until the end of the twentieth century and continued to represent a guide for entrepreneurial action even in environmental conditions that were no longer ideal for their application (Johnson, Kaplan, 1987). By analyzing their principal characteristics it is possible to verify the degree of influence expressed by the environment in which they were developed:

(a) short term orientation (given the stability and breadth of market demand). The short term period is considered to be a temporal fragment in which it is possible to replicate achievable conditions in the long term;

(b) product as preferential cost object (given the direct relationship between efficiency technique of processes and economic results). All the analyses were conducted according to a normative approach and were oriented towards anticipating a more realistic measure of product cost;
(c) consideration of the production volume as the fundamental manufacturing overheads generator (given the content complexity of the internal processes);
(d) focalization on the internal environment (given the power of supply over demand and the stability of markets that limit the enterprise's attention to the sole phase of consumption of company resources implemented in the transformation of raw materials into finished products);

As a consequence of the shift to the short term, the full product cost is generally calculated in a multiple-step process that establishes the domination of the temporal dimension over the spatial dimension; only when the costs of steady consumption are quantified in a given time frame (short term), can one proceed with identifying the referable fee of realized production (object) thereby distinguishing the product costs from the period expenses (relative to resources related to the manufacturing process). In such process, waste is generally considered as an integral part of the cost of the product (McNair, 2004).

In that period the tendency to hold that different cost configurations in function of the possible cognitive scopes pursued was consolidated into doctrine (Clark, 1923). In function of purpose, the stages of the cost computation mutate based on:

(i) typologies and the entity of elementary and acquisition costs that can be detected on the basis of accounting entries or including implicit expenses. To that end one can not omit that the traditional literature, in the proposition of costing models foresaw the use of implicit expenses but never stopped to linger over the effective quantification, on the role and breadth of those elements;
(ii) the modes of evaluation of steady consumption, that can be differentiated in function of the considered time frame (one year or fraction thereof) or to consider the replacement value of productive factors instead of book values;
(iii) typologies and breadth of the cost objects (traditionally departments, production centres, products).

In the stages of determining the full product cost, the theoretical research was chiefly directed to the 3rd and 4th phase of the allocation process (Fig. 17.1). The themes that were principally debated pertain to the logic and practices of allocation of related costs to the products, and there was all but unanimous agreement regarding the use of linear functional criteria based on cause and effect ratios. Based on the characteristics of the in-house environment, cost drivers, based on productive volume (for example, the quantity or the cost of raw materials, the number of hours of direct labour or of machine hours), appeared satisfactory for that scope.

Distinction between techniques of allocation and of indirect costs on the basis of a single-rate allocation method, or on the basis of a multiple-rate method per cost

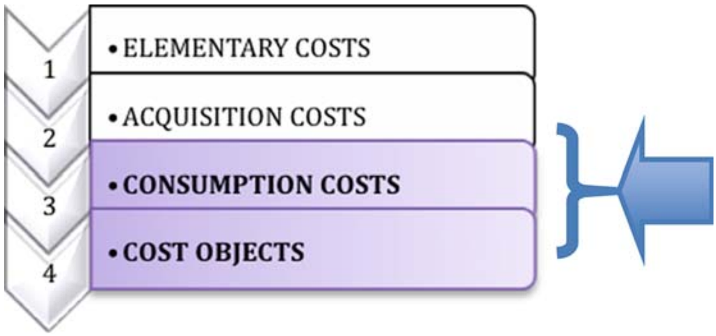

Fig. 17.1 Allocation process: stages object of the research

centres, was consolidated as a method. Already at the beginning of the last century, this method was confronted with an extremely modern approach (although not developed in practice), the question of whether or not to attribute the cost of idle production capacity to products (Whitmore, 1906). In short, this is the demonstration of the fact that "by 1925 virtually all management accounting practices used today had been developed" (Johnson and Kaplan, 1987), on the theme of costs, themes of material and work, accounting of costs, the treatment of indirect costs, the distinction between process costing and job-order costing, scheduled costs and of variance analyses had already been widely advanced.

In virtue of the elevated reliability that characterizes it, full product cost found a use for multiple cognitive scopes such as:

(a) product pricing;
(b) analysis of product profitability;
(c) evaluation of efficiency in resource consumption;
(d) assessment of inventories.

Precisely on that last aspect (c), did Johnson and Kaplan focus their criticisms regarding the leveling of cost analysis systems towards uses related to the financial reporting duties that had an ulterior effect of pushing the orientation of management towards a short term time frame (transition from cost management to cost accounting).

17.2 Second Stage: The Relevance Lost of Full Cost Employment in Business Economics

Business literature identified the manifestation of the main crisis of systems of mass production in the 1960s and 1970s. Although we can not generalize about diverse sectors of economic activities, it is possible to concur with the opinion that, in the years following the 2nd World War, the growing competitive market pressure and the difficulty in responding to ever more diversified needs of consumers (now equipped with increasing buying power), strained the fundamental premises of the reigning productive paradigm. In particular:

(i) the competitive pressure of supply and the related difficulties in the sales of products on the market hampered the maximization of the income period that could be attained only as a go-between of techno-productive efficiency. The sale price, in fact, stopped being a critical factor of success in the environment of the virtuous circle, “reduction in trading value, increase in market demand, contraction of the average unit cost, new reduction in trading value”, and that was particularly evident if one considered the risk that no turnover of the products could render the reaching of productive volumes corresponding to the optimal technique, completely uneconomic;
(ii) product lifecycle times drastically contracted with evident negative repercussions on company structures characterized by a prevalence of rigid technical-productive factors.

The defined environmental conditions generated a change in the way enterprises related to the internal and external environments.

Moving from the external context, we see that qualitative changes in market demand pushed enterprises onto a path towards mass production, based on the homogenization of processes and products, to a production of variety centered on the production of differentiated goods thereby responding to the needs of consumption expressed by classes of consumers having homogenous needs. While in mass production supply defines demand both in terms of quantity and in time frames of manufacturing and sales, in the production of variety goods, it is demand that conditions corporate processes and determines the enterprise’s success or failure in function of its ability to adequately respond to new market needs.

The push towards a production of variety came about at the end of the 1970s, the period in which the average consumer, once satisfying his/her needs of a primarily physiological nature, progressively broadened his/her needs towards products of an immaterial nature, different from strictly functional aspects related to the capacity of a good to carry out a specific task. Among these are attributes of an emotional kind, to be understood as an ability to provoke emotions; of a relational type, as a means of identification with respect to specific groups or social classes; of an epistemic type, as a capacity to give rise to surprise; and or, a circumstantial type, as a capacity to induce purchase in virtue of specific circumstances (Sheth et al., 1991).

The gradual widening of the spectrum of perceived needs provoked a change in the concept of the “quality” of the product. If, until the end of the 1970s quality was synonymous with “technical reliability”, the economy of variety prevalently identified the good’s capacity to respond to perceived multi-dimensioned needs, be they material or immaterial. In short, the price, “strategic” lever, in the economy of mass production, was substituted by the quality of the production.

From the point of view of industry response to appeals from the external environment, to the significant difficulties in sales that enterprises encountered, they responded at least initially by incrementing sales pressure (Lambin, 2008). That choice, for many reasons necessary in relation to separation and change in the market, static conditions in the internal environment of the manufacturers and the absence of useful technologies to render techno-productive processes flexible, is considered by many to be the cause of the rise of consumerism, beginning in the 70s, an ideological movement arising from the protection of consumer rights.

It was probably the crisis of production on a large scale, together with scientific research driven by the need for wartime technologies, that pushed the scientific community to develop new flexible technologies that were able to surpass rigid automation logic of an essentially mechanical nature which was typical of production on a large scale.

"Information and communication technologies," (ICT) which represent electronic, mechanical and informatic synthesis, allowed for multiple uses of technical companies' structures and for significant reductions in the outfitting of machinery, determining factors when facing no longer homogenous markets, also permitted taking quick advantage of the opportunities that came with the opening of new competitive arenas. A first revolution came about in big business with the introduction of flexible technologies that were consistent within an interrelated complex of numerically controlled machines, robots, automatic transporters able to operate uninterruptedly (thereby) surpassing the traditional obstacles to the standardization of products. That system represents one subset of a broader system called "Computer Integrated Manufacturing" (CIM), while constituting the premise of the automated plant, includes, in addition to production, other integrated and computerized functions such as those of procurements, logistics services and the management of human resources. Additionally, in the 1970s, for the first time information technologies were used in enterprises of large dimension with a view towards gathering and storing heavy flows of data so as to generate useful information for management activities in a systematic manner. Clearly the spread of such technologies was initially concentrated in those enterprises capable of reaping higher profits than the prohibitive costs of steady implementation.

Throughout the 70s and all of the 80s, the development of information technologies at a lower cost permitted those enterprises which were faced with growing complexities of the external environment, to employ those systems even in other areas, principally administrative as well as those in production, planning and logistics.

The substitution of principally rigid automated production, from the point of view of opportunity and modes of employment, with automated production systems that were much more flexible and autonomous with respect to human manpower, produced multiple effects in terms of the utilization dynamic of corporate resources. The most significant aspects are highlighted as (Bromwich and Bimani, 1989; Innes and Mitchell, 1993):

(a) the conversion of a large part of employment costs (traditionally held to be elastic), to essentially rigid costs as independent from operational rhythms. The cause of that phenomenon is recognizable in the quantity of employed manpower and in the reconversion of the same into management and process technical control;

(b) the progressive reduction in preponderant weight of production factors whose consumption is directly correlated to operative rhythms (raw material and direct manpower), favored a growth in the use of correlated factors to production only in an indirect way. The reason can be seen both in the additional growth of incurred costs for support activities to production, and in the sizeable increment to employment costs connected to the commercial and distribution capacity leading back to the increasing difficulty in turnover, and in the personalization of finished products;

(c) the change in the "cost determinants", to be understood as causation factors of company resource consumption: production volume no longer seemed able to represent the first cause of indirect costs with respect to the products as so with the proliferation of connected activities to diverse production cycles that had to be realized in ever smaller batches, as related to specific market demands, the true determinant of the product cost becames the complexity. Miller and Vollmann(1985) traced that complexity to the increase in necessary transactions to carry out product differentiation and concerning the increase in the number of purchasing procedures, the different production methodologies in terms of quantity and typologies of set up, the different conditions and the different outlets of the finished products.

In particular, the authors identify the existence of an invisible reality (hidden factory), in the corporate situation and they developed four classes of transactions: logistical transactions, relative to the handling and counting of materials and products in the entry phase of manufacturing and sale; balancing transactions, inherently the verification of correspondence between production factor requests and receipts; quality transactions, necessary in assuring that production be in keeping with planned specifications in response to market demands; change transactions, concerning the need to assure an adequate techno-productive flexibility in terms of adjustments to work hours and scheduled shifts, updating of information systems, review of standards, materials specifications and bills of materials.

It seems that it was increasingly evident how the traditional bases of allocation of overhead costs produced a multiplicative distortion on the configuration of the full cost of the product with the fall of the operational volume paradigm. The traditional techniques for cost-accounting, attributing higher levels of overhead costs to products produced in increased volumes, do not take into account the necessary transactions to simultaneously manage different finished productions in different batches. It is therefore possible, that production managed in larger batches which implied less transportation, equipment and commercial contacts, resulted, in the area of traditional accounting systems, erroneously destined to lower quotes of overhead expenditures. The use of computation principles on volumes generated phenomena of financing crossed over to products thereby inducing the enterprise to make erroneous choices in terms of product pricing (to sell finished goods at inferior prices in small batches and penalize the finished goods produced on a larger scale). In the same way, the lumping together of allocation bases of direct charge factors, can generate strong distortions in terms of choices of make or buy (externalizing phases of production erroneously held to be unreasonable).

In short, around the 1970s, industries found themselves in the paradoxical condition of perceiving a growing degree of inadequacy in accounting techniques of cost analyses for corporate decision making even while beginning to arrange for technical instruments that would be able to accelerate and systematize calculation operations and corporate data processing.

In the presence of innovation in cost accounting instruments that were late to manifest themselves, and of an always greater share of indirect costs that were difficult to understand and therefore also to manage, in the 70s and 80s, in accounting applications and in company policy choices, the configuration of Direct cost or Traceable cost (Shillinglaw, 1977), considered the most reliable since it is partially immune from arbiters driven by the allocation/attribution of overheads, prevailed (Bergamin Barbato, 1997).

That costs configuration substituted the full cost in all its diverse uses. In particular, the problem of the evaluation of profitability of individual products progressively made space for the total valuation of company profitability used while keeping in mind the contribution margin obtainable on the whole. According to the same logic, the sale price – even in the presence of monopolistic power – came to depend increasingly on market conditions and ever less on the accounting unit of full cost.

Even in the choices of economic advantage, a real and true abandonment of information of full cost took place, despite its being the only one able to incorporate consequences of structural conditions, as well as operational structures of the enterprise.

Finally, the employment of standard costs in the planning and controlling of the business generated growing problems in understanding the causes of variance between budget and final balance values: although it appears easy to understand the arena in which the deviation of values came about, it was increasingly difficult to understand what the true causes at the base of its formation were.

It is clear that the evolution of external conditions, whose competitive pressure and diversification of market demand and internal conditions, such as changes in production technology, was not accompanied by a correlating evolution in accounting techniques, methods and costs analysis (Johnson and Kaplan, 1987), and so caused management to make errors by ascribing to the availability of inadequate information (Berliner and Brimson, 1988) and making some hold to the necessity of a complete abandonment of the instruments in use (Goldratt, 1990).

If that is valid for the European and north-American enterprises, the corresponding situation is different in realities such as in Japan where, long before the western world, extremely innovative instruments were developed, such as total quality management, target costing and kaizen costing; their applications were destined to find a place in western enterprises only at the end of the 1980s.

17.3 Third Stage: The New Relevance of Full Cost Configurations

One first fundamental step in the direction of an improvement in the availble instruments came about with the introduction of the Activity-Based Costing model (ABC), as worked out by Cooper and Kaplan (1988), who meanwhile welcomed Johnson and Kaplan's deliberations concerning the inadequacy of duration cost drivers; welcomed Porter's contribution to the logics of the value chain and the systematization theoretics of different categories of cost generators (Porter, 1985); he implicity shed light on a large part of Miller and Vollmann's hidden factory (1985).

In his first formulation, that model, though innovative from many points of view, had a principal limit in recalculating the traditional normative approach as far as it was proposed as a useful instrument in reaching a better quantification of product cost. Nevertheless, he moved the attention of practices and theoretics from the logic of traditional cost centres to corporate activities (according to principles consolidated in the Italian doctrine: De Minico, 1946; Zappa, 1950; D'Ippolito, 1962) paving the way for successive applications of absolute importance.

From the point of view of this paper, one of the most important consequences of the introduction of the ABC model is its ability to provide a different reading of bearing overhead costs, and that of conferring a new look at possible employment of the product full cost. In that sense, the ABC model represents a code that if correctly applied, permits one to decipher the intricacy of the company in terms of transactional determinants of cost bearing while allowing for the appreciation of the rate of overheads with sufficient reliability (not only production but also administrative and commercial), to refer to the products; or, in other words, the influence of structural decisions over operational ones (Table 17.1).

Cooper's contribution seemed to put an end to the accounting impasse that connoted most of the twentieth century in such that from that moment forward, the corporate doctrine did its best to offer a specific response to each characteristic of the new production environment.

In reference to contextual aspects were:

(a) a growing intricacy within the internal environment and a progressive fragmenting of market demand;

Table 17.1 Influence of structural decisions over opertional ones

	Mass production. First stage	Transitory phase. Second stage	Production of variety. Third stage
Hardware life	Very long	Long	Short/very short
Differentiation	Scarce/absent	Significant	Elevated
Indirect costs	Low incidence	In rapid growth	Preponderant
Configuration of prevalent life	Full manufacturing cost	Direct cost/traceable cost	Full cost

(b) growing pressure in both national and international competition in many economic sectors;
(c) a progressive contraction in times of the commercialization of products;
(d) a growing importance of competitive factors such as the quality of the product, the degree of social responsibility and the timeliness of activities carried out;

We can surmise that:

(a) the doctrine responds to the complexity of the internal environment by moving attention away from objects of final cost (traditionally products) to the activities and processes of intermediate goods. In that vein of studies, the techniques that lead back to activity-based management (Turney, 1991), which consider the product to be the final expression of a range of activities that generate consumption therefore causing management to concentrate on those things. The different approach to management of business administration assets allows for the affirmation that, in the 90s, the true passage from cost accounting to those of cost management (this last to be understood as a set of instruments supporting company decisions), came to be. On the same level, kaizen costing had to come, founded on techniques of Japanese management that were developed long before the 70s, and directed at generating a gradual and continuous improvement of conditions of technical and economic efficiency of the enterprise (Monden, 1992).

In response to the diversification of market demand, it is particularly important to focus on and identify (in many sectors) final cost objects and the clients or classes of clients instead of products: the Customer Profitability Analysis opportunely constitutes a simple but efficient application of the ABC technique by extending analyses to the entirety of activities connected to the management of client relationships in a prevalently external prospect (Foster and Gupta, 1994), and that, in its more current prospects, ends in including even incurred costs by the consumer during the consumption period up until its divestment is definitive.

(b) In many economic sectors, the increased pressure of competition hinders the possibility to fix the sale price of goods as a mark-up on the full cost; the price becomes an unalterable fact generated by the meeting of demand and supply and imposes the use of pricing techniques based on the valuation of the possibility of reaching a target cost objective taking into account the market conditions and the hoped for operational income objective. Target costing (Ansari etal., 1997) born from the Japanese context, is increasingly utilized in the sectors with an elevated competitive intensity.
(c) The reduction in times of service life of products and the tendency on the part of some sectors to develop temporary production (programmed obsolescence), imposes the abandonment of administrative practice or of a fraction of this excluding reference periods for cost calculation, leaving for more opportune research based on a product's entire life cycle. To that end, the introduction of

Life cycle costing (Berliner and Brimson, 1988), appears to be a particularly effective response both as an indispensible instrument to the application of target costing, and as an instrument of independent analysis; its employ shows companies that use it as the largest part of incurred costs in the product's full life cycle, that it has a place in the planning stage, even before production begins.

(d) Concerning the evolution of competitive conditions, we see the introduction of instruments such as quality costing (Crosby, 1979; Deming, 1982) or environmental costing useful in providing indications for company objectives that have become critical to reducing, simultaneously, the degree of uncertainty of unproductive overheads. The time factor is certainly the one that more than others merits attention, as the progressive acceleration of economic cycles, be they production or consumption, has called particular attention to the effect of a reduction of throughput time on the level of corporate system economic efficiency. In that sense, instruments such as just in time costing (Schonberger, 1986), the theory of constraints (Goldratt, 1990), and capacity costing should be examined.

Finally, in the face of a competitive environment that pressures enterprises to position themselves in a more flexible way in the market, having to choose between product differentiation or clients and the pursuit of a cost leadership (Porter, 1985), cost management is asked to represent a valid support of the formulations and revisions of business strategies and welcomes a systemic approach oriented at the creation of value over the long run.

Strategic Cost Management (SCM), is treated for the first time in doctrine by Shank and Govindarajan (1989, 1993). The proposed model, based on the individualization and analysis of an extended value chain of the enterprise which even includes that of suppliers and clients, has the goal of obtaining useful information and acquiring a competitive advantage by controlling cost generators better than its competitors (cost driver and competitors cost analyses), or reconfiguring the value chain. An extremely interesting contribution is also offered by McNair et al. (2001) concerning the Value Creation Model which, by emphasizing the client's prospect, proposes a comparison of incurred costs to generate product attributes and the recognized value of those on the part of the clientele. In this new vein of investigation we can, however include even diverse models of performance measurement systems founded on quantitative-physical and quantitative-monetary indicators, such as the balanced scorecard, especially in the case that they are constructed to seek a connection between costs and results (key performance indicators).

The contributions that the company studies doctrine has produced in the last few years have provided a fund of instruments with such diverse scopes and characteristics as to generate confusion in management with respect to which are appropriate to competitive and structural conditions in which industries maneuver (market-oriented or process-oriented) (Miolo Vitali, 2003).

In the concise (yet certainly not exhaustive) descriptions of those instruments it does, however, appear to be clear that, beginning with ABC, full cost acquires a new role. From value which usually refers to the product and is composed by the burden between direct cost and the level of manufacturing overheads allocated on the basis of drivers that are based on production volume, value alters its nature in the full cost of business area, process, product life cycle, distribution channel, customer, specific product characteristic. In progressive computation logic in which every element acquires its own specific function, those subjects are assigned all traceable costs and a share of overheads together incurred on the basis of drivers that take advantage of the dynamics of corporate resource consumption and that result in being even more adequate and comprehensible (therefore manageable) than the analysis that identifies them is accurate. In that process the full product cost does not lose its importance but actually, along with the other cost objects, remains a key aspect of the cost management system, representing a "gradual accumulation of burdens" that are traceable to structural aspects as well as operational, each of which can be included and studied separately with a view to continuous improvement.

17.4 Discussion and Prospectives

In reference to the significant evolution of instruments of cost accounting and management accounting and their use from a strategic point of view, it is still possible to find significant and persistent criticism. In a wholly understandable way, McNair (2004) claims that current models, though representing a step forward with respect to the past, incorporate typical characteristics of the traditional approach that limit the possibility of considering that there has been a true revolution in cost accounting, a pegging for the data revealed in financial accounting – that hinder prospective evaluations – and a tendency to prefer a linear behavior model of costs – that does not demonstrate it is capable of taking advantage of the complexity of the interdependencies and dynamic relationships among the various corporate resources.

Moving from this last aspect, we see that a first attempt to resolve this problem is offered by the multistage activity-based costing model (Horngren et al., 2009), which has as its principle objective, not the one that arrives at the quantifications of full cost, but the one that constructs a casual map able to highlight the ripple effect, or multi-step, of modifications on resources and activities (and related costs) generated by any change at all of the structure or corporate organization.

The present challenge consists in clarifying realities that are ever more complex and articulated, or rather, in the advancement of methodologies that shed light on the consequences of the choices that management makes on the perspective process of the creation of wealth. The new instruments are called on to offer a measure of the opportunity connected to diverse classes of choices to be made, be they related to the acquisition of structural resources: location (dimension, ubication), equipment and technology of the decision making process (layout, scale, flexibility) or infrastructural resources: sales networks (number of outlets, commercial structures, agreements): systems (informational, whether internal or external, organizational systems); human resources (selection and training, incentive systems).

Those decisions, in fact, are the ones that condition the dynamics and degree of competitive and operative flexibility, whose variable principles are represented by: cost (capacity to produce and distribute the product at a low cost), distribution (reliability and speed in distribution), quality (interpretation of market demand and respect for pre-determined standards), variety (mix and volume of production) and level of innovation (capacity to introduce products that are in fact innovative) (Wheelwright and Hayes, 1985; Nanni et al., 1990; Setchi and Setchi, 1990; Beach et al., 2000). Every choice represents a causal variable that is capable of influencing resources, corporate decision making or the competitive positioning of the enterprise by generating consequences on the dynamics of consumption and the creation of wealth (see Fig. 17.2).

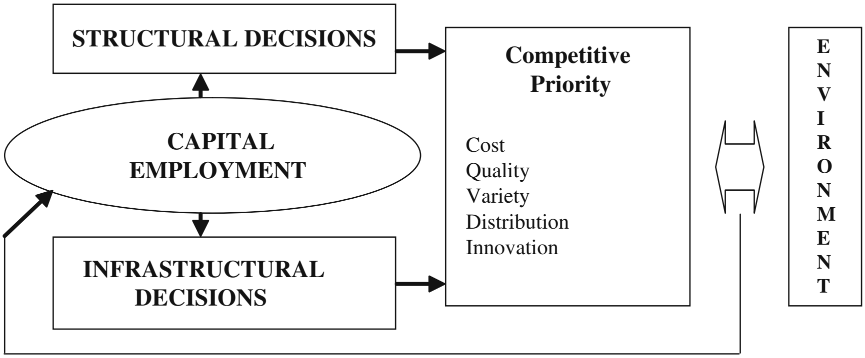

Fig. 17.2 Areas of future research (Adapted from Wheelwright and Hayes, 1985)

The full cost configuration is certainly destined to occupy increasingly more space in those typologies of study, not only concerning pricing policy or profitability analyses, but also – and above all – of assessment of economic choices, in as much as it incorporates the effect of structural and infrastructural variables which is no longer possible to exclude on the basis of a premise, however unacceptable, the hypothesis of short term stability may be.

Although the establishment of a causal map can constitute a valid example of systematic aspects and forecasts in cost analysis, the problem with the nature of the data to be used remains.

What is certain, for different objectives from the stock assessment, is that the instrumental technique will change to its quantification, being ever less tied to accounting data and ever more oriented towards representing indicative values of synthesis of hidden opportunities that underpin corporate evolution.

Many have declared the need to focus attention on not only the system that underpins accounting processes of cost processing, but also on the raw material of those processes (elementary costs and acquisition costs, see Fig. 17.3) and on the time frame taken as a reference. It is necessary, in short, to retrieve concepts of imputed cost and of opportunity cost too long neglected by company doctrine having incorporated time and risk values into the analysis (Brusa, 1997; McNair, 2004).

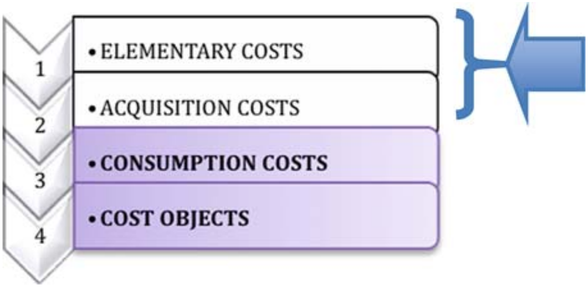

Fig. 17.3 Future Areas of Research

From a management point of view, if we are able to develop models of opportunity cost analysis connected to those characteristics, management will be asked to be able to provide additional capacities with respect to traditional ones. The blame for the failure of decisions taken will inevitably shift from the inadequacy of the instruments available to management's inability to create a vision for future corporate developments.

Another aspect worth noting concerns the progressive transmutation of corporate actions from aspects of a private nature to aspects of a public nature that could involve the same concept of cost and revenue.

Having acquired greater strength based on market demand with respect to supply, civil society has required industries, considered to be social institutions having rights and obligations towards the collective society, to account much more for the burdens and the benefits generated by their activities.

It can not be excluded that in the near future the cost of production could recover its original sense of sacrifice imposed on society as a whole, for the carrying out of the transformation activity as advocated by classical economists in the eighteenth century; and, in the wake of the supersession of financial accounting values in favor of opportunity costs, succeed in incorporating, at least for some cognitive finalities, an estimate that is all the more objective and comparable to physio-psychological and monetary burdens indirectly imposed by the stakeholders on the process of economical and social value creation.

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Part VII
What is next by challenge: PMM Traditional Measurement Cases

Chapter 18
The Measurement System Analysis as a Performance Improvement Catalyst: A Case Study

Luca Cagnazzo, Tatjana Sibalija, and Vidosav Majstorovic

Abstract The capability to manage and control the Business Performances (BPs) of a company is nowadays a leveraging factor for the own competitiveness. One of the most important factors to improve business performance indicators is the development of a structured Quality Management system. Among a plethora of various methodologies, Six Sigma is one of the most important methodologies to improve product and process quality, reduce wastes and costs and achieve higher efficiency and effectiveness, strongly influencing the performance indicators of manufacturing companies. The Six Sigma measurement phase in the DMAIC sequence, as well as all kinds of the measurement activities, should be strictly controlled in terms of effectiveness, precision, variation from the actual values, etc. In respecting these restrictive requirements, the Measurement System Analysis (MSA) is becoming necessary to evaluate the test method, measuring instruments, and the entire process of obtaining measurements in order to ensure the integrity of data used for analysis and to understand the implications of measurement error for decisions making about a product or process. The article presents the MSA action implemented in a manufacturing company, as a case study. Preliminary qualitative and quantitative analysis follow and the main result are presented. The measurement system capability is analyzed. The MSA action strongly influences the company's general business performance as revealed by the final analysis in the article.

18.1 Introduction

Total Quality Management has a significantly positive effect on operational and business performance, employee relations and customer satisfaction (Terziovski and Samson, 1999). The use of Total Quality Management (TQM) as an overall quality programme is still prevalent in modern industry, but many companies are

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extending this kind of initiative to incorporate strategic and financial issues (Harry, 2000). After the TQM hype of the early 1980s, Six Sigma, building on well-proven elements of TQM, can be seen as the current stage of the evolution (Wessel and Burcher, 2004): as a matter of fact, although some conceptual differences exist between TQM activities and Six Sigma systems, the shift from TQM activities to a Six Sigma program is a key to successfully implementing a quality management system (Cheng, 2008). Six Sigma is a business strategy that seeks to identify and eliminate causes of errors or defects – defined as anything which could lead to customer dissatisfaction (Jiju, 2004) or failures in business processes by focusing on outputs that are critical to customers (Snee, 1999); it uses the normal distribution and a strong relationship between product nonconformities, or defects, and product yield, reliability, cycle time, inventory, schedule, etc. (Tadikamala, 1994); the activities of Six Sigma are not limited to process or operation levels, but extended to all the levels of an enterprise to reduce costs and produce high quality products, influencing the performances of the system as a whole. For existing systems/processes, Six Sigma methodology implements, according to DMAIC (Define-Measure-Analyze-Improve-Control), data-driven quality strategy for continuous process improvement (Pyzdek, 2003). In order to reduce process variability and, thereby reduce Cost of Poor Quality (COPQ) and improve overall performance of the company, the first step is to detect and measure major defects types in the process, then find the exact locations where major defects are generated, and finally unclose their root-causes. For this reason, the measurement activity defined within the Six Sigma methodology is a very important aspect for the overall manufacturing companies' performances. In particular, in the manufacturing sector, companies must face the measurement of two types of dimensions to quantify performance, that are the products' measurement and the processes' measurement. The two dimensions are strictly related, since several performance indicators are critically linked with the product's quality characteristics. This implies that the direct measurements of several product's quality characteristics are strictly related to the general performances of a manufacturing company. Thus, product evaluation and process improvement require accurate and precise measurement techniques. This is particularly true by considering the fact that every measurement contains error or bias, keeping with the basic mathematical expression (18.1) that:

$$\text{Measured value} = \text{True value} + \text{Measurement error} \tag{18.1}$$

Thus, understanding and managing measurement error, generally called Measurement Systems Analysis (MSA), is an extremely important function in process improvement (Montgomery, 2005) and in Business Performance (BP) improvement. The accuracy of a measurement system will have a direct influence on the right judgment of a product and process quality. Measurement system, which is different from the traditional measurement instrument, consists of the measured part, measurement method, measurement process, measurement instrument, reference standards, and measurement environment. It means the entire measurement process. In order to ensure the reliability of measurement system, it's necessary to analyze the measurement system in order to determine and control the variation sources.

This article presents the implementation of the MSA approach on a case study of a manufacturing company, within a Six Sigma quality improvement project. The evaluation and assessment of the Measurement Systems used in the company and consequently the actions undertaken to avoid or minimize biases and errors represent a first step to improve the company's general business performances. In particular in the following paragraphs the role of MSA in general performance management and the case study are presented. Processes' mapping and the MSA evaluation follow. The paper ends with preliminary quantitative results and a discussion about the first actions to improve the measurement system capability.

18.2 The Role of MSA in the Performance Management

The effectiveness of a measurement system is strictly related with the gauging accuracy. Nonetheless it depends primarily of the proper gauge use. Common measuring devices are of particular concern when used incorrectly (Hewson et al., 1996). Measuring equipments and processes must be well controlled and suitable to their application in order to assure accurate data collection (Little, 2001).

The MSA reference manual defines data quality and error in terms of "bias", "reproducibility", "reliability" and "stability" (AIAG, 2002). Following the definitions of MSA, bias is the "systematic error" in a measurement, sometimes called the accuracy of a measurement. Repeatability is within operator (one appraiser, one instrument) error, usually traced to the gauge itself, and is considered to be a random error. Reproducibility is between operator (many appraisers, one instrument) error, and is usually traced to differences among the operators who obtain different measurements while using the same gauge (Kappele and Raffaldi, 2005; Montgomery, 2005).

Thus, MSA evaluates if a measurement system is suitable for a specific application (Raffaldi and Kappele, 2004). MSA helps to reduce both the type of risks associated with measurement of a process and making decisions, the risk of false alarms and the risk of missed opportunities. A measurement system incapable of detecting process variation can never be trusted to make a decision on process adjustment (Evans, 2001). Even in cases where the process is centered, the measurement system variation will not be able to establish this fact effectively, and may lead to an over-adjustment and unnecessary tweaking of the process. Unless the measurement system can detect process shifts, special causes can never be identified. If it is excessive appraiser variation, training needs for the appraiser are identified. If there is a problem with bias or linearity, the existing calibration procedure needs to be re-examined. MSA is useful not only to audit existing measurement systems, but also to select the most appropriate ones for a new measurement task (Dasgupta and Murthy, 2001).

For these reasons, representing an important tool for top-level management decision-making and measuring the effectiveness of a measurement system, MSA is strictly related with the global business performances of a company. Controlling and analyzing the measurement system in terms of bias, reproducibility, reliability and stability, is an attempt to assure a higher degree of measurement data objectiveness, with high positive influences on the overall company's management.

18.3 The Case Study

The following case study has been performed in a Serbian manufacturing company that produces enamel, stainless steel and non-stick cookware. The company started a quality improvement project through a Six Sigma approach implementation, aiming to reduce process variability and waste (defects/ nonconformities) and improve business performances. For the observed manufacturing system – enamel pan processing technology – Six Sigma methodology was implemented according to *DMAIC* (*Define-Measure-Analyze-Improve-Control*) quality strategy for continuous process improvement.

As a requirement for Statistical Process Control (SPC) implementation, the MSA action has been required to ensure that measured values are correct and relevant for analysis based on SPC. Thus, MSA has been performed for the measuring system used to measure variable values of the most important product quality characteristic, directly related to the majority of nonconformities found in the observed manufacturing system.

In the following paragraphs the company's processes mapping is presented in order to understand the structure and hierarchy of the observed manufacturing system.

18.3.1 Company's Processes Mapping

Within the *Define* phase of DMAIC cycle, the following steps were undertaken (Sibalija and Majstorovic, 2008):

– mapping of the observed manufacturing system and its processes,
– ranking of the defects found in the most critical man process,
– analysis of the major defect types.

The processes mapping has been realized through the Integration Definition for Function Modeling (IDEF) approach. This methodology, based on Structured Analysis Design Technique – SADT, is a graphical method for system modeling, showing set of hierarchical organized diagrams, and also hierarchy presented in structure of three (Fung and Cheung, 1995). This method can be used for describing the functional steps in manufacturing environments (primary processes – sub processes – activities), with clear indication of structural relations and processing of system components demands.

The method basic principle is the description of a complex system through the activities performed in such a system, in order to assure detailed progressive views since hierarchical decomposition. A set of diagrams that describes the system is called model. Thereby, the creation of IDEF0 (part of the IDEF family) model is often the first task in the system modeling/developing.

The hierarchical representation of the entire manufacturing system – enamel pan processing technology – is represented in Fig. 18.1.

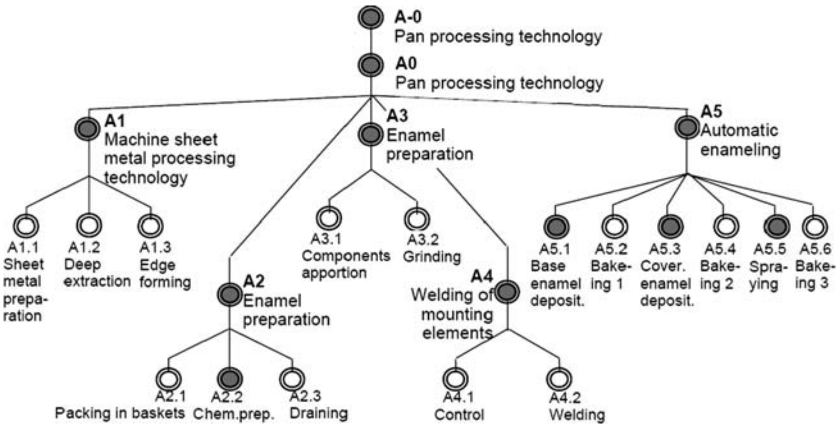

Fig. 18.1 System's representation in hierarchical form

As an explosion of the picture in Fig. 18.1, the decomposed representation of the entire manufacturing system is highlighted in Fig. 18.2.

The most critical manufacturing process in the observed system is the process A5 – Automatic Enameling, in which the company has encountered the majority of defects. The A5-process representation is depicted in Fig. 18.3.

After the system/process mapping, in order to rank and analyze the defect typology found in the A5-process, a Pareto analysis has been performed. It found that vital defects in the process are mainly related to the product quality characteristics – base enamel thickness and cover enamel thickness.

Then, Ishikawa diagrams were used to analyze vital defect types and their main causes. They revealed that the majority of the defect types are related mainly to sub-process A5.1 – base enameling (Sibalija and Majstorovic, 2008).

As described above, in the "Define" phase of the DMAIC method the key issues of the observed manufacturing system were identified.

Then, within the "Measure" phase of DMAIC method, the MSA has been performed for the system involved in the measurement of the critical product characteristic, i.e. the enamel thickness. As presented in the next sections, MSA investigates the measuring system under the 5 dimensions suggested in the MSA manual: bias, reproducibility, reliability, stability (AIAG, 2002) and linearity.

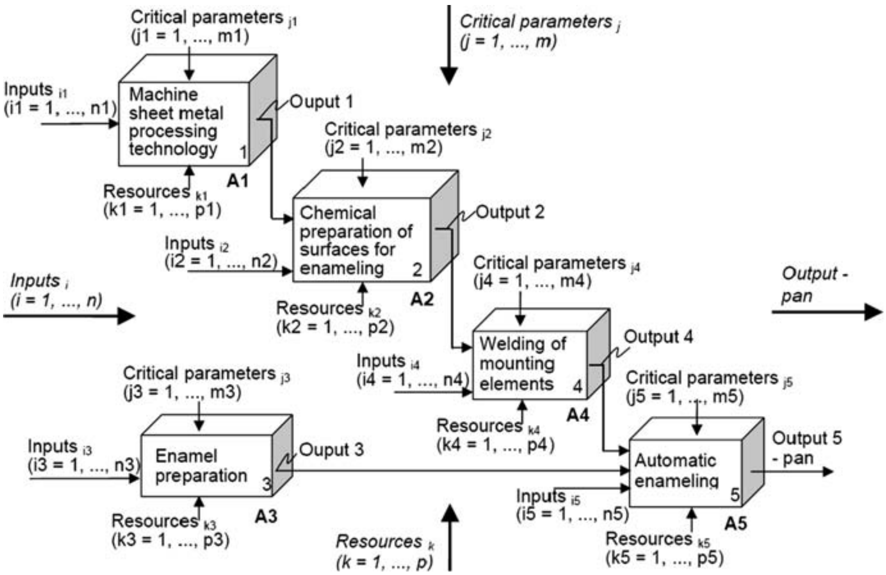

Fig. 18.2 System's decomposed representation

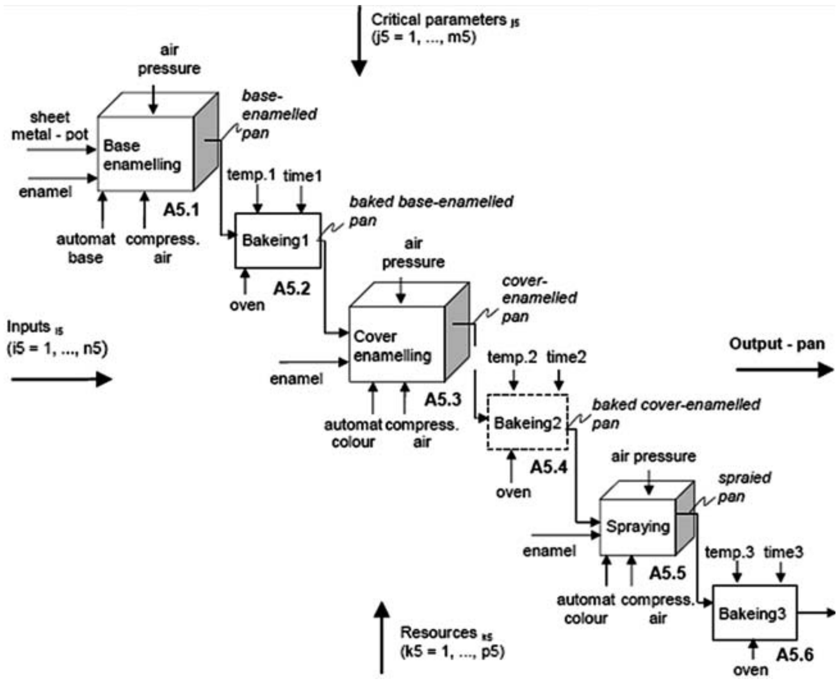

Fig. 18.3 IDEF0 map of the main process automatic enameling (A5)

18.4 The Analysis of the Measuring System for Enamel Thickness Measurements

The observed measuring equipment "MiniTest 600 B" is used to measure variable values of the most important product quality characteristic, that is the pan enamel thickness. In order to assess the overall quality level of the measuring system and its capability to measure the observed product quality characteristic, analysis of the measuring system has been performed using two methods (Sibalija and Majstorovic, 2007):

(1) average and range ($\bar{X}, R$) control charts method, and
(2) ANOVA method, quantifying measuring system characteristics: repeatability and reproducibility, discrimination, stability, bias and linearity.

Results of analysis show constituent components of variation occurred during measuring process: part-to-part variation, operator variation, measuring equipment variation and variation due to interaction effects (if there are any), presenting an input for minimization of variation introduced by measuring process, so that full focus on part-to-part variation (variation of the observed product quality characteristic) can be set. Input data for this MSA are:

– Specification Tolerance of pan enamel thickness:

$$\mathrm{T} = \mathrm{USL} - \mathrm{LSL} = (550 - 170)\,\mu\mathrm{m} = 380\,\mu\mathrm{m}$$

– Discrimination (resolution) of the observed measuring equipment is 2 μm.

Repeatability, reproducibility, discrimination, stability, bias and linearity are deepened in the next sections, highlighting the results achieved.

18.4.1 Stability

Stability of measuring system is presented in Fig. 18.4, by $\bar{X}, R$ control chart. One operator measured enamel thickness of the same product 15 times, over time period of 4 weeks – once per week (Table 18.1).

Stability – R chart:

$$\mathrm{R_{mean}} = 30.5;\,(\mathrm{D4} = 1.653,\ \text{for sub-group size} = 15) \tag{18.2}$$

$$\mathrm{UCL} = \mathrm{D4} \cdot \mathrm{R_{mean}} = 50.416 \tag{18.3}$$

Stability – $\bar{X}$ chart:

$$\mathrm{X_{mean}} = 218.867(\mathrm{A2} = 0.223,\ \text{for sub-group size} = 15) \tag{18.4}$$

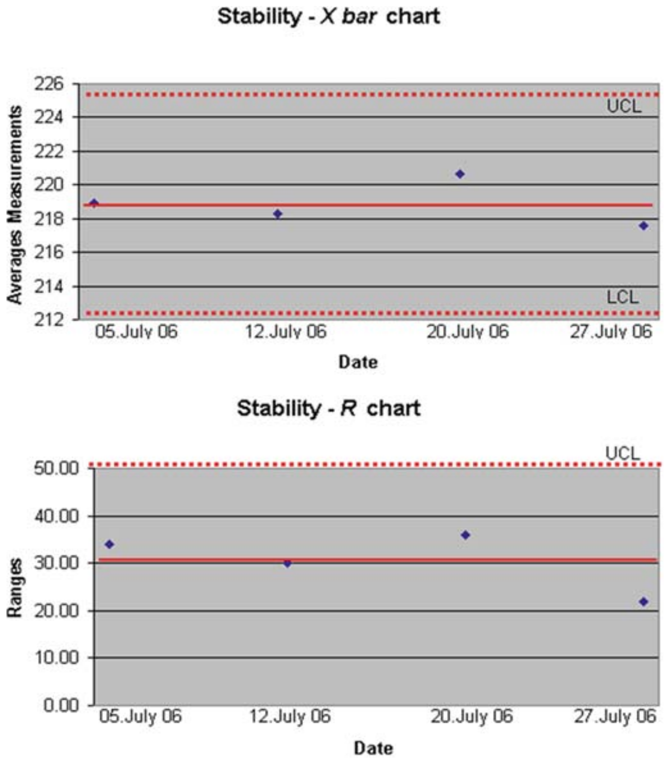

Fig. 18.4 $\bar{X}$, R control chart for stability

Table 18.1 Data for stability of measuring system

Date	Readings (μm)	Average (μm)	Range (μm)
05.07	232; 240; 230; 212; 210; 210; 218; 216; 222; 214; 208; 206; 222; 228; 216	218.933	34
12.07	232; 226; 222; 222; 212; 222; 202; 206; 210; 218; 214; 220; 226; 222; 220	218.267	30
20.07	238; 232; 240; 204; 210; 208; 218; 214; 224; 220; 212; 216; 216; 234; 224	220.667	36
27.07	224; 226; 224; 220; 204; 208; 222; 220; 212; 214; 210; 214; 222; 226; 218	217.6	22
Average		218.867	30.5

$$\mathrm{LCL} \div \mathrm{UCL} = \mathrm{X_{mean}} - / + \mathrm{A2} \cdot \mathrm{R_{mean}} = 212.065 \div 225.668 \tag{18.5}$$

Since there are no points out of control limits on $\bar{X}, R$ chart for Stability (Pyzdek, 2003), the observed measuring system is considered statistically stable.

18.4.2 Bias

Measuring System Bias is calculated by measuring standard part/etalon (known thickness 95 μm) repeatedly 10 times, and finding discrepancy between measurements average value and standard part value (Pyzdek, 2003) (Table 18.2).

Table 18.2 Data for bias of measuring system

Readings (μm)	Average (μm)	Bias (μm)
95; 95; 93; 95; 95; 97; 94; 95; 97; 95	95.1	0.1

18.4.3 Gauge Reproducibility and Repeatability

The analysis of Reproducibility and Repeatability of the Gauge (Gauge R&R) has been performed following both the $\bar{X}, R$ method and the ANOVA method, as described below.

18.4.3.1 Gauge R&R: $\bar{X}, R$ Method

In order to calculate Gauge R&R, 3 operators measured 5 different products/parts 3 times, to estimate measuring equipment variation (repeatability), operator variability (reproducibility) and variation of pan enamel thickness (part-to-part variation).

Results are presented in Table 18.3. $\bar{X}, R$ chart for Repeatability is showed in Fig. 18.5. The same measuring data are rearranged to calculate Reproducibility (Table 18.4); belonging $\bar{X}, R$ chart for Reproducibility is presented in Fig. 18.6.

Results of analysis show part-to-part variation, operator variation – reproducibility and measuring equipment variation – repeatability, as well as measurement variation relative to the tolerance of the pan enamel thickness (Table 18.5), in particular:

(a) Repeatability

Repeatability – R chart:

$$\mathrm{R_{mean}} = 1.6 (\mathrm{D4} = 2.574, \text{ for sub-group size} = 3) \tag{18.6}$$

$$\mathrm{UCL} = \mathrm{D4} \cdot \mathrm{R_{mean}} = 4.118 \tag{18.7}$$

Table 18.3 Data for repeatability of measuring system

	Part	Reading 1 (μm)	Reading 2 (μm)	Reading 3 (μm)	Average (μm)	Range (μm)
Operator 1	1	250	252	252	251.333	2
	2	254	254	254	254	0
	3	258	258	258	258	0
	4	270	272	270	270.667	2
	5	266	266	266	266	0
Operator 2	1	254	252	252	252.667	2
	2	256	256	254	255.333	2
	3	258	258	256	257.333	2
	4	270	268	270	269.333	2
	5	264	268	268	266.667	4
Operator 3	1	250	250	252	250.667	2
	2	252	254	252	252.667	2
	3	260	258	256	258	4
	4	268	268	268	268	0
	5	264	264	264	264	0
Average					259.644	1.6

Repeatability – $\bar{X}$chart:

$$X_{mean} = 259.6444 (A2 = 1.023,\text{ for sub-group size} = 3) \tag{18.8}$$

$$LCL \div UCL = X_{mean} - / + A2 \cdot R_{mean} = 258.008 \div 261.281 \tag{18.9}$$

Standard Deviation for Repeatability (Gauge variation):

$$Sigma_{repeat} = Sigma_e = R_{mean}/d2^* = 0.930 \tag{18.10}$$

($d2^* = 1.72$, for 3 readings and 3 inspectors × 5 parts)

Repeatability:

$$5.15 \cdot Sigma_e = 4.798 \tag{18.11}$$

(5.15 – const. – Z ordinate which includes 99% of a standard normal distribution).

At *R* chart for Repeatability all values are lower than UCL, thus it could be concluded that *the measurement system's variability due to repeatability is consistent – there are no special causes of variation.* At $\bar{X}$ chart for Repeatability more than half of the points are out of control limits, thus it could be concluded that *the variation due to Gauge repeatability error is less than part-to-part variation* (Pyzdek, 2003).

(b) Reproducibility

Reproducibility – R chart:

$$R_{mean} = 4 (D4 = 1.816,\text{ for sub-group size} = 9) \tag{18.12}$$

$$\mathrm{UCL} = \mathrm{D4} \cdot \mathrm{R}_{\mathrm{mean}} = 7.264 \tag{18.13}$$

Reproducibility – $\bar{X}$ chart:

$$\mathrm{X}_{\mathrm{mean}} = 259.644 (\mathrm{A2} = 0.337, \text{ for sub-group size} = 9) \tag{18.14}$$

$$\mathrm{LCL} \div \mathrm{UCL} = \mathrm{X}_{\mathrm{mean}} - / + \mathrm{A2} \cdot \mathrm{R}_{\mathrm{mean}} = 258.296 \div 260.992 \tag{18.15}$$

Standard Deviation for reproducibility:

Standard deviation for repeatability and reproducibility:

$$\mathrm{Sigma}_{\mathrm{o}} = \mathrm{R}_{\mathrm{o}}/\mathrm{d2}^{*} = 1.342 \tag{18.16}$$

($\mathrm{d2}^{*} = 2.98$, for 9 readings and 3 inspectors $\times$ 5 parts)

$$\mathrm{Sigma}_{\mathrm{o}} = \mathrm{Sigma}^2_{\mathrm{repeat+reprod}} = \mathrm{Sigma}^2_{\mathrm{repeat}} + \mathrm{Sigma}^2_{\mathrm{reprod}} \tag{18.17}$$

$$\mathrm{Sigma}_{\mathrm{reprod}} = \mathrm{SQRT}(\mathrm{Sigma}^2_{\mathrm{o}} - \mathrm{Sigma}^2_{\mathrm{repeat}}) = 0.968 \tag{18.18}$$

Reproducibility:

$$5.15 \cdot \mathrm{Sigma}_{\mathrm{reprod}} = 4.983 \tag{18.19}$$

(5.15 – const. – Z ordinate which includes 99% of a standard normal distribution)

Measurem. System Standard Deviation:

$$\mathrm{Sigma}_{\mathrm{m}} = \mathrm{SQRT}(\mathrm{Sigma}^2_{\mathrm{e}} + \mathrm{Sigma}^2_{\mathrm{o}}) = 1.633 \tag{18.20}$$

Measurement System Variation:

$$\mathrm{R\&R} = 5.15 \cdot \mathrm{Sigma}_{\mathrm{m}} = 8.410 \tag{18.21}$$

For Reproducibility, all values at *R* chart are lower than UCL, meaning that *the measurement system's variability due to repeatability and reproducibility is consistent – there are no special causes of variation.* More than half of all points at $\bar{X}$ chart for Reproducibility are out of control limits, so it could be concluded that *the variation due to Gauge repeatability and reproducibility error is less than part-to-part variation* (Pyzdek, 2003).

(c) Part-to-Part Variation

Range of parts averages:

$$\mathrm{R}_{\mathrm{p}} = 17.778 \tag{18.22}$$

Part-to part standard deviation:

$$\mathrm{Sigma}_{\mathrm{p}} = \mathrm{R}_{\mathrm{p}}/\mathrm{d2}^{*} = 7.168 \tag{18.23}$$

Table 18.4 Data for reproducibility of measuring system

Part	Read.1 (µm) Operator 1	Read.2 (µm) Operator 1	Read.3 (µm) Operator 1	Read.1 (µm) Operator 2	Read.2 (µm) Operator 1	Read.3 (µm) Operator 1	Read.1 (µm) Operator 3	Read.2 (µm) Operator 1	Read.3 (µm) Operator 1	Average (µm)	Range (µm)
1	250	252	252	254	252	252	250	250	252	251.556	4
2	254	254	254	256	256	254	252	254	252	254	4
3	258	258	258	258	258	256	260	258	256	257.778	4
4	270	272	270	270	268	270	268	268	268	269.333	4
5	266	266	266	264	268	268	264	264	264	265.556	4
Average										259.644	4

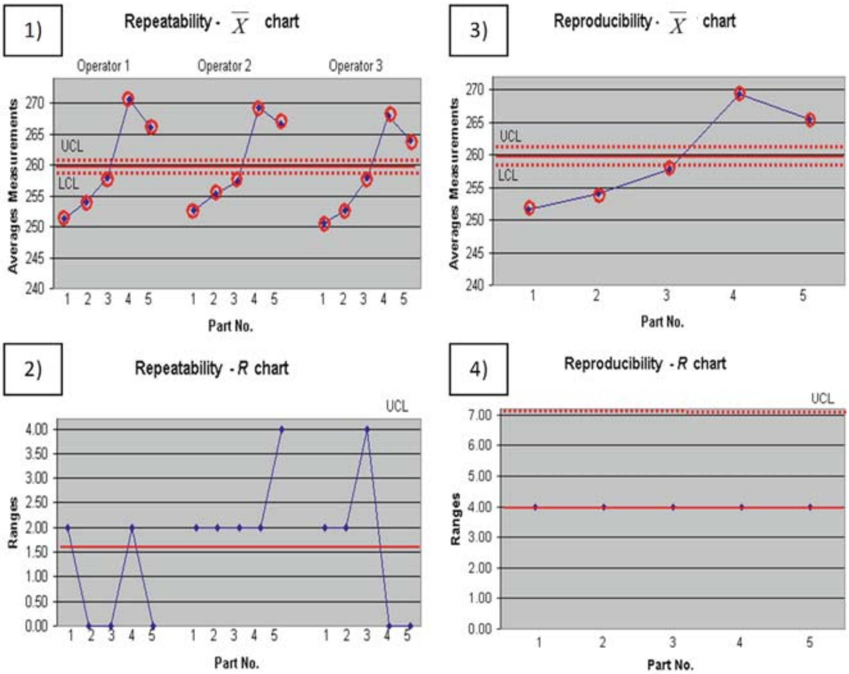

Fig. 18.5 $\bar{X}$, R control chart for repeatability (1 and 2) and for reproducibility (3 and 4)

($d2^* = 2.48$, for 5 parts and 1 calculation for R)

99% spread due to part-to-part variation:

$$\mathrm{PV} = 5.15 \cdot \mathrm{Sigma_p} = 36.918 \tag{18.24}$$

(d) Overall Measuring System Evaluation

Total process standard deviation:

$$\mathrm{Sigma_t} = \mathrm{SQRT}(\mathrm{Sigma_m^2} + \mathrm{Sigma_p^2}) = 7.352 \tag{18.25}$$

Total Variability:

$$\mathrm{TV} = 5.15 \cdot \mathrm{Sigma_t} = 37.863 \tag{18.26}$$

The percent R&R:

$$100 \cdot (\mathrm{Sigma_m}/\mathrm{Sigma_t})\% = 22.213\% \tag{18.27}$$

The number of distinct data categories that can be created with the measuring system:

$$1.41 \cdot (\mathrm{PV}/\mathrm{R\&R}) = 6.189122 = 6. \tag{18.28}$$

With respect to the above calculation, it could be said that, s*ince the number of distinct data categories for the measurement system is 6 (>5 minim. required)* (Pyzdek, 2003), *this measuring system is adequate for process analysis/control.*

Table 18.5 Analysis of spreads – measurement variation related to the tolerance

Source	St. Dev.	Variability (5.15·St. Dev.)	% Variability	% Tolerance (Variability/Tolerance)
Total gage R&R	1.63	8.41	**22.21**	2.27
Repeatability	0.93	4.79	12.65	1.29
Reproducibility	0.97	4.98	13.16	1.35
Part-to-part	7.17	36.92	97.50	9.98
Total variation	7.35	37.86	100.00	10.23

Taking into consideration all relevant factors (cost of measurement device, cost of repair, etc.)*, the observed Measuring System may be accepted since operators and equipment cause 22.21% (< 30%) of measuring variation* (Pyzdek, 2003).

18.4.3.2 Gauge R&R: ANOVA Method

Analysis of measuring results using ANOVA method (Table 18.6) includes analysis of interaction *operator *part.num*. Since "alpha to remove interaction term" is set to 0.05 (for 95% of confidence), variation due to interaction *operator *part.num* is found insignificant (Table 18.6) (Pyzdek, 2003). Results of analysis show components of variation occurred during the measuring process (Table 18.7), as well as variations related to the pan enamel thickness tolerance and to the observed manufacturing process variation (Table 18.8). Figure 18.6 gives a graphic representation overview.

Results for Gauge R&R from ANOVA method differ from results obtained using $\bar{X}, R$ method, since $\bar{X}, R$ method excludes the possibility to discuss interaction effect *operator *part.num* (in this Gauge R&R, the interaction effect *operator *part.num* is found insignificant, but it still takes certain value). Thus, ANOVA method for Gauge R&R is considered more accurate than $\bar{X}, R$ method (Sibalija and Majstorovic, 2007).

Table 18.6 ANOVA table without interaction, for Gauge R&R

Source	DF	SS	MS	F	P
Part.Num	4	2066.31	516.578	338.707	0.000
Operator	2	22.04	11.022	7.227	0.002
Repeatability	38	57.96	1.525		
Total	44	2146.31			

Alpha to remove interaction term = 0.05.

Table 18.7 Components of variance analysis

Source	VarComp	% Contribution (of VarComp)
Total gage R&R	2.1583	3.63
Repeatability	1.5251	2.57
Reproducibility	0.6331	1.07
Operator	0.6331	1.07
Part-to-part	57.2281	96.37
Total variation	59.3864	100.00

Process tolerance = 370.

Table 18.8 Analysis of spreads

Source	StdDev (SD)	Study Var (5.15·SD)	%Study Var (%SV)	%Toleran. (SV/Toler)
Total gage R&R	1.46911	7.5659	19.06	2.04
Repeatability	1.23497	6.3601	16.03	1.72
Reproducibility	0.79570	4.0979	10.33	1.11
Operator	0.79570	4.0979	10.33	1.11
Part-to-part	7.56492	38.9594	98.17	10.53
Total variation	7.70625	39.6872	100.00	10.73

Number of distinct categories = 7.

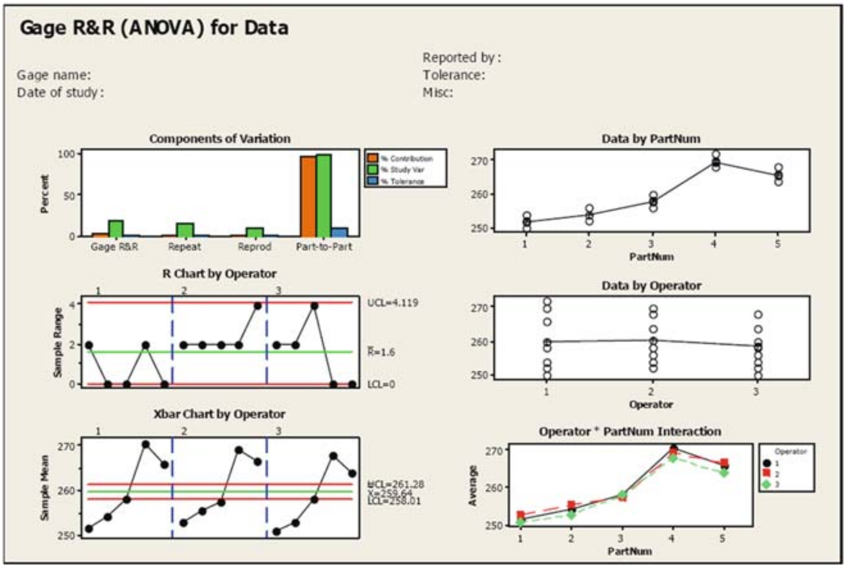

Fig. 18.6 Gauge R&R – ANOVA method

18.4.4 Linearity

Linearity is determined by choosing products/parts that cover most of the operating range of the measuring equipment; then Bias is determined at each point of the range (Pyzdek, 2003). In this case, 4 parts were chosen, with the following expected enamel thickness: 100, 220, 360 and 470 μm; each part was measured 10 times; discrepancy between their average value and expected value presents bias (Table 18.9).

Table 18.9 Data for linearity and bias of measuring system

Part	Readings (μm)	Average (μm)	Reference value (μm)	Bias (μm)
1	101; 101; 102; 103; 102; 102; 102; 101; 102; 104	102	100	2
2	224; 222; 220; 222; 222; 222; 222; 220; 222; 224	222	220	2
3	362; 368; 360; 364; 368; 364; 362; 360; 364; 364	363.6	360	3.6
4	478; 478; 478; 478; 480; 478; 478; 482; 478; 478	478.6	770	8.6

Then, a linear regression was performed (Fig. 18.7). The equation of linearity is:

$$\text{Bias} = -0.800 + 0.01687 \cdot \text{Ref.value} \tag{18.29}$$

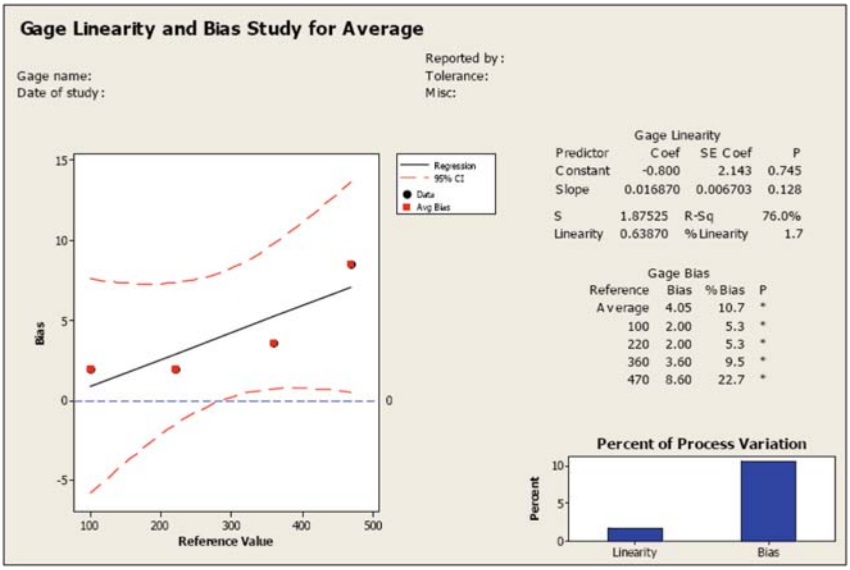

Fig. 18.7 Linearity and bias study of measuring system

Since the obtained *P* values are over 0.05 (Fig. 18.7), *gauge bias is statistically insignificant*. Value *R-Sq* is acceptable and equals 76.0% (>*50*), meaning that the *straight line explains about 76% of the variation in the bias readings.* Further, the variation due to linearity for this gauge is 1.687% of the overall process variation. The variation due to accuracy for this gauge is 10.6963% of the overall process variation.

18.5 Evaluating the Measuring System Capability

18.5.1 Capability Indices for Gauge – Cg and Cgk

According to Dietrich (2006), capability indices for gauge can be calculated by measuring standard part *n* times and calculating average, bias and standard deviation of measurement. From data presented in Table 18.2, the average and standard deviation could be calculated:

$$\text{Average} = 95.1\,\mu\text{m};\ \text{Bias} = 0.1\,\mu\text{m};\ \text{St.Deviation} = 1.197\,\mu\text{m};$$

and, according to Dietrich (2006), capability indices are:

$$\text{Cg} = 0.2 \cdot \text{T}/4 \cdot \text{St.Deviation} = 15.45 > 1.33 \tag{18.30}$$

$$\text{Cgk} = (0.1 \cdot \text{T} - \text{Bias})/(2 \cdot \text{St.Deviation}) = 15.41 > 1.33 \tag{18.31}$$

Since Cg and Cgk values exceed 1.33, it could be noted that the measuring process is capable according to the requirements for capability indices.

18.5.2 Precision-to-Tolerance (PTR) Ratio, Signal-to-Noise (STN) Ratio and Discrimination Ratio (DR)

The precision-to-tolerance ratio (PTR) is a function of variance of measurement system:

$$\text{PTR} = \left(5.15 \cdot \text{SQRT}\left(\text{Variance}_{\text{mesur.system}}\right)\right)/(\text{USL} - \text{LSL}) \cdot 100\% = 2.045\% \tag{18.32}$$

The value for $\text{Variance}_{\text{mesur.system}}$ can be found in Table 18.7 (*VarComp* for Total Gauge R&R).

According with Burdick et al. (2003), the acceptance threshold is 10%. Since PTR for this measuring system is less than 10%, *the measurement system is adequate according to the PTR requirement.*

The adequacy of a measuring process is more often determined by some function of "proportion of total variance due to measurement system" (Burdick et al., 2003), as it is signal-to-noise ratio (SNR) and discrimination ratio (DR):

$$\mathrm{SNR} = \mathrm{SQRT}((2 \cdot (\mathrm{Var_p}/\mathrm{Var_{total}}))/(1 - \mathrm{Var_p}/\mathrm{Var_{total}}) = 7 \tag{18.33}$$

$$\mathrm{DR} = (1 + (\mathrm{Var_p}/\mathrm{Var_{total}}))/(1 - (\mathrm{Var_p}/\mathrm{Var_{total}})) = 54 \tag{18.34}$$

The value $\mathrm{Var_p}/\mathrm{Var_{total}}$ can be found in Table 18.7 (*VarComp* for Part-to-Part/Total Variation).

AIAG (1995) defined SNR as the number of distinct levels of categories that can be reliably obtained from the data (Burdick et al., 2003) and value of 5 or greater is recommended. Also, it has been stated that DR must exceed 4 for the measurement system to be adequate.

For the observed measuring system, values SNR = 7 and DR = 54 indicate that *the observed measuring system is adequate according to SNR and DR criteria.*

18.5.2.1 Confidence Interval for PTR (95% Confidence)

According to Burdick et al. (2003), limits for PTR confidence interval, for 95% of confidence, are:

$$\mathrm{L_{PTR}} = 5.15 \cdot \mathrm{SQRT(Lower\ Bound)/(USL - LSL)} \tag{18.35}$$

$$\mathrm{U_{PTR}} = 5.15 \cdot \mathrm{SQRT(Upper\ Bound)/(USL - LSL)} \tag{18.36}$$

where bounds are:

$$\mathrm{Lower\ Bound} = \mathrm{Estimate\ Variance_{mesur.system}} - \mathrm{SQRT(V_{LM})/(p \cdot r)} \tag{18.37}$$

$$\mathrm{Upper\ Bound} = \mathrm{Estimate\ Variance_{mesur.system}} + \mathrm{SQRT(V_{UM})/(p \cdot r)} \tag{18.38}$$

and:

p = 5 – number of different part measured for Gauge R&R,
r = 3 – number of repeated measurement (readings) for Gauge R&R,
o = 3 – number of operators that performed measurements for Gauge R&R.

$$\mathrm{Estimate\ variance_{mesur.system}} = \left(\mathrm{SD_o^2} + \mathrm{p} \cdot (\mathrm{r} - 1) \cdot \mathrm{SD_e^2}\right)/(\mathrm{p} \cdot \mathrm{r}) \tag{18.39}$$

(the values $\mathrm{SD_o}$ and $\mathrm{SD_e}$ are values StdDev for Operator and Repeatability, respectively, from Table 18.8);

$$\mathrm{V_{LM}} = \mathrm{G_2^2} \cdot \mathrm{MS_o^2} + \mathrm{G_4^2} \cdot \mathrm{p^2} \cdot (\mathrm{r} - 1)^2 \cdot \mathrm{MS_e^2} \tag{18.40}$$

$$\mathrm{V_{UM}} = \mathrm{H_2^2} \cdot \mathrm{MS_o^2} + \mathrm{H_4^2} \cdot \mathrm{p^2} \cdot (\mathrm{r} - 1)^2 \cdot \mathrm{MS_e^2} \tag{18.41}$$

(the values MS_O and MS_e are values MS for Operator and Repeatability, respectively, from Table 18.6);

coefficients are:

$G_2 = 1–1/F(1–\alpha/2, o–1, \text{infinite})$;
$G4 = 1–1/F(1–\alpha/2, p\cdot o\cdot(r–1), \text{infinite})$
$H_2 = 1/F(\alpha/2, o–1, \text{infinite}) – 1$;
$H4 = 1/F(\alpha/2, p\cdot o\cdot(r–1), \text{infinite}) – 1$

where F(.,.,.) is the Fisher test value and $\alpha = 0.05$ – threshold.

Results are:
Estimate $\text{Variance}_{\text{mesur.system}} = 1{,}059$
$V_{LM} = 94.939$; $V_{UM} = 180194.689$
Lower Bound = 0.409; Upper Bound = 29.358
$L_{PTR} = 0.89\% <= PTR <= U_{PTR} = 7.54\%$.

Since lower and upper limit for PRT are below 10%, there is sufficient evidence to claim that *the observed measuring system is adequate for product characteristic measurement, according to PTR confidence interval criteria.*

18.5.2.2 Confidence Interval for SNR and DR (95% Confidence)

As stated by Burdick et al. (2003), SNR confidence interval limits are:

$$L_{SNR} = \text{SQRT}((2 \cdot \text{Lower Bound})/(1 - \text{LowerBound})) \tag{18.42}$$

$$U_{SNR} = \text{SQRT}((2 \cdot \text{Upper Bound})/(1 - \text{Upper Bound})) \tag{18.43}$$

where bounds are:

$$\text{Lower Bound} = (p \cdot L^*)/((p \cdot L^*) + o) \tag{18.44}$$

$$\text{Upper Bound} = (p \cdot U^*)/((p \cdot U^*) + o) \tag{18.45}$$

and:

$$L^* = MS_p/((p\cdot(r-1)\cdot F(1-\alpha/2,p-1,\text{infinite})\cdot MS_e)+(F(1-\alpha/2,p-1,o-1)\cdot MS_o)) \tag{18.46}$$

$$U^* = MS_p/((p \cdot (r-1) \cdot F(\alpha/2,p-1,\text{infinite}) \cdot MS_e) + (F(\alpha/2,p-1,o-1) \cdot MS_o)) \tag{18.47}$$

(the values MS_p, MS_e, MS_o are value MS for Part.Num, Operator, Repeatability, respectively, from Table 18.6).

Results are:

$L^* = 1.087$, $U^* = 179.251$;
Lower Bound = 0.644, Upper Bound = 0.997
$L_{SNR} = 1.904 <= SNR <= USNR = 24.444$

Since not all values in the interval for SNR exceed 5, *there is no sufficient evidence to claim that the measurement system is adequate for monitoring the process.*

According to Burdick et al. (2003), limits for DR confidence interval are:

$$L_{DR} = (1 + \text{Lower Bound})/(1 - \text{Lower Bound})) = 4.624 \quad (18.48)$$

$$U_{DR} = (1 + \text{Upper Bound})/(1 - \text{Upper Bound})) = 598.504 \quad (18.49)$$

$$L_{DR} = 4.624 <= DR <= U_{DR} = 598.504$$

Regarding DR confidence interval, it can be noted that the observed *measurement system is adequate for process monitoring/analysis since both DR limits exceed value 4.*
(*Note:* Above stated equations for confidence intervals are valid only in case when interaction effect operator **part.num* is insignificant.)

18.6 The Benefits of MSA for the Overall Business Performances

Although there were some considerations with regards to variability of the measurements (Gage R&R), this measuring system was accepted for pan enamel thickness measurements (Sibalija and Majstorovic, 2007), which presents the pre-request for the implementation of analysis/control of Automatic enameling process.

According to the preliminary results of implementation of the optimal parameters setting for sub-process "Base Enameling", significant financial benefit was achieved in a relatively short period of time. This allowed the quantity of nonconformities (defects) to be reduced by nearly 1%, which presents direct financial gain. In addition, direct financial gain caused by significant reduction of the number of nonconformities related to base enamel thickness caused a chain reaction in which process runtime and overall process efficiency and effectiveness were increased, product quality was improved and rework and inspection were reduced, thus with high impacts on overall company's business performances. Minor indirect benefits were also perceived, including employee participation in Six Sigma projects, an increased process knowledge and use of statistical thinking to solve problems.

In particular, the very good results in terms of overall company's performance improving have been achieved through the Six Sigma methodology implementation. Since the *Measure* phase of the DMAIC has been exhaustively described in the previous paragraphs of this article, the other phases (Define, Analyze, Improve and Control) are detailed described as follows.

In the *Define* phase of the DMAIC approach Pareto analysis showed that approximately 35% of defects found in the observed manufacturing system are directly related to base enamel thickness and the total quantity of nonconformities (defects) directly related to base enamel thickness is around 3% of total produced quantity (Sibalija and Majstorovic, 2008).

In the *Analyze* phase of the observed DMAIC approach, process analysis was performed using Statistical Process Control (SPC). Based on a large sample data, $\bar{X}, R$ control charts for base enamel thickness was created. This control chart refers to the sub-process A5.1 – Base enameling (Fig. 18.3).

After detailed analysis of the control chart, it was concluded that the chart is in control, but process capability and performance indices do not satisfy 6σ requirements (Cp, Cpk, Pp, Ppk > 2) (Pyzdek, 2003). Also, from capability histogram it was visible that process was off-centre: base enamel thickness mean value was 103.37 μm, and required response target is 95 μm. This indicated the location problem in sub-process A5.1, thus the process needs optimization with respect to base enamel thickness mean value (Sibalija and Majstorovic, 2009).

In the *Improve* phase of DMAIC approach, an experiment was conducted in order to identify the optimal settings of *critical-to-quality* factors (process and enamel parameters), for the Base enameling sub-process.

In order to minimize the number of trials required in the experiment and to reduce effect of noise factors, Taguchi's method for robust design was adopted for Base enameling process optimization. Four process and enamel parameters and two interactions were identified as potentially *critical-to-quality* (CTQs) for base enameling thickness, and thus influencing the company's performances. They were used as design parameters in the experiment and studied at two levels. Design of the experiment was performed using Taguchi orthogonal technique, by orthogonal array L_{16}. For each trial, the base enamel thickness was measured on 5 parts, and then base enamel thickness mean and standard deviation were calculated.

Unlike most other experimental design methods, Taguchi's technique allows us to study the variation of process and ultimately to optimize the process variability, as well as target, using Signal-to-Noise ratio (SN). It presents ratio between response mean (control factors effect) and variation (noise factors effect). Noise factors were considered as unknown in the experiment. SN values for base enamel thickness was calculated according to the formula for *Nominal-The-Best* type of response, since the desired response is the nominal (target) base enamel thickness.

From belonging ANOVA tables for enamel thickness mean, standard deviation and SN value, significant factors for each of the above were found. Based on the requirements to achieve the target response value of 95 μm and simultaneously minimize standard deviation and maximize SN value, using ANOVA and analysis of interaction plots of design parameters the optimal parameters setting was found, giving predicted values: enamel thickness mean = 96.72 μm; standard deviation = 4.85 μm, and SN = 26.24 db. Using optimal parameters setting, verification production run was performed confirming the experimental results (Sibalija and Majstorovic, 2008).

In order to ensure sustainability, achieved results are followed through *Control* phase of DMAIC approach. The improved data on significant factors, as identified from the experimental design, are monitored and the whole process is documented to ensure that improvements are maintained beyond the completion of the pilot-project. The achieved process improvements are monitored and verified in everyday practice by using control charts and process capability analysis with respect to the base enamel thickness characteristics.

18.7 Conclusions and Further Developments

This paper presents a case study of MSA within Six Sigma project, demonstrating how the effective introduction and implementation of statistical tools can lead to detailed understanding of the components of variation during measuring process and evaluation if a measurement system is suitable for a specific application – measurement of the products' most critical quality characteristic.

An analysis of the observed measuring system has been performed with good results for all criteria that consider central location of a measurement. With regards to measurement variability (Gage R&R), we conditionally accepted this measuring system for the considered measurement. Measuring system capability (presented over gage potential Cg and capability Cgk) satisfies the required criteria, as well as confidence interval for PTR and DR ratio. Thus, this measurement system is adequate for monitoring the process, according to Cg, Cgk, PTR and DR criteria. One concern is STN ratio, since its confidence interval doesn't satisfy the required criteria. This could be expected also from ANOVA analysis, because "number of distinct categories" is 7, not far enough from the minimum required value of 5. Further, this corresponds to conditional acceptance of the measuring system, regarding the Gage R&R value.

Nevertheless, significant financial benefits for the company have been achieved in a relatively short period of time. This allowed the quantity of nonconformities (defects) to be reduced by nearly 1%, which presents direct financial gain. In addition, direct financial gain caused by significant reduction of the number of nonconformities related to base enamel thickness caused a chain reaction in which process runtime and overall process efficiency and effectiveness were increased, product quality was improved and rework and inspection were reduced, thus with high impacts on overall company's business performances. Minor indirect benefits were also perceived, including employee participation in Six Sigma projects, an increased process knowledge and use of statistical thinking to solve problems. These results show that quality improvement initiatives have a direct influence on the overall companies' performances.

For the case study analyzed in this article further studies need to be performed. In order to improve and absolutely accept this measuring system for pan enamel thickness measurement, following corrective measures should be considered:

– clamping of the part or measuring instrument during measuring process;
– improved maintenance or repair of the measuring instrument;
– advanced training for operators, to help them to use measuring instrument more consistently.

In addition, new influences on long-term performances as well as a deeper MSA impact analysis on business performances should be evaluated, and the MSA evaluation on the other company's processes need to be further performed.

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Chapter 19
Multi-Echelon Inventory Performance Evaluation: The Case of a Communications Company

Mosè Gallo, Luigi Guerra, and Giuseppe Naviglio

Abstract The optimal deployment of inventory is a vital business function for a firm. The well-documented benefits of running manufacturing operation, or offering services, with leaner inventory range from a permanent reduction in working capital to increased sales and higher customer satisfaction. In this paper some models to assess multi-echelon inventory performance are presented. Particularly, the case of a communication company is described in which inventory levels and replenishment strategies are applied to the different echelons taking into consideration their mutual interactions. Some performance indexes, like inventory cost and service level, are considered and a simulation model is built to delve deeper into system issues.

19.1 Introduction

Today more than ever, proper inventory management is a crucial point for any company in reducing costs and improving the service level provided to the customers.

It can be noted that the inventory in a typical manufacturing company may represent about one third of the owned assets and that in 1992, the value of U.S. manufacturing companies inventory was about 1,100 billion dollars (more than 20% of GDP at the time) (Diaz and Fu, 1995).

With this regard, the spare parts/components decisively contributed in order to achieve the mentioned volumes. This consideration seemed particularly evident in *capital-intensive* firms, where there is an extensive use of mechanical/electronic equipments with high intrinsic value (chemical/petrochemical/pharmaceutical companies, military companies, companies producing electronic components for the hi-tech, telecommunications companies). In these cases, quickly facing production system failures/malfunctions is even more important than in other companies.

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This entails the need to reduce the time within which the parts are to be available (Ben-Daya and Raouf, 1994).

In recent years, two important developments have been observed in spare parts inventory management. In the manufacturing field increasing importance has been given to *just in time* methods, which are sufficiently simple from a logical point of view and designed to ensure a significant reduction of the tangible assets in the production system even if its robustness to external "interferences" may be reduced. At the same time, the importance of the tasks assigned to the logistics increased too. In addition to becoming the *core business* of new companies, logistics has begun to take charge of procurement, distribution and supply systems support, which are growing more and more complex from a logical and physical point of view. In this case, demand forecast and proper inventory management are more critical. Moreover, between these cases, there are contexts (for example commercial activities) in which the problem has simply been shifted onto suppliers, a solution which has not always been proven successful considering the increase in the average number of providers, in relations management complexity and in coordinate procurement criticality.

Generally speaking, the use of the existing models for spare parts management, must be guided by (Sherbrooke, 1986):

- the need to monitor inventory costs and service level provided to the customer;
- strategic needs, leading to specific warehouses structure (for example multi-level structures);
- operational needs.

For manufacturing plants, there is an increase of spare parts effects on operational costs, as the physical resources become more complex and as their rate of use grows (Table 19.1).

Table 19.1 Effect of spare parts inventory in the product-process matrix (adapted from: Schmenner, 1981)

	Project	Shop	Batch	Line	Continuous
Raw materials	Variable	Variable	Medium to low	Medium to high	Medium to high
WIP	High	High	Very high	Low	Low
Finished goods	Low	Low	Variable	High	High
Spare parts	Medium	Medium	Medium	High	High

The same considerations still apply to service companies, in which, the reparable parts have high incidence in context characterized by high rate of equipments use (Table 19.2).

Without having to spell things out, considering what has been said so far and in agreement with inventory management theories, when the complexity of the system grows, it can be observed a proportional increase in the effectiveness (in terms of

Table 19.2 Use of repairable spare parts in service companies (adapted from: Schmenner, 1981)

Intensity of Equipment Use		Customizing Level: *Low*	Customizing Level: *High*
		Service factory (A)	***Service Shop (B)***
	High	• Airlines, Rail transport • Hotels • Community Centers	• Hospitals • Workshops • Assistance Centers
		Mass Service (C)	***Professional Service (D)***
	Low	• Department Stores • Schools • Banks	• Doctors • Lawyers • Accountants • Engineers

A Less varieties of consumable, repairables very critical	**B** High varieties of consumable, repairables critical for operations continuity
C Consumables very important, repairables less important	**D** Consumables for support, repairables not important

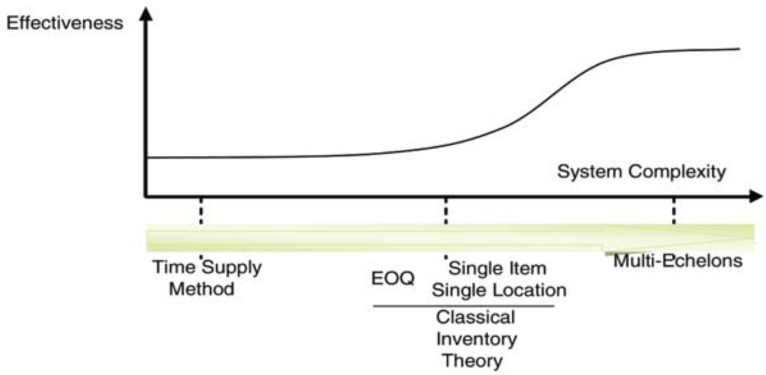

Fig. 19.1 Inventory management techniques effectiveness as system complexity increases

service level provided to the customers) from traditional management techniques to techniques involving the structuring of the system in different layers (Fig. 19.1).

This increase is even more noticeable when considering repairable spare parts. Indeed, traditional structures, in general, fail to provide adequate answers to the specific issues that can occur in these cases (Murphy, 2007):

- lack of repaired parts to meet their demand;
- units procurement and replacement policies must take into account any exit from the system and parts recovery rates;
- choice of the inventory control policy (*periodic* or *continuous*);
- choice of the repair policy (*batches* or *one for one*).

A more comprehensive overview in this regard is found in (Kennedy et al., 2002).

Moreover, when the production system is configured as *supply chain* or as *network organization*, the traditional models would not allow to point out the advantages of supporting suitable repair policies with optimal inventory level definition and *replenishment* policies specification, in terms of service level increase, reduction of costs incurred for stored parts/components, reduced internal/external lead times (Lee, 2003).

Turning to *multi-echelon* systems (Sherbrooke, 1968), may be one way to overcome the above mentioned difficulties, although the introduction of hierarchies in the system entails additional management issues.

The paper is organized as follows. In Section 19.2 some considerations about *multi-echelon* models will be presented. In Section 19.3 the results obtained by the authors in configuring and dimensioning a *multi-echelon* inventory system for a communications firm operating in the Italian market will be discussed. Designing and implementing its logical model in a discrete event-driven simulation, confirmed the effectiveness of the choices and highlighted, at the same time, further possibilities of performance increase. In Section 19.4 brief conclusions are drawn.

19.2 Multi-Echelon Models

In literature it can be found a wide range of applications of *multi-echelon* systems to:

- *supply chain*, where a single level corresponds to a specific stage of the production chain (Svoronos and Zipkin, 1991; Moinzadeh, 2002);
- *distribution systems*, where the levels differ according to the classification as a retailer or supplier (Nahmias and Smith, 1994; McGee et al., 2004);
- *repair and maintenance systems*, where a level corresponds to the repair system or to a warehouse (Sherbrooke, 1971; Graves, 1985; Graves, 1996).

The hierarchies among levels imply some dependencies and interactions that can increase inventory management complexity (Diks et al., 1996; Chopra et al., 1998).

Among *multi-echelon* models there is an important dichotomy that distinguishes between *cyclical models* and *acyclic models* (Fig. 19.2). In acyclic models, finished parts/pieces follow only one direction (for example, from raw materials warehouses to product distribution centres) and they often refer to non repairable products/parts.

On the contrary, in cyclical models, stored parts move in different location of the system, exactly where and when they are demanded. Under some appropriate assumptions it is possible to consider the number of parts in the system as constant, even if subject to possible transformation (failure/repair).

Distribution and production models fall into the acyclic multi-echelon models class and they can be further classified as:

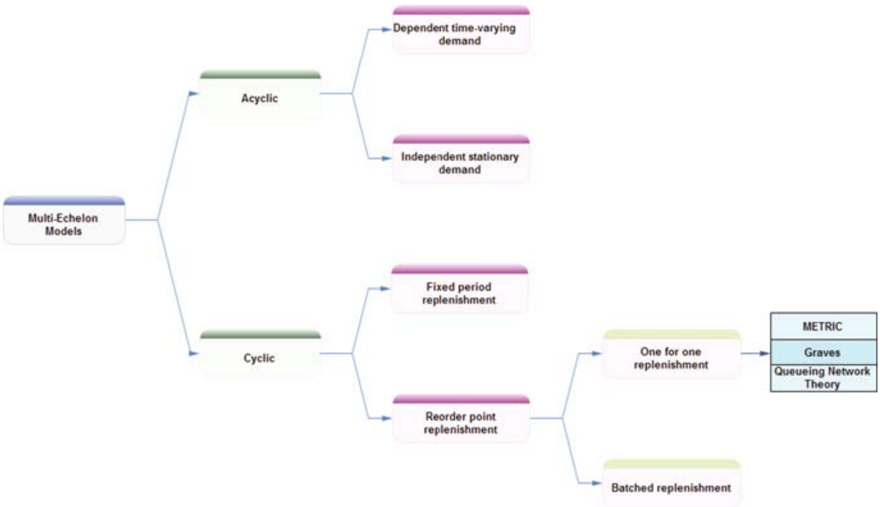

Fig. 19.2 Classification of *multi-echelon* models (Diaz and Fu, 1995)

- *time-varying dependent models*. This models obtain pyramidal requirements aggregating known demands at the different echelons in a hierarchical form, as with MRP for production systems, or for DRP (*Distribution Resources Planning*) in case of distribution (Muckstadt and Roundy, 1993);
- *independent stationary demand models*. In this case the system is broken down, treating each individual lease as an independent and thereby applying techniques for the *single-location* (local optimum problems) or all the possible interactions among different layers of the system can be considered, aiming at global solutions, but with a proportional increase in the computational efforts and making more difficult the practical applicability of the solution (Federgruen, 1993).

In cyclical type models, *replenishment* is either periodic or based on re-order point. Even in this case local or global approaches can be considered, exploiting information originating from specific bases or by using more general system variables. In principle, the problem is reduced to determine the optimal *batch replenishment* policy, which presents a *(Q, R)* formulation. In case of systems in which parts have high intrinsic value, are seldom required at each base and the set-up cost is negligible, it is possible and convenient (Muckstadt and Thomas, 1980) to use *one for one replenishment* policies (commonly denoted as (*S*–1, *S*)). In this case a part is ordered every time it is used and local warehouses control is made considering a single parameter: the reference inventory level. There's a wide literature to trace significant results in this case: METRIC (Sherbrooke, 1968) with its extensions, Graves' model (Graves, 1985) and queuing networks models (Gross et al., 1987; Gross et al., 1993; Albright, 1989; Albright and Gupta, 1993; Bier and Tjelle, 1994).

19.2.1 Multi-Echelon Models for Repairable Parts

Figure 19.3 refers to the simple model proposed in (Diaz and Fu, 1995).

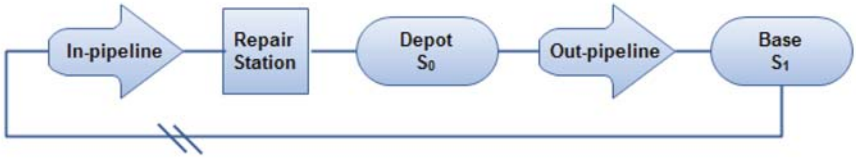

Fig. 19.3 Schematic representation of a *multi-echelon* system for repairable parts

The *repair station*, like the *pipelines*, are modelled by queues, as the parts may have to wait to be moved or repaired, while the *base* and the *depot* are represented by physical stores.

Parts/products movement can occur for three reasons:

1. If a failure happens the damaged part can't be used anymore and it moves from the *base* into the *in-pipeline*. A part, if available, moves from the warehouse of the *depot* that stores the spare parts into the *out- pipeline* to the *base* and if the part is not available a *backorder* is generated at the *depot*. Finally, a part, if it is available, moves from the warehouse at the *base* to restore the system and if there aren't parts available a *backorder* is generated at the *base*.
2. A part finishes the reparation in the *repair station*. The part moves from the *repair station* to the warehouse of the *depot.*
3. The transport of a part is completed and, therefore, the part is stored in the warehouse of the *base* or it arrives to the *repair station*.

Before describing the most common models, it should be stressed that when different parts share the same repair and transportation resources, they have to be determined the policies to decide which part has to be repaired at the repair station, how they have to be distributed to the available resources and, once they are repaired, how they have to be allocated to bases that have generated some backorders. If the repair depot is equipped with infinite repair capacity (*METRIC*), then decisions about repairs order are no long needed. The most common scenarios, however, require *FIFO* logic, priority based logics or dynamic logics (emergency status) to be used, with a proportional increase of management and computational efforts.

Regarding the allocating phase, it can be used the *FIFO* logic (Albright, 1989; Albright and Gupta, 1993), proportional logics (Gross et al., 1983; Reiser, 1981), priority or status dependent logics (Dada, 1992; Cohen et al., 1992; Pyke, 1990). The assumptions on the infinite repair capacity at the repair station and that concerning the constant number of parts in the system have been steadily relaxed (Diaz and Fu, 1997; Sleptchenko et al., 2002) and the performance of the system have been evaluated in terms of total costs expected, service level provided to the customers (Kim et al., 2005), and system congestion (Jung, 2003).

The use of *batch replenishment* policies rather than *one for one replenishment* policies, performed well (in terms of expected number of backorder and operational costs) only if specific conditions are considered (Moinzadeh and Lee, 1986; Axsäter, 1993, Al-Rifai and Rossetti, 2007).

Emergency lateral transhipments (ELT) between bases belonging to the same echelon (Lee, 1987) or on different echelons (Axsäter, 1990) allowed a significant reduction in operating costs (Jung, 2003). A further reduction is achieved combining them with simulation models (Wang et al., 2008). Particularly, in (Burton and Banerjee, 2005) it is shown that using these policies seems to be proportionally more advantageous as the complexity of the system increases.

Finally, if the failures distribution is modelled according to a stationary Poisson distribution, some specific aspects of the problem cannot be considered. In the case of time-varying demand (non-stationary Poisson distribution with average demand rate varying over time) the achieved results are limited to:

- the optimal allocation of the spare parts to each echelon at a specific time (Slay, 1996);
- the optimization of the investments (Lau and Song, 2008).

Moreover, sometimes, the optimization of the solution is not allowed (Jung, 1993).

19.2.1.1 The METRIC Model and Its Extensions

METRIC is a mathematical model designed to determine inventory levels considering reparable parts, which optimizes system performance if the desired investment share is established (Sherbrooke, 1968).

The original model refers to systems with multiple echelons, where a part may be required by various bases that are supported by a single central depot. The demand for parts at the bases is modelled according to Poisson distributions, the repairs can be made at the bases or at the depot, the repair times are statistically independent variables, the parts are always repairable, it is not possible to further disassembly parts into components (*single-indenture*). The objective is to minimize the number of *backorders* at the bases.

Beyond the analytical analysis of the problem, it is interesting to note that the time needed for the fulfilment of a *backorder* and the number of backorders are linearly dependent: this property is important in terms of analytical tractability of the problem. The backorders cost and the inventory cost are linearly dependent too. Furthermore, the failures are correlated to the demand of parts, this means that a fault immediately generates the request for the repair.

The hypothesis that most deviates from the optimal solution (7–11%) is the one concerning replenishment at the bases which is modelled according to independent

Poisson distributions: turning to negative binomial distributions, this error can be reduced to 1% (Graves, 1985).

The main extensions of METRIC are DYNA-METRIC (Hillestad, 1982) and VARY-METRIC (Sherbrooke, 1986).

In DYNA-METRIC non-stationary failure rate and a priority based repair policy are assumed; the aim is to minimize the total number of stored items. It allows ELT between two bases, parts cannibalizing and it assumes limited repair capacity.

In VARY-METRIC the number of expected *backorder* at the bases is calculated when parts can be further disassembled into components (*multi-indenture*). As in METRIC, the model uses a (S–1, S) logic and it not allows for parts to exit the system, nor any kind of ELT. Deterministic repair times are considered and repairs cannot be delayed due to lack of parts.

Several authors have also relaxed some of the assumptions adopted in the model:

- ELTs between two bases (Axsäter, 1990; Sherbrooke, 1992) which allows for emergency supplies distribution, such as in military practice;
- Non repairable parts (Hill et al., 2007);
- Parts can be further disassembled into components (Muckstadt, 1973), however, generally, the product can fail because of the failure of a single component;
- Cannibalizing procedures, which allow to evaluate some issues in part allocation to the echelons due to the reuse of some components from items that can't be repaired anymore (Blazer and Rippy, 1988; Pyke, 1990).

19.2.1.2 Queueing Network Models

Multi-echelon systems can be also modelled by networks of queues; in this way, some assumption in the METRIC model can be relaxed. The most common approaches in literature are:

- *Breaking down in single queues*. This approach is used to represent complex models and it refers to multiple resources and limited repair capacity (bases/depot); the aim is to minimize the backorders number (Daryanani and Miller, 1992). An analytical solution is proposed for the problem of the spare parts in case of non-stationary demand (Jung, 1993), time-varying conditions (Balana et al., 1989) or considering *closed Jackson networks*;
- *Markovian representation*. In this case, the state of the system is represented by a multi-dimensional variable, where R_i is the number of parts to be repaired at the base i, O is the work in process, S_i is the number of spare parts available at the base i, R_o is the number of the parts to be repaired at the depot and S_o is the number of spare parts available at the depot. The problem can be solved using flow balancing equations. In real cases applications, however, the number of possible combinations grows very quickly. So, to reduce problem complexity iterative procedures or decomposition methods are often suggested (Albright, 1989; Albright and Gupta, 1993).

19.2.1.3 Graves' Model

The model developed in (Graves, 1985) concerns with a two levels inventory system. Assumptions are made like those in METRIC and, moreover:

- parts demand is modelled according to a composed Poisson distribution which depends on the number of working parts but not on the number of parts currently operating;
- all damaged parts are repaired at the repair station of the depot that also has a spare parts warehouse;
- *one for one* parts allocation policy is considered;
- a deterministic lead-time for repaired parts delivery is assumed.

After being repaired the part goes into the warehouse of the depot or it satisfies a *backorder* at the bases if it exists.

In order to characterize the orders at the bases (Eq. (19.1)), it is necessary to know the backorders distribution at the depot, $B(t|s_0)$, and make its convolution with the failures distribution at the bases, D. It is also necessary to disaggregate the overall demand, $Q(t)$, in the specific demands at the bases, $Q_i(t)$:

$$Q(t+T_1) \triangleq \sum\nolimits_{i=1}^{N} Q_i(t+T_1) = B(t|s_0) + D(t,t+T_1) \tag{19.1}$$

As proposed in (Simon, 1971):

$$\begin{aligned} \Pr\left[Q_i(t)=j\right] &= \sum\nolimits_{k=j}^{\infty} \Pr\left[Q[t)=k\right] \Pr\left(Q_i(t)=j|Q(t)=k\right) \\ &= \sum\nolimits_{k=j}^{\infty} \Pr\left[Q(t)=k\right] \binom{k}{j} \left[\frac{\lambda_1}{\lambda}\right]^j \left[\frac{\lambda-\lambda_1}{\lambda}\right]^{k-j} \end{aligned} \tag{19.2}$$

where $\lambda = \sum_{i=1}^{N} \lambda_i$ is the overall failure rate. Equation (19.2) requires the calculation of the spare parts needed and their allocation to the specific warehouses.

For this reason, two variants of the algorithm were developed: the first one to determine the exact allocation of the spare parts at each location and an approximate one in the case of huge repair capacity at the depot (Graves, 1985; Svoronos and Zipkin, 1991, Suri et al., 1993).

Grave's model is suitable for many industrial environments; however, when simply minimizing the *backorders*, it's impossible to appreciate the importance of some specific components being optimized and to highlight their availability. In this way one also cannot take into account cannibalization and/or ELTs.

19.3 Case Study

In this section some results will be presented about the configuration and dimensioning of a *multi-echelon* inventory system of a communications firm operating in the Italian market.

The firm offers integrated services for fixed/mobile telephony and Internet based services, with massive catchment area (16 million clients). The whole Italian territory is covered as concerns the fixed telephony and 99.5% of the population is covered by the GSM network.

The telephone system consists of a series of switching nodes distributed all around the national territory, each of which made of different electronic devices (Fig. 19.4).

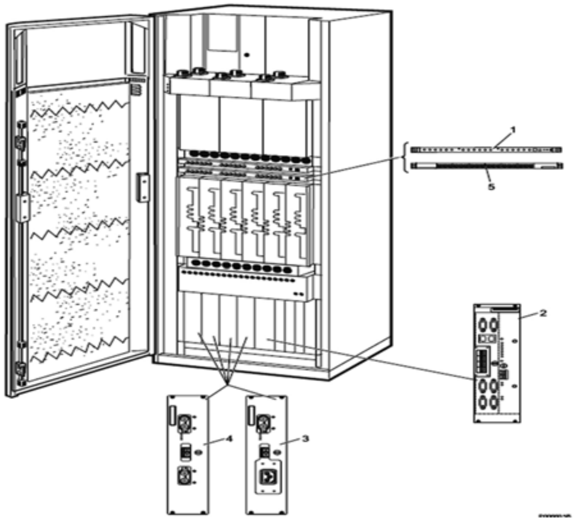

Fig. 19.4 Schematic representation of a switching node

In order to ensure each node is properly operating, a two levels hierarchical inventory system was implemented by the firm (Fig. 19.5, Table 19.3), consisting of logistics platforms (PLTs) and bases, or work-units (WUs). WUs are equipped with their own spare parts warehouse and provide direct support to all the nodes linked (usually, over 500 nodes for each WU). PLTs, on the contrary, group a number of WUs and, in addition to being equipped with their own spare parts warehouse, they provide repair services for the failed parts.

The main goal was to perform a high service level (99.5%) while minimizing the time to replace a failed part and the total inventory cost. The value of the service level is justified by observing that each switching node supplies several hundred users and that the malfunction of a node can generate multiple failure reports.

To ensure these results, the maintenance function of the company defined the inventory level at each echelon turning to a heuristic algorithm which was based on failure rates computing (considering the MTBF stated by the manufacturer of the

Fig. 19.5 PLTs and WUs distributions

Table 19.3 PLTs and linked WUs

PLT	WUs
Lombardia	35
Veneto	19
Lazio 1	9
Lazio 2	11
Toscana	7
Campania	20
Sicilia	9
Sardegna	3
TOTAL	113

electronic components installed in the switching nodes) and assuming the components demand at each WU varying according to a binomial distribution. Although this method has no scientific basis, and as unfavourable events have never happened, the algorithm proved to be sufficient reliable. Further analysis, however, showed that the results provided by the algorithm were obtained thanks to the coexistence of the underestimated value of the parts to be stored at each base or depot, "ad hoc" spare parts allocation in the available warehouses and the improper supply policies at the WUs which often overcame the inventory system hierarchy.

19.3.1 Inventory Dimensioning

Considering the hierarchical structure of the inventory system and since:

- taking into account the nature of the components, the failure rate can be modelled according to a stationary Poisson distribution;
- any fail in a switching node is at the most caused by the failure of one of its components;
- the failure probability of a component in the switching node is not dependent on the failure probability of another component in the same node;
- a *one-for-one* allocation policy is adopted;
- failed parts can always be repaired at the depot, so it never changes the number of parts circulating in the system;
- parts of the same type have the same characteristics;
- sufficient repair equipments are available at PLTs so to make negligible the waiting during the repair of a part;
- after the repair, the reliability decrease in the part is negligible;
- the parts cannot move from one base to another base (no ELTs);
- a deterministic lead-time for repaired parts delivery is assumed;

a new dimensioning of the inventory levels is proposed, applying Graves' algorithm to the eight hierarchical inventory networks. In Table 19.4 a comparison is made between the inventory levels generated by Graves' algorithm and those generated by the empirical algorithm considering one of the inventory systems mentioned above.

Table 19.4 Comparison between inventory levels

	PLT	WU	Total
Graves	41	125	166
Empirical	42	39	81

The small values obtained (if compared with the number of customers) are obviously due to the high value of the MTBFs. Generally speaking, similar inventory levels are obtained at the PLT but the difference at the WUs is much more remarkable. This results applies to any of the eight networks considered. The difference is, however, due to some assumptions and characteristics of the heuristic algorithm. In fact, while the heuristic method provides for a *critical* or *non-critical* classification of the parts, the new method allows for four priority levels. Not being able to modify the old algorithm, the values in the new model were standardized, whereas *non-critical parts* were considered those with priority level equal to 1 and *critical parts* were considered those with higher priority levels. The results are summarized in Table 19.5.

Another correction is due to the practice of considering negligible the bases that are "sufficiently close" to the PLTs, allowing for a direct management of the failures

Table 19.5 Comparison between inventory levels (with priority level correction)

	PLT	WU	Total
Graves	41	60	101
Empirical	42	39	81

Table 19.6 Comparison between inventory levels (with direct management correction)

	PLT	WU	Total
Graves	**35**	**57**	92
Empirical	42	39	81

generated by the linked switching nodes. In this way, some of the clients of the WUs are cancelled and the efficiency rate of the available resources is reduced. Adopting this approach in the new model would result in a further decrease in the overall inventory level at the WUs (Table 19.6).

19.3.2 Building the Simulation Model

In order to verify the reliability of the results provided by Graves' method, the structure of the inventory system has been reproduced in a logical model to perform a discrete *event-driven* simulation (Arena 8.0® has been adopted). Once the model is initialized with the inventory values provided by the algorithm, the service level provided by the specific allocation of the components will be measured and compared with the desired one (99.5%).

The model refers to the example presented in the previous paragraph. In setting its parameters we proceeded consistently with the assumptions made when Graves' method has been applied.

The four blocks "Create" arranged at the beginning of the model (Fig. 19.6), generate a "failure" for each of the four type of parts in a switching node. In this respect, although at each node the distribution of faults should be modelled according to a Poisson distribution, since the large number of switching nodes connected to each base (over 500), it has been preferred to use a single "failures generator", modelled according to a normal distribution whose average and variance were obtained by applying the *Central Limit Theorem* accordingly to the historical data records.

Each sub-model represents the inventory sub-hierarchy referred to the specific part for which a fault is generated (Fig. 19.7).

The "failure" entities will be sorted by the decisional block in an equiprobable way to the other processing blocks. This is a reasonable assumption because each time a fault is generated at a switching node, it will take a piece from the WU which the node is connected to. In our case, not being able to locate the node which generates the fault, it can be assumed that this could happen in any of the nodes, so the removal of the spare part from WUs is equiprobable.

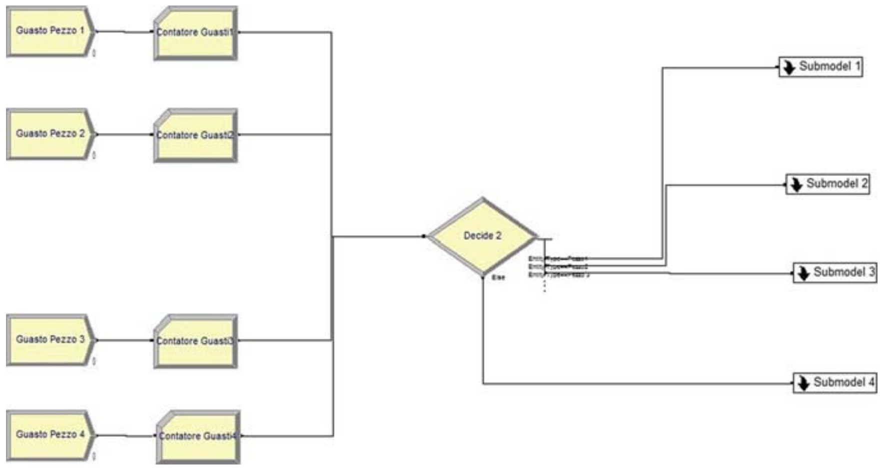

Fig. 19.6 Logical model of the inventory network

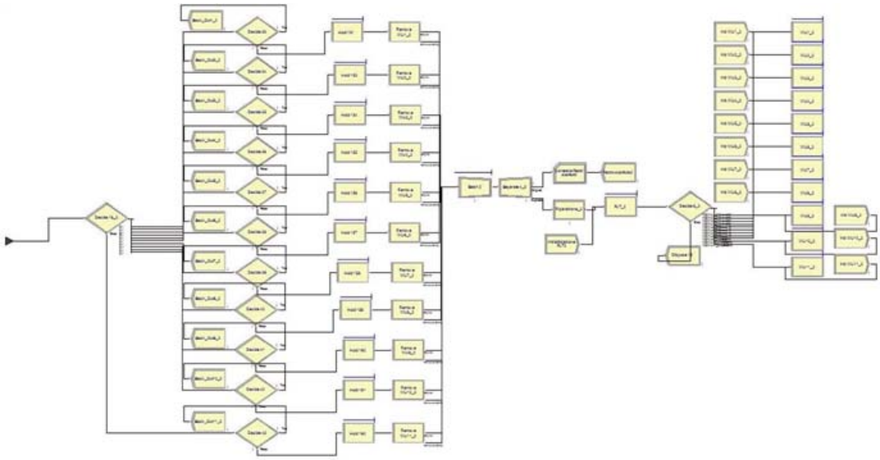

Fig. 19.7 Hierarchical inventories sub-model

Without going into the model details, it is worth remembering that:

- it’s possible to set the *mean time to repair* (MTTR) for each component in the switching node and therefore the time spent at the specific block “Hold” (which represents the repair depot at the PLT);
- the electronic cards are always repairable and after the repair their reliability remains unchanged;
- in the time-frame we referred to, there aren’t any technological innovations such as to justify the replacement of the parts with newer ones;

- backorders are generated in the system when a part requested by a WU is unavailable at the WU warehouse and at the PLT warehouse. The number of backorders generated reduce the expected service level.

Although inventory dimensioning is usually carried out on a 6-month or annual basis, when the simulation has been done, it has been referred to larger time-frames in order to draw the most significant conclusions because of the very high values of the MTBFs (Figs. 19.8, 19.9, and 19.10).

Looking at the diagrams one can deduce that, regardless of time-frame considered, after about 140 iterations the average value of the service level is around 97.6%.

Although this value is sufficiently close to that obtained by Graves' algorithm, it should be remembered that in order to guarantee a 99.5% service level it may be necessary to considerably increase the overall inventory level. The difference

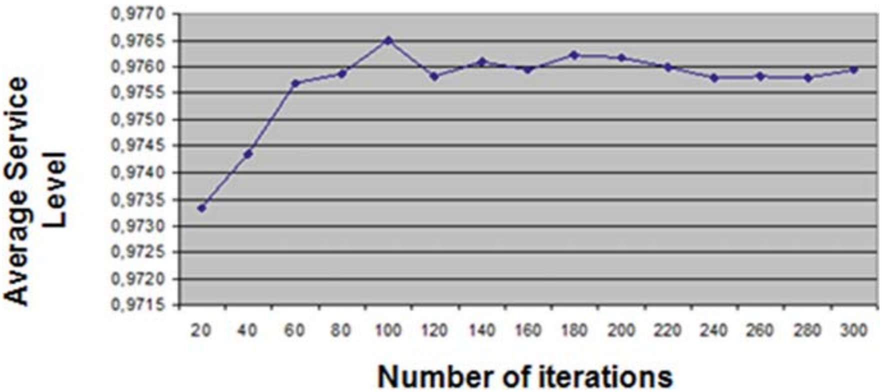

Fig. 19.8 Average service level vs number of iterations (5 years)

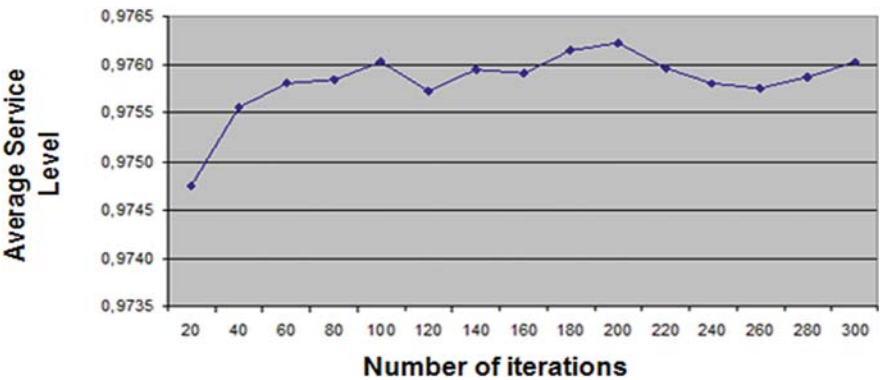

Fig. 19.9 Average service level vs number of iterations (7 years)

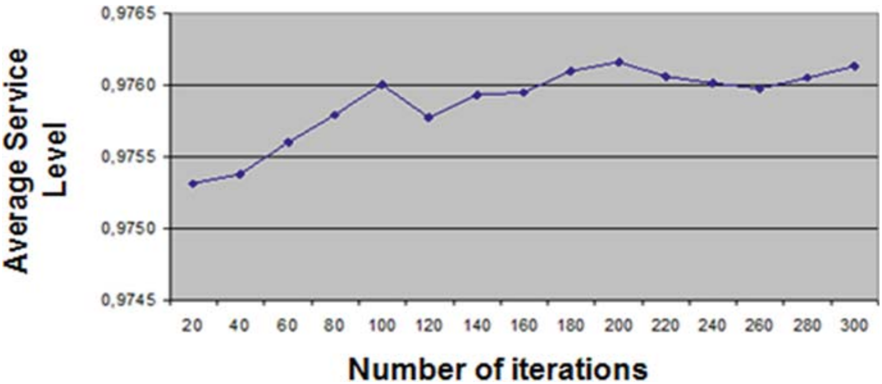

Fig. 19.10 Average service level vs number of iterations (10 years)

is, however, justified by the approximations made in designing the logical model. Particularly, considering a single "failures generator", characterized by a normal distribution of the failures, rather than a set of Poissonian generators, determined a deviation from the expected service level. In fact, the service level increases when considering the inventory networks with the highest number of switching nodes, reaching, at best, 99.3%.

19.4 Conclusions

Proper inventory management is a crucial point for any company in reducing costs and improving the service level guaranteed to the customers. When the production system is configured as a *supply chain* or as a *network organization*, turning to *multi-echelon* inventory systems allows for pointing out the advantages of supporting suitable repair policies with optimal inventory level definition and *replenishment* policies specification, in terms of: service level increase, reduction of costs incurred for parts/components storage, reduced internal/external lead times. After an in-depth literary review about existing inventory management models and techniques, the results obtained by the authors in dimensioning a *multi-echelon* inventory system for a communications company operating in the Italian market were presented. Constructing and implementing its logical model in a discrete event-driven simulation, confirmed the effectiveness of the choices and highlighted, at the same time, further possibilities of performance increase.

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Chapter 20
Alignment of Strategy-Managerial Characteristics and Performance at the Functional Level in Dubai Local Government

Ali Sebaa, James Wallace, and Nelarine Cornelius

Abstract Demographic managerial characteristics are an important influence on strategy (Miller and Toulouse, 1986; Govindarajan, 1989). Building on previous research, this study is novel in that it investigates the models of executive influence at the level of functional managers. The Miles and Snow (1978) typology is applied to the functional strategy for a public sector organisation, to investigate whether functional units pursuing strategies are led by functional managers with dissimilar attributes, and whether the strategy-manager alignment is related to performance of the functional unit. Findings from 294 Dubai local Government employees showed that several demographic managerial characteristics are associated with strategy types and effect performance.

20.1 Overview

Effort has been spent by researchers in the pursuit of a better understanding of the factors that contribute to superior organisational performance. Contingency theorists have consistently argued that the "fit" between the organisation environment and the environment organisation is necessary for optimum performance and effectiveness (Galbraith, 1973). Strategists have also supported this line of thought by advocating that optimum use of the available resources will occur when a "fit" is achieved between the organisation's strategy, its structure and the environment within which it is located (Andrews, 1971).

Strategy research has placed great emphasis on the role of top executives in orchestrating the strategy development process. Andrews argued "... there is no way to divorce the decision determining the most sensible economic strategy from the personal values of those who make the choice" (Andrews, 1971, p.34). Several researchers in this field have concentrated on investigating the relationship

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between leadership and strategy. The seminal study of upper-echelon theory by Hambrick and Mason (1984) emphasises the importance of matching characteristics of top managers with the organisation's strategy. They advocate the importance of these demographic characteristics and view the organisation is a reflection of the characteristic traits of its top managers.

After Hambrick and Mason (1984), many researchers have also investigated the importance of matching characteristics of top managers to strategy, but at both the corporate (Miller and Toulouse, 1986) and business unit levels (Govindarajan, 1989; Thomas et al., 1991). Despite this, matching still needs to be researched, as there is a dearth of empirical studies on these relationships at the functional level of strategy.

This paper extends prior research in the field by investigating the match between the characteristics of functional managers and the impact these have on the successful introduction of functional strategy, by customising an extended model (Hambrick and Mason, 1984; Carl and Baik, 2000; Karen et al., 2004) to accommodate the public sector. This models multiple demographic managerial characteristics, strategy and performance and executive influence at the level of functional managers. Thus, this study applies and extends an extant model to a new population of managers, and at a different organisational level.

Managerial characteristics to be considered included: age, level of education, and tenure. The objective here is to better understand management attributes and their potential relationship with organisational performance through successful implementation of functional strategy in a poorly researched business sector. To achieve this, two research questions are addressed: Are certain managerial characteristics or attributes associated with specific functional strategy types? and; Does alignment of appropriate managerial characteristics, in conjunction with strategic type, improve performance? Research combining these issues and related hypotheses will be tested using data from functional managers for the departments of Dubai local government.

20.1.1 Functional Strategy

There are three different (hierarchical) levels of strategy, namely: corporate, business and, functional. Strategic intent cascades down from the top levels of the organisation to influence and mould the lower levels of strategy. Corporate strategies are formulated by the top management of the organisation and define what business(es) a firm should be involved in and how its resources should be allocated across these businesses. Business strategies are formulated by the management of individual business units or strategic business units and focus on how the business should compete in a particular industry or product/market segment. Functional strategies are the plans and activities of functional units such as marketing, production, finance, etc., and aim to achieve business objectives and corporate goals. Business strategy reinforces corporate strategy and, in turn, is supported and operationalised by functional level strategies. In theory, then, strategies at the lower levels of management should be consistent with the higher corporate levels to foster the successful accomplishment of these higher levels (Hofer and Schendel, 1978).

20.2 Research Model

Researchers have frequently used typologies to study organizational strategy, with several typologies receiving substantial attention. Some strategic classification schemes primarily relate to specific industrial or for-profit environments. Examples of schemes more appropriate for the for-profit sector are Porter's (1980) low cost leadership and Galbraith and Schendel's (1983) industrial products; these typologies generally have less applicability to the non-profit environment. Miles and Snow's (1978) typology, however, has been shown to have wide applicability and suggests that all organizations follow behaviour patterns that can be classified into one of four fundamental strategic types: prospectors, defenders, analysers or reactors. Each strategic orientation leads to a different response to, what the authors, term entrepreneurial, engineering and administrative problems.

Here they define a prospector organisation as a creator of change in their industry. Being the first to market with a new product is the constant goal with innovation as the key to their success. Therefore, they focus their efforts more consistently than other strategic types on growth and innovation. Defender organisations usually direct their products or services to a clearly defined market and emphasise a stable set of products and customers. They constantly strive to update their current technology to maintain efficiency. Innovative change, growth and diversification are achieved incrementally through market penetration. Reactor organisations do not take a lead; rather, they react to market pressures and demands. They do not seek to innovate or to be the first-to-market and have little involvement in research and development.

The analyzing strategy can be seen as, "essentially an intermediate type between the prospector strategy at one extreme and the defender strategy at the other" (Walker and Ruekert, 1987b, p. 17). As we are interested in applying the Miles and Snow model to functional units in public sector organizations, and as these typically deal with conflicts that have competing goals, more so than functional units in non-public sector organisations (Pollitt and Bouckaert, 2004; Kickert, 2008), it is unlikely that this "composite mix" strategic type could be successfully pursued. Consequently, the analyzer strategy type is not included in the model that we introduce (Andrews et al., 2007).

The basic premise on which the proposed model is based is that different strategies require different managerial characteristics to increase the likelihood of success and that when an alignment between the characteristics of top executives and the requirements of their strategies is achieved, performance will be enhanced. From the literature we propose the model exhibited in Fig. 20.1 for modelling the performance of implemented functional strategies as a consequence of the match or alignment between the characteristics of managers from functional units and functional strategy.

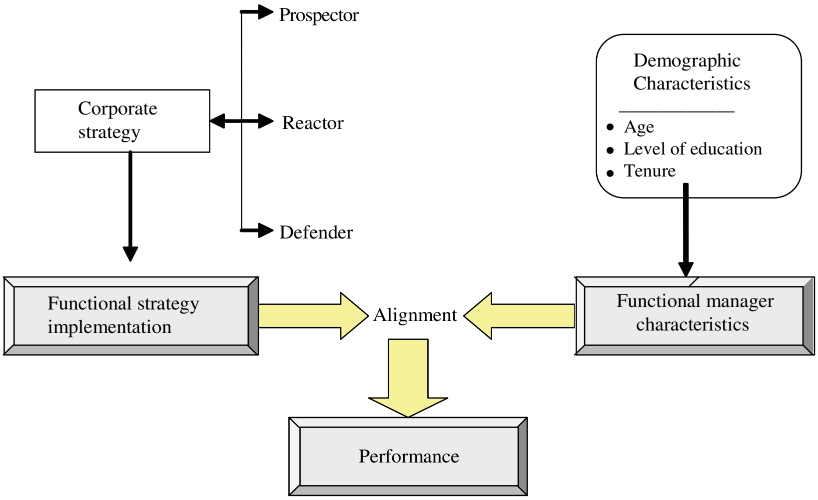

Fig. 20.1 The research model

Over time, manager's characteristics are reflected in the decisions, actions and the implementation of strategy in the organization. Implicit in our model for functional managers is the assumption that alignment of characteristics and strategy type will also lead to improved performance. When this alignment between functional manager characteristics and functional strategy does not exist, results may be disappointing. As the functional manger also has a pivotal role in implementing functional strategy (Steven and Bill, 1992), we argue that this assumption is both plausible and credible.

20.2.1 Hypotheses

Several studies have investigated the relationship between managerial characteristics and strategy implementation, and related research has emphasised three streams (Finkelstein and Hambrick, 1996). The majority of these research works have concentrated on background characteristics, which includes: age, gender, tenure, formal education, and experience. Whilst the ethnic backgrounds of employees in the United Arab Emirates are highly varied, it is currently still not usual for large numbers of females to hold senior managerial positions. We do not, therefore, investigate gender as a determining characteristic due to a lack of cases. In addition, the reactor functional manager will, by implication, exhibit, on average, intermediate demographic characteristics to those of the prospector and defender manager. Performance results are also expected to be rather mixed and somewhat arbitrary due to the lack of strategic focus. As a consequence, we also do not investigate this strategy type any further. The model used for this study consequently includes manager's demographic characteristics of age, level of education, tenure and experience. We now justify inclusion of these characteristics and develop testable hypotheses for relationships between these.

20.2.1.1 Age

A number of studies have examined the age of managers in relation to change, innovation and risk taking. Age of the manager has been found to correlate, negatively, with: receptivity to change (Wiersema and Bantel, 1992); innovativeness and innovation (Bantel and Susan, 1989); willingness to take risk (Hambrick and Mason, 1984), and; with organisational growth (Ellis and Child, 1973).

Based on the literature, we posit that prospector and defender organisations will approach strategic direction differently and that this approach will be reflected in the selection of their managers. Prospectors will seek leaders who are younger, with a fresh perspective conducive to change and innovation. Defenders will seek older leaders to ensure valued core efficiency and control competencies. Specifically, we argue that:

H1: Functional managers of successful prospector units will be, on average, younger than functional managers of successful defender units.

20.2.1.2 Educational Levels

A number of researchers suggest that the education levels of managers are reflected in their organisational outcomes. Notably, this level of education has been found to be positively associated with receptivity to innovation (Bantel and Susan, 1989; Hambrick and Mason, 1984; Wiersema and Bantel, 1992; Finkelstein and Hambrick, 1996). From the literature, we can conclude that education level is, on average, positively correlated with receptivity to innovation, change and growth.

Miles and Snow's (1978) typology defines a prospector organisation as a creator of change in their industry. Being the first to market with a new product is the constant goal with innovation as the key to their success. Therefore, they focus their efforts more consistently than other strategic types on growth and innovation. Defender organisations usually direct their products or services to a clearly defined market and emphasise a stable set of products and customers. They constantly strive to update their current technology to maintain efficiency. Innovative change, growth and diversification are achieved incrementally through market penetration.

From the literature, therefore, level of education is related to innovative activity. As Miles and Snow identified innovation as a characteristic of the prospector strategy type, we hypothesise that:

H2: Functional managers of prospector units will have, on average, higher educational levels than those for functional managers of defender units.

20.2.1.3 Tenure

Tenure is defined in a number of ways in the literature (Patrick et al, 2006). It is the amount of time spent by an individual in a job, organisation, position or industry. Specifically, this study is interested in job and organisation tenure: job tenure is defined as the time a person has been the manager of a functional department; organisation tenure is the time that a manager has been employed in any capacity by their current organisation.

Those studies that investigated the relationship between managerial characteristics and behaviour also found evidence for similar relationships between managerial behaviour and tenure (Thomas et al., 1991; Hambrick and Mason, 1984; Ellis and Child, 1973; Wiersema and Bantel, 1992; Bantel and Susan, 1989). Hambrick and Mason (1984) argued that those managers who have spent a long time in one organisation are likely to have limited perspectives and tend to avoid radical changes. Ellis and Child (1973) also found that longer tenure is associated with a conservative and more averse risk-taking outlook. Thomas et al. (1991) also found that long-tenured executives tend to pursue defender strategies whereas short-tenured executives are more likely to pursue prospector strategies.

Organisations associated with defender strategies are more closely aligned with stability and resistance to change. Thus, organisations adopting the defender strategic type are likely to value long tenure (Miles and Snow, 1978). Prospector organisations are considered to be innovative and accepting of change, and consistent findings throughout the literature associate shorter tenure with organisational change, willingness to accept risk and openness to fresh, diverse information (Finkelstein and Hambrick, 1996).

It is therefore argued that prospectors will innovate more and are comfortable with change. As these are also characteristics associated with shorter tenure, it is expected, that functional managers pursuing a prospector strategy will have, on average, shorter tenure than their counterparts pursuing a defender strategy.

Consistent with the above arguments, it is posited that:

H3a: Functional managers of prospector units will have average organisational tenure that is shorter than that for functional managers of defender units.

H3b: Functional managers of prospector units will have average job tenure that is shorter than that for functional managers of defender units.

20.2.1.4 Alignment and Performance

We have argued that firms will perform better when functional manager's demographic attributes align with the functional strategy. Therefore, it is expected that functional managers who are young, more educated, and have shorter job and organisational tenure will perform better, on average, in functional units pursuing a prospector strategy. In contrast, functional managers who are older, less educated, and have longer job and organisation tenure will perform better, on average, in functional units pursuing a defender strategy.

These observations are represented in the following hypotheses:

H4: Prospector functional units will show higher performance, on average, when led by younger managers.
H5: Defender functional units will show higher performance, on average, when led by older managers.
H6: Prospector functional units will show higher performance, on average, when led by more educated managers.
H7: Defenders functional units will show higher performance, on average, when led by less educated managers.
H8: Prospector functional units will show higher performance, on average, when led by a shorter-tenured manager.
H9: Defender functional units will show higher performance, on average, when led by long-tenured managers.

20.3 Research Methodology

The target population for our research is Dubai local government, which consists of 18 organisations. The data were collected from managers of two levels for each organisation, First, Strategy survey were conducted of 18 organisations comprising more than 800 functional managers. Data were collected from managers at two levels in each of the organisations. Firstly, a strategy survey was conducted for board member managers as well as in-depth interviews with one board member manager for each organisation. Secondly, a questionnaire based survey of functional managers was conducted on 683 randomly selected managers from the functional units. To investigate and test the research model, data collection started with interviewing a board member manager for each organisation. So that participation was informed, each was a manager of their organisation's strategy unit, responsible for designing, implementing and measuring the organisation's strategy. The interviews were analysed using content analysis.

Depending on the study objectives, two separate questionnaires were further developed and sent to two different levels of managers in each organisation. The first questionnaire examined the organisation's strategies and was sent to between 5 and 7 board members in each organisation, depending on size of the organisation. A total of 98 board member managers were contacted and provided with hard copies of the questionnaire. Forty eight managers responded with the desired minimum of two responses from each of the 18 organisation being achieved.

The second questionnaire was sent to 683 functional managers of the 18 organisations. This contained questions informed both by the interviews conducted with the strategy unit board member managers and relevant questions from the extant literature. To increase the response rate the 683 randomly selected functional managers were contacted personally, prior to the distribution of the questionnaires, and the objectives of the research were explain to them. They were also notified of the complete support for the survey by senior management of Dubai's local government and given assurances of confidentiality. They were subsequently provided with hard copies of the questionnaire. Due to cultural issues and the demographic nature of the residents of Dubai this is the preferred contact protocol by public sector managers. A total of 255 completed responses were received from the functional managers, with an additional 39 responding to a reminder, making a total of 294 usable responses. This is a response rate of 43.4% which is consistent with that to other questionnaire based surveys that have been conducted in the region (Hossam, 2008).

20.3.1 Research Variables

In this study, three major groups of variables, namely, functional strategy, managerial demographics and performance are used and measured. We discuss the individual indicators for these in the following sections.

20.3.1.1 Measurement of Strategy

A single nominal variable, based on the typology of Miles and Snow (1978), will be used to classify the functional strategy. Strategic orientation was measured in four ways, namely: self-typing; objective indicators; external assessment, and; investigator inference (Snow and Hambrick, 1980). Combinations of these four approaches were used.

The *self-typing* measure is typically done in two ways. One is referred to as a "paragraph" approach. This approach entails the presentation of short, descriptive paragraphs of each strategic style to the respondents, who then choose the description that most closely resembles their organisation compared to their competitors. The self-typing paragraph approach is the quickest for respondents but does not get at all the nuances of the adaptive cycle (Snow and Hambrick, 1980). The other approach consists of a multi-item scale. In this case, questions were singly used to refer to an aspect of the adaptive cycle. The four possible responses to each question equate to each of the strategic types - prospector, defender, analyser and reactor, without referring to them by name. The use of multiple indicators does provide for more detail in strategic response (Conant, Mokwa and Varadarajan, 1990). Both approaches for the self-typing method are widely used as they provide the best way to assess the strategy of a company from those enacting it.

Objective indicators have been used by Hambrick (1983). Hambrick classified organisations by strategic type using percentage of sales of new products relative to the same measure from the firm's three largest competitors. The major disadvantage is the difficultly in finding the appropriate data that reflects strategic orientation from competitors (Snow and Hambrick, 1980).

External assessment entails using the same instrument as for self-typing but administering it to a panel of expert judges within the industry rather than to internal respondents (Meyer, 1982). External measures provide an "expert" judgement on an organisation's strategic orientation. The advantage here is the impartial assessment given by the outside observers. Disadvantages of this type of measure include the chance that the expert does not have current knowledge of the strategic orientation of all the firms of interest to the researcher. Moreover, as Snow and Hambrick (1980) observe, their opinions may be inaccurate in some instances.

Investigator inference makes use of the judgements of the researchers who base their responses on interviews with company officials (Walker and Ruekert, 1987a). Investigator inference is perhaps the weakest of the methods discussed. It does have the potential advantage of providing a very accurate assessment of strategic orientation but only if the researcher thoroughly understands the inner workings of each company he/she is investigating and possesses the most current information. These conditions, of course, impose limits on the size of the sample that can be effectively analysed and highlights the difficulty involved in securing current data. Other disadvantages include the investigator's perceptual bias and the researcher's desire to fit the results to a preconceived theoretical framework. Due to these limitations, this method is the least reliable of the four examined (Snow and Hambrick, 1980).

The order of "accuracy" of these measures from the most accurate would be: self-typing, external assessment, objective measurement, and finally, investigator inference (Snow and Hambrick, 1980). The *self-typing* method and *investigator inference* methods were used here to gain the most accurate measure of strategic orientation. In applying the self-typing method, we targeted the two organisation levels in this study. We combined both approaches in the drafting and administration of the board members' and functional managers' questionnaires. The paragraph approach was used in the functional managers' questionnaire; the respondents were expected to responses to short, descriptive paragraphs of each strategic style by asking them to choose the description that most closely resembles their functional strategy. This approach is the most appropriate one to be used here, since it is likely to be easy to understand by the functional managers. This in turn helps them to make a clear and direct indication of their preferred functional strategy. In addition, this method is the quickest approach for respondents since it will help to conserve time so that the time can be used for the other portions of functional mangers questionnaire (managerial characteristics and performance measurement).

Since the board member has an informed view of strategy implementation, it was deemed appropriate to use a more detailed approach to examine their perceptions. Here, the multi-item scale is more suitable than the paragraph approach. Consequently, respondents were asked 12 questions adapted from the survey instrument reported by Andrews et al. (2008). This survey is appropriate for the present study as it has been recently applied successfully to a diverse UK based local authorities.

The prospector strategy was assessed through four measures of innovation and market exploration, as these are characteristics in Miles and Snow's (1978) definition of this orientation. The specific measures are derived from the works of Snow and Hambrick (1980) and Stevens and McGowan (1983). To explore the defender strategy, three questions assessing whether the approach to service delivery was focused on core activities and achieving efficiency were included (Snow and Hambrick, 1980; Stevens and McGowan, 1983; Miller and Toulouse, 1986). In contrast, reactors are expected to lack a consistent strategy and to await guidance on how to respond to environmental change. Five questions about the existence of definite priorities in the service they provide and the extent to which their behaviour was determined by external pressures were present in the questionnaire. We again based these measures on prior work (Snow and Hambrick, 1980), taking particular care to avoid leading questions, for example, by excluding the term “react” from the relevant items.

The second method used to measure the strategy orientation was the investigator inference method. This was by conducting interviews with the board member managers of strategy units for each organisation. These are expected to have a clear view about the organisation strategy. The style for the “interview” was semi-structured since this type of interview is flexible because it does not restrict the researcher to specific questions prepared in advanced. Face-to-face interviews were used as these generally achieve higher response rates than interviews by telephone, especially, when targeting managers in the public sector. Moreover, the interviewer can benefit from tracing any possible body language and investigate this further, if required.

20.3.1.2 Demographic Characteristics Measures

The demographic characteristics include age, level of education and tenure of the functional managers. Age was simply measured by number of years. Education has been measured as a continuous variable in many studies. For example, Thomas et al. (1991) measured level of education by adding their years of college experience to the number 12, which represents a high school diploma. This procedure created a continuous measurement with a bachelor’s degree equalling 16 and a master’s degree equating to 18. In this study, a similar continuous measurement technique was used to assess level of education. Respondents were asked to indicate the highest level of education they had attained among these alternatives: some high school, high school diploma, some college, bachelor, master and doctoral degree. These were then transformed to a number grading using a six-point scale, the highest on the scale reflecting the highest level achievable (that is 6 = doctoral degree).

> Tenure was also measure in years of service. Specifically, this study included job and organisation tenure. As such, the survey simply asked the functional managers for the number of years already spent in their current organisation and their tenure in years as a manager of their current functional unit.

20.3.1.3 Measurement of the Performance of the Functional Units

Performance for business organisations in typically based upon accounting data such as profit growth, profit margin, sales increase, market share, and return on investment, etc. However, given the nature of the target organisation some adaptation of measures was required for a public sector environment. A robust measure of performance for public sector organisations should be a comprehensive measure that covers many of the concerns of public management researchers, such as quality, efficiency, effectiveness, responsiveness, and equity (Venkatraman and

Ramanujum, 1986; Carter et al., 1992; Boyne, 2002). The study used the Core Service Performance measure (CSP), a measure that has been used successfully in English local government (Andrews et al., 2007). It covers six dimensions of performance: quantity of outputs, quality of outputs, efficiency, formal effectiveness, value for money, and consumer satisfaction. These embrace all the main areas of local government activity.

Here we used 10 questions from this instrument for the questionnaire for functional managers. These are Likert type questions and the average value for these is used as a dependent variable, represent the performance of functional unites.

20.3.1.4 Data Analyses

To test hypotheses H1, H3a and H3b, independent samples t-tests were conducted. This is appropriate as the samples are large in all instances. Hypotheses H4, H5, H8 and H9 were appraised using one-tailed tests of the Pearson correlation coefficient. For H6 and H7, a one-tailed (directional) test of the Spearman correlation coefficient was undertaken as education is measured on the ordinal scale. H2 was tested using a Mann-Whitney test, again, as education is ordinal.

20.4 Results and Discussion

Summary statistics for the demographic characteristics are exhibited in Table 20.1. All standard deviations for corresponding prospector and defender data are similar and subsequent tests for equality of the variances confirmed this. The independent samples t-tests consequently assumed equal variances and were one-tailed to reflect the directional nature of the hypotheses they were testing.

Table 20.1 Summary statistics for demographic characteristics

Characteristic	Strategy	Sample Mean	Standard Deviation
Age	Prospector	34.90	6.672
	Defender	34.43	6.609
Education	Prospector	3.73	1.112
	Defender	3.43	1.197
Organisation tenure	Prospector	9.38	5.679
	Defender	11.06	5.827
Job tenure	Prospector	5.29	2.835
	Defender	6.10	2.702

Sample size: Prospector = 178; Defender = 82.

Table 20.2 presents the results for these tests for H1, H3a and H3b. The mean age of functional managers from prospector units is not significantly different from that for their counterparts in defender units, and so we have no support for H1 from our data. The results do, however, support H3a and H3b since functional managers of

Table 20.2 t-Statistics for independent samples tests

Characteristic	Hypothesis	t-Statistic
Age	H1	–0.532 (NS)
Organisation tenure	H3a	2.197*
Job tenure	H3b	2.160*

NS = Not significant at $\alpha = 0.05$, *= P<0.05.

prospector units have significantly shorter organisation and job tenures than those of defender units. From the Mann-Whitney test, functional managers employed in prospector units have significantly higher levels of education, on average, (P=0.024, 3 d.p.) than functional managers of defender units, which lends support to H2.

The effect of strategy type and managerial characteristic alignment on performance was tested using one-tailed tests for the resultant correlation coefficients [Spearman for H2]. As shown in Table 20.3, age is not a significant characteristic in determining higher performance for either prospector or defender functional managers. Education did prove to be highly significant for both strategy types thus providing strong support in favour of H6 and H7, respectively. Finally, both organisation and job tenure were significant, for prospectors and defenders providing significant support for H8 and highly significant support for H9.

Table 20.3 Hypothesis and correlation coefficients for performance and demographic characteristics

Hypothesis	Strategic orientation	Characteristic	Correlation coefficient (r)
H4	Prospector	Age	–0.111 (NS)
H5	Defender	Age	0.091 (NS)
H6	Prospector	Education	0.226*
H7	Defender	Education	–0.255*
H8	Prospector	Organisation tenure	–0.176**
H8	Defender	Job tenure	0.244*
H9	Prospector	Organisation tenure	–0.137**
H9	Defender	Job tenure	0.330*

NS = Not significant, *P = <0.01, **P = <0.05.

20.5 Conclusions

Our research confirms the traditional view that prospector managers have, on average, higher educational status than that of defender managers. However, in Dubai local government, age is not a determining characteristic whereas both organisation tenure and job tenure are.

We further demonstrate that overall increases in performance can be achieved at the functional management level by alignment of demographic characteristics with strategic orientation. We identify educational attainment and organisation and job tenure as instances of demographic characteristics where alignment is desirable. Age was not shown to be of relevance, though. This study consequently supports the view that results from upper echelon theory also apply at the functional level, emphasising the role of the functional managers in strategy implementation at the lower management levels of the organisations.

The study is limited in that it has been conducted at a single destination, in a single organisation, and specifically in a public sector employer. Moreover, Dubai has one of the fastest growing populations and economies in the world. The case may therefore have limited external validity other than for public sector administration in rapidly developing economies.

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Part VIII
What is Next by Challenge: PMM Innovative Way of Measurement

Chapter 21
Understanding Organisational Knowledge-Based Value Creation Dynamics: A Systems Thinking Approach

Francesco Sole, Daniela Carlucci, and Giovanni Schiuma

Abstract In the modern knowledge economy knowledge assets play a pivotal role in companies' value creation. Despite that, there is still a lack of approaches suitable to disentangle and assess how these assets take part in value creation. This represents a critical issue to face in order to make managers able to take better informed management decisions with regard to knowledge assets allocation and management This paper describes a model for analyzing how knowledge assets, properly managed, create value over time. The proposed model is grounded on principles underpinning the Systems Thinking approach and strategy maps. The paper presents a practical application of the model.

21.1 Introduction

The emergence of the knowledge economy has seen knowledge assets becoming a strategic source of company's competitiveness (e.g. Grant, 1996; Itami and Roehl, 1987; Teece, 2000).

Companies have become more and more aware that their sustainable competitive advantage results both from the possession of resources that are hard to transfer and accumulate, inimitable, not substitutable, tacit in nature, synergistic, not consumable because of their use and the ways of developing them. Consequently, managing knowledge assets has become relevant for companies in order to enhance value created for key stakeholders and to maintain competitive strength (e.g. Boisot, 1998; Grant, 1996; Liebowitz, 1999; Teece, 2000).

Despite that, there is still a vague view about knowledge assets as value drivers. Especially, the mechanisms through which knowledge assets take part in value creation are not yet well understood (Daum, 2002; OECD, 2007; 2008). Certainly, understanding in depth how knowledge assets create value is quite challenging. Nevertheless it is highly important both for strategic and managerial purposes such

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as, for example, the formulation of strategic assumptions concerning the exploitation and development of knowledge assets or the proper management of company's knowledge assets. More generally, a better understanding of how knowledge assets convert into value helps to overcome causal ambiguity of how value is created by investing in the development of knowledge resources.

Recently, several scholars have investigated the interrelationships between intangible resources and organisational performance, by focusing on different questions or adopting specific point of views (see e.g. Carmeli and Tishler, 2004; Kaplan and Norton, 2004; Roos et al., 2005; Teece, 2007).

The academic and practitioner interest about knowledge assets as value drivers is growing and the research on this emergent subject appears still widely open to new theoretical and practical contributions. Especially, more actionable approaches and tools, able to disentangle the complex dynamics through which knowledge assets take part to company's value creation need to be addressed (Adams, 2008; Carmeli and Tishler, 2004; Daum, 2002).

This paper proposes a model, the Knowledge Assets Value Dynamics Map, (KAVDM) aimed to the understanding of the ways through which knowledge assets are dynamically involved in company's value creation, in accordance to cause-and-effect mechanisms.

The model provides a visualisation and description of the causal links between knowledge assets and organisational performance outcomes and allows to understand the dynamics through which knowledge assets drive value creation in terms of performance improvement.

The KAVDM draws on strategic management issues, regarding the use of the strategy maps (Kaplan and Norton, 2000; 2004) and the success maps (Neely et al., 2002) and on principles of the Systems Thinking.

The paper is organised as follows. In the second section, the role of knowledge assets in company's value creation is briefly addressed. In the third section, the mapping methodology is introduced as a powerful approach to visualize the knowledge foundation of company's value creation. Then, in the fourth section, the KAVDM is presented. In the fifth section, a case example of the application of the proposed model is described. Finally, in the last section, conclusions and suggestions for future research are provided.

21.2 Knowledge Assets and Company's Value Creation

Understanding why knowledge assets matter for company's value creation entails a clarification of the concept of value creation and the relationships linking knowledge assets to company's ability to generate value.

Management literature suggests that for a company value creation means, first and foremost, to define and deliver the value propositions aimed to satisfy its key stakeholders (Berman et al., 1999; Donaldson and Preston, 1995; Freeman, 1984; Jawahar and McLaughlin, 2001). For this purpose, a company manages the processes that allow to produce and deliver value in terms of outputs and outcomes. On the other hand, the effective management of the organizational processes depends on the appropriate development, exploitation and deployment of organisational competencies (Amit and Schoemaker, 1993; Grant, 1996; Lev and Daum, 2004; Prahalad and Hamel, 1990; Teece et al., 1997). Organisational competencies, in turn, are closely related to knowledge assets. In this regard, several authors (e.g. Hamel, 1994; Mills et al., 2002; Sanchez, 2001) have argued that competencies result from a set of knowledge resources coordinated in a way that provides a particular level of performance in a firm. Andriessen (2004) states that value is created not through transfer between knowledge assets, but such transfer that occurs in the context of organizational competencies. Sanchez (2001) describes competencies as the ability of an organisation to sustain coordinated deployments of assets in ways that help the organization to achieve its goals.

Therefore, the development, combination and exploitation of knowledge assets affect the growth of organizational competencies. This, in turn, influences the effectiveness and efficiency of organisational processes and, consequently, the company's ability to generate value (Carlucci et al., 2004).

21.3 Understanding the Knowledge Foundation of Organizational Value Creation Through Knowledge Assets Mapping

The use of maps for visualizing, describing and understanding phenomena and "reality" is not new. In fact, map represents one of the oldest forms of nonverbal communication. It has a high descriptive power and supports thinking processes. Maps have been used to deal with many strategic and managerial subjects, such as for example, innovation, change management, project management, knowledge management, training, quality, as well as with specific issues, e.g. strategy elaboration, hypotheses evaluation and activities planning.

Referring to strategic management purposes, the use of maps is relatively new. In particular Kaplan and Norton (2000; 2004) have proposed the strategy map as a visual framework of the cause-and-effect relationships among the components of an organization's strategy, and as a means to integrate the four perspectives of the Balance Scorecard. Neely et al. (2002) have introduced the Success Map as a useful technique to help managers to align company's strategy, processes and capabilities with the delivery of stakeholders' satisfaction and contribution. Both the strategy map and the success map provide a visual representation of the organization's strategy and elucidate how an organization intends to achieve its strategic outcomes. Moreover, they promote much greater clarity and commitment to the strategy within an organisation. In fact, they provide both managers and employees with a platform for understanding the strategy, its components and the related links, and the management actions at the basis of the achievement of strategic objectives.

The visual representation of a strategy by means of a map can then support managers in their critical thinking and decision making processes regarding the company's strategy formulation, implementation and evaluation.

The advantages connected to the use of a map as descriptive and thinking tool, especially for facing strategic issues, suggest its exploitation also for investigating the knowledge dimension of value creation pathways.

We propose the use of a map to visualize, describe and understand the relationships linking knowledge assets to company's value creation.

Especially, we exploit the mapping as a powerful approach for disentangling the knowledge dimension of the complex "system" describing company's value creation "phenomenon". Several elements characterize this "system" such as knowledge assets, knowledge assets management initiatives, organizational competences, processes performance, strategic objects, value propositions.

These elements interact through feedback dynamic relationships. This calls for making a map able to describe the feedback dynamic relationships linking knowledge assets to the other components of the "system" and to illustrate the evolution of the "system" over time.

The application of the System Thinking logic to build the map seems to deal with this need.

The model that we propose, the Knowledge Assets Value Dynamics Map (KAVDM), draws on cognitive mapping principles (e.g. Novak, 1998) and develops according to the System Thinking logic.

It provides a description of those feedback dynamic relationships which result from the implementation of knowledge assets management initiatives and which, somehow, illustrate the conversion of knowledge assets into value over time.

Building the KAVDM requires preliminarily the building of a map which visualizes the links among knowledge assets, organisational competencies and processes performances and highlights the knowledge assets grounding the value creation of an organization, i.e. knowledge assets value drivers.

21.3.1 Mapping Knowledge Assets Value Drivers

Mapping knowledge assets value drivers requires, first of all, the identification both of key processes performances and competencies estimated as important in order to achieve targeted processes performances objectives.

Then, company's knowledge assets which significantly contribute to define organizational competencies, have to be identified. For this purpose the matrix of direct dependencies can be used (Carlucci and Schiuma, 2007; 2009). Moreover, to identify the interactions among competencies as well as among knowledge assets founding organizational competencies, the matrix of indirect dependencies can be used (Carlucci and Schiuma, 2007; 2009).

The identified key processes performances, competencies, knowledge assets and the related relationships, can be arranged in a hierarchical frame.

The frame, so built, provides a visualisation both of the elements, i.e. processes performance, knowledge assets, competencies, and their reciprocal relationships involved in value creation. However it merely describes but does not provide any information about the level of involvement of each element in value creation.

The application of a method for evaluating the relative importance of competencies and knowledge assets for achieving targeted performance, allows to overcome this drawback. In this regard, the Analytic Hierarchy Process (AHP) method seems to be particularly appropriate (Carlucci and Schiuma, 2007). The AHP (Saaty, 1980) is a multicriteria decision method which uses a system of pairwise comparisons to measure the weights of the elements of a decision problem, and finally to rank the alternatives in a decision.

The main outcome of the AHP application to our frame is the evaluation of the relative importance of each knowledge asset against key processes performance. This importance is captured through the size of the nodes of the map. While, the width of an arrow stands for the importance of a knowledge asset for the achievement of the competence in which the arrow ends (see Fig. 21.1).

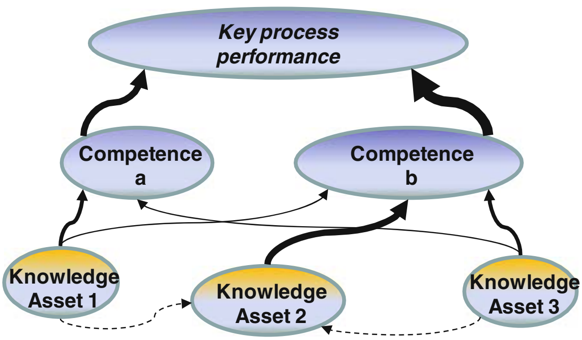


Fig. 21.1 A map of knowledge assets value drivers

From an operational point of view, the AHP can be performed by collecting managers' opinions and judgments regarding the importance of each decision element, i.e. competencies against the key processes performance achievement; knowledge assets against connected competencies. The collection can be carried out through several methods such as, for example, interviews, questionnaires, workshops and focus groups. Especially, for determining the relative importance of the elements, the managers have to be asked to respond through a series of pairwise comparisons with Saaty's nine-point scale. Therefore, collected judgments have to be properly handled in order to obtain the priority weights for each decision element. For this purpose, the software ExpertChoice can be effortlessly applied.

The map provides very useful information. In particular mainly it provides:

- a visualization of the links between knowledge assets and competencies;
- an evaluation of the relative weight of knowledge assets against competencies;
- a disclosure of those knowledge assets that, due their high importance, significantly support the achievement of processes performance objectives, and, then, the strategy execution and the value creation, i.e. knowledge assets value drivers.

The identification of the knowledge assets value drivers has great relevance. In fact, knowing these assets, managers can design knowledge assets management initiatives which might have a great impact on company's performance. In other terms, knowing company's knowledge assets value drivers, allows managers to plan initiatives focused on the effective management of knowledge assets estimated as the most valuable.

21.4 Disentangling Knowledge Based Value Creation Dynamics Through a Systems Thinking Approach

Identifying knowledge assets value drivers is important for designing effective knowledge management initiatives. However, once the initiatives are planned, it is likewise important for managers to understand how knowledge assets, properly managed, convert into value over time. As above argued, the application of the Systems Thinking allows to deal with this need.

In particular, by applying the Systems Thinking method it is possible to explore, represent and analyse the dynamics which link knowledge assets value drivers to the development of organizational competencies, and, in turn, to processes performance achievement.

21.4.1 Systems Thinking

Systems Thinking is an approach to problem-solving that considers problems in their entirety (Senge, 1990). The Systems Thinking logic is based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation. According to the Systems Thinking the only way to fully understand why a problem or element occurs and persists is to understand the part in relation to the whole.

This guarantees a better understanding and responsiveness to a problem.

A large amount of methods, tools, and principles encompasses Systems Thinking, all basically aimed to disclose relationships within the system.

Literature includes a number of approaches and frameworks which adopt the systems thinking logic. Among them: Soft Systems Methodology (Checkland, 1981), Spiral Dynamics (Beck and Cowan, 1996), and Life cycle assessment (Miettinen and Hämäläinen, 1997).

From an operational point of view, the Systems Thinking approach describes the behavior of a system by using causal loops diagrams. These diagrams consist of arrows (causal links) connecting variables (things that change over time) in a way that shows how one variable affects another. Each arrow in a causal loop diagram is labelled with a "+" or "–" The sign "+" means that when the first variable changes, the second one changes in the same direction. The sign "–" means that the first variables cause a change in the opposite direction in the second variable.

From the combination of the signs associated to the links, we can establish the behaviour of a single closed loop. The dynamics that describe the behaviour of the system arise from the interaction of just two types of feedback loops, positive (or self-reinforcing) and negative (or self-correcting) loops. Positive loops tend to reinforce or amplify whatever is happening in the system, otherwise negative loops describe processes that tend to be self-limiting, processes that create balance and equilibrium.

21.4.2 The Knowledge Assets Value Dynamics Map

Managing knowledge assets for creating company's value is not a single effort but a continual process of incremental improvement and evolution.

The Systems Thinking can enhance our understanding about the ability of knowledge management initiatives to respond to the value creation purpose of an organization over time. It allows to depict complex, dynamic processes which link knowledge assets management initiatives to the strategic goals and objectives of an organization.

In doing this, it helps to maintain a clear view of the purpose of knowledge assets management, by highlighting what is being done and why it is being done.

Essentially, the Systems Thinking allows to elucidate and monitor the achievement of the main aim of knowledge assets management initiatives, i.e. improving company's ability to create value. This is accomplished via the overall view of the different elements and related synergies involved in knowledge asset management initiatives.

In summary, the Systems Thinking method seems to be particularly useful for analysing how key knowledge assets, properly managed, take part to value creation. Applying the Systems Thinking allows to look through a magnifying glass the dynamics which involve the following elements: the knowledge assets value drivers, the key process performances, the knowledge assets management initiatives, and finally the budget available for the latter.

As above mentioned, the closed loop diagrams are the main tool of Systems Thinking methodology for visualizing the dynamics of a system. For our purpose, the first main closed loop diagram to consider is the loop called "B1" (see Fig. 21.2). This loop highlights the value creation dynamics connected to the improvement of the key process performances.

In particular, it shows how the implementation of specific knowledge assets management initiatives can pick up the key process performance by improving the knowledge assets. This process will end when the key process performance will reach its target. For this reason the described loop is a balancing loop.

The second loop, named "B2" (see Fig. 21.3), focuses the attention on the key knowledge asset dynamics. It shows how the implementation of a specific knowledge asset management initiative can reduce the gap between the observed level of a knowledge asset and its target. In this loop the equilibrium point is reached when the level of the knowledge asset achieves the fixed target. It leads to stop the

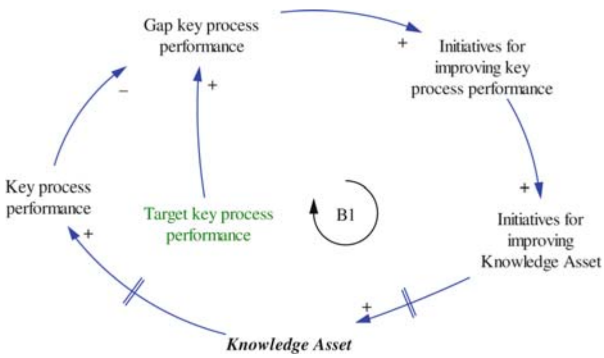
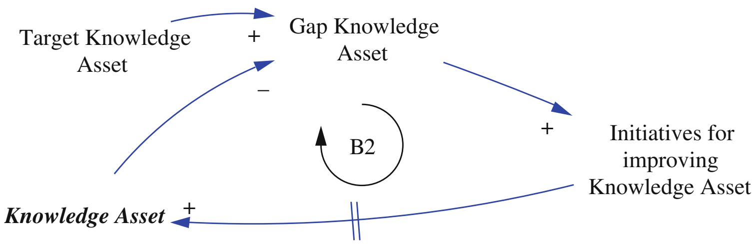


Fig. 21.2 Loop B1



Target knowledge asset = the target of the knowledge asset fixed by managers

Gap Knowledge Asset = target knowledge asset - knowledge asset

Fig. 21.3 Loop B2

implementation of further knowledge management initiatives aimed to improve the knowledge asset.

The final loop, named "B3" (see Fig. 21.4) otherwise, focuses the attention on the dynamics connecting the implementation of the knowledge management initiatives and the available budget. The loop shows that the implementation process of key knowledge assets management initiatives will stop when the residual budget will be equal to zero. The main aim of this loop is to stress the importance of the alignment between budgeting and the knowledge assets management process.

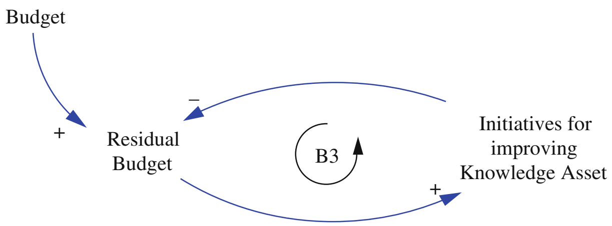


Fig. 21.4 Loop B3

Finally, by including the above described loops in a common frame, we obtain the system shown in Fig. 21.5. The example is related to the "competence a" of Fig. 21.1.

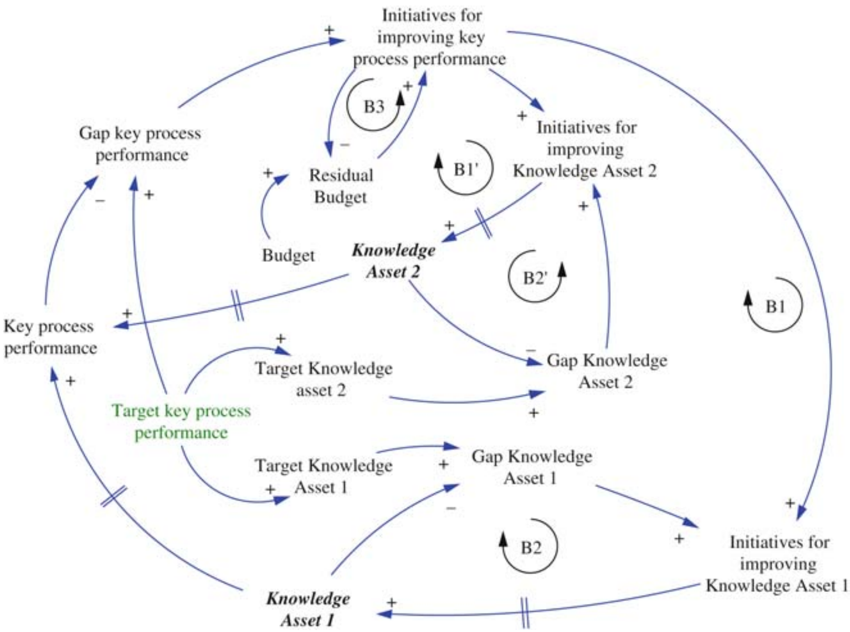


Fig. 21.5 The knowledge assets value dynamics map: an archetype

Figure 21.5 shows two narrow lines in the middle of some arrows. These lines highlight that the effect of the previous variable on the following one is characterized by a time delay.

In particular, we can distinguish two main typologies of delay:

- action delay = time between the start of the knowledge management initiatives implementation and the real improvement of the key knowledge asset.
- impact delay = time between the improvement of the key knowledge asset and the positive impact on the key process performance.

In conclusion, the proposed model provides:

- a qualitative description of the dynamics which involve knowledge assets and key process performances;
- a clear picture of "stretching" variables, i.e. the knowledge assets gaps and the key process performances gaps;
- a preview of how some knowledge management initiatives can affect the development of knowledge assets and, as a result, contribute to the achievement of targeted performances.

21.5 Empirical Study

In the following, the results of the application of the proposed model on a real world case study are described. The model has been implemented within a small company. The company's core business concerns the design and selling of residential compounds. Especially, the company designs residential buildings and, before constructing the buildings, sells the projects to end customers. The construction activities are managed in outsourcing. At the time of the case study, the company was engaged in a significant re-examination and codification of its strategy.

Analysing the knowledge based value creation dynamics through Systems Thinking lens, has supported the implementation of these important activities. In fact, it helped managers to review, map and better understand the knowledge foundation of the company's value strategy.

21.5.1 The Implementation of the Model

The model has been developed within the company during the last year. The model has been implemented through the following main phases:

- phase (1) identification of key processes performances and related key competencies;
- phase (2) identification both of the knowledge assets founding the key competencies and the relationships among the identified knowledge assets and among competencies;
- phase (3) identification of the knowledge assets value drivers;
- phase (4) definition of management initiatives for exploiting and developing the knowledge assets value drivers;
- phase (5) analysis of dynamics linking knowledge assets value drivers and the related management initiatives to key processes performances.

Phase (1). During this phase key processes performances and competencies estimated as important in order to achieve targeted performances have been identified.

Regarding the key processes performances, managers have indicated the efficiency of design and sales processes. More in particular they have outlined the need to improve the efficiency especially in terms of time spent for performing the design process.

Regarding the company's key competencies, top managers, with the support of researchers, have identified the following competencies as particularly relevant for successfully performing the design process: "competence in designing buildings in an integrated way" and "competence in managing relationships and external communication".

The "competence in designing in an integrated way" concerns the ability to manage, in tightened coordination, all the various elements related to buildings designing (e.g. architectural features, technical choices, rules, customers' and community well-being) and making attention to the effective possibility about placing what imagined during planning phase in work.

Phase (2). During this phase the knowledge assets grounding the key competencies have been identified and analysed. For this purpose a targeted focus group which has involved top managers and researchers has been performed. The researchers acted as facilitators. Especially the "Knoware Tree" (Schiuma et al., 2005) has been adopted for disclosing and analysing the company's knowledge assets. Then company's knowledge assets have been examined with reference to the targeted key competencies. In particular, through the matrix of direct dependencies the knowledge assets founding the key competencies have been identified. Then, through the matrix of indirect dependencies, the interactions among knowledge assets as well as among competencies have been determined. Knowledge assets, competencies, key processes performances and their relationships have been arranged in a hierarchical frame.

Phase (3). During this phase the managers' judgments concerning the relative importance of knowledge assets against competencies, and competencies against the key process perfomance, have been collected during a focus group, through a series of pairwise comparisons with Saaty's scale. Then the geometric mean has been used to aggregate their assessments. The AHP has been applied by using ExpertChoice. From the AHP application, the relative importance of knowledge assets is resulted. The importance has been captured in the nodes and arrows of the map shown in the Fig. 21.6. Especially, based on the discussions with the researchers about contents shown in the map, managers have identified the following knowledge assets value

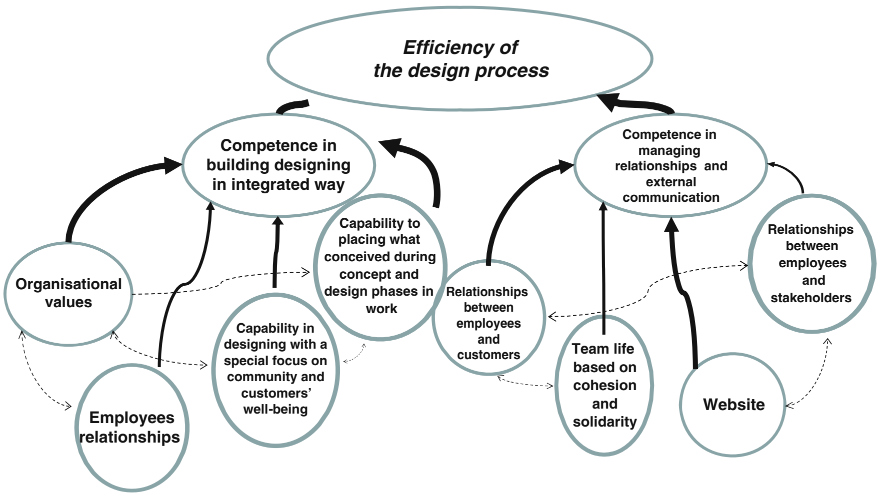


Fig. 21.6 Mapping knowledge assets value drivers: an example

drivers related to “competence in designing buildings in an integrated way”: organisational values; capability to placing what conceived during concept and design phases in work; capability in designing with a special focus on community and customers’ well-being; while with reference to “competence in managing relationships and external communication” the following key knowledge assets value drivers have been identified: Website, Relationships between employees and customers.

Phase (4). For developing the knowledge assets value drivers and, as a result, the related competencies, managers with the support of researchers have planned the knowledge assets management initiatives shown in Table 21.1.

Table 21.1 The knowledge assets management initiatives

Competencies	Key knowledge assets value drivers	Knowledge assets management initiatives
Competence in designing buildings in an integrated way	Organisational values	Meeting on organizational culture; training on self-expression; initiatives promoting socialisation
	Capability of designing with a special focus on community and customers well-being	Meeting and trips aimed to promote knowledge sharing and knowledge creation; market survey
	Capability to placing what conceived during concept and design phases in work	Training on software for building information modelling; training on project management; training on rules regarding design
Competence in managing relationships and external communication	Website	Design and implementation of the company’s web site
	Relationships between employees and customers	Knowledge transfer of targeted information about company to the key company’s stakeholders; reorganizing sales area for enhancing customers’ relationships

Despite at first both competencies were estimated as equally important for achieving an improvement of efficiency in design process, during the focus group managers have expressed their intention to prioritise the enhancement of the “competence in designing buildings in an integrated way” and related knowledge assets.

Phase (5). During this phase researchers and managers have further analyzed according to the Systems Thinking approach, the elements and the links previously mapped (see Fig. 21.6). Particularly, an assessment of the potential impact, action delays and impact delays, with regard to the planned knowledge assets management initiatives, has been carried out.

Figure 21.7 shows the results of this analysis for the company's key competence "designing buildings in an integrated way".

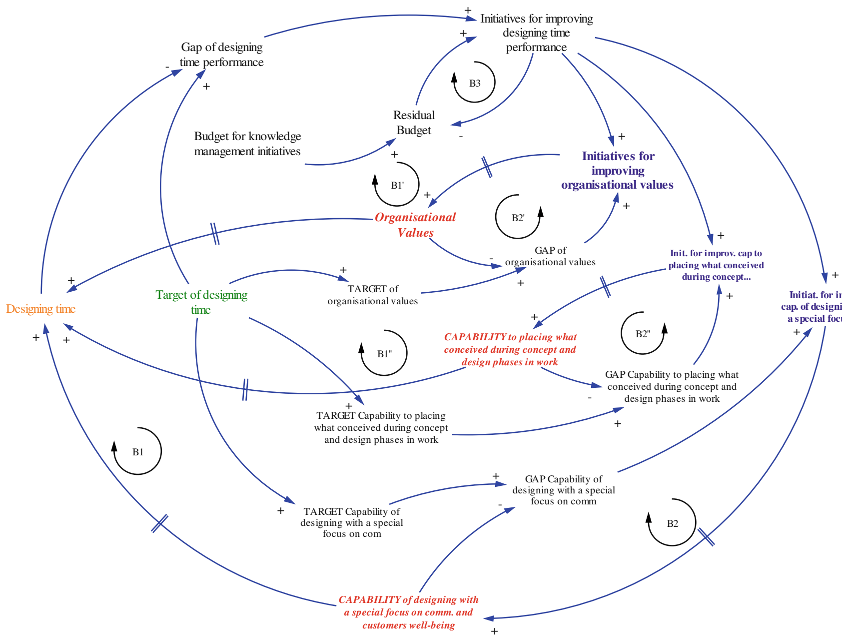


Fig. 21.7 An example of KAVDM

21.6 Conclusions

This study suggests the mapping as a valuable method for disclosing and assessing how organizational knowledge assets, separately and as a cluster, take part in company's value creation. In particular, the study proposes a model Systems Thinking-based for analysing and evaluating the involvement of knowledge assets in company's value creation pathways.

The proposed model draws on strategic management literature, regarding the use of the strategy maps and on principles of the Systems Thinking.

Through the implementation of the model managers have the opportunity to reflect on the knowledge components at the basis of company's value creation and to better understand the ways through which these assets, properly managed, contribute to generate value.

Especially, the application of the Systems Thinking enhances the understanding of *if* and *how* knowledge assets management responds to the value creation purpose of an organization. More in general it provides an overseeing able to reveal the general sense of direction for knowledge management initiatives.

In the examined case, the application of KAVDM has been essential for disclosing the knowledge based foundations of the company's strategy and for disentangling the mechanisms through which knowledge assets take part to value creation.

Especially, the application of the model has mainly contributed to create at managerial and organisational level:

(i) an increased understanding of the company's knowledge assets and their relation to strategic objectives;
(ii) an augmented managerial attention to the company's knowledge assets development;
(iii) a valuable knowledge platform for making better informed decisions about the design, implementation and assessment of proper knowledge assets management initiatives.

The use of the Systems Thinking approach has required time, efforts, and a close collaboration between researchers and managers. In spite of this, currently the built System Thinking based map represents a useful tool that managers intend to use for monitoring and evaluating the success of the planned knowledge assets management initiatives.

The proposed model is seen as open for future extension and development. Especially we call for further research on a more widespread exploitation of the model in strategy planning and execution as well as in the design and implementation of knowledge management initiatives aimed to support company's value creation dynamics.

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Chapter 22
Neural Networks and Regressive KPI Metamodels for Business Corporate Management: Methodology and Case Study

Roberto Revetria and Flavio Tonelli

Abstract In order to answer to the new market demand industry turn to software vendors looking for specific ERP systems and starting specific projects for supporting Business Process Redesign (BPR). In such a context authors identified a lack of anticipatory models able to drive the ERP implementation process to the right thus proposing a meta-modeling approach able to bridge this gap. Proposed methodology integrates Data Analysis, Regression Meta-Modeling and Artificial Neural Networks processing, in order to identify hidden relationships among KPI guiding BPR decision makers. The paper presents the methodology as well as a practical application.

22.1 Introduction

Since the Nineties we have managed to integrate enterprises ERP systems. Modern ERP systems have integrated the main management aspects (Human Resources Management, Sales, Marketing, Distribution/Logistics, Manufacturing and Accounting) and they have become the point of reference for business process.

From an evolution point of view, ERP systems have shifted their focus either on terms of functionality or on a technological level. That has led to direct consequences on the ERP specific market. Recent success of Information and Communication Technology clearly shows the information value is a more and more important aspect of the industrial product value. As a matter of fact, not only the production methods, but also time and availability do help in the quality of it.

Therefore ERP systems shift their objective on those applications enabled to manage data in order to transpose them in information useful for the decision-making process. In fact, the chief ERP Vendors are working at an evolution of the

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species, which is leading to an integration of additional modules such as CRM, Advanced Planning System, SCM, Business on Demand, BPR, BI, PDM. Analysts, like Gartner Group, believe that such an evolution will lead to a new ERP model, called ERP II or VCRP (Value Chain Resource Planning), which should substitute the current ERP systems from the year 2005 onward.

However, looking back to recent past, except for few and rare successful cases, companies have met great difficulties to carry out their plans with consequent exceeding budgets in costs and time. The main difficulty of the companies is still their business process formalization, analysis and rationalization. The problem is still to adapt the ERP system to the company context, or to make it a chance to modify radically their own business process.

We would like to put in evidence that the ERP model is not a software application but a method of organization and management to rationalize and optimize a complex system. In general, can we be sure that nowadays companies are able to install and implement an ERP system being sure of its result in terms of cost and performance? And in particular, are really systems controlling and measuring the companies' performances, the so-called CPM (Corporate Performance Management), able to have the company capitalize the carried out investment?

An article published by Gartner Group in June 2003 relates expressly a new management area called Business Performance Management (BPM). In particular it relates that it is able to set an integration of planned, elaborated and collected performances through an advanced setting of data analysis and summary based on ERP system. Moreover, encouraging results about a few management areas are published with a related hypothetical improvement in several other fields, as well, such as banking, financial, medical, pharmaceutical, and governmental and in particular manufacturing ones.

Actually BPM represents an evolution of Business Intelligence (BI) based on the idea of Business Activity Monitoring (BAM). The aim of the integration of BAM solutions overtakes the physical boundaries of a deployment or of a department, and the idea of real time (time required for one or more data processing) is not necessarily expressed in nanoseconds but it is rather determined by the business process bill. Therefore, BPM is in general an amount of services and implements offering an explicit management process in analyzing, planning, programming, executive and monitoring areas. The ideal setting of it, inside the manufacturing industry is in collaborative contexts with evolved transactional systems (ERP II) and with Supply Chain Management systems.

On the other side BPM refers to Corporate Performance Management systems (CPM), assigned to coordinate formalization of clue enterprise methodologies, metrics and processes with a view to improve the company performances. Both BPM and CPM (see Drucker, 1998) are based on parameters permitting to determine the efficiency of an aspect of the company activity objectively; these parameters have been defined Key Performance Indicators (KPI). Actually they provide the base for strategic decisions. CPM appears transversal to different applications systems such as ERP, CRM, SCM, and legacy systems; in other words it appears transversal to an ERP II system. Either technologies or applications in this area are already consolidated, even if not completely widespread, above all on our nation.

About 86% of the companies is expecting a competitive benefit reducing the time wasted to collecting and answering to information, while a good 74% of the companies has executive managers demanding IT manager to restrain the clue operation data receiving time. Nevertheless, today only 35% of the companies is able to exploit the benefits received from real time information. What makes the difference between the values expected from applications and the applicability of them in order to goal the planned results?

As far as the more recent international literature is regarded, the following steps are not explained.

- Lack of a theory for the quantitative evaluation of the proposed business schemes in order to identify:
  - Better processes
  - Better KPI
- Lack of a support for the distribution of the transactional systems modeling; in fact, ERP are often composed by connected parts on geographical nets of even wide dimensions.
- Lack of specific semantics for Process Redesign, not based on General Purpose approaches.
- Extensive gap between the clue productive point of view (physical processes) and the clue commercial one (processes linked to demand and to financial fluxes).

Quoting a recent article from a technical revue: "To be effective, process design, control and improvement demand the use of modeling methods with scalable and dynamic properties providing seamless links between business and technical process issues" (Kamath et al., 2004) The paper proposes an innovative and holistic approach of modeling enabled to provide a quantitative evaluation of companies Business Processes by identifying the relationships among the various KPI by using RSM and neural networks meta-modeling (Sarle, 1994).

22.2 Proposed Methodology: From Massive Simulation to Meta Modeling

22.2.1 General Aspects of a Manufacturing Supply Chain and Related KPI

In distributed manufacturing, Supply Chain Management (SCM) play a central role by identifying the correct value stream and the complex relationship existing among SCM actors (Simchi-Levi, 2000). The comprehension of the underlying process that drive a complex production and distribution systems is generally affected by several blocking factors such as: the complexity level required to build a credible model, time consumed by specific stream projects and data unavailability.

This last point is one of the more critical and less evident of the entire problem. Modern ERP, in fact, produces huge amount of information that made Data Warehousing a difficult task, more a lack of the comprehension of the KPI structure demonstrates that some time set points are just guessed rather than designed on a specific purpose. Control matrix available on highest direction levels presents static view of the business while managers needs dynamic interpretation of the emerging forces present in a complex system. Data are collected without finalization and poorly interrelated, reports, very often, are meaningless.

In the proposed methodology KPI are assumed as measures of an underlying process only partially known where the true hidden relationship has to be identified, main activity emerging from the application of the proposed methodology can be summarized in the following tasks:

– Comprehension of relationships occurring between KPI;
– Review of common used KPI;
– Addition of new KPI, if necessary to better control specific process' areas.

In the proposed application of the methodology a real life case study specific SCM KPI have been considered resulting in the following control tree (Fig. 22.1). On the top level general SCM performances are measured with referenced to the following 3 high level KPI: ATP, DTP and DOS.

ATP measures the level of customer satisfaction regarding his products request on his first request, while DTP measures the level of customer satisfaction on the

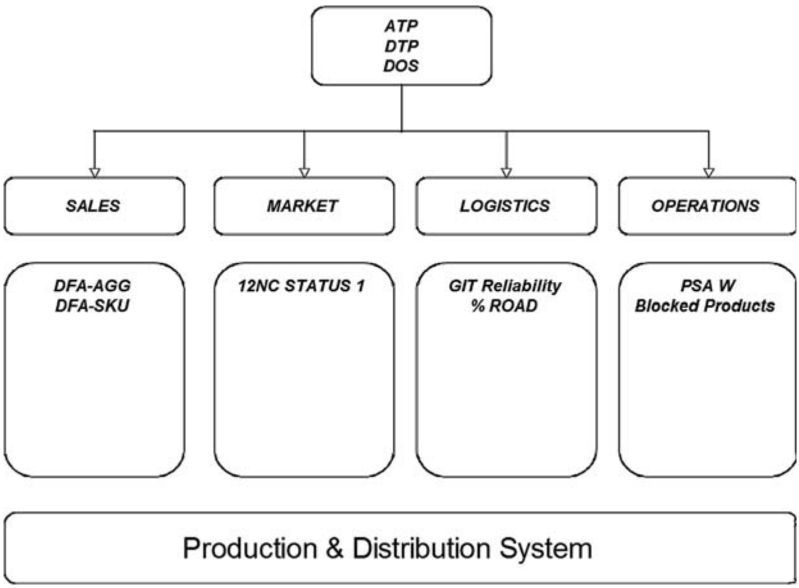


Fig. 22.1 High level control matrix for SCM

last delivery date promised, DOS is a measure of the total product inventory available in the reference period. Below this high level view 4 streams specify their KPIs according to common used Balanced Score Cards. On Sales stream 2 KPI measure the Demand Forecast Accuracy (DFA) both at SKU level and aggregation level. Market stream's KPI identify the offering range of products in term of #items available, while Logistic stream is focused on the delivery reliability (GIT Reliability) and transportation choices (% ROAD). Operations stream is driven by two separate KPIs, the first measure the actual production execution performances vs the planned ones (PSA W) and the second measure the level of production flow failures (Blocked Products). In such schema hierarchical relationship between KPI is clear but the interdependences between KPI are unknown. Managers can now measure their position respect their competitors and can evaluate the differences between actual values an set points but cannot know which stream they have to improve to maximize the effect on the high level KPI.

Perfect diagnosis, unknown therapy is the typical condition of the complex systems management where the lack of a Computer Anticipatory Systems turns every action on the system into a crystal ball guess (Revetria et al., 2005). Considering the target to achieve and the analysis done so far, the proposed methodology is able to link primary performance indicators with objective indicators based on decreasing hierarchical level (top-down) by analyze the existing connection between KPIs as well as the relation between one KPI and the others and identify, at the same time, the relevant coefficients using Multivariate Analysis of Variance Tests. Effective models codified into specific algorithms enables, by imposing one ore more independent KPIs, to know the dependent KPI behavior in the form of an iso-level chart. The neural model, particularly, is used for those relationships, whose regressive performance won't be considered satisfactory. This model, even if more powerful by the regressive side, is more difficult to use due to it is lack of an effective statistic test when doing hypothesis on performances achieved. As the system realized is strongly "data driven" by itself, the tool allows, through it's modular structure, the maintenance and laying out of models related to a precise data evolution. In order to track data reliability, a series of statistics signals are used on regressive model, and a series of performance warnings are calculated neural algorithms.

22.2.2 Regression Meta-Models and Artificial Neural Networks for Supporting BPR

A simulation meta-model or a response surface in the simplest case is an approximation of the input/output function implied by the underlying simulation model. It's behavior could be represented as a black-box or a function $\mathbf{y} = (\mathbf{x_1}, \mathbf{x_2}, \ldots, \mathbf{x_n})$, with n model input parameters. The objective of a meta-model is to accurately reproduce the simulation over wide ranges of interest, and to help in simulation analysis due to its higher transparency and easier handling than the original simulation model. Computer simulation could be used to define interconnections between independent and dependent KPI, in similar way such relationship could be built by applying

Design of Experiment (i.e. Central Composite Design in order to fit a 2nd order response surface) to the simulation output (Steppan et al., 1998). For specific opportunity reasons the use of a complete simulation model some time is not applicable due to its high cost level, in this case raw data coming up from KPI records could be used directly to identify the hidden relationship by applying regressive multivariate analysis in the form of Linear Regression.

Linear Regression simply means that the functional relationship between $\mathbf{KPI_{DEP}}$ and the regressors can ($\mathbf{KPI_{INDEP,\mathit{k}}}$) be expressed by a linear equation or, in other words, a sum of terms including the error (1).

$$\mathrm{KPI_{DEP}} = b_0 + \sum_{i=1}^{k} b_i \mathrm{KPI}_{\mathrm{INDEP},i} + \sum_{i=1}^{k}\sum_{j=1}^{k} b_{ij}\, \mathrm{KPI}_{\mathrm{INDEP},i}\, \mathrm{KPI}_{\mathrm{INDEP},j} + \mathrm{err} \qquad (1)$$

The method used to find the coefficients $\mathbf{b}_j$ and $\mathbf{b}_{ij}$ of model equation (1) is called least squares estimation. This means that the error term used in the model equations is defined as the difference between observed response variable $\{\mathbf{KPI_{DEP}}\}$ and estimated $\mathbf{KPI_{DEP}}$ for a given setting of the $\mathbf{KPI_{INDEP,\mathit{k}}}$ at each data point. The total error must somehow be defined by summations over all data points or "cases". Since is assumed a random distribution of the individual errors with a mean of zero, a simple summation would ideally lead to zero. At least it leads to negative and positive differences canceling each other out. This can be avoided by squaring the errors for each data point and sum these squares. The desired optimum regression model then has to give a minimum for this sum of squared errors. Suffice it to say that the starting point of the calculations is the matrix notation (2) for the system of sample equations, where $\boldsymbol{k}$ are the total $\mathbf{KPI_{INDEP}}$ and n is the total number of data set available

$$\mathrm{KPI_{DEP}} = \begin{bmatrix} 1 & \mathrm{KPI}_{\mathrm{INDEP},1,1} & L & \mathrm{KPI}_{\mathrm{INDEP},k,1} \cdot \mathrm{KPI}_{\mathrm{INDEP},k,1} \\ 1 & \mathrm{KPI}_{\mathrm{INDEP},1,2} & L & L \\ L & L & L & \mathrm{KPI}_{\mathrm{INDEP},k,n-1} \cdot \mathrm{KPI}_{\mathrm{INDEP},k,n-1} \\ 1 & L & L & \mathrm{KPI}_{\mathrm{INDEP},k,n} \cdot \mathrm{KPI}_{\mathrm{INDEP},k,n} \end{bmatrix} \times \begin{bmatrix} b_0 \\ b_1 \\ M \\ b_{k-1,k} \\ b_{k,k} \end{bmatrix} + \begin{bmatrix} \mathrm{err} \\ \mathrm{err} \\ M \\ \mathrm{err} \\ \mathrm{err} \end{bmatrix} \qquad (2)$$

By using a quick notation is possible to rewrite the (2) in the compact form of (3) and present some interesting calculation on it (bold small letters or words denote vectors, bold capital letters symbolize matrices):

$$\mathbf{y} = \mathbf{Xb} + \mathbf{err} \qquad (3)$$

Finally, the vector of the estimated coefficients b is given by (4) where $\mathbf{X}'$ denotes the matrix transpose and $\mathbf{X^{-1}}$ denote the inverse of matrix $\mathbf{X}$:

$$\mathbf{b} = (\mathbf{X}'\mathbf{X})^{-\mathbf{1}}\mathbf{X}'\mathbf{y} \qquad (4)$$

Second Order regression meta-models sometimes suffer from lack of performances when used with data affected from high order relationship, in this way a different approach should be used.

For the particular purpose of the application a special feature of the Artificial Neural Networks (ANN) may be used in order to approximate the unknown relationship between dependent KPI and independent ones. ANNs differ from conventional techniques, because it is not required to specify the nature of the relationships involved. Starting from simple identification of the inputs and the outputs the MLP's main strength lies in its ability to model problems of different levels of complexity, ranging from a simple parametric model to a highly flexible, nonparametric model. For example, an MLP that is used to fit a nonlinear regression curve, using one input, one linear output, and one hidden layer with a logistic transfer function, can function like a polynomial regression or least squares spline. It has some advantages over the competing methods. Polynomial regression is linear in parameters and thus is fast to fit but suffers from numerical accuracy problems if there are too many wiggles. Smoothing splines are also linear in parameters and do not suffer from numerical accuracy problems but pose the problem of deciding where to locate the knots. MLP with nonlinear transfer function, on the other hand, are genuinely nonlinear in the parameters and thus require longer computational processing time. They are more numerically stable than high-order polynomials and do not require knot location specification like splines. However, they may encounter local minima problems in the optimization process.

22.3 The Implemented Application

22.3.1 The Software Environment

The implemented methodology as been set in a software solution made of a light web application built on top of an Apache-Tomcat servlet container using a mix of JSP Tag library and applet modules. This choice is due to guarantee the interoperability of the implemented application in a LAN where users can actively interact based on a set of predefined roles (Fig. 22.2).

The application can be logically split in several layers according to the responsibility of the single component designed as a building block. The JSP application part is representing the "glue" of the entire application connecting a Relational Database (RDBMS) hosting the raw data coming from the EDI systems in general and the ERP system in particular.

The access is based on a predefined set of profile in which is possible to recognize: Administrators, Users, Viewers; while the first has the complete control of the application the second can operate with full rights except the possibility of grant privileges to users. Viewer Role has a limited capability of accessing elaborated data and can operate drill down analysis on the results.

An applet is designed for supporting data import from the Excel files generated by the ERP providing the minimum instruments to support data manipulation, a backup procedure is fired periodically on the collected data. Two applet modules have been implemented in order to model the relationships among the KPI and to perform goodness-of-fit tests on the various models. A set of "traffic lights" is used

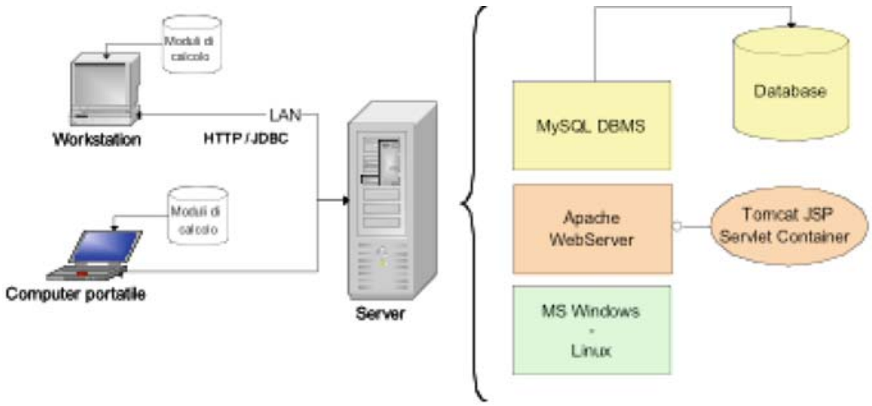


Fig. 22.2 Implemented tool architecture

to present criticalities in the implemented model re trained with the actual data; the first applet is based on mathematical models (multivariate statistical analysis and regression) while a second one is designed around a Neural Network model.

A simple yet powerful reporting module is made of JSP Tag in order to provide a way to compare results and to help decision makers to better understand the relationships among the KPI. Statistical tests are used to monitor model confidence in order to identify the significance of the implemented model and to provide extra training and deeper analysis.

The architecture is based on a MS Windows server, connected to the company's LAN; on this server is installed and configured the Apache web-server, integrated to the servlet container Tomcat, and the DBMS MySQL; both tools are worldwide recognized and widespread.

The application interface is realized using HTML/JSP pages; it will call up and execute, locally on the client, Java applets realized following the J2SE 1.4.x. specifics.

When executed, the features open a direct connection via JDBC on the MySQL database, in order to transfer and store data. The loading and maintenance main application (applet java) is composed by 4 procedures, which acquire data from company ERP and perform consistence checks.

The calculation core of the proposed tool is implemented as a separate applet performing two separate tasks:

- Training and Testing Artificial Neural Neworks to be used as intelligent regressor;
- Perform Statistic and Multivariate Analysis building 2nd order Regression Metamodel.

The computational module performs also a set of statistical and testing check in order to ensure proper generalization to the implemented models. For the Regression

Metamodels (Merkuryeva, 2000) the test was performed by extracting 5% of the data randomly from the dataset, using the remaining part for model building and investigate the difference between output of predicted value and this 5% real life data. For Neural meta-models, no F-tests were possible so the authors decided to extend the testing phase by increase the percentage from 5 to 8%, no further test were possible since the limitation of the training case (#45 data rows).

22.4 Verification and Validation of the Proposed Implementation

In order to validate the proposed methodology a set of tests was performed, practically data coming from designed relationships were randomly extracted and used to build input datasets for the proposed methodology. Based on such data both regressive module and neural module were able to construct an approximating relationship that was compared with the real response surface. After successfully implement such test a new set of investigation was posed by adding, to a newly randomly extracted data, a white noise signal on top. Again the two modules were able to recognize the underline model linking the input variables with the output. Dataset were collected in the same magnitude and in the same size of the real data.

22.4.1 First Validation Experiment

First model was a 2nd order as the basic regression metamodel used, as is possible to see regressive metamodel was closed to perfect fitting. Neural network approximation was also close to the real model itself. Similar results were obtained from noisy data. Max amplitude of the inputs was 10.0 and max amplitude of the noise was 2.0.

22.4.2 Second Validation Experiment

Real life model was built as quadratic linear relationship showing higher curvature respect the precedent one. Again both the module were able to correct reconstruct the right behavior also in presence of noise.

22.4.3 Third Validation Experiment

This experiment presents some interesting behavior since the real life model was based on a linear composition of the squared roots of the inputs. According to the expected regressive metamodel approximate the surface with a 1st order surface while the neural networks truly adhere with the real data, similar results were obtained with noisy datasets.

22.4.4 Fourth Validation Experiment

The implemented model was based on 3rd order linear composition of the inputs resulting for the regressive metamodel a bit hard to cope, neural approximation was much closer to the real model. The general approximation theorem demonstrates here, with noisy datasets, its powerfulness adapting very sparse data with the right model.

22.4.5 Fifth Validation Experiment

Last experiment was used to test the capability of the model to operate with sparse dataset, model was based on a 2nd order linear composition of the inputs with mixed sign coefficients. Regression metamodel was able only to perform well on the central part of the function while the neural approximation fits the right underlying function.

In Table 22.1, the 5 experimental tests are presented and compared.

22.5 Quantitative Results

Proposed methodology has been used on a real data in order to identify relationship between KPI for a manufacturing industry. Production was split across several plants along Europe, KPI were calculated for each plant and for each country aggregation.

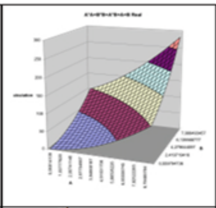
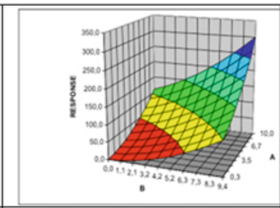
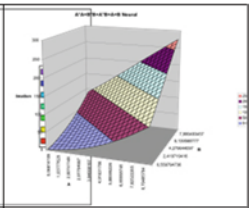
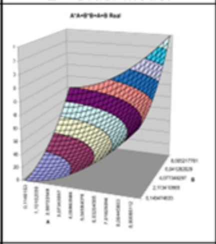
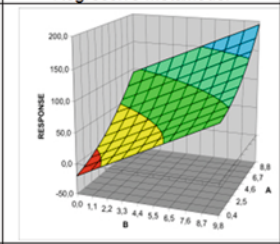
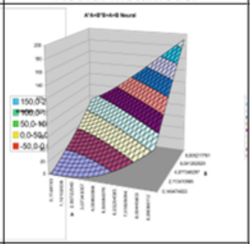
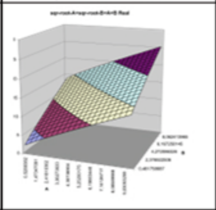
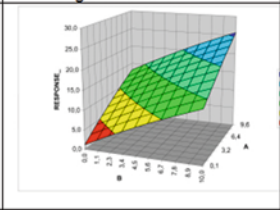
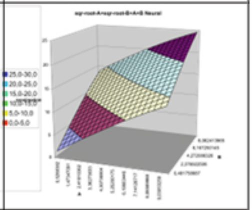
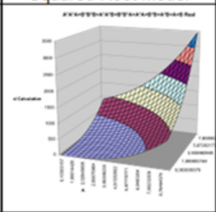
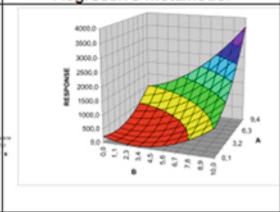
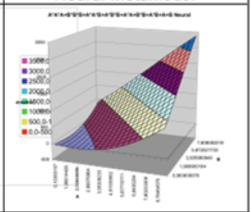
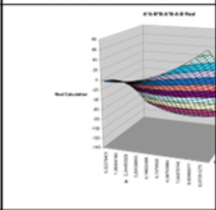
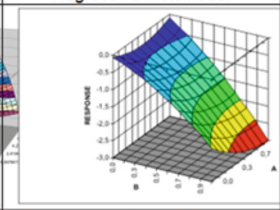
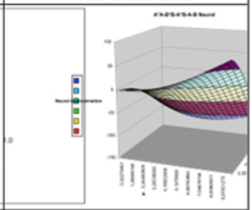
The data obtained directly from ERP procedures were integrated in a ad hoc database in order to validate them and to identify inconsistency and reporting error.

Former presentation of the KPI report was known as “control matrix” so the investigation was extended in the previous 45 reporting weeks where data were available. In effect, data were considerably more than 45 weeks but the rapid change of the Supply Chain structure introduce a loose of significance of the data proportional to the elapsed time.

First studied relationship was obtained with a regression meta-model and was designed to understand the dependence of the DOS KPI from other low level KPI, the 2nd order regressive model was tested significant by Fisher and obtained a adjusted R^2 value of 0.72.

As is possible to see from the Fig. 22.3, the behavior of the DOS KPI, and lastly the inventory, can be predicted by looking at the independent KPI through the regressive identified relation. In particular a reduction in the market offer (12NC STATUS 1) can be considered one of the best hypothesis to cut inventory costs. From the other hand, a significant increase of the forecast quality (DFA-AGG) is some time related to an increase of the DOS. This last issue rose from the data analysis in a surprising manner, managers usually expected that an increase in the sale forecasts capability will determine a reduction in the DOS but here is just the opposite. From an analytical point of view this phenomena can be seen as an

Table 22.1 Model-metamodels comparison

1			
	2nd Order Model	Regressive Metamodel	Neural Metamodel
2			
	Quadratic Model	Regressive Metamodel	Neural Metamodel
3			
	Squared Root Model	Regressive Metamodel	Neural Metamodel
4			
	3rd Order Model	Regressive Metamodel	Neural Metamodel
5			
	Mixed Model	Regressive Metamodel	Neural Metamodel

effect of the raising DOS on the DFA-AGG capability rather that an effect of the DFA-AGG on the DOS. In this way the proposed methodology was clearly able to identify a criticality in the system previously not seen in the “control matrix”.

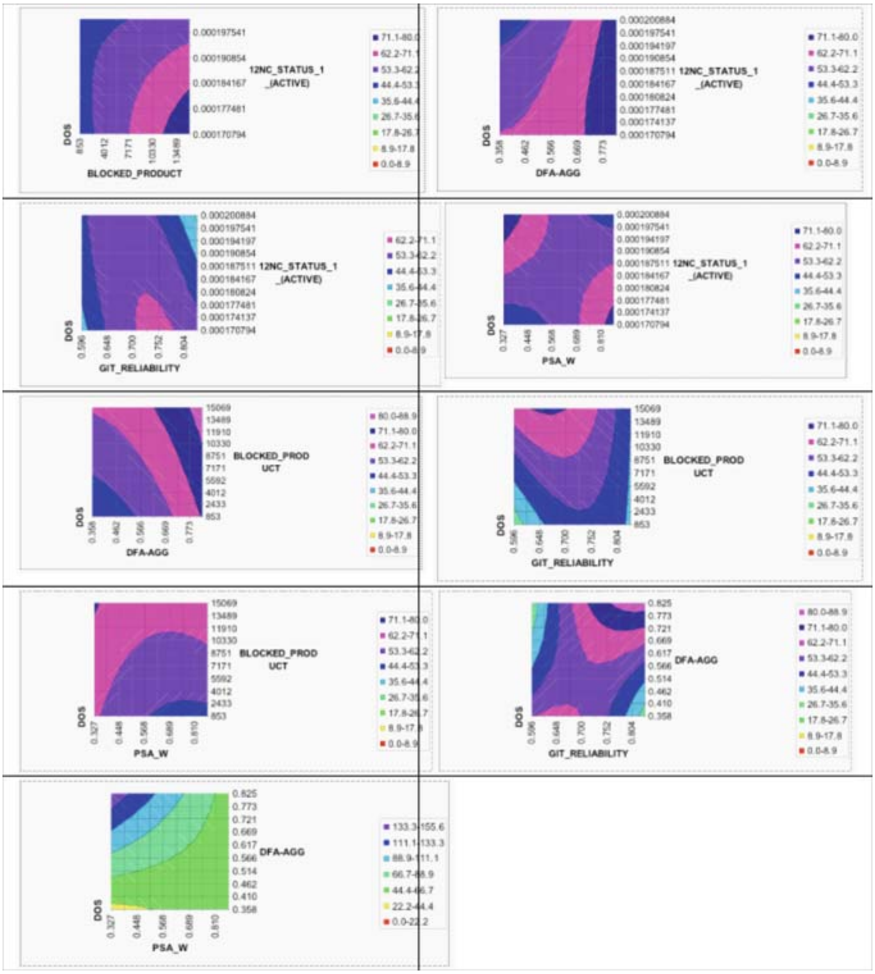


Fig. 22.3 DOS regressive meta-model

Another example taken from the investigated relationship is the ATP behavior as calculated from the neural model, the auto-fitted model was built as back-propagation feed forward full connected neural network built by 4 input neurons, 2 hidden layer neurons with a sigmoid transfer function and a single neuron with a linear transfer function on the output layer (Fig. 22.4).

Since the lack of statistical tests available for estimating the generalization error, authors used a small subset (8%) of the available data as a testing set. On a total base of 44 weeks of published data 2 weeks were kept separated from the training set and used to verify the generalization skill of the implemented meta-model.

Based on such assumption ATP data from week 200445 was estimate within an error of 1.65% and week 200510 within an error of 5.11%, as is possible to see error in the evaluation of the performances for unknown data were below 10%.

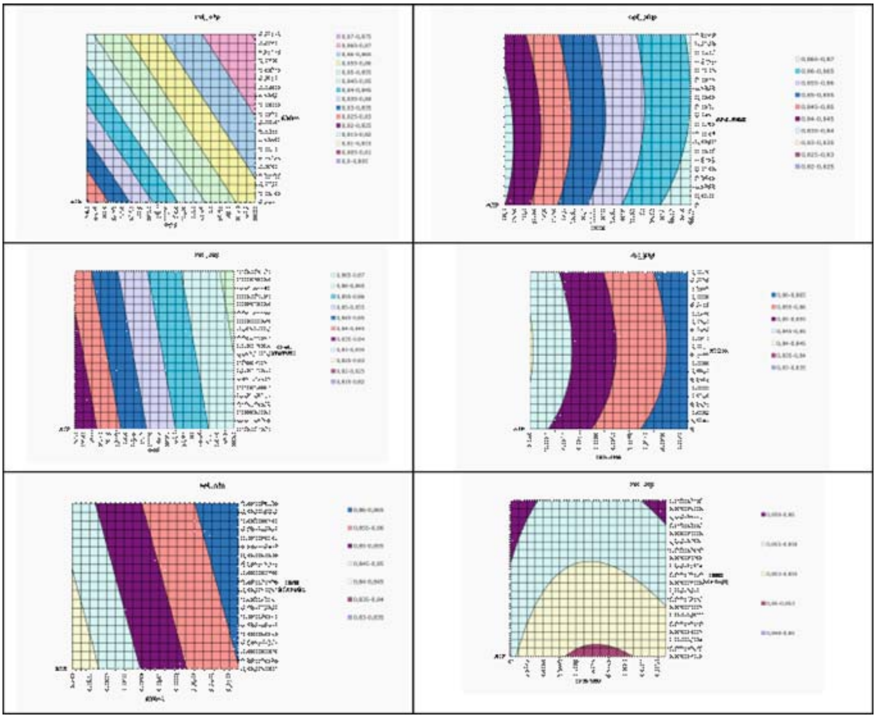


Fig. 22.4 ATP neural meta-model

Neural meta-model was able to clearly identify a priority in the Supply Chain intervention action lists, it was clear, in fact, that the increasing of the demand forecast accuracy was less important than the reduction of the blocked products. In the logistics GIT Reliability was able to play a decisive role only in conjunction of a high inventory level (DOS) and this last aspect was related to an increase in the percentage of good shipped by truck.

Proposed methodology was able, under several points of view, to correctly identify known relationship starting from poorly collected data as well as investigate unknown relationships among KPI later confirmed by ad hoc investigation and analysis.

22.6 Conclusions

The use of regressive and neural meta-modeling have been demonstrated to be very effective for supporting unknown KPI relationship approximation by identifying underlying behavior among independent KPI.

The use of the proposed methodology applied to a real industrial case served as base case to demonstrate the high potential of such meta-modeling technique.

The use of a black box technique such as neural network have been enhanced via the complete mapping of the response surface explicating the relationship among the independent KPI and the dependent one via the slicing technique.

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Chapter 23
Performance Measurement Systems and Organisational Culture: Interpreting Processes of Unlearning and Change

Cristiano Busco and Angelo Riccaboni

Abstract This paper explores the intertwined relationship between performance measurement systems and organisational culture. With the aim of interpreting how they evolve across time and space, we intend to understand the way in which systems of measurement and accountability contribute to the ongoing creation and re-definition of organizational culture. Intepreted as a set of rules (the formalised statements of procedures), roles (the network of social positions) and routines (the practices habitually in use), the papers relies on Schein's work on organisational culture and Giddens structuration theory to portray management accounting systems as socially constructed and institutionalised practices involved in the production and reproduction of organisational order. On this respect, the insights from an explanatory case study will inform the discussion on the role of accounting practices within evolutionary vs. revolutionary processes of unlearning and change, as well as their cognitive vs. behavioural implications.

23.1 Introduction

The purpose of this paper is to explore the intertwined relationship between performance measurement systems[1] and organisational culture. With the aim of interpreting how they evolve across time and space, we intend to understand the way in which systems of measurement and accountability contribute to the ongoing creation and re-definition of organizational culture. For this purpose we will develop an interpretive perspective which relies on Giddens theory of structuration

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[1] In particular, to be consisted with the literature reviewed, in this paper we will also use the term "management accounting systems".

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to combine both cognitive and behavioural dimensions of processes of unlearning and change (Barley and Tolbert, 1997; Burns and Scapens, 2000).

Even if the implication of accounting practices within processes of organisational change does not seem to be in question (see Macintosh and Scapens, 1990; Dent, 1991; McNamara et al., 2004; Bhimani and Roberts, 2004), what is still far from clear is our understanding of the modalities through which such a linkage is accomplished during day-to-day corporate life. This will require us to look beyond the processes of making the numbers and how systems of accountability are enacted; and to take into account the way in which less visible organisational dimensions, such as the cultural, social and institutional, enable and constrain processes of individual unlearning and organisational transformation.

The paper is structured as follow. After having reviewed the concepts of routines and organizational culture, we portray management accounting practices as socially constructed rules (i.e., the formalised statements of procedures), routines (the practices habitually in use) and roles (the network of social positions) which, along with other organisational systems, act as repositories and carriers of organisational and individual knowledge. Next, the insights from an explanatory case study will inform the discussion on the role of management accounting systems within evolutionary vs. revolutionary processes of change, as well as their cognitive vs. behavioural implications. The paper ends by sketching a framework to interpret how management accounting systems may contribute to processes of unlearning and organizational change.

23.2 Interpreting the Organizational Context: Routines, Culture and Accounting Systems

23.2.1 Routines, Memories (Mental Models) and Agency

The literatures on organizational learning, cognitive psychology and the sociology of knowledge provide a number of concepts which will be useful for exploring the intertwined relationship between management accounting systems and organizational culture. We will begin with the concept of organizational routine (Nelson and Winter, 1982). The understanding of routines has played a major role in the organizational learning literature. Levitt and March (1996) described learning as a routine-based, history-dependent and target-oriented activity. They see "organizations... as learning by encoding inferences from history into routines that guide behaviour" (p. 516). Accordingly, organizational actions and patterns of behaviour draw upon established routines (March and Simon, 1958; Cyert and March, 1963; Gersick and Hackman, 1990). Described by Cohen and Bacdayan (1996) as multi-actor, interlocking, reciprocally-triggered sequences of actions, routines are portrayed as "a major source of the reliability and speed of organizational performance" (p. 403). This is not to say that organizational routines cannot be the source of sub-optimal or inopportune behaviour when they are used in inappropriate circumstances. Nevertheless, routines do give a sense of certainty and stability to the organizational realm and, importantly, to members of the organization.

Although organizational routines cannot be reduced to individual memories, their patterns and processes of change are strongly linked (Hastie et al., 1984; Johnson and Hasher, 1987; Levitt and March, 1996). The active role of memory in gaining, storing and retrieving knowledge represents a fundamental link between organizational and individual learning (March and Olsen, 1975; Daft and Weick, 1984; Kim, 1993). With the aim of operationalizing the concept of memory, Cohen (1996) indicates how recent studies of "organizational learning are nicely complemented by current developments in psychology" (p. 188). In particular, Cohen builds on the work of Singley and Anderson (1989) to distinguish between declarative and procedural memory. Declarative memory stores facts and events. As such, it is more subject to decay, more explicitly accessible, and more easily transferable to novel circumstances, than procedural memory which is the form of memory in which the individual's skilled actions are stored. Procedural memory encompasses both cognitive and behavioural activities, and is relatively automatic and inarticulate (Cohen, 1996). It is also hard to access; it is the locus where organizational routines are stored and, for this reason, it can be a source of resistance to change. Procedural memory can be compared with the concept of individual skills and habits. According to Stinchcombe, individual's skills are the foundation of organizational capabilities; they are completely routinized and "once a routine is switched on in the worker's mind, it goes on to the end without further consultation of the higher faculty" (1990, p. 63).

Such perspectives emphasise the interplay of the social and psychological dimensions of the processes through which routines emerge and eventually change as result of interactions between procedurally remembering individuals (Cohen and Bacdayan, 1996). Among others, two issues deserve particular attention at this stage: firstly, the reasons behind the routinization of behaviour; and secondly, the way in which knowledge is learned, stored and recalled in the form of routines. These issues are pivotal to understanding the dynamics of stability and change, and the relationship between management accounting systems and organizational culture.

To explore the reasons behind the routinization of behaviour, we rely on Berger & Luckmann's sociology of knowledge. Berger and Luckmann (1966) describe the mechanisms through which a shared cultural order is continually produced and reproduced despite the biological characteristics of individuals. They argue that "the human organism lacks the necessary biological means to provide stability for human conduct" (1966, p. 69). Therefore, social orders become the means of sustaining human nature, supplementing cognitive and normative structures. Through processes of routinization individuals retain knowledge acquired from their social experiences and they can recall this knowledge during processes of social interaction without constantly questioning meanings and patterns of behaviour. As such, Berger & Luckmann see the cultural order of any organization as a never-ending social product, which combines both stability, through the repeated enactment of established patterns of behaviour, and the potential for change. Importantly, the latter is made possible through the "world-openness", which characterise agents relationships with their environment and which is crucial for processes of learning (1966, p. 65). When validated through processes of social interaction, the knowledge so acquired can become routinized.

However, the second question remains: how is knowledge is acquired and validated before it becomes routinized. Building on the work of Kolb (1984) and Senge (1990), Kim (1993) argues that learning involves thought and action in both the conceptual (cognitive) and the operational (behavioural) realms, and explains how in learning "a person continually cycles through a process of having a concrete experience, making observations and reflections on that experience, forming abstract concepts and generalizations based on those reflections, and testing those ideas in new situations, which leads to another concrete experience" (p. 38). Although learning is undoubtedly acquired through experience, memory is fundamental for storing what has been learnt. However, memories, or individuals' mental models to use Kim's terminology, are not involved exclusively with storing. They include explicit (declarative) and implicit (procedural) knowledge that, consciously or unconsciously, provide an ontological construction for interpreting new situations in the light of existing stocks of knowledge. Mental models encompasses both the operational learning, which concerns the know-how gained through experience, and conceptual learning, which refers to the deep-rooted assumptions and values that characterise the individual. Therefore, processes of learning, routinization and recalling continuously operate at two levels: cognitive and behavioural.

23.2.2 Organizational Culture as Both a Socially Constructed and Institutionalized Phenomenon

The concept of culture has been central to many research studies in fields ranging from sociology to organization theory, and from anthropology to management studies. Although a review of these studies is beyond the scope of this paper, it is important to recognise that the conceptualization of culture has historically been influenced by the traditional dualism between the objective and subjective perspectives; between organizations having cultures and organizations as cultures (see Mouritsen, 1989); and culture as a critical variable or root metaphor (Smircich, 1983a, p. 339). On the one hand, the objective perspective, which treats culture as a critical variable, views it as something an organization has (Calas and Smircich, 1989). Thus, culture is portrayed as a contingent factor in designing efficient organizational structures; a variable which can be "crafted and manipulated by management intervention to instil particular company values and attitudes and to create particular forms of behaviour" (Preston, 1995, p. 284). On the other hand, the subjective perspective treats culture as a root metaphor. Such a social constructionist view, conceptualises culture as something an organization is. Organizations are cultures, i.e., "systems of knowledge, beliefs and values in which action and artifact are vested with expressive qualities" (Dent, 1991, p. 705). As such, organizations are themselves cultural phenomena, rather arenas in which cultures are located (Czarniawska-Joerges, 1991, p. 288).

In line with Berger and Luckmann's institutional approach (1966, p. 65), it can be argued that social constructionism and functionalism converge in an interpretative perspective according to which organizations both reflect and shape their own reality (Parker, 2000). If culture represents "shared interpretive schemes, expressed in language and other symbolic constructions that develop through social interaction", it needs to be acknowledge that "such schemes provide the basis for shared systems of meaning that allow day-to-day activities to become routinized or taken for granted" (Smircich, 1983b, p. 160). Drawing on Schein (1991, 1992, 1999), we conceptualise organizational culture as an institutionalised phenomenon, which binds time and space through ongoing processes of social interaction. Thus, organizational culture is interpreted as a socially constructed/validated pattern of shared basic assumptions, which have been developed by a specific group of individuals (organizational members) as they learn to cope with the problems of external adaptation and internal integration. Such taken-for-granted assumptions represent a mutual stock of knowledge stored in organizational routines, which can be passed on to newcomers as the appropriate way to act, think, and feel in relation to specific situations (Schein, 1991).

The involvement of accounting practices in the creation, diffusion, maintenance and change of organizational culture seems to be generally acknowledged in the organisational-based accounting literature (Berry et al., 1985; Ansari and Euske, 1987, Covaleski and Dirsmith, 1988; Mouritsen, 1989; Dent, 1991). As observed by Dent (1991), the literature contains various examples of the constitutive role of management accounting in the construction of organizational reality (see also Hopwood, 1987; Miller and O'Leary, 1987; 1994; Hopwood and Miller, 1994). Portrayed as playing a "powerful role in organisational and social affairs", accounting practices have been said to "influence perceptions, change language and infuse dialogue, thereby permeating the way in which priorities, concerns and worries, and new possibilities for action are expressed" (Hopwood, 1990, p. 9). In addition, particularly during the last decade, several case studies have attempted to investigate the way in which accounting and other organisational practices contribute to the ongoing processes of production and reproduction of a specific organisational context (see, among the others, Dent, 1991; Miller and O'Leary, 1994; Scapens and Roberts, 1993; Carmona et al., 1998; Jazayeri and Hopper, 1999; Johansson and Baldvinsdottir, 2003).

Building on the contributions of Roberts and Scapens (1985), Macintosh and Scapens (1990) interpret management accounting systems in light of Giddens' structuration theory (1984). In particular, they portray structuration theory as indicating "the ways in which accounting is involved in the institutionalization of social relations" (p. 474). In so doing, they argue that management accounting systems can be interpreted as modalities of structuration in the three dimensions of signification, legitimation and domination identified by Giddens. Although separable analytically, these three dimensions of structure are, in practice, inextricably linked, and can be drawn upon in interpreting the nature and the role of accounting practices:

> "command over the management accounting process, for example, is a resource which can be used in the exercise of power in organisations. Drawing on the domination structure certain organisational participants hold others accountable for particular activities. Management accounting is a key element in the process of accountability. However, the notion of accountability in management accounting terms makes sense only in the context of the signification and legitimation involved in management accounting practices. Organizational participants make sense of actions and events by drawing upon meanings embedded in management accounting concepts and theories. Furthermore, management accounting gives legitimacy to certain actions of organizational participants" (Macintosh and Scapens, 1990, p. 457).

23.2.3 Interpreting Management Accounting Systems as Modalities of Structuration

On trying to reconcile the apparently irreconcilable paradigms emerging within the sociological traditions, Giddens' theory of structuration follows the lines traced by Berger and Luckmann's contribution in affirming how the basic domain of social science is neither the experience of the subject, nor the existence of any form of societal totality, but social practices, where these two realms are incorporated and, ultimately, synthesised. The term structuration refers to the conditions governing the continuity or transformation of structures and social systems, and indicates that structure – the "codes" for social actions – and agency – the activities of individual members of the systems – exist in a recursive relationship. Thus, while agents draw on structures during their processes of interaction, by performing social activities they reproduce the actions that make these practices possible.

Relying on these assumptions, Giddens identifies three modalities of structuration (see Fig. 23.1), representing the three dimensions of social structures on which

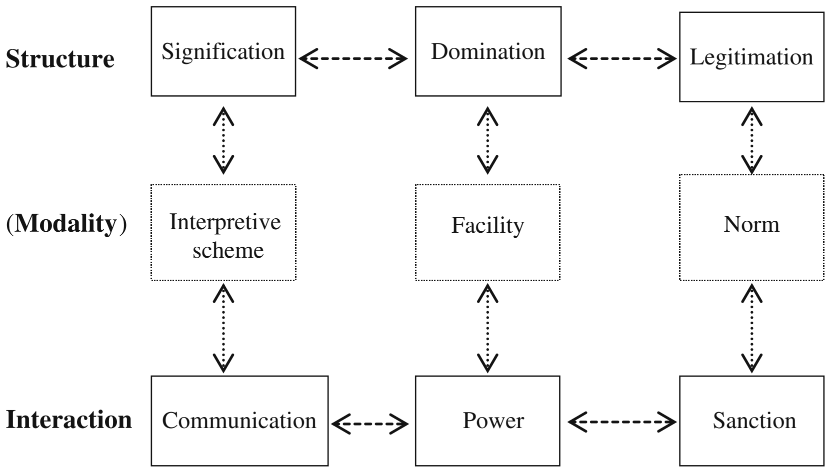

Fig. 23.1 Dimensions of social structures

individuals draw in their day-to-day activity of interaction. These modalities of structuration are portrayed as interpretive schemes with regard to signification structure – i.e. "the core of mutual knowledge whereby an accountable universe is sustained" (Giddens, 1979, p. 83; emphasis added), as facilities within domination structure – i.e. "reproduced relations of autonomy and dependence in social interaction" (Giddens, 1979, p. 93) and, finally, as norms with reference to legitimation structure – i.e. "the actualization of rights and enactment of obligations" (Giddens, 1976, p. 86). Consequently, according to Giddens's view, by relying on such structures and on the related modalities of structuration, the institutionalisation of a socially constructed order may be achieved: i.e. a frame of mutual meanings may be communicated, a system of authority and power may be established and, finally, a moral code of conduct may be recognised.

As suggested above, Macintosh and Scapens conceptualise management accounting practices as "modalities of structuration", i.e. having a pivotal role in the recursive relationship between agency and structure along the three dimensions of signification, legitimation and domination.In particular, individuals have the potential to draw on accounting practices as interpretative schemes for communicating meanings and understandings within the signification structure (see Fig. 23.1). Management accounting provides managers with a means of understanding the activities of their organization and allows them to communicate meaningfully about those activities. As such, a management accounting systems is an interpretative scheme which mediates between the signification structure and social interaction in the form of communication between managers. The signification structure in this case comprises the shared rules, concepts, and theories which are drawn upon to make sense of organisational activities.

Looking at the legitimation structure, Macintosh and Scapens (1990) propose that accounting systems participate in the institutionalization of the reciprocal rights and obligation of social actors. In so doing, they argue how management accounting systems "embody norms of organizational activity and provide the moral underpinnings for the signification structure and the financial discourse" (p. 460; emphasis added). They legitimate the rights of some participants to hold others accountable in financial terms for their actions. They communicate a set of values and ideals about what is approved and what is disapproved, and what rewards and penalties can be utilized (sanctions). As such, management accounting systems are not an objective and neutral means of conveying economic meanings to decision makers. They are deeply implicated in the reproduction of values, and are a medium through which the legitimation structure can be drawn upon in social interaction within organisations.

Finally, the third dimension of structure, i.e., domination, is strongly related to the concept of power. While in a broad sense power is considered as "the ability to get things done and to make a difference in the world" (Macintosh and Scapens, 1990, p. 461), its narrow meaning simply implies domination. Roberts and Scapens (1985) pointed out that, within structuration theory, agency is conceptualised as being involved with power in both the broad and narrow sense. In particular, it is important to emphasise the role of "resources" as facilities through which individuals draw upon the domination structure in the exercise of power. Asserting that in particular space-time locations the capacity to exercise power may be related to asymmetries in the distribution of resources, Giddens distinguishes two types of resources: authoritative resources, deriving from the co-ordination of the activity of social actors, and allocative resources, which arise from the control of material products or aspects of the material world. As Macintosh and Scapens suggest, "both types of resources facilitate the transformative capacity of human action (power in the broad sense), while at the same time providing the medium for domination (power in the narrow sense)" (1990, p. 461). In this sense, management accounting systems are conceptualised as socially constructed resources which can be drawn upon in the exercise of power in both senses.

Next, we extend the institutional perspective developed by Barley and Tolbert (1997) and Burns and Scapens (2000) to illustrate a possible conceptualization of management accounting and its interplay within processes of production and reproduction of organisational culture. In particular, we portray Management Accounting Systems as a set of rules (i.e., the formalised statements of procedures), routines (the practices habitually in use) and roles (the network of social positions) which, along with other organisational systems, act as repositories and carriers of organisational and individual knowledge. Therefore, it is important to recognize that management accounting systems can facilitate processes of organizational unlearning and change, but they can also prevent the questioning of existing knowledge and cultural assumptions (Hopwood, 1987; Argyris, 1990; Dent, 1991). A discussion of the role of management accounting systems within evolutionary vs. revolutionary processes of change, as well as their cognitive vs. behavioural implications is provided below.

23.3 Performance Measurement, Accounting and Culture: A Framework for Interpreting Processes of Unlearning and Change

The literature on organisational change has in recent years offered some notable studies of the cognitive and cultural (Willmott, 1987; Pettigrew, 1987), as well as the behavioural and structural dimensions of change (Barley and Tolbert, 1997). Drawing on a wide range of disciplines, many researchers have abandoned the earlier context-free descriptions of change, and started to explore its processual dynamics (Laughlin, 1991, p. 209), and various models or pathways for understanding and classifying organisational change have been developed. In particular, single-loop and double-loop learning (Argyris and Schon, 1978), morphostasis and morphogenesis (Robb, 1988), first-order and second-order change (Bartunek and Moch, 1987), evolutionary and revolutionary change (Nelson and Winter, 1982) and reorientation and colonization (Laughlin, 1991) are some of the labels which have been attached to classifications of individual and/or collective reactions to environmental disturbances.

Nevertheless, researchers have paid relatively little attention to the reasons why particular pathways are followed, or why a particular kick (Morgan, 1986, p. 249), environmental impetus (Bartunek, 1984, p. 356), jolt (Laughlin, 1991, p. 209), or stimulus (Harris, 1994, p. 311) preserves, rather than changes, the organisational order. Furthermore, there are few holistic studies linking the cognitive dynamics, which characterise organisational culture, and the behavioural and structural modalities through which culture is reproduced. Therefore, by combining Giddens' sociological insights, with Schein's psychological perspective, we intend to develop a framework to interpret how organisational culture evolves across time and space, as well as the role of management accounting practices in such processes.

For this reason, although we are aware of the difficulty of the task, an attempt is made here to provide a working definition of "change". In particular, we see change as the ongoing process of cognitive and behavioural definition and redefinition which influences agents' motivation for action. This is consistent with Giddens's conceptualisation of the organisational code which is stored both as memory traces and within routinised pattern of behaviour. In this sense, change may be conceptualised as a continuous re-examination of the stored knowledge and patterns of behaviour which characterize agency. Consequently, while recognising that the process of change is continuous, and involves inertial forces resulting from the routinised practices and patterns of behaviour which provide continuity over time (Nelson and Winter, 1982), the models or pathways cited above represent contingent dynamics depending on the depth and intensity to which the cognitive, regulative and normative structures are impacted by endogenous and/or exogenous disturbances.

In particular, drawing on Nelson and Winter (1982), we would describe as "revolutionary" those episodes which have a significant impact on the existing routines and institutions (see also Burns and Scapens, 2000). Thus, while often (but not always) caused by major external events, such as economic shocks, ownership change and technological innovations, revolutionary change needs to be understood as involving radical disruptions to the institutionalised values and patterns of behaviour which characterise the existing organisational culture (Schein, 1992). In contrast to revolutionary change, in which the taken-for-granted assumptions are questioned fundamentally, "evolutionary" change is incremental and involves only minor and, sometimes, unconscious adjustment to the taken-for-granted assumptions (see Burns and Scapens, 2000). As such, the potential for evolutionary change is constrained and also enabled by the underlying rationales and institutions encoded within organisational roles, rules and routines. Next, we sketch a framework to interpret how management accounting systems may contribute to processes of unlearning and organizational change. In so doing, the insights from an explanatory case study will inform the discussion on the role of management accounting systems within evolutionary vs. revolutionary processes of change, as well as their cognitive vs. behavioural implications.

23.3.1 "Evolutionary" Processes of Change

The empirical investigation and interpretation of processes of change and institutionalisation is a difficult task. Consequently, in order to decipher the duality of social interaction and taken-for-granted assumptions, we must focus on the organisational processes through which it occurs (Laughlin, 1991). As suggested by Barley and Tolbert (1997, p. 100): "research on these processes requires a conceptual framework that specifies the relations between interactional episodes and institutional principles". To overcome the static approach of Giddens' structuration theory, they argued that whereas the cognitive assumptions which characterise organisational culture enable and constrain situated interaction synchronically (i.e., at a specific point in time), the ongoing enactment of specific patterns of behaviour allows "position-practice" incumbents to produce and reproduce these assumptions diachronically (i.e., through their cumulative influence over time). This time dimension is represented in Fig. 23.2 by the thick and bold horizontal lines/arrows at the top and at the bottom, which represent the realms of institutionalised culture and organisational interactions. The connection between these two realms is provided by formalised statements of procedures (rules), the network of social positions (roles) and practices habitually in use (routines) – it is here that management accounting systems (along with other organisational systems) perform a pivotal role as modalities of structuration.

Drawing from Barley and Tolbert (1997) and Burns and Scapens (2000), the evolutionary path in Fig. 23.2 is represented by four moments of change: encoding,

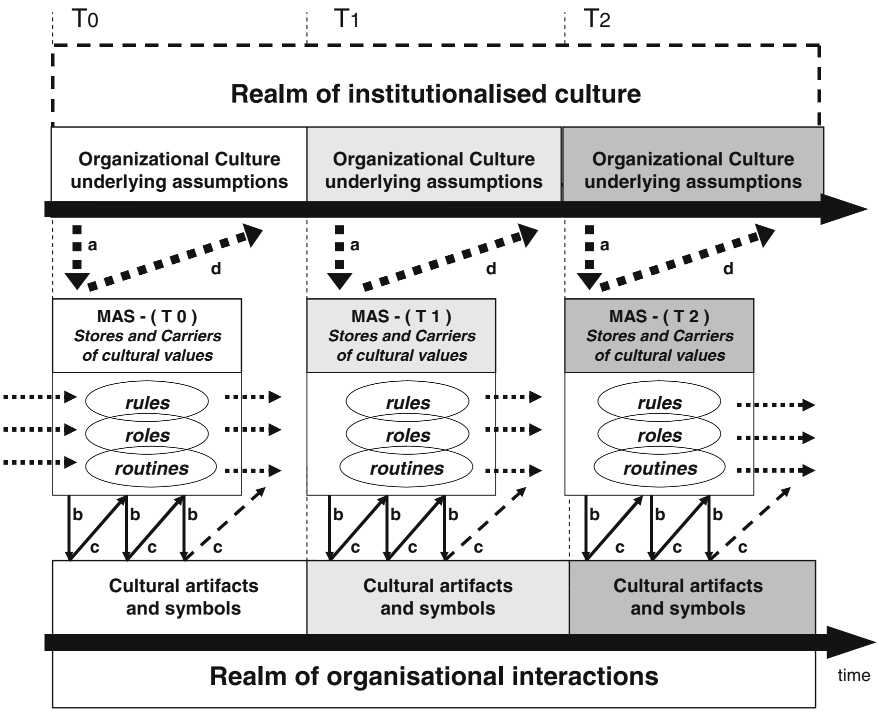

Fig. 23.2 Realm of organisational interactions

enacting, reproducing and institutionalisation.[2] The first moment (arrow a) concerns the "encoding" of institutionalised, i.e., taken-for-granted, cognitive assumptions within localised behavioural regularities. As such, the rules, roles and routines (which characterise management accounting systems) are informed by the values and beliefs embodied in these institutions. Although this process of encoding involves all the dimensions of structure, it generally relies upon the employment of specific resources of power drawn from the institutionalised structures of domination (see Burns and Scapens, 2000).

The second moment (arrow b) refers to the "enactment", through the day-to-day activities of specific organizational participants, of the patterns of behaviour which are informed by the encoded cognitive assumptions. As such, it is through the enactment of the organisational rules, roles and routines that the essence of organisational culture becomes instantiated in organisational interactions. Although this enactment sometimes involves conscious choice, it is generally the outcome of reflexive monitoring informed by the agents' tacit knowledge (Giddens, 1984). It is through this reflexive monitoring that the third moment (arrow c) takes place – i.e., the "reproduction" of the routinised activities. It is through such a recursive process of enacting and reproduction that accounting practices, conceptualised as both repositories (Giddens, 1984) and carriers (Jepperson, 1991 and Scott, 1995) of organisational culture, evolve across time and space.

Finally, the fourth moment (arrow d) involves a dissociation of values and assumptions from the repositories and localised situations in which they were created – i.e., they become "institutionalised". In this sense, they undergo a deep cognitive transformation to become the shared taken-for-granted assumptions, or institutions, which provide the unquestioned basis for social interaction. It is through such processes that organisational culture gets its stability. As Burns and Scapens suggest, such taken-for-granted assumptions are more abstract than the rules, roles and routines in which they are stored. For this reason, dotted lines are used for arrows a and d. However, through the enabling and constraining processes of social interactions period by period, they bind time in situated contexts of co-presence. Hence, there are several b and c arrows for each pair of a and d arrows. Finally, the phases of encoding and institutionalisation represent ongoing processes, rather than single identifiable movements. This explains the broad lines used for arrows a and d.

Nevertheless, described as "circumstances of radical disjuncture of an unpredictable kind which affect substantial numbers of individuals, [or] situations that threaten or destroy the certitudes of institutionalized routines" (Giddens, 1984, p. 61), critical situations threaten the agent's sense of psychological safety which is embedded within the routinised patterns of behaviour. When (in such critical situations) these routines are unfrozen, anxieties arise and individuals tend to question their taken-for-granted assumptions, and it is then that "revolutionary" episodes of

[2] It is important to recognise that these separate "moments" are used for analytical purposes only and that, as processes of change are continuous, they will be difficult to distinguish empirically.

change may occur (Schein, 1992). Next, we will rely on the insights of the "cultural revolution" which took place within an Italian company, Nuovo Pignone (NP), as it was acquired by General Electric (GE), a US-based multinational. Drawn upon as an illustrative example, the case material offers a basis for exploring the way in which management accounting practices participate in the in processes of unlearning and organizational change.

The insights from the GE-NP case are based on a longitudinal study of close observation during which we had the opportunity to spend considerable amounts of time in the company (for additional details see Busco, 2003; Busco et al., 2006-forthcoming). From 1995 to 2004 we were given the opportunity to explore the process of accounting and performance measurement change as it unfolded, and to interpret the reactions of a community whose "culture" was deeply challenged by the GE acquisition. We were offered wide-ranging access to the organisational setting, where we took part in workshops, seminars, group discussions and meetings. Overall, we conducted more than 90 interviews up to the end of 2004.

23.4 Transforming Culture Through Systems of Measurement and Accountability

Originally established in 1842 as Pignone, Nuovo (new) Pignone was set up in 1954 following acquisition by a state-owned holding company and it was later, in 1994, acquired by the US multinational, General Electric (GE). The case focuses on the integration of NP into the global GE organisation. Although various programmes of organisational restructuring were implemented within NP, ranging from downsizing and delayering to boundaryless working and outsourcing, the process of integration was grounded in a major change in the understanding of measurement, and especially performance measurement, within NP.

As far as measurement systems were concerned, the culture of NP was so totally different to GE that a massive process of cognitive and practical redefinition was required. Whereas NP had no tradition of using performance measurement systems, GE's management and organisational style relied extensively on such systems for both communication and control. Before the acquisition, NP was a state-owned and largely bureaucratic company, which had to produce budgets and various reports for both head office and the state bureaucracy, but they were used largely for ceremonial purposes and not integrated into management processes. Although, this did not prevent NP from being reasonably profitable, due largely to its excellent products and production systems, following the acquisition by GE significant changes took place. There were two major components of organisational change within NP: the first was the re-design of the company's systems of accountability, and the second was the subsequent implementation of a Six Sigma Initiative – a measurement-based quality improvement programme.

23.4.1 Breaking the "Old Culture"

GE is a massive global business, managed through a common organisational language and widely-shared cultural values. Following the acquisition, the "GE Way"[3] was applied very aggressively throughout NP. "We knew the world was going to change. And the world has changed totally!" confirmed an NP finance manager. Despite its undoubted technical competence, speed and promptness were not typical characteristics of the old NP, which sometimes described itself as a bureaucratic giant. However, the processes of change which GE brought to NP, besides being radical, were also very rapid. This was quite in line with GE's tough and aggressive business philosophy.

An interesting example concerns human resource management. Talking to a meeting of GE operating managers, the CEO of GE categorised managers and employees as: A players, who subscribe to the company's values and who have to be kept and rewarded; B players, who still deserve to be trusted because they have the potential to improve their skills and productivity; and C Players, who do not subscribe to the company's values and, without remorse, deserve to be fired. "It wasn't a normal change, it was a shock! An earthquake in our daily way to think and behave . . . from a rather relaxed system mainly based on egalitarian principles, we suddenly faced the A,B,C ranking theory. I am not arguing it was right before, I am not arguing that at all, but it was scary" was the comment of a B-ranked engineer.

When asked to describe NP's control systems before GE's arrival, a management accountant emphasised how "there were no pressures for financial improvements. No particular information were required . . . The tools were there, the data were there, but they didn't look so interesting or 'burning' as now". "I still have doubts that anyone bothered to read those documents carefully", he continued. The extent of the change that took place within NP was quite obvious in an interview of a business analyst who, while nervously consulting his calendar, explained that:

> GE's headquarters need numbers to show to Wall Street. Consequently, we need to be fast, reliable and, indeed, profitable. If not, the week after tough inquirers start to cross the Atlantic . . ..

23.4.2 Facing the Pressure of Change by "Wearing the Hat of Finance"

NP's employees were not left alone facing the uncertainties of change. They were provided with a number of instruments for learning and coping with the new business reality, one of which was the language of accounting and measurement. "We are building up the necessary kit-for-survival, aren't we?" commented a project

[3] This is the term used to describe the established ways of working within GE.

engineer at the end of a financial fundamentals training session. Thus, while experiencing the pressure for change, everyone within NP was learning a new vocabulary and a set of practices which helped to exorcise the fears connected to the re-defined organisational context.

Redesigning the systems of accountability involved major extensions to the company's financial systems, and a re-structuring of the accounting and finance function. The latter comprised a restructuring of the department traditionally responsible for cost accounting and the establishment a new department of financial planning and analysis for NP as a whole. In addition, a new group of Finance Managers was created. They were located in the individual divisions and responsible for supervising budgeting and reporting at the operating level, as well as providing financial support to operating managers. As such, they were able to assist managers to cope with the new systems of accountability.

In addition, managers at all levels were given intensive training in the new systems, and they were encouraged to think in financial terms. The language of measurement became an important instrument in the processes of learning. An interesting example concerns sales managers, and other sales personnel, who were encouraged to see their customers as financial entities. "Financial solution selling will be a strategic weapon in our sales arsenal", declared an internal booklet, which continues:

> [as] sales and sales support professionals, you 'wear many hats' and possess many skills that keep our corporation at the sales and support forefront ... Now, you're being asked to wear one more hat – probably the most important and powerful one in your career – that of a financial consultant. Wearing that hat will open up new sales vistas and greater opportunities. You will be increasingly challenged to know and assist your accounts better than ever – to look for every opportunity to improve their financial condition by selling General Electric solutions that truly affect their 'bottom line'... (emphasis in the original).

23.4.3 Towards a "New Culture": The Crystallising Potential of Successful Experiences

Despite the benefits of "wearing the hat of finance", it was probably the Six Sigma Initiative which played the major role in bringing about change in NP. Six Sigma is a quality improvement philosophy, which has had a major impact on a number of large businesses over the past decade. It comprises a range of tools, techniques and processes for achieving very tight quality targets (Sigma is a measure of the number of mistakes per million discreet operations – with six sigma there are only 3.4 mistakes per million.). However, the systems which are needed for the successful implementation of Six-Sigma require a vast array of both financial and non-financial measures, integrated into a holistic system of performance measurement and accountability – something which had not traditionally been a strength of NP.

The integration of financial and non-financial measures requires corporate-wide information systems and, being grounded in a quality-based philosophy, the implementation of Six-Sigma extended the culture of measurement to all parts of NP.

As a result using Six-Sigma, managers within NP are now able to communicate with other GE managers, wherever they are located, using financial terms and the language of Six Sigma. “By empowering engineers with financial systems of accountability they [NP management] didn’t create new figures, they didn’t reproduce accountants. On the contrary, they have infused operating roles with a broader view of the business. They created a minimum common base of knowledge to talk about contents, without losing any time arguing about meanings” (NP’s project manager).

Successful experiences can crystallise the new business reality in the individual’s cognitive schemes. Systems of measurement and accountability played a pivotal role in this process. They were perceived as the source of a new organisational identity and as devices for achieving and maintaining a new sense of psychological safety and security. Waving a folder containing Six-Sigma training material, “the sharing of these measures allowed our outcomes to be understood and appreciated world-wide” was the enthusiastic comment of an engineer a few months after his project had received an awarded as the best Six-Sigma project of the year within GE Power Systems. Thus, although local management’s conduct was initially regarded by union leaders as opportunistic behaviour and a betrayal “by someone who has suddenly lost his memory due to being well paid!”(a trade union poster), trust for change has become increasingly shared within NP. Nowadays, the language of accounting and measurement is continuously drawn upon in day-to-day activities within NP, and as such symbolises a re-defined organisational culture.

The case study of NP, in the period following its acquisition by GE, provides an interesting example of the processes of organisational unlearning and transformation. We have endeavoured to understand the how and why of these processes, and specifically to explore the processes of “disconfirmation” or “unfreezing”, cognitive re-definition and, then, institutionalisation or “re-freezing” of mutual stocks of organisational knowledge, and to illustrate the role played by systems of measurement and accountability. The use of a longitudinal case study provides an opportunity to incorporate the various elements of these processes within an institutional framework of unlearning and change. Next, we rely on the insights from the GE-NP case to finalize the interpretive perspective offered within the paper.

23.4.4 “Revolutionary” Change: Interpreting Cognitive and Behavioural Discontinuity

A recognition of the ongoing and cumulative evolutionary path is crucial for understanding processes of change in organisations. One of the key features of agency is that, by relying on their self-reflective abilities and mutual stocks of knowledge, the individuals have the potential to make a difference during the ongoing process of day-to-day organisational interaction, either enabling or resisting change. Nevertheless, in specific circumstances, major episodes of disruption can create a discontinuity in the path-dependent process, and give rise to revolutionary change (Giddens, 1984).

By relying on Lewin's contribution (1951), Schein (2003) argues for a tied relationship between radical processes of change and phases of stability. "Change and stability are two sides of the same coin" (p. 34), he emphasises. Additionally, he describes three different stages which need to be carefully analysed when interpreting processes of profound change. These phases are the following: (1) unfreezing, (2) changing through cognitive redefinition, and (3) refreezing. According to Schein, "no change will occur unless the system is unfrozen, and no change will last unless the system is refrozen. Most change theories tend to focus only on the middle stage and then cannot account for inability to produce change in the first place, or inability to maintain the changes that have been achieved" (2003, p. 36).

Schein describes the phase of unfreezing as the creation of a motivation to change. Such motivation to change can be stimulated by changing the set of forces which act on the system, such that:

(1) the present state is disconfirmed to some extent;
(2) survival anxiety or guilt is created because of failure to achieve the planned goals or to meet the standards;
(3) a certain amount of psychological safety is generated to overcome the defensive mechanisms, such as the learning anxiety or the defensive routines which may eventually prevent change (Schein, 2003).

In such episodes of disruption, the institutionalised (cognitive) stocks of knowledge will no longer help organizational participants, who must now assemble new rationales and resources, thereby leading to a collective questioning of the existing rules, roles and routines. As such, the existing institutions remain consciously locked into a past temporal frame, and thereby they lose their ability substantially to shape current behaviour (see "e" in Fig. 23.3). The disruptive consequences of such episodes for the ongoing dynamics of organisational culture explain the sudden slippage of the two longitudinal arrows in Fig. 23.3 and the return to a "white" background.[4]

Unlearning and change are conditions built in and on practices (Gherardi and Nicolini, 2001; Nicolini et al., 2003). When disconfirming episodes occur, participation in a practice facilitates processes of critical reflection, and offers the opportunity to re-assess existing ways of thinking. In this respect, organisational systems such as management accounting inform social actors at socially constructed loci (i.e., work places), thereby enabling them to reflect upon and assess the trustworthiness of the existing rationales and cultural assumptions, as well as to evaluate the risks and the opportunities associated with acting differently.

In the case of NP, GE's top management purposively accompanied the unfreezing of the existing culture with the introduction of a number instruments, projects and initiatives for dealing with the new business reality, and embodying a certain

[4] The white background reflects the relative absence of "history" in the ongoing, path-dependent, cumulative evolutionary process. The revolutionary change, to some extent, wipes the slate clean.

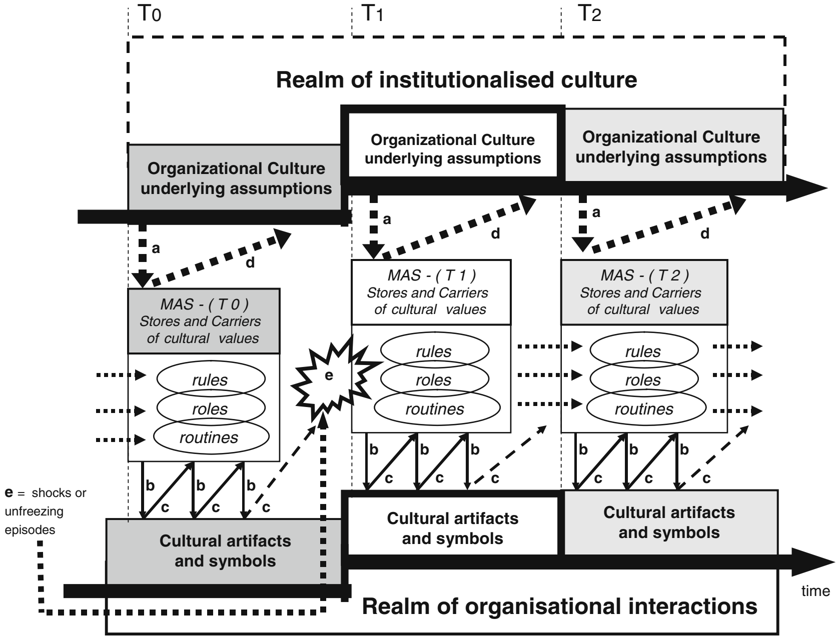

Fig. 23.3 Realm of organisational interactions

degree of confidence in the face of the proposed change. In that respect, it could be said that the language of accounting and measurement supported NP's employees in making sense of the new organisation, and informed processes of critical reflection on their experiences ("We are building up the necessary kit-for-survival, aren't we?" – cited earlier). Therefore, within NP, management accounting's rules, roles and routines participated in the processes of unlearning and change by questioning the "old culture" and making visible the trustworthiness of the GE Way.

23.5 Conclusions

The need to understand and manage organisational complexity is undoubtedly one of the main challenges for current corporate leaders. Facing ongoing problems of external adaptation and internal integration, global corporations (such as GE) are increasingly relying on measurement-based systems of management to align business processes with corporate strategies. As global organization grow by acquisition, they are undertaking continuous processes of transformation and infusing organisational culture with shared systems of performance measurement. This paper has explored the nature of these processes of change, and has tried to interpret the intertwined relationship between management accounting systems and organisational culture.

The paper is intentionally eclectic, drawing on heterogeneous literature. These contributions lead us to conceptualise change as the ongoing process of cognitive and behavioural definition and re-definition which influences agents' motivation for action. Viewed as a set of rules (the formalised statements of procedures), roles (the network of social positions) and routines (the practices habitually in use), management accounting systems can be interpreted as socially constructed and institutionalised practices involved in the production and reproduction of organisational order. In this sense, management accounting change tends to be "evolutionary" and path dependent.

However, as the GE-NP case illustrates, organisational transformations can sometimes be particularly intense. When crisis situations arise, and organisations are faced with a need to unlearn and change, organisational members can find themselves under intense pressure. Their rationales and routinised behaviours, which are driven by their existing knowledge and cultural assumptions, are challenged. During these episodes they may find new "ways" and resources with which to question the existing organisational rules, roles and routines, as well as the cultural assumptions which they encode. In these circumstances, management accounting practices may play an active part (along with other organizational systems) within "revolutionary" processes of unlearning and culture change.

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