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A Journey through Manufacturing and Supply Chain Strategy Research

A Tribute to Professor Gianluca Spina

ASSOCIAZIONE GIANLUCA SPINA
education, management, ethics

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Foreword by Giovanni Azzone

I met Gianluca Spina for the first time in the end of the 1980s, just after he graduated in Electronic Engineering at Politecnico di Milano. Ever since then, we have been colleagues, at the Department of Management, Economics and Industrial Engineering and at the business school, and close friends.

This makes it very difficult for me to distinguish between the man and the scientist, as I shared most of my professional and personal life with him. Luca was so active and so full of ideas for the future that I am still unable to fully realise that he will not be able to apply them in practice or see the results of his actions.

However, as men of culture and science, we do know that our role in the world is not measured by the time we spend here, but rather by the effects of our ideas. And I am very happy that some of Prof. Spina's ideas are collected in this book, with commentary from the most important scholars in the field of research into manufacturing and supply chain strategy.

The papers show the leading role that Prof. Spina covered in the field over more than 20 years, since the early 1990s, when he, with Emilio Bartezzaghi, started his research at Politecnico di Milano. They also clarify the approach employed by Prof. Spina, to combine a sound strategic framework with a wide empirical basis, and always keeping in mind the *social role* of his studies, where the results should not only be of academic interest but should also have the aim of increasing the competitiveness of real manufacturing companies.

They also show how Gianluca was a key man in the network of international researchers promoting the development of new paradigms for European manufacturing and, above all, his capacity to create a strong group of clever scholars. These scholars—from Raffaella Cagliano to Stefano Ronchi, from Giulio Zotteri to Federico Caniato, to name a few of the better known—will be the biggest legacy that Gianluca and his passion has left to our world.

Giovanni Azzone
Rector, Politecnico di Milano

Foreword by Cristina Masella

I met Luca many years ago, at the start of our careers. We were on the second floor of the Electronics Department, "shoved" into offices that were a bit too small and (at least mine) very untidy, but with the advantage of being close together. What I remember about those days were the expeditions to the EurOMA conferences, schools and AiIG conferences, and the enthusiasm and energy with which we faced every new project.

We progressed through the university together and shared many important moments in our careers, but until 7 years ago, Luca for me was "only" a close colleague whom I admired for his vision and lucid analyses. This changed on the day when he asked me in for a meeting and, playing an exclusion game that I learnt to know well, convinced me—in agreement with his life-long friend Giovanni Azzone—to stand for Director of the Department of Management Engineering. I, therefore, want to talk about the Luca Spina of this last period and my co-existence with him in my "tsarina" role (which is what Luca called me as a joke).

Luca was naturally very intuitive, he was capable of seeing far ahead and, when he took a decision, he travelled much faster than most of us. He found my prudent approach extremely irritating, and often over-influenced by the contingent situation. There were countless episodes of attrition between us. Over the years, however, we learnt how to reconcile his impetuousness and my prudence, his vision and my policy of small steps. I am sure that, without his drive, today we would not be the School of Management that we have become.

Luca was a natural leader, and this often meant that he took on a dominant role when decisions were being made, in particular, when he was taking on a project. I can remember, for example, during the time when he was President of AiIG, his work to spread the culture of research of quality within our academic community, or the long process of transforming the MIP consortium into a consortium company, or again, the evolution of SoM's organisational structure, which, I am sure, is behind many of our results.

Luca was intelligent, stubborn and prickly with incredibly strong work and business ethics. We totally agreed on these points. Possibly because, underneath,

we were not very different. This led to us having a very high level of confidence: "our" moments came during the EFMD Conferences for Deans and Directors. During these two highly intensive days, we used to discuss—while respecting our mutual responsibilities—wrong decisions, errors made, counter-productive behaviour, unmet targets. And we obviously returned to Milan full of good proposals and with a bundle of projects. He running, I trotting.

This, and many other things that cannot fit into this introduction, transformed a dear colleague into a friend to whom I owe so much of my recent professional growth.

Cristina Masella
Head of the Department of Management
Economics and Industrial Engineering
Politecnico di Milano

Foreword by Andrea Sianesi

I started knowing Gianluca in 2001–2002.

In those days, Emilio Bartezzaghi was President of MIP, Gianluca ran the Master in Business Administration and I had just returned to Politecnico after a short interval at LIUC. The first project that I was involved in was to study, with Gianluca, and then launch, the International MBA.

Thinking back to what MIP was then and comparing it with today is the best way to understand what Gianluca has helped us to build over 15 years, many in a leadership position, leaving his own highly personal imprint.

Gianluca belonged to that tiny platoon of colleagues who, right from the beginning of this century, strongly believed in the power of internalisation as a tool to grow and survive competition. Until 2003, no courses were taught in English, while today, at MIP, we have 11 international Master's programmes and most of our students on Master's courses are from other countries.

Gianluca was a firm believer in meritocracy and in quality *above all else*, with no compromise. Today, the School of Management has embarked on a new journey towards our remaining accreditation, AACSB, after having successfully gained recognition from ASFOR, AMBA and EQUIS.

EQUIS, in particular, was a challenge that Gianluca pushed strongly and he spent an incredible amount of time on the process. Even daring to think about such a difficult process 10 years ago, when there was only one international programme at MIP and all our faculty were Italian, indicates how much Gianluca believed in the school's process of development, a journey that was so cleanly mapped out in his mind that he knew exactly what strategic actions had to be taken.

Internationalisation was one challenge, digitalisation was the next. The term *Smart Learning*, which outlines the direction of MIP programmes (and not just theirs) over the next years, was invented by Gianluca. *Smart Learning* is certainly his greatest achievement and our inheritance, determined by his ability to see far ahead. While, 15 years ago, internationalisation may have seemed a great novelty for us, although others had understood its immense potential, it was different for digitalisation. With Gianluca, MIP took on the role of innovator, and because of him, the school is now among the first movers globally in this area.

Finally, Gianluca firmly believed in the process of management and management methods. Being the driving force to get people to develop, whether researchers or MIP staff, challenging them by giving them increasingly more challenging positions, tasks and responsibilities, is a great quality, and he showed this in abundance over the years we spent together. I think that the time we spent together also helped me to grow.

I did not really know Gianluca the researcher, but I knew Gianluca the research group leader extremely well. Through the joint work carried out between our respective research groups, in 2009, Politecnico di Milano was able to activate a Supply Chain Management stream in the MSc and then we started looking at the key sectors for our country, such as fashion and luxury goods, in a totally new light.

I did know Gianluca my friend very well. With him, when skiing together at Gressoney, whenever we could, we have been working out any disagreement or difference of opinion, and, with him, I spent, who knows how many hours, discussing things that seemed like dreams then, and are the reality of MIP today.

Andrea Sianesi
Dean, MIP Graduate School of Business
Politecnico di Milano

Foreword by Francesca Bodini Spina

I met Luca for the first time when he was still an engineering student at Politecnico di Milano. We never could have imagined, then, that Politecnico would have played such an important role in his entire life and a little bit in mine as well.

His was a long journey, initially a difficult one, when he decided to stay at Politecnico before they even had a Ph.D. programme. How could I ever forget that little office facing the Giurati sports centre which he and Roberto Verganti, both still very young, shared with two already established professors, Emilio Bartezzaghi and Adriano De Maio? His journey then gained speed, incredibly so when compared to normal academic progress, following the success and development of the course in Management Engineering. Luca spent, who knows how many nights and how many weekends writing papers, thinking about publications, totally immersed in his work. Tired? Sometimes. But his determination and passion never languished, because he was doing what he loved.

We married at this time, and alongside his professional growth, our family also grew. The words that come into my mind are: happiness, dedication and his—and our—project. Together we created this wonderful life's project, allowing both of us to grow, personally and professionally, and our family too, with the arrival of Pietro and Annachiara.

And along this journey, Politecnico was always with us, joined later by MIP, the business school in which Luca believed so strongly ever since the days of Via Rombon, becoming, ultimately, its President. He was not alone in his journey. His life was filled with people, his parents, Giorgio and Anna, his sister, Fabiana. and brother, Leonardo, our children, Pietro and Annachiara, and his inseparable friend, Alessandro, and there were so many others. I can think of his teacher, Emilio Bartezzaghi, and his students, Raffaella Cagliano, Stefano Ronchi, Federico Caniato and many of his colleagues who became our friends, like Giovanni Azzone and Andrea Sianesi. And the great MIP and AiIG families.

He always told our children that in life, dedication and passion are everything, and if they are missing, you may do many things, but you will not go far.

Francesca Bodini Spina

Preface

This book is intended to be a tribute to Gianluca Spina, and to his intense and inspiring work as a researcher, professor, dean, colleague and friend.

Gianluca was Professor of Business Management and Organisation and Supply Chain Management at the School of Management of Politecnico di Milano. He was an active scholar in the field of manufacturing and supply chain strategy, highly involved in international communities and networks such as EurOMA, POMS and IPSERA and a reference point for the Italian Management Engineering Association (Associazione Italiana di Ingegneria Gestionale—AiIG). He was also the Dean of MIP Graduate School of Business for a decade, and become very active in the international communities of management education, in particular European Foundation for Management Development (EFMD).

Very sadly, Gianluca passed away on the 21 February 2015 in a tragic skiing accident in his beloved mountains.

While trying to make sense of the loss that all of us felt, we thought that the best way to do so was to put together a testimony of the legacy that he left to us. For those who did not have the chance of meeting and knowing him as well as we did, this is the opportunity for absorbing some of his teachings and learning by his example.

We, therefore, decided to write this book, collecting together a number of papers that Gianluca had published with his close friends and colleagues in renowned, international journals. We then asked his friends and colleagues to review them, adding their commentaries to try to extract the key messages and values that continue to be valid many years after their publication.

We used the following selection criteria. First, we tried to give the sense of Gianluca's research journey over the years, and to present the main research streams that distinguished his work. We also selected papers with highest impact on the research community (measured through the number of citations received). Finally, we tried to include the most important research collaborations that Gianluca had established in Italy and abroad. Following these criteria, we selected seven papers, and we then asked a number of scholars in the field, who are among his closest friends and colleagues, to review and comment on these papers.

From our side, in the first chapter of the book, we prepared a summary of Gianluca's research journey set out in parallel with the key developments in the field of manufacturing and supply chain strategy. We have also outlined the very important contribution that Gianluca brought to management education, which, in his approach, was always closely intertwined with his research activity. In addition, we have tried to set out the key values which we think inspired Gianluca in all his work, summarising the legacy that he left to us.

The book also contains forewords by Giovanni Azzone, Rector of Politecnico di Milano, Cristina Masella, Head of the Department of Management, Economics and Industrial Engineering, and Andrea Sianesi, Dean of MIP Graduate School of Business. We asked them to write these forewords not only because of their institutional roles, but mainly because of the close friendship that linked them to Gianluca. And a foreword has been also prepared by Gianluca's beloved wife, Francesca.

We would like to remind here also our colleagues and friends of the GIGA Group (Gianluca's research group at the School of Management)—and, in particular, Roberto Verganti, Mariano Corso, Matteo Kalchschmidt, Tommaso Buganza and all the younger group—who also shared with us these inspiring years with Gianluca.

We hope that we are able to convey through this book all the values, inspiration, energy and enthusiasm that all of us experienced throughout the long journey that we had the good fortune to travel on with Gianluca.

Emilio Bartezzaghi
Raffaella Cagliano
Federico Caniato
Stefano Ronchi

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This book is supported by Associazione Gianluca Spina that was founded by a group of friends and colleagues with the aim of raising funds to finance initiatives to promote education and research in management, with particular emphasis on the topics dearest to Gianluca. In particular, the association will fund academic positions to attract international faculty and researchers to Milan to continue working on the research and education topics closest to his heart and to which he devoted such a large part of his academic life. Moreover, funds will be used to offer awards, prizes and scholarships for excellent students in the field of management. Finally, a number of cultural initiatives will be organised in order to keep Gianluca values and contribution alive. Further details are present at the following webpage: http://www.mip.polimi.it/en/association.

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- Bartezzaghi E., Spina G. e Turco F., (1992), The Impact of the Just-in-Time Approach on Production System Performance: A Survey of Italian Industry, *International Journal of Operations & Production Management*, 12(1), 5–17. **Emerald Group Publishing**
- Spina, G., Bartezzaghi, E., Bert, A., Cagliano, R., Draaijer, D., & Boer, H. (1996), Strategically flexible production: the multi-focused manufacturing paradigm. *International Journal of Operations & Production Management*, *16*(11), 20–41. **Emerald Group Publishing**
- Cagliano, R., and Spina, G., (2000), Advanced Manufacturing Technologies and Strategically Flexible Production, *Journal of Operations Management*, 18(2). **Elsevier**
- Spina G., Verganti R., Zotteri G., (2002), A model of codesign relationships: definitions and contingencies, *International Journal of Technology Management*, 23(4), 304–321. **Inderscience**

– Cagliano, R., Caniato, F., Spina G. (2003), E-business strategy: how companies are shaping their manufacturing and supply chain through the Internet, *International Journal of Operations and Production Management*, 23(10), 1142–1162. **Emerald Group Publishing**
– Brun, A., Caniato, F., Caridi, M., Castelli, C., Miragliotta, G., Ronchi, S., Sianesi, A., Spina, G. (2008), Logistics and supply chain management in luxury fashion retail: empirical investigation of Italian firms, *International Journal of Production Economics*, 114 (2), 554–570. **Elsevier**
– Spina, G., Caniato, F., Luzzini, D., Ronchi, S. (2013), Past, present and future trends of purchasing and supply management: An extensive literature review, *Industrial Marketing Management*, 42 (8), 1202–1212. **Elsevier**

Contents

Chapter 1
Gianluca Spina's Contribution to Manufacturing and Supply Chain Strategy Research and Management Education

Emilio Bartezzaghi, Raffaella Cagliano, Federico Caniato and Stefano Ronchi

Abstract The chapter presents a professional profile of Gianluca Spina, summarizing his contribution to both research and management education. Gianluca's research journey started in the field of manufacturing strategy, focusing on JIT first and then on innovative manufacturing paradigms. Subsequently he extended his interests to customer-supplier partnerships, focusing in particular on codesign, and supply chain management, with a focus on Internet technologies and global supply chains. Finally he concentrated on purchasing management, with a focus on purchasing strategy and the theoretical development of the discipline. His main traits as researcher are also presented. On the education side, Gianluca strongly contributed to the development of the Management Engineering degree at Politecnico di Milano during his whole career, and also at National Level as President of the Italian Association of Management Engineering. Besides, he has led MIP, the Business School of Politecnico di Milano, in its evolution from a small, local school to a large, international player, recognized and accredited by the main international institutions, capable of introducing significant innovations on the market. Finally, Gianluca's legacy is presented.

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1.1 A Journey Through Gianluca Spina's Research

Looking at the major developments in Manufacturing and Supply Chain Strategy literature over the last 25 years, we can often come across studies by Gianluca Spina, whose research has always been at the forefront of the field.

Gianluca started his research work when he joined a research project conducted by Emilio Bartezzaghi and Francesco Turco on **The Impact of Just-in-Time on production system performance** (Bartezzaghi and Turco 1989a, b), with another young scholar, Marco Perona. It was at the beginning of the 1990s, when Just-in-Time started spreading outside Japan and USA. In Europe, a common research question was asking whether it was possible to change the current status of Operations/Production Systems Management and introduce the principles and practices typical of Japanese production systems—Just-in-Time (JIT). The research project took on the challenge of exploring the level of adoption and diffusion of JIT practices in Italy through an extensive survey carried out among medium-large Italian companies (Chap. 2; Bartezzaghi et al. 1992; Perona et al. 1991).

However, the researchers' ambition reached further than this—as pointed out by Filippini and Forza (Chap. 2). On the one hand, they tried to develop a greater understanding of the JIT model, by recognising that there were many practices that could be included under the wide umbrella of JIT and that these needed to be separated into categories, since each type of practice was able to influence manufacturing performance in a different way. On the other hand, they did not limit their analysis to the level of diffusion of these practices, but tried to understand what impact the practices had on production system performance. This involved testing a framework where the impact of JIT practices on production system performance was examined through a number of operating conditions. Their findings were influenced by the times and the national context of the research, but they were able to provide insightful interpretations on the competitive advantage that could be achieved through JIT.

Gianluca and his colleagues were particularly interested in the performance of JIT, and they were among the first to recognise that one of the core principles of JIT was to focus on processes, and that lead time is one of the key performance indicators of any process where JIT can have a significant impact (Spina and Verganti 1992). On the basis of these two intuitions, they developed a model of lead time in (production system) processes, with the purpose of analysing the various components of lead time and the different levers that could be used to reduce the effect of each of these components (Bartezzaghi et al. 1993, 1994). To the best of our knowledge, this was a pioneering study in its approach and results, and—despite focusing on production system/operations processes—anticipated many of the studies on business process re-engineering and improvement of the 1990s.

After these initial studies, Gianluca's research followed two main paths throughout the 1990s. In one, Gianluca and Emilio Bartezzaghi, in collaboration with Harry Boer (who was at that time at Twente University in the Netherlands) and with the support of Raffaella Cagliano (then a young PhD student)—made advances in

the studies of emerging manufacturing models that had originated with research on JIT, by proposing a **new manufacturing paradigm**, called Strategically Flexible Production (SFP). In the other stream, they developed a strand of research on **manufacturing strategy content and process**. The two streams were closely intertwined, crossing each other's paths at different points in time.

Both research streams sprung from participating actively within the International Manufacturing Strategy Survey (IMSS). This was a research network that gathered academics from around the world to study Manufacturing (and later on Supply Chain) Strategies on an ongoing basis through an extensive survey (see e.g. Lindberg et al. 1998). Emilio Bartezzaghi and Gianluca joined the network at its foundation and Gianluca soon become one of the more active members, with his research group at Politecnico di Milano becoming the network coordinator in 2011.

The first stream of research was positioned in the debate that arose at the beginning of the 1990s about the new manufacturing models and practices that were spreading across Europe and the industrialised world (e.g. Jaikumar 1986; Hayes et al. 1988; Drucker 1990). Just-in-Time was not alone in becoming a common practice among many manufacturing companies, and key in achieving significant improvements to performance. Many companies were also trying out other models, such as Volvoism at Volvo's Uddevalla plant (see e.g. Berggren 1994) or Reflective Production (e.g. Ellegard et al. 1992) and the Flexible Specialisation approach used in many Italian industrial districts (e.g. Piore and Sabel 1984), among others. These emerging models were considered to be of great relevance in helping European economies to be competitive. The European Union was also analysing the spreading of what went under the name of "new forms of work organisation" among European manufacturing companies and their possible impact on the productivity and profitability of European companies and—as a consequence—on European economies (e.g. EC 1997; Garibaldo and Telljohann 2007).

The assumption made by Gianluca and his colleagues was that, behind the emerging models and the practices adopted by single companies, there were distinctive principles, common to all the emerging models and inspiring all the various advanced practices that companies were implementing (Bartezzaghi 1999). These principles were significantly different from the ones that had been used for defining manufacturing strategies and organisation in the mass production model. Gianluca and his colleagues synthesised these principles into three points: (i) strategic flexibility; (ii) process integration; (iii) process ownership (Chap. 3; Spina et al. 1996). As underlined by Chris Voss (Chap. 3), some of the ideas involved in formulating this new model were particularly novel and significant, and formed the basis for other new streams of research.

With reference to the new manufacturing model, Gianluca and his colleagues explored a number of questions relating to the emergence and diffusion of Strategically Flexible Production (SFP) in different research pieces.

These included examining the contingent factors that influence the adoption of SFP (Spina et al. 1996); the impact of implementing SFP on manufacturing performance (Spina et al. 1996); the relationships between the adoption of SFP and the use of Advance Manufacturing Technologies (Chap. 4; Cagliano and

Spina 2000a); room for strategic choices within the new paradigm (Spina 1998); the diffusion of the new model and competitiveness of regional local authorities (Bartezzaghi et al. 1997); and the use of flexible forms of work within the new model (Cagliano et al. 2014). The intention was to gather all these studies together in a book, which would have been entitled *Beyond the Machine*, but unfortunately was never completed.

The second stream of research developed by Gianluca with Raffaella Cagliano was expediently framed within the flourishing literature on manufacturing strategy. During the 1970s and 1980s—following the seminal work of Skinner (1969) and other colleagues first in USA (e.g. Hayes and Wheelwright 1979, 1984; Buffa 1984; Fine and Hax 1985) and then in Europe (e.g. Hill 1989; Voss 1992)—manufacturing strategy was recognised as a key competitive weapon for manufacturing companies, leading to the development of a general framework for studying manufacturing strategy. Manufacturing strategy was first of all defined by its content, i.e. the competitive priorities and capabilities sought by companies and the decisions and improvement programmes that were implemented for this purpose. All the same, some studies—albeit many fewer—focused on the process of formulating manufacturing strategies.

Since the publication of these seminal works, many other authors had been trying to understand how companies around the world were using this new (or newly rediscovered) competitive weapon, by looking at the different strategic choices, contingent factors, best practice, performance achieved and so on. Many of these studies were survey-based (e.g. Flynn et al. 1997; Whybark 1997; Ferdows et al. 1996).

Gianluca's stream of research on manufacturing strategies followed along this path, mainly using IMSS data and centred upon three distinctive types of question:

- The process of formulating manufacturing strategies (Cagliano and Spina 2000b): Gianluca and Raffaella Cagliano looked at the different drivers that explained the choice of manufacturing improvement programmes, including competitive priorities, contingent factors and previous experience (payoffs) gained from the implementation of the programmes. Through their study, based on longitudinal, empirical evidence, they were able to show that not all strategic choices are coherently made by companies. Some types of programme in particular, especially the most up-to-date—or "trendy"—choices, tend to be made more often, creating misalignment with the company's competitive priorities. With this result, the study also entered into the debate on management fads and fashions, a discussion that has been very important throughout the history of management in general, and manufacturing best practice in particular (e.g. Abrahamson 1991; Laugen et al. 2005)
- The interlink between strategic choices and the new manufacturing paradigm (Spina 1998): this is where the two streams of research cross each other; Gianluca entered into a very important debate at that time, which was to understand whether, if companies adopted the emerging manufacturing model, this would restrict them in terms of defining their own strategies and so be able to

differentiate themselves from their competitors (e.g. Voss 1995; Clark 1996; Hayes and Pisano 1996). The empirical results of Gianluca's research showed that there was strategic manoeuvring room for companies even when they followed the principles of the new paradigm. This was further confirmation and reinforcement of a number of conceptual studies of that time.

- Manufacturing strategies of small and medium-sized companies (Cagliano and Spina 2001, 2002). Following a study carried out in collaboration with Chris Voss at the London Business School, Gianluca and Raffaella Cagliano were able to explore manufacturing practices among Italian SMEs and their impact on performance. The research question was relevant, on the one hand, because of the extremely high number of manufacturing SMEs in Europe in general and Italy in particular. On the other hand, it was of timely interest because of emerging literature showing that SMEs tend to use their own distinctive models rather than less mature versions of those of large companies (e.g. d'Amboise and Muldowney 1988; Jennings and Beavers 1997). At the same time, the debate on the importance of SME management practices was ongoing, with a number of authors maintaining that the success of SMEs depends more on the ability, skills and intuition of the owner-manager, rather than on the practices adopted (e.g. Storey 1994; Peterson 1989). By analysing the adoption of best practice among SMEs and its impact on performance, Cagliano and Spina were able to show that SMEs were competing in a specific way compared to large companies. They were also interested in understanding the differences between independent SMEs and sub-contractors, where the latter are often subject to the influence of their customers when designing and managing their production system/operations processes.

The shift from this stream of research to the study of Supply Chain and Purchasing Strategy was an easy and natural step, in a context where, in many studies on Operations Management, there was the recognition that a company's competitive advantage does not only rely on internal practices, but is also influenced to a high degree by the practices put in place for managing the entire supply chain, starting from their strategic relationships with suppliers.

Gianluca embarked upon this new stream of research at the end of the 1990s, initially focusing on **customer-supplier partnerships**, which were a key element of the Japanese model for managing the automotive production system (e.g. Lamming 1993). Gianluca worked closely in this area with two of his Politecnico di Milano colleagues, Roberto Verganti and Giulio Zotteri.

The first contributions focused on analysing specific industrial cases in Italy, other than in the automotive sector, where the concept of partnership involved a mix of successes and failures. Spina et al. (2000) examined how transport is managed within in the cement industry, while Spina and Zotteri (2000) analysed a case in the textile machinery sector. In this study, the focus was to understand which decision criteria are the most appropriate when deciding between a partnership, in-house production or traditional, arm's length outsourcing. Once a partnership was seen as the most suitable form of relationship, Gianluca also examined the

conditions that would lead to the desired benefits, looking especially at the enabling factors and the protection mechanisms for the parties involved. A further development of this stream was to analyse the strategic context that led to customer-supplier partnerships being established, achieved by adopting a contingent perspective and a different methodological approach. Spina and Zotteri (2001) used the IMSS data to broaden the scope of analysis and demonstrate that partnership was not driven mainly by contingent factors linked to country, industry or size, but rather by strategic variables, such as level of vertical integration, commitment to innovation and improvement-related priorities.

Within this stream of research, Gianluca and his colleagues were particularly concerned with co-design, i.e. customer-supplier partnerships established within the New Product Development (NPD) process to improve the company's overall performance in terms of innovation, time to market and cost. In their research, they adopted multiple methods, including in-depth case studies within a specific industry and a large panel of survey data. Spina et al. (2002a, Chap. 5) investigated four co-design projects set up by a large household appliance manufacturer, which helped to classify co-design relationships, based on the know-how being exchanged and the features of the decision-making process. Spina et al. (2002b) used the IMSS data once again (the Italian sub-sample data) to analyse the drivers that led to adopting a co-design approach, considering structural characteristics, strategic priorities and internal consistency with purchasing and NPD practices. This stream of research allowed them to open the black-box of co-design, moving research in this area one step further and revealing, on the one hand, the different forms of co-design and, on the other, the contextual variables that can guide their adoption process.

The CO-IMPROVE project was a further evolution of this stream. This was an EU-funded initiative involving several research groups and manufacturing companies from Italy, Denmark, Netherlands and Ireland. The project consisted in extending the traditional concept of continuous improvement to collaborative supply networks, through an action research approach, with the help and collaboration of another colleague, Mariano Corso (Cagliano et al. 2005a).

At the turn of the millennium, a radical technology innovation was rapidly changing the world. The Internet was extending its impact to every aspect of business. Supply Chains were not spared, since there was the need for better, faster and cheaper means of communicating and sharing information between customers and suppliers which laid the foundations for the widespread adoption of Internet-based technologies. Gianluca, Raffaella Cagliano and Federico Caniato (at that time, a new PhD student), opened a new research stream on this topic, once more basing themselves on the IMSS project. IMSS data for 3rd edition was gathered in 2001 and included questions about **Internet-based technologies adopted in the supply chain** (i.e. with suppliers, internally and with customers). This led to a first published paper (Cagliano et al. 2003). The main contribution of this work consisted first in showing that, despite all the hype, at that time only a small number of large companies surveyed in the IMSS European sample were adopting the new technologies. But even more importantly, the combined analysis of

the adoption of the technology with supply chain integration practices was used to understand the role of technology in supporting a broader, strategic partnership approach, as well as the structural contingent factors that explained such results. This paper was included in the special 25th anniversary issue of the International Journal of Operations and Production Management-IJOPM, which contained a selection of the most influential papers published in IJOPM. The authors were also requested to add a brief update of the research, which reflected on the rapidly growing expansion of Internet-based tools in supply chains (Cagliano et al. 2005). In 2009, together with two other colleagues, Matteo Kalchschmidt and Ruggero Golini from the University of Bergamo, they published a new paper (Caniato et al. 2009), which replicated the original work using new IMSS data (4th edition), providing a longitudinal perspective on how the adoption of Internet-based tools in supply chain relationships has evolved. This stream, therefore, spanned across almost a decade, covering the period in which digital communication technology evolved from being the new frontier of supply chain integration to the standard tool, although not yet common practice for many companies.

In the first half of the 2000s, the stream of research on customer-supplier partnerships did not just involve the impact of new technologies, but rather took on a broader perspective, to consider supplier integration practices in general alongside supplier selection criteria, analysing their impact on the operational performance of the buying company. These works were also based on the IMSS project, therefore stemming from the traditional operations strategy approach, with a contingent perspective. Cagliano et al. (2004) proposed a taxonomy of supply strategies, based on supplier selection criteria and integration mechanisms, and analysed their impact on performance. The best performing strategies were in line with the Lean and Agile paradigms, which had already found popularity in the scientific literature of the time (Lamming 1993; Christopher 2000). The lesser performing models were in line with the traditional approach to supply relationships. Subsequently, Cagliano et al. (2006) investigated the relationship between supply chain integration and two most popular manufacturing improvement programmes, lean production and ERP systems. They analysed how closely internal manufacturing strategies and external supply chain ones were related. Results showed that, while lean production had a strong influence on integrating both information flows and physical flows along the supply chain, adopting ERP did not influence supply chain integration.

In the mid-2000s Gianluca and his colleague Andrea Sianesi, who was leading a research group on supply chain planning, decided to join forces and start a new project, focusing on **supply chain management in the Italian fashion and luxury goods industry**. While the sector was well known world-wide, at that time it was facing the challenges of globalisation and needed to evolve rapidly in terms of its supply chain strategies and models. The "positioning paper" of this stream, the first in a long series, was published in 2008 (Chap. 7; Brun et al. 2008) and presented an empirical investigation of 12 Italian fashion luxury retailers. The research studied their operations and supply chain strategies, analysing their impact on the critical success factors of the industry (see Chap. 7 in

this book). The project was subsequently carried forward by a large research team that included Maria Caridi, Alessandro Brun, Cecilia Castelli, Luca Crippa and Antonella Moretto, and led to several publications. This stream of research first focused on the supply side, investigating the role of suppliers in both the NPD and the production processes for fashion companies. This resulted in the paper by Caniato et al. (2015), where the authors analysed the different strategic approaches to internationalisation and outsourcing, as well as collaborations within and across organisations, according to brand positioning, company size and the technical complexity of the products. Subsequently, the research focused on the downstream supply chain of fashion firms, i.e. on distribution and retail operations on a global scale, with the researchers investigating the strategic role of these supply chains in achieving competitive advantage for the company. In their paper, Caniato et al. (2014) focused on the role of international retail operations within the NPD process of Italian fashion companies, investigating how retail contributed to align new products with the characteristics of the main international target markets.

In the 2000s, another key topic in SCM research was **global SCM**, and Gianluca's research covered this topic. The IMSS project was clearly an ideal source of data, as reflected in the paper by Cagliano et al. (2009), in which global supply chain configurations were investigated by adopting a longitudinal perspective and comparing the latest two IMSS databases. Alongside this, Gianluca supervised a PhD student from Argentina, Julio Loppacher, who investigated global sourcing strategies of multinational companies operating in Italy and Argentina, which resulted in the publication of three papers (Loppacher et al. 2010, 2011a, b).

In 2007, Gianluca, together with Stefano Ronchi, Federico Caniato and a new PhD student, Davide Luzzini, decided to launch a new major project, the **International Purchasing Strategy (IPS) survey**. The idea was to replicate the successful model of IMSS in the field of Purchasing and Supply Management (PSM), which had become increasingly relevant in both research and practice. However, no major international survey-based research project had yet been carried out and, more in general, there was the need to encourage theoretically sound and methodologically robust research. To achieve this goal, the team approached some of the best-known PSM researchers in Europe and North America, among whom Finn Wynstra and Erik Van Raaij at Rotterdam School of Management, Michael Essig at Bundeswehr University in Munich, Alistair Brandon-Jones at the University of Bath, Asta Salmi and Katri Kauppi at Aalto University in Helsinki and George Zsidisin at Bowling Green State University in USA, with a proposal to join forces and initiate a new ambitious project.

The initiative gathered together a group of highly-motivated people and resulted in administering a first round of the survey in 2010 and a second round in 2014. IPS introduced some innovative features, such as its focus on single purchasing categories, since the concept of purchasing strategy is more appropriate to a single category than to the whole company. The project lead to several publications on different topics, in particular Gianluca contributed to the paper by Luzzini et al. (2012). In their work, the authors used the IPS data to propose a classification of strategic purchasing categories based upon the Transaction Cost Economics

theory, contributing towards providing a theoretically sound and empirically tested foundation to the traditional portfolio approach to purchasing strategy originally proposed by Kraljic (1983). In another paper by Luzzini et al. (2014), the authors used the IPS data to focus on a new emerging topic, sustainability. They focused on collaborative capabilities, both intra-company and inter-company, to enhance the sustainability-related performance of the upstream supply chain.

The IPS project was not the only project in the PSM field. Gianluca promoted and coordinated other research initiatives; in particular, a focus on vendor evaluation systems and a large scale literature review. The former (Luzzini et al. 2014) was based on a case-based study of 13 large companies in different industries, where they investigated the design of vendor evaluation systems in terms of strategic alignment, process configuration and execution, as well as the corresponding benefits and costs, identifying three groups linked to different levels of maturity. This paper obtained Best Paper Award at the ISPERA Conference 2013.

This last initiative involved a major effort of collecting and analysing 1055 PSM papers from 20 journals between 2002 and 2010. The project led to the publication of two papers. Spina et al. (2013, Chap. 8) presented the main results of the literature review, including the extent of the overall production, background theory, unit of analysis, research method and main topics investigated. The authors outlined the state-of-the art of PSM research from a content-specific perspective, including an evaluation of PSM maturity as a discipline. Spina et al. (2016) used the same dataset, but narrowed the scope of the analysis, to discuss the extent to which External Grand Theories are used in PSM to base research on well-established theoretical frameworks derived from other fields. This paper contributed to the debate on the theoretical foundations of PSM research and its maturity as a self-standing discipline, as discussed by other authors (e.g. Harland et al. 2006; Chicksand et al. 2012).

During his research and education work, Gianluca was always focused on not loosing the link with the real world, and he took part in consultancy projects in various different industries. At the same time, he also used the media to spread the culture of management engineering across the Italy. He was a strong believer in a virtuous cycle, defined as research-consultancy-education-culture. Research allows us to understand management problems in depth and express possible interpretations, consultancy projects allow us to try out potential solutions in real contexts. The empirical evidence from both research and consultancy enables researchers and professors to teach management subjects in an effective manner. Ultimately, our mission is to spread a mature, responsible and solid management culture throughout society.

Overall, if we want to summarise the **main points** of Gianluca's research over the years, we can identify four main points:

- Gianluca preferred to focus on wide, **comprehensive and far-reaching questions**, rather than on incremental contributions to existing knowledge. His constant curiosity, his propensity to turn every aspect of reality into a problem to be solved and not taking any truth for granted led him to explore the emerging phenomena with deep insight and novel perspective. He always tried to

make a difference in everything he did, especially in research. This is one of a Scholar's key duties (Pettigrew et al. 2001); as we were reminded by Andy Neely in his speech in memory of Gianluca at the Annual Conference of the Italian Management Engineering Association (http://www.ingegneriagestionale.it/gianluca-spina/);

- Gianluca always tried to address research through a **multi-disciplinary approach**, masterfully interpreting the essence of Management Engineering in Italy. His main angle was that of operations strategy and organisation, but he interpreted the phenomena though different lenses, either technological, or through human resource management and organisational behaviour, or even through industrial organisation and policies. This allowed him to understand fully all the different implications of any emerging phenomena, which helped to make his research both meaningful and different;
- The **relentless rigour** in using the most appropriate research methodologies, ranging from case studies and action research, to surveys—his core competence—to conceptual modelling and systematic literature reviews. However, despite his rigour in selecting and implementing the methods, his first concern was always the relevance of his results, markedly discarding "data dredging" approaches or the use of over-sophisticated methodologies to prove the obvious. And relevance meant, on the one hand, a closeness to practice, listening to companies, understanding their problems, going back to the theory to find solutions and interpret emerging phenomena. On the other hand, it meant asking the right questions at the right time (Neely 2015: http://www.ingegneriagestionale.it/gianluca-spina/);
- Finally, Gianluca liked doing **research in collaboration** with other colleagues. All his main research projects have been developed in collaboration with colleagues in Italy and abroad. He built strong networks within the OM community inside Europe and outside, being among the founders of both the IMSS and the IPS networks, as well as actively participating in EurOMA first and IPSERA afterwards. He also built very strong relationships with his colleagues when researching Operations Management in Italy, especially those at the Universities of Padua and Udine. Finally, his contribution has been fundamental in developing one of the most influential and highest renowned research groups in Operations and Supply Chain Management in Europe—as was recognised by Behara et al. (2014) in their paper on OM research networks in Europe.

1.2 The Contribution of Gianluca Spina to Management Education

During his career, Gianluca was also heavily involved in management education and he contributed greatly to the development of the Management Engineering degree at Politecnico di Milano, both by teaching and by actively participating in long discussions with all other faculty members during the phases of concept and

design of this programme. His contribution to the Management Engineering field in Italy was highly significant.

He started his academic work by supporting Emilio Bartezzaghi and Adriano De Maio in their courses on "Business Management and Organisation" at Politecnico di Milano. Those courses were offered to students in Management Engineering and in other engineering fields, mainly Electronics and Information Systems Engineering. The experience gained during years of teaching these subjects was gathered in a book where he tried to translate the results of his research group into key topics for education at both lower and higher executive level (Bartezzaghi et al. 1999).

In the late 1990s, he was appointed to his own course in "Business Management and Organisation" at the Como campus and in "Financial Accounting" taught to Mechanical Engineering students in Milano. The common thread of these courses has always been to give students an overarching and comprehensive view of a company and its processes, including outside its boundaries. In the early 2000s, Gianluca's deep knowledge of these subjects led the launch of the new course in "Business Management and Organisation" within the new Bachelor in Management Engineering at the Milano campus. This is one of the key subjects for our students, and is based on four keystones.

Students are first exposed to organisation design topics so that they learn the basics of how a company functions and the relative coordination mechanisms. Secondly, they learn how decisions are made within complex organisational settings by examining the decision-making process in detail. After looking at these two aspects internal to the company, students then learn the two other key components of the company's value chain. On the one side, they look downstream at its connections with its customers, by studying the critical components of the marketing process; on the other side, they investigate the upstream relationship with its suppliers, by studying the supply process. Gianluca used the material gained from developing these topics, and the numerous study cases used for in-class discussion with his students, to publish his book "La Gestione dell'Impresa" (Spina 2006, now in its third edition—Spina 2012) with the support of his colleagues Raffaella Cagliano, Federico Caniato, Matteo Kalchschmidt and Stefano Ronchi.

More recently, Gianluca designed the course in "Supply Chain Management" with Andrea Sianesi. This was a natural development from the research carried out in the field of supply chain management. The course is the crucial one in the new stream in "Supply Chain Management" launched in 2009 as part of the Master of Science in Management Engineering at Politecnico di Milano. The new stream, with its clever mix of the methodological skills needed by management engineers and the critical supply chain problems faced by companies, has been successful since the beginning with students and recruiters.

Gianluca also contributed actively to the development of Management Engineering in Italy, sitting for several years on the Board of the Italian Association of Management Engineering (Associazione Italiana di Ingegneria Gestionale—AiIG), and in his role as President of the Association over the period 2011–2013. During these years as President, Gianluca led a number of initiatives,

including the publication of a history of Management Engineering in Italy (authored by Fabio Lavista), he organised the first school for young researchers in Management Engineering (managed by Sergio Mariotti), he defined the first listing and classification of the most relevant academic journals in the field in Italy (also managed by Sergio Mariotti), as well as his contribution to the first national evaluation of the quality of research (managed by Maurizio Sobrero). Beyond this formal role, Gianluca was appreciated within the national community for his academic standing and commitment to teaching. As mentioned above, the Association organised a special session to recall Gianluca's contribution to research, education and the development of this field at their national conference on 15th October 2015, with national and international colleagues sharing their thoughts and memories (http://www.ingegneriagestionale.it/gianluca-spina/).

In 2001, Gianluca began his managerial career at MIP, the Graduate School of Business of Politecnico di Milano, with Emilio Bartezzaghi as President. After directing the full-time MBA, which at the time was a domestic programme, in 2004, he was appointed as Dean of the School, and became President in 2011. In those years, the School had developed a long-term strategy that was the drive behind its impressive growth over the following decade. Among the many successes, there were at least three major breakthroughs.

Firstly, he was a strong and resolute supporter of the School's internationalisation process. In concert with this vision, in 2003 he launched the full-time international MBA with Andrea Sianesi. This was a great challenge for a smallish School running a limited number of programmes for a domestic market. This experience was the trigger for launching, over the following decade, other international programmes and formats both within the MBA sector and in that of Specialised Masters. Through its process of internationalisation, the School became recognised internationally, gaining a place among the leading business schools certified by international associations such as EQUIS-EFMD (European Foundation for Managerial Development) in 2007 and AMBA (Association of MBAs) in 2012. In 2009, the School appeared for the first time in the Financial Times' rankings of global business education.

Secondly, in those years, he also pushed the School to invest substantially in Executive Education, launching Executive Master programmes for the open market and the School's most important clients. These were programmes that addressed a number of key needs, filling the gap in competence for talented people mid-way through their career and offering them a flexible and customised life-long learning process; at the same time, they provided companies with a mechanism to help them retain their most talented people.

More recently, Gianluca drove the "Smart Learning" approach in post-graduate education, by combining digital learning techniques with a customised and personal attention offered to participants. The School developed its own digital platform to deliver digital material and create a strongly interactive digital community among the participants. This investment led to the launch of our Flex EMBA in autumn 2013 and the decision to implement the "Smart Learning" approach within other programmes for individuals and corporate clients.

Overall, Gianluca's contribution as Dean and President of the School has been enormously important and he clearly had all the qualities needed in a Dean to steer a straight course through the daily challenges encountered by any business school or educational institution in today's world.

1.3 The Legacy

Undoubtedly, Gianluca was a leader and not just for his work and projects, but above all for the values that permeated through his work.

Firstly, he had a marked **feeling for the institution**. Although this may seem obvious, it is certainly not the case, especially in a university environment, where often there is marked individualism, self-centredness, lack of cooperation and lack of accountability in building and developing the institution.

Secondly, his was an approach always **based on design and driven by initiative**. He was unsurpassed in the way he was continuously making plans, looking at where to make innovations and pursuing his aims doggedly, with determination, dedication, perseverance and leadership.

Finally, he stood for the **rigour and shunned compromise**, to the point of sometimes even looking quite hard (Emilio Bartezzaghi used to call him "Spike" affectionately, with reference to the old spiked helmet of the German/Prussian army), but he always totally **loyal, direct and transparent**.

Our memory of Gianluca consists above all of his pursuit of the values that are fundamental to our academic community.

References

Abrahamson, E. (1991). Managerial fads and fashions: The diffusion and rejection of innovations. *Academy of Management Review, 16*(3), 586–612.

Bartezzaghi, E. (1999). The evolution of production models: Is a new paradigm emerging? *International Journal of Production and Operations Management, 19*(2), 229–250.

Bartezzaghi, E., Spina, G., & Turco, F. (1992). The Impact of the just-in-time approach on production system performances: A survey of Italian industry. *International Journal of Operations & Production Management, 12*(1), 5–17.

Bartezzaghi, E., Spina, G., & Verganti, R. (1993). Modelling the lead time of operations processes. *Service Superiority, Operations Management Association, Warwick*, 117–124

Bartezzaghi, E., Spina, G., & Verganti, R. (1994). Lead-time models of business processes. *International Journal of Operations and Production Management, 14*(5), 5–20.

Bartezzaghi, E., Spina, G., & Verganti, R. (1997). Strategically flexible production and the extra-firm infrastructures: How regions become attractive. *Integrated Manufacturing Systems—Manufacturing Technology Management, Special Issue on Manufacturing Strategy, 8*(5), 333–347.

Bartezzaghi, E., Spina, G. & Verganti, R. (1999). *Organizzare le Piccole e Medie Imprese per la crescita—Come sviluppare i più avanzati modelli organizzativi per competere: gestione dei processi, lavoro per progetti, sviluppo delle competenze.* Milano: IlSole24Ore.

Bartezzaghi, E., & Turco, F. (1989a). The Impact of just in time on production system performance: An analytical framework. *International Journal of Operations and Production Management, 9*(8), 40–61.

Bartezzaghi, E., & Turco, F. (1989b). The impact of just-in-time on production system performances: Results of a field research. *World Congress APIC: "The Challenge to Integrate*", Amsterdam, June 7–9.

Behara, R. S., Babbar, S., & Smart, A. P. (2014). Leadership in OM research: A social network analysis of European researchers. *International Journal of Operations and Production Management*, *34*(12), 1537–1563

Berggren, C. (1994). Nummi vs. Uddevalla. *Sloan Management Review* (Winter), 37–49.

Brun, A., Caniato, F., Caridi, M., Castelli, C., Miragliotta, G., Ronchi, S., et al. (2008). Logistics and supply chain management in luxury fashion retail: Empirical investigation of Italian firms. *International Journal of Production Economics, 114*(2), 554–570.

Buffa, E. S. (1984). *Meeting the competitive challenge: Manufacturing strategy for U.S. companies*. Homewood: Irwin.

Cagliano, R., Caniato, F., Corso, M., & Spina, G. (2005a). Collaborative improvement in the extended manufacturing enterprise: Lessons from an action research process. *Production Planning and Control, 16*(4), 345–355.

Caniato, F., Cagliano, R., Golini, R., Kalchschmidt, M., & Spina, G. (2009). Evolutionary patterns in e-business strategy. *International Journal of Operations and Production Management, 29*(9), 921–945.

Cagliano, R., Caniato, F., Longoni, A., & Spina, G. (2014). Alternative uses of temporary work and new forms of work organization. *Production Planning and Control, 25*(9), 762–782.

Cagliano, R., Caniato, F., & Spina, G. (2003). E-business strategy: How companies are shaping their supply chain through the Internet. *International Journal of Operations and Production Management, 23*(10), 1142–1162.

Cagliano, R., Caniato, F., & Spina, G. (2004). Lean, Agile and traditional supply: How they impact manufacturing performance? *Journal of Purchasing and Supply Management, 10*(4–5), 151–164.

Cagliano, R., Caniato, F., & Spina, G. (2005b). Reconsidering e-business strategy and the impact on supply chains. *International Journal of Operations and Production Management, 25*(12), 1328–1332.

Cagliano, R., Caniato, F., & Spina, G. (2006). The linkage between supply chain integration and manufacturing improvement programmes. *International Journal of Operations and Production Management, 26*(3), 282–289.

Cagliano, R., & Spina, G. (2000a). Advanced manufacturing technologies and strategically flexible production. *Journal of Operations Management, 18*(2), 169–190.

Cagliano, R., & Spina, G. (2000b). How improvement programmes of manufacturing are selected: The role of strategic priorities and past experience. *International Journal of Operations and Production Management, 20*(7), 772–791.

Cagliano, R., & Spina, G. (2001). *Pratiche gestionali e successo competitivo nella piccola impresa e nell'artigianato. Una ricerca nelle imprese manifatturiere e nei distretti dell'Emilia Romagna.* Franco Angeli.

Cagliano, R., & Spina, G. (2002). A comparison of practice-performance models between small manufacturers and subcontractors. *International Journal of Operations and Production Management, 22*(12), 1367–1388.

Caniato, F., Caridi, M., Moretto, A., Sianesi, A., & Spina, G. (2014). Integrating international fashion retail into new product development. *International Journal of Production Economics*, *147*(part B), 294–306.

Caniato, F., Crippa, L., Pero, M., Sianesi, A., & Spina, G. (2015). Internationalisation and outsourcing of operations and product development in the fashion industry. *Production Planning and Control, 26*(9), 706–722.

Chicksand, D., Watson, G., Walker, H., Radnor, Z., & Johnston, R. (2012). Theoretical perspectives in purchasing and supply chain management: An analysis of the literature. *Supply Chain Management: An International Journal, 17*(4), 454–472.

Christopher, M. G. (2000). The agile supply chain: Competing in volatile markets. *Industrial Marketing Management, 29*, 37–44.

Clark, K. B. (1996). Competing through manufacturing and the new manufacturing paradigm, *Production and Operations Management, special issue on manufacturing strategy*. *Spring, 5*(1), 42–57.

d'Amboise, G., & Muldowney, M. (1988). Management theory for small business: Attempts and requirements. *Academy of Management Review*, *13*(2), 226–240

Drucker, P. F. (1990). The emerging theory of manufacturing. *Harvard Business Review* (May–June), 94–102

EC—European Commission. (1997). *Partnership for a new organisation of work—Green paper*. Bulletin of the European Union, Supplement 1/97.

Ellegard, K., Jonsson, D., Engstrom, T., Johansson, M. I., Medbo, L., & Johansson, B. (1992). Reflective production in the final assembly of motor vehicles—an emerging Swedish challenge. *International Journal of Operations and Production Management, 12*(7/8), 117–133.

Ferdows, K., Miller, J. G., Nakane, J., & Vollman, T. E. (1996). Evolving global manufacturing strategies: Projections into the 1990's. *International Journal of Operations and Production Management, 6*(4), 6–16.

Fine, C. H., & Hax, A. C. (1985). Manufacturing strategy: A methodology and an illustration. *Interfaces, 15*(6), 28–46.

Flynn, B. B., Schroeder, R. G., Flynn, E. J., Sakakibara, S., & Bates, K. A. (1997). World-class manufacturing project: Overview and selected results. *International Journal of Operations and Production Management, 17*(7), 671–685.

Garibaldo, F., & Telljohann, V. (Eds.). (2007). *Globalisation, company strategies and quality of working life in Europe*. Bern: Peter Lang.

Harland, C. M., Lamming, R. C., Walker, H., Phillips, W. E., Caldwell, N. D., Johnsen, T. E., & Zheng, J. (2006). Supply management: Is it a discipline? *International Journal of Operations and Production Management, 26*(7), 730–753.

Hayes, R. H., & Pisano, G. P. (1996). Manufacturing strategy: At the intersection of two paradigm shifts. *Production and Operations Management, special issue on manufacturing strategy, 5*(1), 25–41.

Hayes, R. H., & Wheelwright, S. C. (1979). Link manufacturing process and product life cycles. *Harvard Business Review* (January).

Hayes, R. H., & Wheelwright, S. C. (1984). *Restoring our competitive edge, competing through manufacturing*. New York: Wiley.

Hayes, R. H., Wheelwright, S. C., & Clark, K. B. (1988). *Dynamic manufacturing. Creating the learning organization*. New York: The Free Press

Hill, T. J. (1989). *Manufacturing strategy. Text and cases*. IL: Irwin.

Jaikumar, R. (1986). Postindustrial manufacturing. *Harvard Business Review* (November–December), 69–76

Jennings, P., & Beaver, G. (1997). The performance and competitive advantage of small firms: A management perspective. *International Small Business Journal, 15*(2), 63–75.

Kraljic, P. (1983). Purchasing must become supply management. *Harvard Business Review, 61*(5), 109–117.

Lamming, R. (1993). *Beyond partnership: Strategies for innovation and lean supply*. Hemel Hemstead: Prentice Hall.

Laugen, B. T., Acur, N., Boer, H., & Frick, J. (2005). Best manufacturing practices: What do the best-performing companies do? *International Journal of Operations and Production Management, 25*(2), 131–150.

Lindberg, P., Voss, C. A., & Blackmon, K. L. (Eds.). (1998). *International manufacturing strategies: Context, content and change*. Berlin: Springer Science & Business Media.

Loppacher, J. S., Cagliano, R., & Spina, G. (2010). Key factors in a global supply headquarters-subsidiary control systems. *Journal of Manufacturing Technology Management, 21*(7), 794–817.

Loppacher, J. S., Cagliano, R., & Spina, G. (2011a). Key drivers of buyer-supplier relationships in global sourcing strategies. *International Journal of Procurement Management, 4*(2), 156–180.
Loppacher, J. S., Cagliano, R., & Spina, G. (2011b). Key dimensions of global supply strategy: A model of interrelated decisions. *International Journal of Procurement Management, 4*(5), 455–482.
Luzzini, D., Caniato, F., Ronchi, S., & Spina, G. (2012). A transaction cost approach to purchasing portfolio management. *International Journal of Operations and Production Management, 32*(9), 1015–1042.
Luzzini, D., Caniato, F., & Spina, G. (2014). Designing vendor evaluation systems: An empirical analysis. *Journal of Purchasing and Supply Management, 20*(2), 113–129.
Perona, M., Spina, G., & Turco, F. (1991). Success measure of just-in-time: Shifting manufacturing trade-offs. A field research in Italy.
Peterson, R. T. (1989). Small business adoption of the marketing concept vs other business strategies. *Journal of Small Business Management* (January).
Pettigrew, A. M., Woodman, R. W., & Cameron, K. S. (2001). Studying organizational change and development: Challenges for future research. *Academy of Management Journal, 44*(4), 697–713.
Piore, M., & Sabel, C. (1984). *The second industrial divide: Possibilities for prosperities*. New York: Basic Books.
Skinner, W. (1969). Manufacturing—Missing link in corporate strategy. *Harvard Business Review* (May–June), 136–145
Spina, G. (1998). Manufacturing paradigms versus strategic approaches: A misleading contrast. *International Journal of Operations and Production Management, 18*(8), 684–709.
Spina, G. (2006). *La Gestione dell'Impresa*, ETAS.
Spina, G. (2012). *La Gestione dell'Impresa,* Terza Edizione, ETAS.
Spina, G., Bartezzaghi, E., Cagliano, R., Bert, A., Draaijer, D., & Boer, H. (1996). Strategically flexible production: The Multi-focused manufacturing paradigm. *International Journal of Operations and Production Management, 16*(11), 20–41.
Spina, G., Campanella, N., & Codeluppi, G. (2000). Make vs Buy vs Partnership in Distributing Commodities: A case study and a methodology. *Integrated Manufacturing Systems, 11*(2), 112–120.
Spina, G., Caniato, F., Luzzini, D., & Ronchi, S. (2013). Past, present and future trends of purchasing and supply management: An extensive literature review. *Industrial Marketing Management, 42*(8), 1202–1212.
Spina, G., Caniato, F., Luzzini, D., & Ronchi, S. (2016). Assessing the use of external grand theories in purchasing and supply management research. *Journal of Purchasing and Supply Management 22*(1), 18–30.
Spina, G. L., & Verganti, R. (1992). Process specialization versus integration: Why the trade-off is shifting. In R. H. Hollier, R. J. Boaden, & S. J. New (Eds.), *International operations: Crossing borders in manufacturing and service* (pp. 311–316). Amsterdam: Elsevier.
Spina, G., Verganti, R., & Zotteri, G. (2002a). Factors influencing co-design adoption: Drivers and internal consistency. *International Journal of Operations and Production Management, 22*(12), 1354–1366.
Spina, G., Verganti, R., & Zotteri, G. (2002b). A model of codesign relationships: Definitions and contingencies. *International Journal of Technology Management, 23*(4), 304–321.
Spina, G., & Zotteri, G. (2000). The implementation process of customer-supplier partnership: Lessons from a clinical perspective. *International Journal of Operations and Production Management, 20*(10), 1164–1182.
Spina, G., & Zotteri, G. (2001). The strategic context of customer-supplier partnerships: Evidence from a global survey. *Integrated Manufacturing Systems, 12*(7), 483–492.
Storey, D. J. (1994). *Understanding the small business sector*. London: Routledge.
Voss, C. A. (1992). *Manufacturing strategy: Process and content*. London: Chapman & Hall.
Voss, C. A. (1995). Alternative paradigms for manufacturing strategy. *International Journal of Operations and Production Management, 15*(4), 5–16.
Whybark, D. C. (1997). GMRG survey research in operations management. *International Journal of Operations and Production Management, 17*(7), 689–696.

Part I
Manufacturing Strategy and Paradigms

Chapter 2
The Impact of the Just-in-Time Approach on Production System Performance: A Survey of Italian Industry. A Review and Outlook

Roberto Filippini and Cipriano Forza

Abstract Just in Time (JIT), as a wide philosophy to manage and control production activities, has dominated the way industry is run in the last decades. In the original paper the authors performed an early study on this subject, recognizing the disruptive potential of this approach and proposing a solid framework for its analysis. From the one hand, they distinguished the overall managerial approach and philosophy from the specific techniques used to implement it. While the general approach is long lasting and widely generalizable, the specific techniques might be more contingent. On the other side, they studied the impact of JIT on two set of performance dimensions, the operating conditions and the external performance of the production system. Through a wide empirical evidence of Italian companies in the metalworking industry, the authors were able to show the ability of JIT to shift the trade-off between productivity and service. The commentary underlines that, although results are today outdated, the framework proposed by the paper is still very useful to study the evolution of JIT and its impact on performance. Also, the paper is valuable for its balance between scientific rigour and practical relevance.

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2.1 Original Paper[1]

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Introduction

Recently Just-in-Time manufacturing (JIT) has attracted wide interest throughout Italian industry and the number of applications is steadily increasing.

As diffusion of JIT throughout Western countries continues, much has been written since the seminal works by Schonberger[3], Hall[4] and Monden[5]. Yet most of the subsequent literature concerns specific experiences in model cases and often intends to demonstrate that transfer of Japanese manufacturing techniques to Western industries is, at least in part, possible.

In recent years, some extensive sample surveys have investigated the state of JIT implementation and development throughout different Western countries. Whereas there are extensive English[6] and American[7,8,9] studies, there has to date been nothing similar in Italy.

This article discusses the main findings of an extensive survey on JIT implementation in Italy. We intend to explore elements, benefits, costs and problems

*Financial support for this research was provided by Mediocredito Lombardo. The conceptual framework was presented in a previous article in this joumal[l]. Partial results of the field research were presented at the APICS World Congress, Amsterdam, 1989[2]. The authors would like to thank Professor Chris A. Voss, London Business School, for his helpful comments.

involved with JIT adoption related to some context factors, such as size and type of firm and specific manufacturing strategies, which may affect its adoption. Our primary concern is to verify JIT application in Italy, rather than to study its diffusion.

Conceptual Framework

The analytical framework that we use was presented in a previous article in this journal[1]. Here we only summarize its salient features.

Two Meanings of JIT

We consider JIT from two points of view. First, we see JIT as a set of techniques, synergistically addressed both at implementation and during continuous improvement of the production system. It is easy to note that most of these techniques go back to traditional principles of industrial engineering rather than being exclusive to JIT[10]. According to Schonberger[3], JIT techniques aim towards product and process simplicity, process continuity and operational regularity, synchronization between production and the marketplace, speed-up of material flow, workforce flexibility, and supply reliability.

Secondly, we consider JIT as a global and innovative approach to production system management[ll,12]; in this light JIT attempts to reconcile market needs, in terms of quality, price and service, with the traditional and necessary needs of production economy. As a global approach, JIT suggests a continuous improvement of the current parameters of manufacturing, which could shift the traditional "trade-off" between flexibility and productivity.

Two Levels of Potential Benefits of JIT

We assume that the possible application of JIT depends on the comparison between the benefits of its adoption and its costs. We also assume that JIT techniques may directly influence some internal parameters that, taken together, describe the functioning characteristics of the production system. These parameters, which we call operating conditions, are, for example, time variables such as lead time and throughput time, physical measurements such as lot size, and relative parameters such as capacity utilisation and percentage of defects[1].

Yet the actual benefits depend on improving performance of the production system. By production system performance we mean the results directly perceivable and measurable by customers or by a higher-level system (the business unit or company), in terms of productivity, flexibility, quality and service[13,14,15]. These

are expressed by the percentage variation of certain indicators during the last three years. These indicators are, for example, mean delivery time, mean delivery delay, WIP turnover, mean time to introduce new products and direct labour cost.

Distinguishing operating conditions from performance indicators is important: improving operating conditions, rather than being a direct source of competitive advantage in itself, can shift some traditional trade-offs between productivity on the one hand and flexibility, quality and service on the other hand. For example, reducing internal lead time changes the trade-off between productivity and service because it can be used to improve either WIP turnover or mean delivery time.

Aims and Basic Hypotheses of the Research

Returning to our main purpose, we investigate the application of JIT, both as a global approach and as a set of techniques, related either to the strategic goals of a business unit, or to some exogenous factors such as size and type of firm and the nationality of the ownership[l].

In more detail we have conducted the field survey to analyse the six following issues.

The Adoption Rate of JIT

Our primary concern is to reveal the interest in JIT. JIT is distinguished from two other orientations:

- MRP (Materials Requirement Planning) in the widest definition of the computer-based approach to production planning and control;
- the "hard" technological approach based on investment in machinery and means of production (including flexible automation); this approach is referred to hereinafter as "Technology-driven Approach" (TDA).

JIT Elements

We want to know what types of JIT techniques are most widely adopted. We hypothesize the existence of some core techniques, typical of JIT; these are generally regarded (according to the literature on the subject) as the main causes of potential benefits.

More specificially, tools and interventions which characterize JIT were grouped into 21 techniques (see Table II). It is hypothesized that, among these, only some are actually characteristic of (but not exclusive to) this approach. According to experts[3,4], the core techniques are: levelled master production scheduling, pull-controlled flow, set-up time reduction, product modularization and parts

standardization, pull-controlled delivery, working-time flexibility, job enlargement, and job enrichment.

JIT Benefits

We aim to explore the benefits from JIT implementation; as explained previously, these benefits can be measured through the variation of the parameters of the operating conditions and the performance indicators.

Concerning the operating conditions, a major impact of JIT is expected on internal lead time, time for producing all the range, machine availability, and purchasing and production lot sizes. Consequently, high performance should derive from JIT implementation in terms of delivery readiness, mix flexibility, process quality and working-capital productivity, which can be respectively measured through mean delivery time and delay, number of products realizable in the minimum planning horizon, reworking and defects rate, and inventory turnovers[12,16,17].

Manufacturing Strategy and JIT Adoption

We aim to explore the priorities in manufacturing performance expressed by the co-operating firms. We suspect that differences in manufacturing strategy may influence the decision to adopt JIT. JIT-oriented firms should be more interested in mix flexibility, delivery readiness, in-house quality conformance and working-capital productivity.

Exogenous Factors and JIT Adoption

We try to identify the exogenous factors (if they exist), such as size and type of production unit, nationality of the holding company and production typologies which may influence adoption. The best candidates for JIT implementation should have an intermittent manufacturing process, part assembly lines and a large number of products with low production volume per product. Therefore, the types represented by the mechanical, industrial equipment and electronic industries should be those involved with JIT.

Finally, the existence of a holding company and its nationality should indicate a higher exposure to an innovative managerial culture. Therefore we expect production units which belong to international holding companies to be more interested in JIT.

This research leaves out the role of the endogenous factors relating to management orientations and the degree of awareness[l].

Costs, Problems and Organizational Features

Finally we want to ascertain costs and problems of JIT. We want to verify the organizational and managerial nature of the JIT approach: it should not require major investment, but rather the allocation of relevant internal resources to improve and rationalize the production system[18].

The Sample Examined

From a sample of 600 companies 173 postal questionnaires were completed (29 per cent). Mailing was followed by telephone contacts and, in several cases, by visits to the production unit, in order to test and complete the collected data.

Firms with less than 100 employees and/or less than $7 million in sales have been excluded from the sample, because of the difficulty of collecting significant information in small firms.

The sample includes mechanical, electromechanical, electronic, textile and clothing production and all classical intermittent manufacturing processes, all traditionally involved with JIT applications. It also includes other manufacturing firms, generally called "process industries", but potentially interested in JIT approaches, such as pharmaceutical, food, rubber and plastics, wood and furniture industries. Finally the sample includes some chemical firms which produce a wide range of tailor-made products.

The size distribution of the answering firms is: 22 per cent large (more than 500 employees), about 25 per cent medium (from 250 to 500 employees), 53 per cent small (from 100 to 250 employees).

The industrial distribution of the co-operating firms is: 43 per cent mechanical and industrial equipment, 22 per cent process industry, 11 per cent electronic, 10 per cent electrotechnical, 14 per cent others.

Results

JIT and Other Approaches to Production System Innovation

A significant interest in JIT emerges: about one-third (31.2 per cent) of the respondents have already implemented it (Table I). This value is similar to the 35.8 per cent of JIT adopters found by Gilbert[7] in a sample of 134 American manufacturers. Another 25 per cent of the respondents now plan to adopt JIT.

In total, about 55 per cent declared that they had experimented with this approach or plan to do so (Table I). This rate is almost equal to the 57 percent of JIT users revealed in an English survey[6]. A few firms abandoned JIT after implementation.

Table I. Adoption of Different Approaches: Three Innovative Approaches are Identified: JIT, MRP, in the Widest Sense of Production Planning and Control, and TDA (Technology-driven Approach Including Flexible Automation)

Approaches	(1) Implemented	(2) Planned	(3) Implemented or planned	(4) Implemented and planned	(5) New adoptions	(6) Abandoning
JIT	31.2	49.7	55.5	25.4	24.3	18.5
MRP	57.2	63.0	78.0	42.2	20.8	26.3
TDA	76.3	74.0	85.0	65.3	8.7	14.4
None	8.7	3.5	9.8	2.3	1.1	73.3

Total sample: 173

The columns contain:

(1) percentage of production units (PU), out of the total sample, which have implemented the various approaches in the last three years or are now implementing them;

(2) percentage of PU, out of the total sample, which plan to adopt the various approaches in the next three years;

(3) number of PU, out of the total sample, which either have implemented or are implementing or plan to adopt the various approaches;

(4) percentage of PU, out of the total sample, which have implemented and plan to adopt the various approaches;

(5) percentage of new adopters, out of the total sample; (5) = (3) − (1);

(6) percentage of PU, out of past users, which are abandoning the various approaches (they have implemented but do not plan to adopt in the future); (6) = [(1) − (4)]/(1).

The adoption rate of JIT, even though lower than the two other main approaches (78 per cent for MRP and 85 per cent for TDA) indicates an increase: the number of potential adopters (i.e. production units which have not tried JIT yet, but which plan to adopt it within the next three years) is higher than those of the other approaches; this may be regarded as an effect of the diffusion of innovation: JIT is the newest approach and therefore is least diffused. On the other hand, JIT is growing faster than both information systems of production management (MRP approach) and technological innovation (TDA).

However, firms do not generally show interest in only a single approach, but rather prefer compatibility and the complementarity of different approaches. In several cases, the interventions (some of which have been carried out, others of which are planned) were inspired by various innovative approaches. Nearly 40 per cent of the sample availed itself of the three approaches at the same time. The adoption of a single approach is less frequent, particularly in the applications of JIT.

This conclusion agrees with results from an American survey on the impact of computer technology on JIT manufacturing by Kim and Lee [9]: 81 surveyed manufacturers out of 122 used JIT and Computer Integrated Manufacturing (CIM,

which includes both MRP and TDA) at the same time. Only 15 firms used JIT on its own.

Finally, our empirical results do not reveal any particular sequences or priorities in the adoption of the three approaches.

JIT as a Set of Techniques

Results show the existence of some core techniques, characteristic of the JIT approach; these are the ones that show the largest difference of use between the JIT adopters and non-adopters (Table II).

There is strong statistical evidence that the following techniques are characteristic of the JIT approach: product modularization, parts standardization, set-up time reduction, pull-controlled flow, levelled production planning, job enlargement/enrichment, supply quality certification, dedicated suppliers' production capacity and total-cost suppliers' evaluation. Finally, preventive maintenance comes out as more characteristic than we expected. High-level Bill of Materials (BOM) diversification, manpower flexibility, layout improvement and pull-controlled deliveries seem to be less characteristic than we expected.

JIT implies a large use of the whole set of techniques (Table II, second column). This set seems not to be exclusive to JIT as the techniques are widely used by non-adopters (third column). However, JIT implies a wider adoption: the difference in the frequency of use between JIT adopters and non-adopters is always positive and statistically significant for 18 techniques (out of 21).

Finally, the implementation of a JIT programme seems to go through two phases, in which different techniques are used: during the first phase the major interest is in the product-process scope; in the second, more attention is paid to job organization, production management and supplier relationships.

The Benefits of JIT

As already noted, the benefits obtained by co-operating firms have been measured from the variation of indicators of the operating conditions (internal parameters of the production system) and from the performance given by the production system itself.

The production units that adopted JIT obtained better results compared to others for almost all the indicators considered. In particular, regarding operating conditions (Table III), the greatest benefits of JIT concern internal lead time, time for producing all the range, the reduction of purchasing lot size and the production lot size.

Table II. Techniques for Manufacturing Improvement: Rate of Implementation — Percentage of Production Units which Have Implemented or Plan to Adopt Each Technique

Areas and techniques	Total sample (n = 173)	JIT adopters (n = 96)	Non-JIT adopters (n = 77)	Difference JIT/non-JIT adopters	Significance level[a]
Product design					
Parts standardization	82.7	89.6	74.0	15.6	0.01
Product modularization	58.4	70.8	42.9	27.9	0.001
High level BOM[b] diversification	51.4	58.3	42.9	15.4	0.05
Product-process standardization	76.9	83.3	68.8	14.5	0.05
Total-cost design and engineering	60.7	68.8	50.6	18.2	0.05
Process equipment					
Set-up time reduction	66.5	75.0	55.8	19.2	0.01
Layout improvement	67.0	72.9	59.7	13.2	ns
Process quality control	84.4	90.6	76.6	14.0	0.05
Preventive maintenance	72.3	82.3	59.7	22.6	0.001
Production planning and control					
Pull-controlled flow	60.1	72.9	44.2	28.7	0.001
Levelled master production schedule	68.8	77.1	58.4	18.7	0.01
Organization and people					
Job enlargement/ enrichment	79.8	90.6	66.2	24.4	0.001
Working-time flexibility	47.4	54.2	39.0	15.2	0.05
Job mobility flexibility	82.7	88.5	75.3	13.2	0.05
Efficiency improvement	78.6	85.4	70.1	15.3	0.05
Product vs functional organization	56.7	65.6	45.5	20.1	0.01
Supplier relationship					
Supply quality certification	73.4	83.3	61.0	22.3	0.001
Long-term purchasing contracts	80.3	81.2	79.2	2.0	ns
Dedicated suppliers' production capacity	38.7	47.9	27.3	20.6	0.01
Total-cost suppliers' evaluation	63.6	72.9	51.9	21.0	0.01
Pull-controlled deliveries	61.9	66.7	55.8	10.9	ns

[a] Differences tested by Fisher test; ns = not significant.

[b] Bill of materials

Table III. Operating Conditions: Results Obtained and JIT Adoption —Percentage Variations of the Parameters in the Last Three Years (JIT Adopters vs JIT Non-adopters)

Operating conditions	Total sample (n = 136)[a]	JIT adopters (n = 49)	Non-JIT adopters (n = 87)	Difference	Significance level[b]	Missing (out of 136)
Internal lead time	−15.6	−21.8	−12.0	−9.8	0.0041	11
Time for production of all the range	−13.8	−19.6	−10.1	−9.5	0.0044	42
Purchasing lot size	−8.6	−15.8	−4.3	−11.5	0.0319	37
Production lot size	−8.1	−13.3	−4.5	−8.8	0.0477	31
Diversification lead time	−10.0	−13.7	−8.0	−5.7	0.1249	50
Capacity utilization	3.7	5.6	2.5	3.1	0.1449	26
Vendors' lead time	−11.5	−13.4	−10.4	−3.0	0.2481	19
Design lead time	−9.5	−11.7	−8.1	−3.6	0.2905	32
Machine availability	4.9	6.2	4.0	2.2	0.4102	26
Manpower efficiency	6.2	7.1	5.7	1.4	0.5193	27
Scrap accepted in supply	−8.1	−8.2	−8.1	−0.1	0.9814	27

[a] 37 firms did not reveal these data.

[b] Significance level represents the probability that the difference is random (differences tested by Fisher's test).

In contrast, the increase of machine availability was not found to be a particular JIT benefit, just as the improvement obtained by adopters is not significantly greater than that obtained by non-adopters.

The major improvements in the operating conditions are also reflected in major benefits on performance indicators (Table IV). The adopters of JIT obtained greater mix flexibility, measured in terms of the number of products feasible in a minimal programming horizon. Additional benefits were obtained in the productivity of materials, whether of WIP or of raw material turnover.

These results agree with what Voss and Robinson[6] pointed out, that reduction in WIP and increased flexibility were consistently ranked by the British manufacturers as the major benefits derived from JIT. Finally, the advantages obtained in work productivity are notably superior.

Contrary to predictions, some service indicators (the mean delivery time and mean delivery delay) were not greatly improved for those oriented toward JIT. It is clear that the improvement in operating conditions (internal lead time, for example) does not necessarily lead to an improvement at performance level (delivery time, for example), but it does shift the trade-off between performances traditionally considered as contradictory (service level and productivity, for example); Italian firms seem to use the reduction of internal lead time to reduce stocks rather than to shorten delivery time.

Table IV. Performances: Results Obtained and **JIT** Adoption — Percentage Variation of the Parameters in the Last Three Years **(JIT** Adopters vs **JIT** Non-adopters)

Performances	Total sample (n = 131)[a]	JIT adopters (n = 47)	Non-JIT adopters (n = 84)	Difference	Significance level[b]	Missing (out of 131)
Mix flexibility[c]	8.4	15.5	2.9	12.6	0.0050	67
WIP turnover	11.7	18.3	6.7	11.6	0.0091	32
Direct labour cost	−8.4	−12.3	−5.9	−6.4	0.0130	12
Raw material turnover	10.9	16.9	6.9	10.0	0.0199	24
Clerical labour cost	−0.4	−3.1	1.4	−4.5	0.0345	16
Re-working rate	−9.2	−12.6	−6.8	−5.7	0.0553	34
Maximum number of products	7.0	10.7	3.9	6.8	0.0943	65
Depreciation	2.8	4.6	1.4	3.2	0.2207	32
Time to introduce new product	−8.1	−10.8	−6.2	−4.5	0.2232	40
Incidence of variable costs	−1.5	−2.1	−1.0	−1.1	0.5517	31
Finished products turnover	12.4	14.0	11.3	2.7	0.5616	32
Indirect labour cost	−3.2	−4.0	−2.7	−1.3	0.5702	13
Mean delivery delay	−12.0	−13.3	−11.2	−2.1	0.7123	29
Incidence of direct material	−0.3	−0.5	−0.2	−0.3	0.8114	23
Mean delivery time	−13.0	−13.5	−12.8	−0.7	0.8339	26
Defect rate	−10.0	−10.3	−9.9	−0.4	0.9052	26
Number of interventions (guaranteed)	−7.8	−7.6	−7.9	0.4	0.9152	49

[a] 42 firms did not reveal these data.

[b] Significance level represents the probability that the difference is random (differences tested by Fisher's test).

[c] Number of products feasible in a minimal programming horizon.

As a whole, the benefits derived from the adoption of JIT seem therefore superior to those obtainable without it, whether in depth or breadth: there are in fact many indicators for which the improvement is significantly more meaningful.

JIT Adoption in Relation to Manufacturing Strategy and Exogenous Factors The adoption of JIT does not appear to be tied to particular strategic priorities, expressed in the list of productivity objectives, quality, flexibility and service required by the production system (Table V). The average profile of such priorities for firms that tend to choose Just-in-Time does not differ significantly from that of firms uninterested in it.

The hypothesis that strategy influences the choice of an innovative approach to manufacturing is not therefore confirmed by the research results: all the approaches to innovation seem useful in respect of strategic priorities. This fully

Table V. Ranking of Manufacturing Performance Objectives — Performances are Grouped in the Same Rank in the Case of Lack of Significant Difference, on the Basis of the Wilcoxon Test at 5 Per Cent Level

Total sample (n = 152)[a]	JIT Adopters (n = 85)	JIT Non-adopters (n = 67)
1. Quality of design 1. Product reliability	1. Quality of design	1. Quality of design 1. Product reliability 1. In-house conformance 1. Readiness 1. In-field conformance
2. In-house conformance 2. Readiness	2. Product reliability 2. In-house conformance 2. Readiness 2. In-field conformance	2. Productivity 2. Mix flexibility
3. In-field conformance 3. Productivity 3. Mix flexibility	3. Productivity 3. Mix flexibility	3. Technical assistance 3. Product flexibility 3. Volume flexibility
4. Technical assistance 4. Product flexibility 4. Volume flexibility	4. Product flexibility 4. Volume flexibility 4. Technical assistance	

[a] 21 firms did not reveal their strategic priorities

agrees with what Gilbert[7] pointed out, that no significant differences exist between adopters and non-adopters of JIT in the ranking of the most important aspects for the functions of marketing, purchasing and production.

It is interesting to note that, independently of JIT adoption, the co-operating firms favour quality objectives in the manufacturing area. Project quality, product reliability and in-house conformance appear as the top priorities in the average profile, followed by a service objective (mean delivery time); productivity and mix flexibility are in an intermediate position; the other items of flexibility (product and volume) and technical assistance are at the lowest level of attributed importance. This scale of priorities substantially agrees with the results of the manufacturing futures survey[19]: European firms in the later 1980s declared, compared to their Japanese competitors, an absolute priority for quality objectives in all their aspects and a second-level preference for service objectives; they gave an intermediate importance to the objectives of mix flexibility and cost (and therefore to the total productivity factors) in that they tended not to emphasize the price battle; finally, they considered volume flexibility and the breadth range less important.

The adoption of JIT does not appear to be significantly influenced by context variables such as production unit sizes and the nationality of the group in control of the firm (Table VI). Differences emerge which are not necessarily significant from a statistical point of view, in respect of the industrial type and the prevalent productive typology in the production units: greater adoption rates are detected in

Table VI. Exogenous Factors and JIT adoption — Percentage of Production Units, Out of the Total Sample, which have Implemented, or are Implementing or Plan to Adopt JIT

	Implemented or planned	Number of cases
Firm Size		
Large	62.2	37
Medium	48.8	43
Small	55.9	93
Total	55.5	173
Significance level [a]	0.4904	
Type of control		
Independent unit	55.6	72
Italian holding group	54.2	48
Foreign holding group	56.6	53
Total	55.5	173
Significance level [a]	0.971	
Type of industry		
Process industry	42.1	38
Electronic	63.2	19
Electrotechnical	64.7	17
Machinery and plants	51.3	39
Mechanical	63.9	36
Others	58.3	24
Total	55.5	173
Significance level [a]	0.401	

[a]Significance level is tested by the Fisher test and the value represents the probability that differences through the classes are random.

repetitive production (orders for large series and repeated orders for specific areas) and in electro-technical and mechanical types.

The hypothetical frame of *the influences of exogenous context factors on the adoption of JIT is not then confirmed,* but the capacity of the adaptive approach to serve the most diverse conditions and operational realities is shown.

JIT as an Organizational and Management Innovation

Analysis of cost, time, and problems encountered in the realization of the interventions permit some conclusions on the nature of JIT innovation. The necessary investment per unit of invoicing and per employee is lower comparedto those of

other approaches; therefore it would appear that JIT leverages moreon internal resources than on the investment in new means of production (machines, computers, etc.), the use of which often needs large external service support. In confirmation of this, none of the firms oriented toward JIT declared having financial problems, while 27 per cent of those using other approaches did.

The differences in the extent and in the cost structure amongst pure adopters of diverse approaches are high, which confirms the nature of JIT as an approach with a prevalently organizational and managerial character, low in cost and therefore appropriate for small to medium-sized firms. This is indirectly confirmed by the fact that the adoption of JIT is not significantly linked to the size of the firm.

It is necessary, however, to specify that, while these conclusions are valid within the limits of the sample examined, they are by necessity restricted to only "pure" adopters of diverse approaches. Finally, the research results show a trend toward faster JIT implementation of interventions, compared to those inspired by other approaches. This could be a result of the larger use of internal resources and of the modality of change typical of JIT, which is not subject to important changes of a technological nature.

Some Considerations on the Research Results

The Applicability of JIT

The results concerning the benefits and the considerations on the organizational and managerial nature of the approach demonstrate positive indications as to the "applicability" of the JIT approach, intended as a comparison between benefits obtained and costs met (or between expected benefits and costs).

Thus defined, the applicability of JIT is still more widespread, as the research results do not confirm some hypothesis about the influence of exogenous context factors (firm size and type) on JIT adoption. As the strategic profile of a firm also seems irrelevant to the aims of JIT adoption, JIT confirms itself as an instrument suitable for different application contexts and diverse strategic objectives.

The Urgency for an Integrated Approach

Examining the overall results of this study, we can state that JIT adopters realize better results characterized by the speed-up of production flow (i.e. lead-time reduction), and a synchronization between production and market and between the different productive and logistic phases. JIT also brings about a noticeable reduction of purchasing and production lot sizes. In terms of performance this leads to an increase of working-capital productivity and to an improvement of readiness

and delivery punctuality. Moreover, it is important to underline the improvement in quality conformance (both in house and in the field) and of labour productivity (both direct and clerical).

JIT seems therefore able to shift the traditional "trade-off" between static economic efficiency and flexibility. The results achieved probably derive from the simultaneous utilization of different approaches. It is therefore difficult to identify the contribution of a single approach. Yet JIT represents the newest innovative approach, so that most JIT adopters have tried or will try other approaches simultaneously.

The general impression to be drawn from this survey is that the differences among the approaches tend, in practice, to fade away. The different approaches and their intervention levers are regarded as compatible and complementary tools with which to redesign the production system in relation to performance objectives ensuing from the exigencies of competitive strategy.

The survey does not provide elements to determine whether firms conform to a comprehensive vision of manufacturing innovation or an integrated approach. On the contrary, the results support the idea of partial vision and fragmentary innovation effort.

A wider diffusion of an integrated vision of manufacturing innovation must still be hoped for. Manufacturing excellence (so-called World Class Manufacturing) is a consequence of a whole set of new criteria and paradigms and of their influence on the choice of techniques, rather than the consequence of the techniques themselves and their own potential. The change in conditions under which firms operate requires a new orientation to one more able to manage a situation of growing complexity. This is possible thanks to technological and manufacturing innovations, but the effectiveness of interventions remains tied to the search for a new coherence and a general re-orientation of the process of decision making in manufacturing.

The pursuit of an integrated approach means therefore:

(1) Stating new general criteria for the design and the management of the production system, taking into consideration strategic plans[20,21].
(2) Picking out the best intervention levers from the entire set proposed in the single approaches (for example, Gunn[22] supports the idea that World Class Manufacturing is built on three pillars: Computer Integrated Manufacturing (CIM), Total Quality Control (TQC), and Just-in-Time (JIT)). In this sense every firm must project its own innovation pattern even if some general schemes may be taken as a reference.

The main difficulties in manufacturing are probably two: firstly, the ability to organize and interiorize the new "directions" of management and secondly the fact that new principles generally differ from those of consolidated production "wisdom".

References

1. Bartezzaghi, E. and Turco, F., "The Impact of Just-in-Time on Production System Performance: An Analytical Framework", International Journal of Operations & Production Management, Vol. 9 No. 8, 1989, pp. 40-61.
2. Bartezzaghi, E. and Turco, F., "The Impact of Just-in-Time on Production System Performances: Results of a Field Research", The Challenge to Integrate: Pathways to Competitive Manufacturing, APICS World Congress, Amsterdam, 1989.
3. Schonberger, R J., Japanese Manufacturing Techniques. Nine Hidden Lessons in Simplicity, The Free Press, Macmillan, New York, 1982.
4. Hall, R.W., Zero Inventories, Dow Jones Irwin Inc., Homewood, Illinois, 1983.
5. Monden, Y., Toyota Production System. Practical Approach to Production Management, Institute of Industrial Engineers, Atlanta, 1983.
6. Voss, C.A., and Robinson, S.J., "Application of Just-in-Time Manufacturing Techniques in the United Kingdom", International Journal of Operations & Production Management, Vol. 7 No. 4, 1987, pp 46-52.
7. Gilbert, J.P.,The State of JIT Implementation and Development in the USA'', International Journal of Production Research, Vol. 28 No. 6, 1990, pp. 1099-109.
8. Im, J.H. and Lee, S.M., "Implementation of Just-in-Time Systems in US Manufacturing Firms", International Journal of Operations & Production Management, Vol. 9 No. 1, 1989, pp. 5-14.
9. Kim, G.C. and Lee, S.M., "Impact of Computer Technology on the Implementation of Just-in-Time Production Systems", International Journal of Operations & Production Management, Vol. 9 No. 8, 1989, pp. 20-39.
10. Abernathy, W.J., Clark, K.B. and Kamtrow, A.M., Industrial Renaissance, Basic Books, New York, 1983.
11. Hall, R.W., Attaining Manufacturing Excellence. Just in Time, Total Quality, Total People Involvement, Dow Jones Irwin, Homewood, Illinois, 1987.
12. Schonberger, R.J., World Class Manufacturing. The Lessons in Simplicity Applied, The Free Press, Macmillan, New York, 1986.
13. Juran, J.M. and Gryina, F.M., Quality Planning and Analysis, McGraw-Hill, New York, 1970.
14. Buzacott, J.A., "The Fundamental Principles of Flexibility in Manufacturing Systems", Proceedings of the 1st International Conference on Flexible Manufacturing Systems, Brighton, UK, 20-22 October 1992.
15. Slack, N., Flexibility of Manufacturing Systems", International Journal of Operations & Production Management, Vol. 7 No. 4, 1987, pp. 35-45.
16. Monden, Y., "Smoothed Production Lets Toyota Adapt to Demand Changes", Industrial Engineering, Vol. 13 No. 8, 1981, pp. 42-51.
17. Monden, Y., "How Toyota Shortened Supply Lot Production Time, Waiting Time and Conveyance Time", Industrial Engineering, Vol. 13 No. 9, 1981, pp. 22-31.
18. McElroy, J., "Making Just-in-Time Production Pay Off", Automotive Industries, Vol. 162 No. 2, 1985, pp. 77-80.
19. De Meyer, A., Miller, J.G., Nakane, J. and Ferdows, K., "Flexibility: the Next Competitive Battle", Strategic Management Journal, Vol. 10 No. 2, 1989.
20. Hayes, R.H., Wheelwright, S.C. and Clark, K., Dynamic Manufacturing, Creating the Learning Organisation, The Free Press, London, 1988.
21. Drucker, P.F., "The Emerging Theory in Manufacturing", Harvard Business Review, May-June 1990, pp. 94-102.
22. Gunn, T.G., Manufacturing for Competitive Advantage. Becoming a World-class Manufacturer, Ballinger Publishing Company, Cambridge, MA, 1987.

2.2 Review and Outlook

2.2.1 The Paper and Its Significance

At the end of the eighties, Bartezzaghi, Spina and Turco considered that there was an emerging paradigm coming from Japanese firms. A few years before, Schonberger (1986) wrote his book entitled 'World class manufacturing. The lesson in simplicity applied', reporting the new vision of what would later be called 'lean manufacturing', formally presented in the famous book 'The machine that changed the world' by Womack et al. (1990). The 'simplicity' underlined by Schonberger was a disruptive message at a moment when a number of scholars (e.g. Goldhar 1985) and practitioners in the western world were promoting computer-integrated manufacturing (CIM), an approach highly based on information technologies [e.g. Material Requirements Planning (MRP)] for production planning and control and automation (including flexible automation) in manufacturing.

Gianluca and his colleagues perceived in a timely manner the potential strategic impact of the new paradigm, in which Just in Time (JIT) is one of the most promising approaches for increased competitiveness. However, they did not see the new approach coming from Japan as totally alternative to CIM. Thus, they investigated JIT while also considering technologies. Gianluca and his colleagues were not interested in studying the level of diffusion of JIT in Italian companies; rather, they wanted to understand the benefits, costs and problems implied by JIT application.

In 1992, JIT literature was still relatively new. The first article on the implementation of JIT in manufacturing appeared in the 1970s (Sugimori et al. 1977). Since then, hundreds of JIT papers have appeared in professional journals, mainly focusing on general descriptions of JIT implementation (Moras et al. 1991). Various sets of dimensions have been proposed to characterise JIT, but no consistent proposal clearly emerged until 1992. Despite the volume of publications (Sohal et al. 1988; Ramarapu et al. 1995), wide empirical studies on the impact of JIT on performance were very limited (Forza and Di Nuzzo 1998). We have found one survey-based study in the UK (Voss and Robinson 1987) and four in the USA (Kim and Lee 1989; Golhar et al. 1990; Inman and Mehra 1990; Stamm and Golhar 1991). Thus, there was still a lack of generalisability in terms of the applicability of the results of JIT outside Japan and its impacts on performance in 1992.

Bartezzaghi et al.'s survey-based paper contains an interesting framework and findings concerning JIT. In particular, to investigate the impacts of JIT implementation, the framework distinguishes between the operating conditions of the production system (i.e. the functioning characteristics, such as throughput time) and the performance of the production system (i.e. the results, such as delivery lead time, directly perceivable by customers or by a higher-level system of the company). In the framework, the operating conditions act as mediators towards performance indicators. The implementation of JIT, by modifying the operating conditions, allows the company to modify the trade-offs between different

performance dimensions. For example, as the authors put it, “reducing internal lead time changes the trade-off between productivity and service because it can be used to improve either Work in Progress (WIP) turnover or mean delivery time”. However, it is the management that will decide whether to improve WIP turnover or reduce mean delivery time, based on manufacturing priorities. Therefore, the framework models the impact on performance as mediated by both the operating conditions and the manufacturing priorities.

The framework also includes a number of antecedents of JIT adoption, although it deliberately excludes internal antecedents, such as management orientations. More specifically, it considers contextual factors such as priorities in manufacturing performance, the size of the company, type of production unit, the nationality of the holding company and production typology. The inclusion of all these contextual factors that can act as antecedents of JIT adoption is interesting in terms of the possibility it affords to infer which contexts are more or less favourable for JIT adoption. This is an important issue in transforming research results into something useful for practitioners.

The reference framework used to investigate the application of JIT also has an additional element of interest. On the one hand, the authors consider JIT as an approach for managing and controlling the production system (in a sense, this is the soft side of JIT and the lean approach, which refers to the vision and the mindset of the people); on the other hand, they view JIT as a set of techniques. They split the 21 techniques into five groups: (a) product design (i.e. standardisation), (b) process equipment (i.e. reducing set-up time), (c) production planning and control (i.e. pull system), (d) organisation and people (i.e. job enlargement/enrichment), (e) supplier relationships (i.e. long-term purchasing contracts). It should be noted that these elements represent what we today consider to be pillars of the popular lean organisation.

The findings from the survey indicated that one third of the manufacturing companies in the sample had implemented more than one technique and increasing numbers were planning to adopt them. The interventions most commonly adopted concerned standardisation and the reduction of set-up time, but many others were planned by companies. This result shows that companies were using a step-by-step approach in implementing the new paradigm, following a ‘path’ approach coherent with a learning perspective, which is the appropriate and effective way to become world class or lean (Filippini et al. 1996).

Even if JIT adoption and diffusion was in its infancy at that time, some interesting findings concerning performance and improvements emerged from the survey. Now, after several empirical studies, we know that the time span between intervention and its results is quite long. JIT or lean approaches and techniques require several changes in the sociotechnical system and the path towards stable improvements is long and complex. The findings found by Gianluca and colleagues reflect this. There are a few positive performance improvement indicators among JIT adopters, namely mix flexibility and WIP turnover (with significant differences compared to non-adopters). Also, internal lead time exhibits significant improvement. Many other performance indicators seem not to be influenced by JIT

application, or the difference between JIT adopters and non-adopters is not significant. This is the case for mean delivery time, which is almost the same between the two groups. Why? The authors suggest that "it is clear that the improvement in operating conditions (internal lead time) does not necessarily lead to an improvement at performance level (delivery time) but it does shift the trade-off between performances traditionally considered as contradictory (service level and productivity); Italian firms seems to use the reduction of internal lead time to reduce stock rather than to shorten delivery time". They were right!

2.2.2 The Heritage

What can we tell 25 years after this research? We can observe that the type and the level of competition at the end of eighties were different. Probably at that time companies had strong demand from the market and many of them had a significant portfolio of orders; in these conditions, speeding up the delivery time was not a strategic factor—or in other words, delivery time was not an order winner—whereas nowadays it is. To support this point, an interesting question is discussed in the paper: "*Does JIT appear to be tied to a particular strategic priority?*" Data from the sample showed that quality was the first strategic priority, whereas delivery time was almost entirely absent from lists of priorities. However, we know, based on experience, that JIT is also able to contribute to increasing external performance, in particular delivery time and reliability. At the time, productivity and cost reductions were important for both JIT and non-adopters. From this perspective, JIT was considered useful to improve operational performance and efficiency.

Bartezzaghi et al.'s paper is dated 1992 and we can see that time has passed. The method and writing style are probably the two aspects where its age is more detectable. Yes, the paper provides a lot of information on the characteristics of the sample and the sample itself is designed in such a way that a number of interesting contingency factors can be included in the analyses. Yes, the paper is not data driven, as all the analyses are based on sound theoretical expectations. In these respects, the paper is a 'modern one'. However, it mixes under the term 'hypothesis' both exploration and theory testing. It also devotes limited space to the motivation for the hypotheses developed and that space is devoted to the most important aspects that justify them. In addition, the measurement apparatus is limited in comparison with the requirements nowadays required in Operation Management (OM) research. The sophistication of the research methods is limited in comparison to the OM research that is published nowadays. However, this limited sophistication is not a shortcoming as the methods used allowed Bartezzaghi et al. to provide a wide picture of JIT implementation. Very likely, more sophisticated methods would have constrained the scope of the research.

Another value that characterises the paper concerns the importance of the application, as clearly emerged in the objectives of the paper. The main reason for the research was not to describe the level of diffusion of JIT in Italy; rather, it was to

see whether JIT was applicable in Italy and for that reason, the paper explored the benefits, costs and problems of JIT adoption. Thus, it adopted a contingency perspective, considering some contextual factors, such as the size and type of firm and specific manufacturing strategies, which might affect adoption of JIT and reporting a number of details regarding the sample in the paper.

2.2.3 Final Remarks

The application of research results was always a driving force and core value for Gianluca. He did not limit himself to investigating how to improve the Business School of the Politecnico di Milano: he guided the School, taking on the burdens of planning and implementing changes. He was not satisfied simply analysing the existing situation of Engineering and Management and making suggestions to improve it: instead, he served as member on the Board and as President of the Italian Management Engineering Association (AiIG—Associazione Italiana di Ingegneria Gestionale).

In the paper, we can sense another trait of Gianluca's personality, namely his openness towards discussion. On the one hand, the paper joins what was—at the end of the eighties—a hot debate on JIT versus CIM. On the other hand, the paper offers OM scholars the possibility of further debate, namely concerning the role of JIT as a trade-off shifter. This is typical of Gianluca. We miss his sincere spirit of confrontation—sometimes strong confrontation, but also open, reciprocal and constructive. In the end, such confrontation is valuable, a pleasure and a constructive way to live.

References

Filippini, R., Forza, C., & Vinelli, A. (1996). Improvement initiative paths in operations. *Integrated Manufacturing Systems, 7*(2), 67–76.

Forza, C., & Di Nuzzo, F. (1998). Meta-analysis applied to operations management: Summarizing the results of empirical research. *International Journal of Production Research, 36*(3), 837–861.

Goldhar, J. M. (1985). Computer integrated flexible manufacturing: Organizational, economic, and strategic implications. *Interfaces, 15*(3), 94–105.

Golhar, D. Y., Stamm, C. L., & Smith, W. P. (1990). JIT implementation in small manufacturing firms. *Production and Inventory Management Journal, 20*(2), 44–48.

Inman, R. A., & Mehra, S. (1990). The transferability of just-in-time concepts to American small business. *Interfaces, 20*(2), 30–37.

Kim, G. C., & Lee, S. M. (1989). Impact of computer technology on the implementation of Just-in-Time production systems. *International Journal of Production and Operations Management, 9*(8), 20–39.

Moras, R. G., Jalali, M. R., & Dudek, R. A. (1991). A categorized survey of the JIT literature. *Production Planning & Control, 2*(4), 322–334.

Ramarapu, N. K., Mehra, S., & Frolick, M. N. (1995). A comparative analysis and review of JIT 'implementation'. *International Journal of Production and Operations Management, 15*(1), 38–49.

Schonberger, R. J. (1986). *World class manufacturing*. New York: The Free Press.

Sohal, A. S., Keller, A. Z., & Fuad, R. H. (1988). A review of literature relating to JIT. *International Journal of Production and Operations Management, 9*(3), 15–25.

Stamm, C. L., & Golhar, D. Y. (1991). Customer and supplier linkages for small JIT manufacturing firms. *Journal of Small Business Management, 29*(3), 43–49.

Sugimori, Y., Kusonoki, K., Cho, F., & Uchikawa, S. (1977). Toyota production system and Kanban system: Materialization of a Just-in-Time and respect for human system. *International Journal of Production Research, 15*(6), 565–594.

Voss, C. A., & Robinson, S. J. (1987). Application of Just-in-Time manufacturing techniques in the United Kingdom. *International Journal of Operations and Production Management, 7*(4), 46–52.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world*. New York: Simon and Schuster.

Chapter 3
Strategically Flexible Production: The Multi-focused Manufacturing Paradigm. A Review and Outlook

Chris A. Voss

Abstract In the Nineties companies were experiencing a number of different strategic and organizational models in running their manufacturing activities to overcome the limitations of the Fordist paradigm in the face of growing complexity and turbulence of the environment. Despite the differences, it was possible at that time to recognize few guiding principles that were common to the most advanced and effective models. In particular, the original paper summarized these principles in three: i) Multi-focusedness and strategic flexibility; ii) Process Integration; and iii) Process Ownership. This approach was called the Strategically Flexible Production. Using data from the International Manufacturing Strategy Survey, the authors were able to show the wide adoption of the paradigm across the sample and across all regions. It also tested the impact of the new paradigm on operational performance, showing better results obtained by those companies that fully adopted the paradigm compared to partial or non-adopters. The commentary underlines that after twenty years the value of this paper resides first of all in having challenged the established paradigms of manufacturing strategy at that time. Also, the paper was among the first ones to underline the value and importance of strategic flexibility and multi-focusedness for manufacturing companies. On both these aspects the paper has been an important platform for future work and for the evolution of the field.

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3.1 Original Paper[1]

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Research background: beyond Fordism

Over the past 20 years manufacturing and assembly activities have experienced many changes, not only technological but also organizational and managerial.

A wide range of innovations have been implemented across countries and industries, such as just-in-time, total quality management, concurrent engineering and others. As a result, both the internal organization of the factories and the external environment – including market demand, technology development, workforce

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education and expectations, labour and capital market– appear to be very different today from the general features that dominated the industrial development in the past, which is generally referred to as the Fordist paradigm. This paradigm shift has been described from both a macro and institutional perspective; see the comprehensive reviews by Roobeek[1] and Kenney and Florida[2]. Also, from a managerial point of view, clear-cut breaks with the consolidated Fordist practices have been highlighted. For example, Jaikumar[3] proposed new mission statements about the management of new technologies, Drucker[4] and Hayes et al.[5] put forward new principles to organize and manage manufacturing systems, others pointed out new performance requirements; e.g., Slack[6] on the flexibility and Stalk and Hout[7] on time-based performances. However, with all the literature on paradigm shifts in manufacturing, some valid questions are still open:

- Can a new manufacturing paradigm be identified, despite the different strategic choices that industrial companies make and the different internal and external conditions they have to meet?
- Is this paradigm a definite breakthrough with Fordism? Is it possible to find out a limited set of shared principles to design and manage the production systems, that pools different models and paths of innovations?
- If the paradigm exists, how can it be defined and operationalized to support empirical investigation?
- How is the emerging paradigm adopted across countries and industries?
- What is the performance improvement along specific measures that comes from the orientation to the paradigm?
- Are there different paths to achieve the full orientation to the paradigm?

This article explores the answers to some of these questions. Assuming that a new paradigm is actually emerging, we define and operationalize it precisely, and investigate its adoption, performance improvements and innovation tracks, by using data from the International Manufacturing Strategy Survey (IMSS), a worldwide research project involving 600 companies from 20 countries, within the assembly industry.

The basic assumption about the emergence of a new paradigm entails that the different post-Fordist experiences are drawing together; also, despite the variety of strategies and innovations implemented, both organizational and technological. Indeed, the shift away from mass production to a new industrial organization has followed different paths, some of which drew enthusiastic attention but were abandoned or reshaped later on – e.g. the experiences of Volvo in Kalmar and Uddevalla and the so-called "neo-craftsmen" models. Other examples (see also [2] for a review) include the model of "flexible specialization"[8]. Cases in point are the textile district in Northern Italy and the textile machinery district of Baden-Würtemberg. Though fascinating, "flexible specialization" appeared to be inapplicable to the most important capital intensive sectors. Also, the Japanese way has been regarded as a replacement for the Fordist paradigm. The development of the just-in-time concept at Toyota since the 1950s and further refinements seem to discard the basic principles of Fordism (see, for example [9]). However this view has been questioned [10] and the Toyotism with its superexploitation of workers'

capabilities has been depicted also as "hyper-Fordism". Indeed, western manufacturers have experienced many difficulties in adopting or adapting the Japanese style of management and way of organizing the production systems.

Ever more companies are drifting away from Fordism, and it seems that a new paradigm is emerging, which embodies some features of the previous post- Fordist experiences, but also introduces radically new aspects. Based on a limited set of shared principles to design and manage production systems, the paradigm pools different models that companies implement to cope with the competition in their marketplaces and to exploit their capabilities. These principles appear to discard the traditional Fordist assumptions about strong labour specialization, heavy control hierarchies, functional organization, tradeoff management, co-ordinating mechanisms based on formal procedures and so on. Indeed, the whole research project on what we call the multi-focused manufacturing paradigm, moves from the idea that a clear distinction is needed between three levels:

(1) The *techniques* to innovate the production systems, that is, the technological, managerial and organizational innovations.
(2) *Manufacturing models,* i.e. the systemic implementations of combinations of techniques that companies select and customize, according to their internal and external environment; the implementation results in specific practices that suit the company's situation best.
(3) The emerging *multi-focused manufacturing paradigm,* that is a limited set of new principles that underpins the innovation techniques and pools the manufacturing models. This new paradigm is supposed to replace the prevailing *modus operandi* within different countries and assembly industries, which is generally referred to as the Fordist paradigm.

A vast body of literature has already investigated the adoption and diffusion of the single techniques. In addition the transferability of some successful models has been studied, e.g. the "Toyota model" – just to discover that they can hardly be imitated, due to a number of country-specific factors. The basic assumption of the present research is that the single innovative techniques are actually universal and thus relatively easy to imitate. Consistent and, hence, effective combinations of these techniques are much more difficult to achieve. Exactly which combination is the most suitable for a company depends on: contextual factors – for example relating to country; industry and company size – technology; strategy and goals.

The consistency of a manufacturing paradigm

The rising of the multi-focused manufacturing paradigm comes from the environmental changes that have taken, and are still taking, place. These require companies and their production systems to adapt in order to remain effective. Many authors indicate how manufacturing should be organized in order to meet present market needs, resource availability, workforce expectations and so on (e.g. [11-13]). In addition, the effectiveness of manufacturing systems has been linked theoretically to their consistency, i.e. the fit between the component elements of the organization

and its environment (e.g. [14]). Hayes and Wheelwright[13] distinguish external and internal consistency. External consistency refers to the match between the manufacturing strategy and the business environment of the company. Internal consistency refers to the match within the manufacturing function and across functions within the business unit. So, environmental changes call for new internal and external consistency. If the environmental changes are big enough they may not only require changes on technique level or model level but even on paradigm level.

As effectiveness is a relative dimension, to assess the current and future strengths of the adopters of a new paradigm, internally and externally consistent, it is advisable to describe their position relative to rivals. This is in line with Pfeffer[15], who maintains that effectiveness can only be assessed comparatively. We can measure the position of a company relative to a competitor via two dimensions:

(1) its relative position regarding performance in the marketplace;
(2) the relative speed of organizational change aimed at improving performance[14].

Here we follow the second alternative, by addressing the question as to whether the multi-focused manufacturing paradigm enables a better degree of performance improvement than companies that have a lower degree of adoption of the paradigm. We expect cumulative effects on performance improvements depending on different degrees of adoption of the paradigm.

Several studies prove the effectiveness of manufacturing improvement programmes. Individual programmes proved to be associated with individual, related performance improvements, but success in manufacturing seems to require synergistic investments in a wide portfolio of programmes[16]; world-class companies, adopting a wide range of best practices, perform well on a wide range of measures[17-18]. In addition, cumulative effects on different performances have been highlighted – see the "sandcone model"[19] – and some techniques or approaches demonstrated to improve simultaneously different performances regarded as antithetical[20], thus shifting traditional trade-offs. This kind of literature explores the practice-performance link, either individually or synergistically. In this contribution we move to the paradigm-performance link. In fact, the actual possibility to improve manufacturing performances through innovative activities depends on their proper implementation[21]. In our view, the orientation to the multi-focused manufacturing paradigm, whatever the programmes or the practices implemented, can measure the success of the implementation.

The multi-focused manufacturing paradigm

The basic principles

Recently, much has been written on the general changes that occur in the manufacturing systems. For example, [4,5] and [22] have proposed conceptual frameworks that identify a limited number of basic criteria. All these contributions suggest a

number of principles underpinning different manufacturing models. Though there are different emphases in those proposals, they can be regarded as coherent identifications of a unique paradigm, based on the external and internal consistency. Actually, today's external consistency seems to require:

- multiple performances required simultaneously;
- rapid priority changes;
- time effectiveness and quick response;
- increased quality of working life; and, in general,
- more involving and motivating tasks for an increasingly educated workforce.

To match these requirements, internal consistency is needed:

- global optimization;
- process focus in the organizational design just to keep quality and time fit with customer needs;
- development of internal capabilities and local problem solving;
- alignment of the manufacturing and the new product development processes.

According to [22], and integrating that framework in the light of other contributions, the multi-focused manufacturing paradigm can be articulated in three basic principles:

(1) *Multi-focusedness and strategic flexibility*. This first element relates to the manufacturing strategy. The multi-focused manufacturing paradigm drives companies to pursue a number of different objectives, traditionally regarded as antithetical, simultaneously, rather than focusing on specific objectives considered mutually exclusive. In addition, the paradigm implies a strategic flexibility, that is the ability to rapidly shift competitive and manufacturing priorities from one set of goals to another, within the same manufacturing system. This principle challenges the traditional assumption about rigid trade-offs involving manufacturing performances.
(2) *Integration.* This second element relates to production organization from a macro-structural perspective. It entails a resolute process focus, concerning especially those processes directly involved in the value-adding chain. Process integration is pursued across the internal functions and with both customers and suppliers. The previous emphasis on functional optimization should be abandoned in favour of a redesign of the company pivoted by the concepts of operating continuity, and process integrity, across the functional barriers.
(3) *Process ownership[23].* This third element also relates to production organization, from a micro-structural perspective. It aims at involving all employees at any hierarchical level, in decision making and problem solving. Delegation, involvement and knowledge of the process are embodied in this principle. The ultimate purpose is to develop at least some degree of local problem-solving capabilities, in order to detect and resolve process anomalies as soon as possible, and to avoid time consuming hierarchical referrals.

Both integration and process ownership are strictly related to multi-focusedness. In fact, integration fosters the globalization of the goals and the strategic

flexibility, making the organization more capable to follow market turbulence rapidly and to seize volatile opportunities. Process ownership is a basic contribution to enhance the quality of the outputs and to reduce the leadtime of the business processes, which in turn is the primary mechanism to reduce or, even better, avoid the trade-offs between performances traditionally regarded as antithetical. Thus the implementation of the three principles should be approached as an integrated problem, in order to achieve the required external and internal consistency.

The operationalization

The operationalization needed to investigate the adoption and the performances of the multi-focused manufacturing paradigm is based on a set of state variables that show, at a given time, to what extent a manufacturing unit is simultaneously oriented to multi-focusedness, integration and process ownership. The multi-focused manufacturing paradigm is a complex and multidimensional concept and relates to a complex system – i.e. the whole of the operations. It is difficult to describe a complex concept, using precise statements and numeric variables. Thus, the operationalization of the paradigm is necessarily based on a wide set of attributes, including also many, "linguistic variables, that is variables that are not numbers but words or sentences in a natural language"[24]. This set provides the basis to evaluate the degree of belonging of a unit to the paradigm, at a given time. In fact, the paradigm is not a "yes or no matter". The process of adoption is supposed to be progressive over time, so that at a certain point in time, a company may show a degree of belonging to the paradigm, maybe weak, strong, or all the gradations between the two extremes. For all the above reasons we use a fuzzy-logic approach (see for instance [24]). First, the set of state variables connected to the paradigm has been identified (see the items on the right-hand side of Figure 1).

Then, membership functions were built up to relate the single state variable to the degree of belonging, ranging from 0 (non-belonging) to 1 (complete belonging). The tuning of the membership functions is based mostly upon the literature on current best practices all over the world within the assembly industry (see Appendix 1 for some examples and [25] for a complete description). Starting from the basic set of variables, a hierarchical methodology was assessed that aggregates the leaves into the intermediate concepts, up to the three basic principles and to the paradigm as a whole.

Figure 1 shows the whole filter and in particular the operators we used for the aggregation of the leaves to the final degree of belonging to the paradigm (see also Appendix 2). These are mainly FUZZY-AND and AND operators, given the necessity of the presence at the same time of the three principles and their sub-principles. OR and FUZZY-OR operators were used when single items can be regarded as alternative with respect to the paradigm adoption. Of course, the so-computed degree of belonging to the paradigm embodies a certain degree of subjectivity, relating to the selection of the state variables, the definition of the

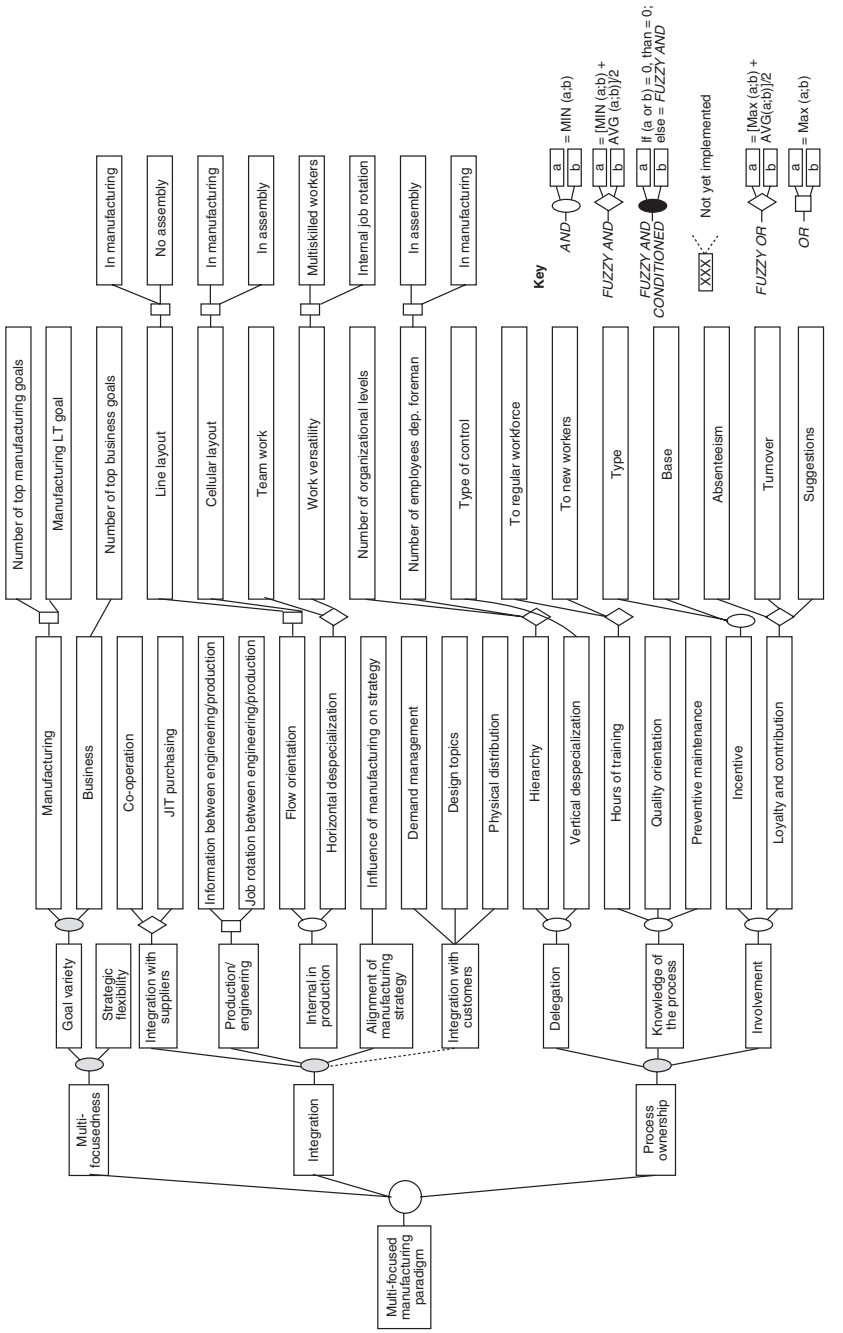

Figure 1. The operationalization of the multi-focused manufacturing paradigm

membership functions and the logic of the aggregation. The belonging to the multi-focused manufacturing paradigm is an absolute figure, but the degree of belonging to it can be regarded as a relative concept, useful to benchmark manufacturers from different countries and industries. In addition, the tuning of both the membership functions and the parameters of the fuzzy operators influences the absolute figure of the degree of belonging, but not the rank of the units within the sample, just saving the opportunity for cross-sectional comparisons.What is important to get a reliable rank is to select properly the OR/FUZZY-OR and the AND/*FUZZY-AND* operators, and the shape of the membership functions (increasing, decreasing, S-curve, step function, etc.).

Research hypotheses and methodology

The operationalization of the paradigm allows us to investigate two basic issues about the multi-focused manufacturing paradigm, respectively concerning:

(1) the adoption of the multi-focused manufacturing paradigm across industries and countries;
(2) the effectiveness of the multi-focused manufacturing paradigm, i.e. its ability to provide the adopters with superior improvement capabilities.

Two sets of specific hypotheses have been formulated for the two issues, respectively.

The adoption of the multi-focused manufacturing paradigm. We expected that some context factors may influence the adoption of the multi-focused manufacturing paradigm across industries and countries. We expect that the paradigm is adopted:

(1) Widely across countries but basically in the industrialized countries (Japan, North America and the most advanced European countries); the NICs and the less developed European countries will be less oriented to the multi-focused manufacturing. In fact, some unfavourable conditions are expected to hamper the paradigm adoption, such as the poverty of the public infrastructures, the shortage of a well-educated workforce, and low labour cost that is expected to attract mass production rather than innovation.
(2) Widely within the assembly industry and not only in the automotive industry, which attracted much of the attention since it was the cradle of both Fordism and post-Fordist experiences; we expect that the paradigm thrives also within other assembly sectors and mainly the electronic and electro-mechanical industries.
(3) By large and medium-sized companies, since they are expected to have a more robust managerial culture and to be more sensitive to managerial and organizational innovations.

The effectiveness of the multi-focused manufacturing paradigm. As far as effectiveness is concerned, we investigated if full adoption of the paradigm results

in a better performance improvement compared with companies which did not, or only partially adopted the paradigm. To address this issue we had to test:

- if companies that have adopted the principles of the paradigm are better capable of improving their performance compared to non-adopters;
- if partial adoption of the paradigm also qualifies for a better performance improvement;
- if the three principles of the paradigm reinforce each other.

A specific methodology has been built up to explore different degrees of adoption of the paradigm and the related performance improvements.

The "starmodel" in Figure 2 distinguishes companies with several degrees of belonging to the paradigm. This is also useful to study all kinds of innovation tracks which have to do with pursuing a full adoption of the paradigm. Three classes of belonging to the paradigm can be defined (see Figure 2):

(1) complete adoption, referring to the companies which have adopted all three principles (core adopters);
(2) partial adoption, i.e. companies that adopted two out of the three basic principles (star adopters);
(3) non-adoption, referring to companies that have only one principle out of three adopted or show no adoption at all (non-adopters).

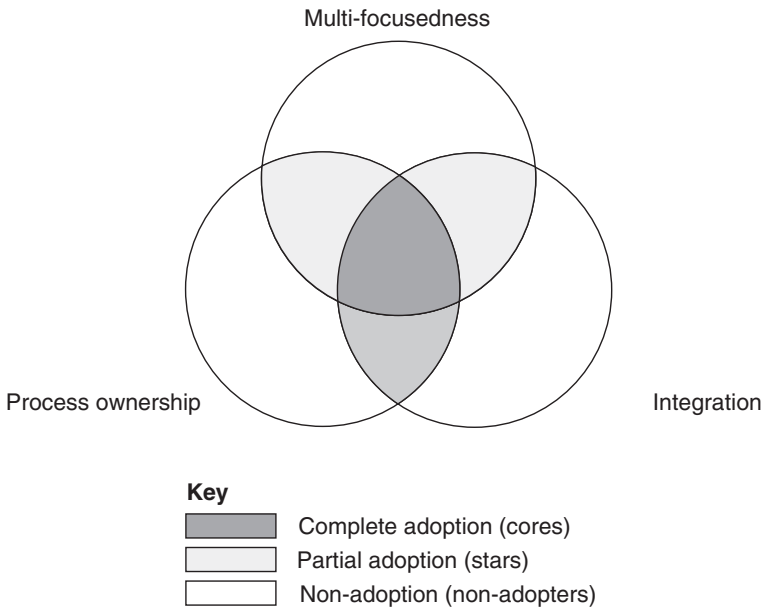

Figure 2. The starmodel: intersection of principles

We consider a principle to be adopted if the company has a score higher – for the single principle at hand – than the mean within the sample. In order to be a core adopter a company must have a score higher than the mean within the sample for all three principles.

In summary, our major line of argument is that:

- a new manufacturing paradigm is emerging and gradually replacing Fordism;
- it involves strategic multi-focusedness, integration of business processes across functions and process ownership;
- it can be operationalized using a fuzzy-logic approach;
- it is widely adopted across countries and industries, but there are some factors that influence its adoption;
- it results in a higher improvement capability compared to non-adopters; and
- different paths of innovation are feasible, since companies can implement the three principles according to different sequences.

The research sample

In order to explore the emerging paradigm on a global basis, we analysed the IMSS database but had to restrict ourselves to 443 companies. In fact, due to missing answers, it was not possible to evaluate properly 157 units out of 600, using the filter presented in Figure 1. Appendix 3 describes the procedure used to select processable respondents. The dropping of non-processable cases has not modified significantly the distribution of the original sample of the IMSS database (600 companies). Tables I and II show the distribution of the sample by industry and country.

The adoption of the multi-focused manufacturing paradigm within the assembly industry

The multi-focused manufacturing paradigm seems to emerge on a global basis. Looking at the global sample in Table III, it appears that strategic multi-focusedness is on hand for most of the companies, while process ownership seems to be the least adopted. Process integration lies in between. How can we explain the widespread poor orientation to process ownership?

Our primary concern was to verify the appropriateness of the membership functions we used to score the companies. All of them appeared to be realistic, since we could find companies in the sample that reached the complete belonging to the paradigm, for each item in the filter; also for those related to process ownership. However, while a number of companies can achieve the complete orientation to the three sub-principles of process ownership –delegation; knowledge of the process and involvement – separately, the sample does not comprise any company that has achieved them jointly. Indeed, many companies declare to implement

Table I. Distribution of the 443 processable companies by industry (number and percentage on total sample)

ISIC	Description	Respondents
381	Metal products (except machinery)	142 (32.1)
382	Machinery (except electrical)	66 (14.9)
383	Electrical machinery apparatus, appliances and supplies	92 (20.8)
384	Transport equipment	55 (12.4)
385	Measuring and controlling equipment, optical goods	40 (9)
–	Not specified or other	48 (10.8)

Note: Percentage in parentheses

Table II. Geographical distribution of the 443 processable companies

Country	Number
Sweden	42
Norway	11
Finland	16
Denmark	13
Great Britain	27
Germany	18
Austria	21
The Netherlands	20
Belgium	2
Italy	34
Portugal	24
Spain	24
USA	33
Canada	14
Mexico	51
Argentina	28
Brazil	21
Chile	4
Japan	16
Australia	24

multi-focusedness at the business and manufacturing level and integrate different business processes at the same time, while delegation, knowledge of the process and involvement appear, to some extent, to be mutually exclusive. This is hardly justifiable from a theoretical perspective, since the three sub-principles should reinforce one another, and no definite process ownership should be possible without the concurrency of the three sub-principles.

The possible explanation is that the adoption of the multi-focused manufacturing paradigm is a step-by-step process, in which:

- multi-focusedness is a market-driven pattern and thus first adopted;
- integration appears to be the organizational answer at a macro level to face the challenge of multi-focusedness;

Table III. The multi-focused manufacturing paradigm around the world

		A1 multi-focusedness			A2 integration					A3 process ownership				
	No.	Business level	Manu-facturing level	*Total A1*	Suppliers	Production/ engineering	Internal production	Manu-facturing strategy	*Total A2*	Delegation	Knowledge of the process	Involvement	*Total A3*	Belonging to the paradigm (final score)
Total	*443*	*0,82*	*0,88*	*0,78*	*0,71*	*0,66*	*0,69*	*0,59*	*0,49*	*0,31*	*0,36*	*0,27*	*0,19*	*0,15*
Japan	16	0,90	0,97	*0,90*	0,77	0,73	0,73	0,81	*0,61*	0,16	0,47	0,49	*0,17*	0,16
Denmark	13	0,79	0,78	*0,69*	0,74	0,79	0,68	0,54	*0,50*	0,57	0,49	0,39	*0,35*	0,25
Sweden	42	0,87	0,89	*0,83*	0,73	0,80	0,80	0,61	*0,57*	0,50	0,40	0,39	*0,30*	0,25
Finland	16	0,82	0,88	*0,79*	0,67	0,75	0,60	0,48	*0,49*	0,44	0,35	0,25	*0,21*	0,20
Norway	11	0,87	0,85	*0,83*	0,87	0,71	0,60	0,50	*0,52*	0,36	0,24	0,40	*0,16*	0,14
Scandinavia	*82*	*0,85*	*0,87*	*0,80*	*0,74*	*0,78*	*0,72*	*0,56*	*0,54*	*0,47*	*0,38*	*0,36*	*0,27*	*0,23*
USA	33	0,89	0,92	*0,85*	0,76	0,86	0,69	0,61	*0,58*	0,30	0,31	0,40	*0,23*	0,19
Canada	14	0,99	1,00	*0,99*	0,64	0,64	0,74	0,46	*0,44*	0,27	0,23	0,18	*0,13*	0,11
North America	*47*	*0,92*	*0,94*	*0,89*	*0,73*	*0,79*	*0,70*	*0,57*	*0,54*	*0,30*	*0,28*	*0,33*	*0,20*	*0,17*
Australia	24	0,83	0,71	*0,67*	0,75	0,87	0,76	0,66	*0,60*	0,36	0,30	0,30	*0,19*	0,15
Brazil	21	1,00	0,98	*0,99*	0,78	0,68	0,72	0,67	*0,55*	0,28	0,43	0,27	*0,23*	0,18
Mexico	51	0,73	0,96	*0,77*	0,72	0,36	0,72	0,67	*0,43*	0,22	0,30	0,09	*0,10*	0,09
Argentina	28	0,28	0,93	*0,80*	0,62	0,55	0,59	0,70	*0,34*	0,21	0,35	0,27	*0,12*	0,09
Chile	4	0,85	0,88	*0,79*	0,84	0,75	0,75	0,88	*0,41*	0,22	0,21	0,26	*0,03*	0,00
South America	*104*	*0,81*	*0,95*	*0,83*	*0,71*	*0,49*	*0,69*	*0,67*	*0,43*	*0,23*	*0,34*	*0,18*	*0,13*	*0,11*
Portugal	24	*0,86*	0,87	*0,83*	0,60	0,58	0,54	0,58	*0,40*	0,36	0,51	0,31	*0,25*	0,20
Spain	24	0,79	0,85	*0,75*	0,70	0,57	0,71	0,57	*0,47*	0,33	0,38	0,25	*0,21*	0,17
Pen. Iberica	*48*	*0,82*	*0,86*	*0,79*	*0,65*	*0,57*	*0,63*	*0,58*	*0,43*	*0,34*	*0,45*	*0,28*	*0,23*	*0,18*
Italy	34	0,82	0,77	*0,69*	0,73	0,67	0,65	0,54	*0,50*	0,27	0,33	0,28	*0,19*	0,14
Great Britain	27	0,82	0,81	*0,74*	0,78	0,69	0,71	0,46	*0,45*	0,25	0,40	0,25	*0,17*	0,11
Austria	21	0,72	0,77	*0,61*	0,53	0,58	0,61	0,45	*0,36*	0,31	0,38	0,22	*0,20*	0,10
Belgium	2	0,90	1,00	*0,92*	0,25	0,50	0,50	0,37	*0,28*	0,19	0,27	0,17	*0,24*	0,12
Germany	18	0,77	0,86	*0,74*	0,54	0,73	0,59	0,50	*0,45*	0,22	0,36	0,05	*0,10*	0,07
The Netherlands	20	0,66	0,88	*0,69*	0,74	0,63	0,78	0,50	*0,51*	0,30	0,43	0,10	*0,16*	0,12
DM Area	*61*	*0,72*	*0,84*	*0,68*	*0,59*	*0,64*	*0,65*	*0,48*	*0,43*	*0,28*	*0,39*	*0,13*	*0,15*	*0,10*

- eventually, process ownership should provide the local mechanism to support the integration at a micro level.

But, on the average, it is supposed not to be fully recognized yet as the key enabling factor, at the moment. In addition, the implementation of this concept is expected to meet more organizational inertia and cultural barriers. Such a phased adoption of the multi-focused manufacturing paradigm might account for the low orientation to the process ownership; yet, it cannot be overlooked. The investigation of the effectiveness of the new paradigm clearly provides an empirical proof, since the core adopters of the paradigm achieve better and quicker performance improvements than adopters not oriented to process ownership. Our findings with respect to the five specific hypotheses are presented in the following sections.

The geo-economic context

The basic hypothesis about the diffusion of the paradigm in the most advanced countries appeared to be confirmed. The orientation to the multi-focused manufacturing paradigm seems to be present in different economic areas, even though not uniformly. The country factor is strongly related to the degree of belonging to the paradigm and also to the three principles and all their subprinciples. In fact the one-way ANOVA tests the probability p that the differences in the mean score of the national samples is random less than one per cent for all the sub-principles scored in Table III. In particular, the Scandinavian area appears to be much oriented to the paradigm, with far higher levels than the mean of the sample for all the three aspects – delegation, knowledge of the process and involvement – of process ownership. Also the average score of integration exceeds the mean of the sample and particularly the integration of production-engineering. Japanese companies confirm to be strongly oriented to the paradigm for most of the subprinciples. Integration is more pursued than elsewhere and, in particular the link between manufacturing and business strategy seems to make the difference. Mainly because of the heaviness of the hierarchies, i.e. many organizational levels, delegation scores are very low, which negatively affects the score of the Japanese firms. In turn the knowledge of the process and the involvement score is very high. Actually they seem to dominate the rest of the sample as to the orientation to the multi-focused manufacturing paradigm except for the delegation. Companies from the Deutschmark area show the lowest degree of belonging to the paradigm, due to the poor orientation to process ownership. In particular, the German companies in the sample score very low as to involvement and delegation. They tend not to use group incentives, suffer higher short-term absenteeism and enjoy less improvement suggestions. Consequently, the average level of involvement is far below the mean of the sample. In addition, those companies maintain a highly centralized control of the production system, which causes the low level of delegation. US companies stand out for their effort to integrate production and engineering,

and they are also markedly oriented to the involvement of the workers. The multi-focused manufacturing paradigm seems to be adopted also in the NICs. For example, Brazilian companies proved to be extremely multi-focused, to pursue different kinds of process integration, and to commit themselves to develop the knowledge of the process in the workers. Indeed, the Brazilian sample is biased towards the best-practice companies, often by foreign corporation, while most of the national samples do not show such a bias.

It is interesting also to note that the philosophy of the multi-focused manufacturing paradigm seems to overcome some unfavourable national conditions, e.g. the shortage of well-educated manpower, the poverty of the infrastructures and the low labour cost that is expected to attract mass productions rather than lean ones, at least when in the track of a global, corporate culture.

The industrial context

The multi-focused manufacturing paradigm is widely adopted within the assembly industry. Widespread orientation to the paradigm has been detected not only in the ISIC 384, which in the database is mainly formed by car assemblers or car component producers. Indeed the electrical and machinery industry show the highest orientation to the paradigm on the whole (degree of adoption 0.17 and 0.19, respectively). Multi-focusedness still remains more pursued within the transport industry (score = 0.82 vs 0.78 in the whole sample), even though no statistical significance of the differences was discovered. On the contrary, the one-way analysis of variance (ANOVA) test revealed that the industry factor significantly affects only the process ownership ($p = 0.008$) and mainly delegation ($p = 0.001$) and in this case the electrical and machinery industry far exceed the other assembly industry (0.38 for both vs 0.27-0.29 for others).

Company-size

Company size is strongly related to the adoption of the paradigm. Small companies show lower scores than large and medium-sized ones (0.13 vs 0.18). The differences are statistically significant for all the three basic principles: as to the multi-focusedness (T-test: $p = 0.015$) the difference mainly depends on the business level ($p = 0.010$); in the case of integration ($p = 0.002$) the dominance of large companies can be traced back to the very differential integration between business and manufacturing strategy ($p = 0.000$); finally the superior orientation to process ownership ($p = 0.003$) within the large companies mainly relies on their capability to develop the knowledge of the process within their workers ($p = 0.050$). Two-way ANOVA allows us to state the independent influence of the size factor. In fact, size and industry can explain separately the adoption of the paradigm

within the sample, while no significant interaction was detected for all the principles and their sub-principles. Quite the same was found for size and country factors, though process integration shows some joint effect of the two factors. In fact, the US and the Japanese units within the sample are also larger than the other, so it is hard to extract size or country as independent factors.

The multi-focused manufacturing paradigm and performance improvements

The effectiveness of the multi-focused manufacturing paradigm is linked to the capability it gives the adopters to improve the performances of the production systems; to improve and speed up performance than the non adopters, thus catalysing the improvements arising from single action programmes. The operationalization of the different degrees of belonging to the paradigm allows us to test the hypotheses about the effects of its adoption on performance improvements, through the framework previously described – the "starmodel"– which allows us to distinguish among different degrees of adoption of the multi-focused manufacturing paradigm.

The 443 processable companies had the following distribution over the "starmodel": 83 companies (19 per cent) of the sample could be classified as core adopters; approximately 36 per cent of the companies resulted in stars – i.e. with a score higher than the mean on two principles out of three, the remaining 45 per cent represented poor scores or non-adoption at all.

It seems that the multi-focused manufacturing paradigm generally provides its adopters with a higher improvement capability compared to non-adopters.

Looking at the global sample in Table IV it appears that:

- The adopters of the paradigm are better capable of improving their performances than non-adopters on almost all performance criteria. There is a general dominance of the adopters over the non-adopters. In fact, when comparing the adopters with the rest of the sample (stars and non adopters) four differences in performance improvements are significantly better, namely: inventory turnover; speed of product development; customer service and delivery lead time (see Table IV).
- Connected with the stars and different innovation tracks we found that partial adoption of the paradigm also resulted in advantages in a subset of performances, i.e. a partial dominance over the non-adopters.
- As full adoption is a general dominance and partial adoption is a partial dominance as to performance improvement, the fuzzy-logic approach is enforced. This implies that the simultaneous presence of the three principles enforces improvement gains (the more you put together the more you gain).

These findings support the idea that the multi-focused manufacturing paradigm requires consistency and leads to effectiveness, since it allows companies to improve more so. The empirical evidence, and in particular the conclusion of "partial adoption is partial dominance and full adoption is general dominance", is also

Table IV. Performance improvements within different classes of adoption of the multi-focused manufacturing paradigm

Performance criteria	Core adopters	Stars non-adopters	Average improvements *t*-test significance (%)	Stars	Non-adopters	*t*-test significance (%)
Conformance to specification	39.87	26.04		32.82	21.10	
Unit manufacturing cost	16.80	12.61		16.14	9.45	
Inventory turnover	40.87	22.38	1.9	28.84	18.01	
Speed of product development	29.49	15.55	0.8	18.11	13.76	
On-time deliveries	46.35	21.60		27.52	16.63	1.9
Equipment changeover	25.82	16.21		20.47	13.32	2.7
Market share	12.56	11.16		18.97	5.66	
Profitability	8.12	10.27		16.16	7.09	
Customer service	26.99	17.83	4.4	22.46	13.99	0.6
Manufacturing lead time	45.95	23.07		31.10	16.35	0.4
Procurement lead time	36.03	15.12		18.37	12.33	
Delivery lead time	36.28	19.75	1.5	22.77	16.53	4.1
Product variety	19.03	13.03		13.06	12.91	

coherent with the idea of cumulative performance improvements[20] associated with the implementation of practices increasingly oriented to the paradigm.

Having said this, some comments must be mentioned as well. Given the data of IMSS, no strict causality can be inferred in an absolute sense between the degree of the adoption of the paradigm and performance improvements. As Hamblin and Lettman[26] have pointed out, the usual statistical tests do not allow us to state a causal link between techniques and performances. In fact one may contend that the performance improvements, for example in inventory turnover and market share, can create additional resources (cash-flows) to be invested in the multi-focused manufacturing, so that the causal link would be the reverse (more improvements: innovation towards the multi-focused manufacturing). To state strict causality we should employ two-way models based on time series on the two classes of variables (as with Granger causality[27]), which we cannot do at the moment, given the non-longitudinal structure of the IMSS survey. So, from a methodological perspective we simply tested the presence of multi-focused manufacturing and performance improvements at the same time. Yet, when considering manufacturing performances (cost, delivery time, etc.) rather than business ones (profitability and market share), the causal link between the degree of adoption of the paradigm and the degree of performance improvements may be reasonably assumed.

Innovation tracks

The last purpose of this contribution is to explore the patterns that companies can follow to reach core adoption of the multi-focused manufacturing paradigm.

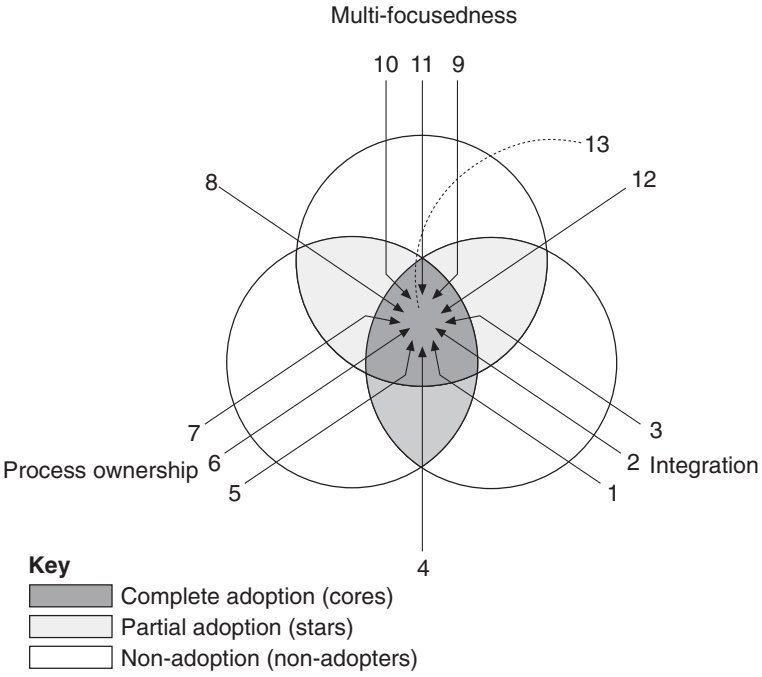

Figure 3. Innovation tracks

In theory, 13 different paths (see Figure 3) can be distinguished. The IMSS data show that some of them are more favoured by companies than are others. In the total sample:

- 16 per cent of the companies are process ownership adopters, i.e. score higher than the mean (0.19) of the sample; in other words, a relatively small number of companies score above a relatively low mean;
- 50 per cent of the companies are process integration adopters, i.e. score higher than the mean (0.49) of the sample: in other words, a relatively average number of companies score above a relatively average mean;
- 59 per cent of the companies are multi-focusedness adopters, i.e. score higher than the mean (0.78) of the sample: in other words, a relatively high number of companies score above a relatively high mean

This seems to imply that the favoured paths are those starting with the implementation of multi-focusedness. These are followed closely by those starting with the implementation of process integration. Finally, these in turn are followed on a considerable distance by those starting with the implementation of process ownership.

The different paths can be explained from a theoretical point of view as follows. An incremental approach towards full adoption starts with the

implementation of process integration, followed by process ownership and, finally, multi-focusedness (path 1). This approach is an example of: "strategy follows process follows organization"; "Jobs must often be specialised vertically because they are specialised horizontally"[28]. This implies that the first logical step has to be job enlargement (process integration), followed by job enrichment (process ownership), rather than the other way around. A more radical approach is path 4, that involves the simultaneous implementation of process integration and process ownership using, for example, semi-autonomous groups or self-managed teams. A well-known example of this approach is the Uddevalla plant[29]. These approaches lay the foundations required for the organization to become really strategically flexible (rather than "just" multifocused).

Two other approaches represent companies that start with the implementation, or are based on the presence, of multi-focusedness. Typically, companies following path 9 (multi-focusedness, then process integration and then process ownership) and 12 (process integration plus multi-focusedness and then process ownership) are multi-purpose, do-all plants and, hence, not optimally efficient. They create the necessary conditions, i.e. process integration and process ownership, not only to increase their efficiency, but also to be able to make the next step to strategic flexibility. The most radical approach provides to implement simultaneously the three principles (path 13); this case mainly occurs in a greenfield situation.

The existence of different paths that non-adopters can follow in order to become core adopters shows that companies face many options when considering the adoption of the multi-focused manufacturing paradigm. This supports the idea of the existence of a considerable design space for a company to choose its own way to the paradigm.

Conclusions

This article set the hypothesis of the emergence of the multi-focused manufacturing paradigm, based on the simultaneous implementation of strategic multi-focusedness, integration of business processes and process ownership. It also proposes a model that allows the evaluation of the orientation of a company to the paradigm and thus makes possible the investigation of its diffusion, the performance improvement capacity it provides, and the innovation paths through which companies can implement it.

The paradigm rises as a coherent set of principles underpinning the wide range of techniques and approaches for the innovation of the manufacturing systems, and provides manufacturers with a higher level of strategic flexibility. The identification of the paradigm has been based on internal and external consistency, as implied by today's business environments. Such a post-Fordist paradigm embodies both established previous experiences and radically new elements. It has been operationalized through a fuzzy-logic and hierarchical methodology. Using data from a sub-sample of 443 companies from the International Manufacturing

Strategy Survey database, the adoption of the paradigm has been detected across a wide range of countries. Also large cross-industrial transferability emerges. Furthermore, large companies appear to be more oriented to the paradigm than small ones. On the whole, process ownership is not very much implemented at the moment. It is expected to be the most difficult part of the paradigm to reach, given that the orientation to the multi-focused manufacturing paradigm is a step-by-step process rather than a radical "turn-key" switch. In addition, big differences across countries have been found about process ownership, which requires more interpretation on the basis of cultural and institutional differences. The empirical evidence also suggest that a higher degree of belonging to the paradigm results in a higher performance improvement. This leads us to conclude that the three principles re-enforce one another. Finally, the existence of different innovation tracks to approach the multi-focused manufacturing paradigm supports the idea that it does not act as a new "one best way" to organize manufacturing activities, but actually provides considerable space for different manufacturing strategies. Further investigation is currently performed on this issue.

References

1. Roobeek, A.J.M., "The crisis in Fordism and the rise of a new technological paradigm", *Futures*, April 1987, pp. 129-54.
2. Kenney, M. and Florida, R., "Japan's role in a post-Fordist age", *Futures*, April 1989, pp. 136-51.
3. Jaikumar, R., "Postindustrial manufacturing", *Harvard Business Review*, November-December 1986, pp. 69-76.
4. Drucker, P.F., "The emerging theory of manufacturing", *Harvard Business Review*, May-June 1990, pp. 94-102.
5. Hayes, R.H., Wheelwright, S.C. and Clark, K.B., Dynamic Manufacturing. Creating the *Learning Organization*, The Free Press, New York, NY, 1988.
6. Slack, N., "Flexibility as a manufacturing objective", *International Journal of Operations & Production Management*, Vol. 3 No. 3, 1983, pp. 4-13.
7. Stalk, G. Jr and Hout, T.M., *Competing against Time*, Free Press, New York, NY, 1990.
8. Piore, M. and Sabel, C., *The Second Industrial Divide: Possibilities for Prosperities*, Basic Books, New York, NY, 1984.
9. Womack, J.P., Jones, D.T. and Ross, D., *The Machine that Changed the World*, Macmillan,London, 1990.
10. Doshe, K., Jurgens, U. and Malsch, T., "From Fordism to Toyotism? The social organization of the labour process in the Japanese automobile industry", *Politics and Society*, Vol. 14 No. 2, 1985, pp. 115-46.
11. Skinner, W., *Manufacturing: the Formidable Competitive Weapon*, John Wiley & Sons, New York, NY, 1985.
12. Hill, T., *Manufacturing Strategy*, Macmillan, Basingstoke, 1985.
13. Hayes, R. and Wheelwright, S.C., *Restoring Our Competitive Edge*, *Competing through Manufacturing*, John Wiley & Sons, New York, NY, 1984.
14. Draaijer, D., "Market-oriented manufacturing systems", PhD thesis, University of Twente, Enschede, 1993.
15. Pfeffer, J., "On usefulness of the concept", in Goodman, P.S. and Pennings, J.M. (Eds), *New Perspectives on Organizational Effectiveness*, Jossey-Bass, San Francisco, CA, 1977.

16. De Meyer, A. and Ferdows, K., "Influences of manufacturing improvement programmes on performances", *International Journal of Operations & Production Management*, Vol. 10 No. 2, 1990, pp. 120-31.
17. Voss, C.A. and Blackmon, K., "Practice performance relationships in UK manufacturing industry", *Proceedings 1st International EurOMA conference: Operations Strategy and Performance 27-29 June*, Cambridge University Press, Cambridge, 1994, pp. 1-6.
18. Flynn, B.B., Bates, K.A., Schroeder, R. and Sakakibara, S., "World class manufacturing in the United States", *Proceedings DSI*, Vol. 2, 1989, pp. 880-82.
19. Ferdows, K. and De Meyer, A., "Lasting improvements in manufacturing performance: in search of a new theory", *Journal of Operations Management*, Vol. 9 No. 2, 1990, pp. 168-84.
20. Perona, M., Spina, G. and Turco, F., "Success measure of just-in-time: shifting manufacturing trade-offs. A field research in Italy", in Shatir, A. (Ed.), Just-in-Time Manufacturing Systems. Operational Planning and Control Issues, Elsevier, London, 1991.
21. Voss, C.A., "Successful implementation of new processes", *Business Strategy Review*, Spring 1992, pp. 29-44.
22. Bartezzaghi, E., "I nuovi modelli del manufacturing", in Filippini, R., Pagliarani, G. and Petroni, G. (Eds), *Progettare e gestire l'impresa innovativa*, Etaslibri, Milano, 1992 (in Italian).
23. Schonberger, R.J., *Building a Chain of Customers*, The Free Press, New York, NY, 1990.
24. Zimmermann, H.J., *Fuzzy Set Theory and Its Application*, 6th ed., Kluwer Academic Publishers, London, 1993.
25. Spina, G., "L'adozione del nuovo paradigma produttivo nell'industria di assemblaggio.
Note metodologiche ed evidenze empiriche", *Proceedings of the 5th AiIG Annual Meeting*, "*Leve strategiche nei mercati integrati*", Napoli, 1994, pp. 167-98 (in Italian).
26. Hamblin, D. and Lettman, A., "Performance causality in manufacturing research", *Proceedings 1st International EurOMA conference: Operations Strategy and Performance 27-29 June*, Cambridge University Press, Cambridge, 1994, pp. 409-14.
27. Granger, W.W.J., "Investigating causal relations by econometric models and non-spectral methods", *Econometrica*, Vol. 37, 1969, pp. 24-36.
28. Mintzberg, H., The Structuring of the Organizations, Prentice-Hall, New York, NY, 1979.
29. Karlsson, C., "Radically new production systems", *International Journal of Operations & Production Management*, Vol. 16 No. 11, 1996.

Appendix 1.

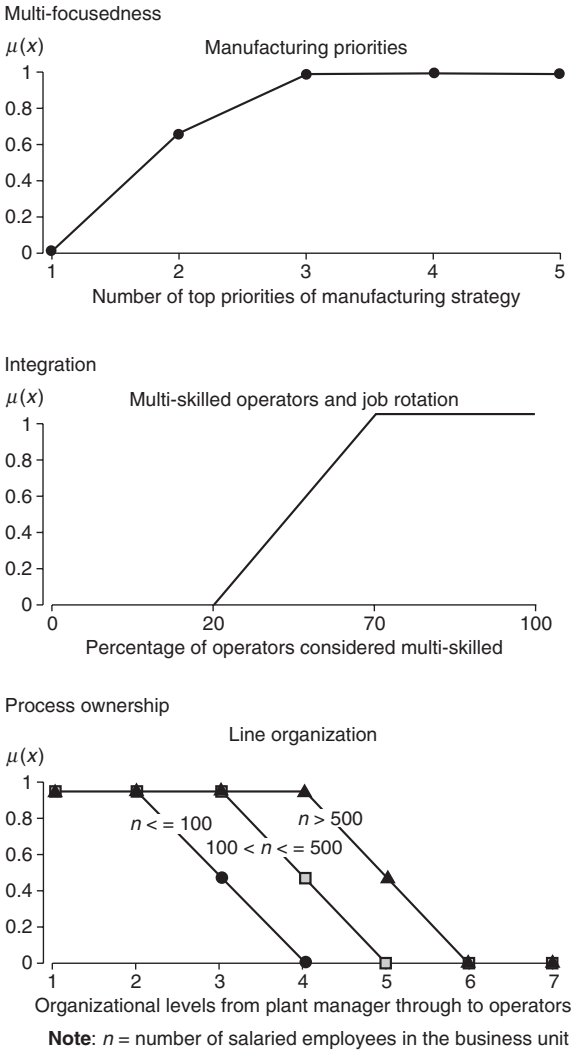

Figure A1. The membership functions (some examples)

Appendix 2. The aggregation operators

AND	min	$\{\mu_a(X), \mu_b(X)\}$
FUZZY AND	α*	min $\{\mu_a(X), \mu_b(X)\}$ + (1 – α) * average $\{\mu_a(X), \mu_b(X)\}$
FUZZY OR	α*	max $\{\mu_a(X), \mu_b(X)\}$ + (1 – α) * average $\{\mu_a(X), \mu_b(X)\}$
OR	max	$\{\mu_a(X), \mu_b(X)\}$
FUZZY AND CONDITIONED	if $m_a(X) = 0$ or $m_b(X)$ / then 0 *else FUZZYAND*	

Appendix 3. The dropping procedure

The standard procedure used to select processable companies is aimed at determining which are the companies that can be assigned a correct score as adopters or non-adopters of the paradigm. The problem concerns missing answers to some of the questions used in the filter. The following rules were used when processing a single company:

- a *missing* value prevails over a *zero* value (non-orientation to the paradigm) if they are combined either through an *OR* or a *FUZZY OR,*
- a *missing* value prevails over a generic *non-zero* value (some orientation to the paradigm) if they are combined either through an *AND* or a *FUZZY AND,*
- in the other cases it is possible to evaluate correctly the fuzzy score of the aggregation of a missing information with whatever data. In fact, *"missing" or "non-zero"* $\Longrightarrow$ *"non-zero"* and *"missing" and "zero"* $\Longrightarrow$ *"zero"*;
- this algorithm is pushed from the leaves of the filter up to the three basic principles of the paradigm;
- a company is discarded if it is impossible to assign a fuzzy score to each of these principles.

3.2 Review and Outlook

3.2.1 Background

It is generally accepted that the foundations of what is now known as manufacturing strategy were developed at Harvard in the 1940s and 1950s. Researchers started looking at industries and began to see that there were many different ways in which companies were choosing to compete within particular industries. These in turn were accompanied by different choices concerning production technology and production management. The development of the field of manufacturing strategy was based on the seminal work of Skinner (1969), and developed further by researchers and teachers such as Hayes et al. (1988). The field of manufacturing strategy was built around a number of important principles. First, that there should be alignment between the market-based priorities (order winners) and the priorities or choices within the manufacturing plant. Second, that the choice of process should be based on the product and product domain characteristics and in particular the product volume and variety. So for example, high volume commodity products where the market competed on costs, needed a production system also aligned to low cost and this in turn would require line-based manufacturing processes. Building on this, Skinner (1974) proposed the concept of the focused factory. This argued that a plant should be focused on a limited set of competitive priorities and that there should be internal as well as external consistency. Skinner recognised that organisations may have to deal with different markets and proposed the concept of a plant within a plant have different focus.

There was further refinement by Hayes et al. (1988) in their product process matrix. They viewed process both in a static and in a dynamic mode. In a static mode they argued that the choice of process was contingent on the context of manufacture, in particular the volume and variety of the production task. They showed how misalignment could lead to poor manufacturing and business performance. They also argued that as markets evolved and changed, so did the required process and hence focus. Finally, they also related this to more complex environments such as multi-process, multi-product environments where there was a need for focused plants.

Around this time, a step change was beginning to take place in manufacturing technology, with the development of more agile and flexible manufacturing. Initially the attention was around flexible manufacturing systems (FMS). Concurrent with this, scholars began to consider the phenomenon of Mass Customisation, where manufacturing technology would allow products to be tailored to individual needs. Over his period, the potential of just-in-time production (now called lean) was beginning to be realised as companies slowly explored the nature and the implementation of the Toyota Productions System.

3.2.2 The Paper

However, even though technologies and manufacturing practices such as lean production were rapidly evolving, and markets were changing, the core principles of Manufacturing Strategy had not been challenged as to how they might reflect this rapidly changing environment. Spina and his co-authors were among the first to recognise that *"As a result, both the internal organization of the factories and the external environment—including market demand, technology development, workforce education and expectations, labour and capital market—appear very different today from the general features that dominated the industrial development in the past."* (p20). They argued that this was a paradigm shift. He and his colleagues then set out to explore whether a new paradigm was emerging and for example:

- Can a new manufacturing paradigm be identified, despite the different strategic choices that industrial companies make and the different internal and external conditions they have to meet?
- Is this paradigm a definite breakthrough with Fordism? Is it possible to find out a limited set of shared principles to design and manage the production systems, that pools different models and paths of innovations?
- If the paradigm exists, how can it be defined and operationalised to support empirical investigation?
- How is the emerging paradigm adopted across countries and industries?
- What is the performance improvement along specific measures that comes from the orientation to the paradigm?
- Are there different paths to achieve the full orientation to the paradigm?

Based on this a "multi-focused paradigm" was proposed. This paradigm is based on three elements:

1. *Multi-focusedness and strategic flexibility*. This relates to the manufacturing strategy. The multi-focused manufacturing paradigm drives companies to pursue a number of different objectives, traditionally regarded as antithetical, simultaneously, rather than focusing on specific objectives considered mutually exclusive. In addition, the paradigm implies a strategic flexibility, that is the ability to rapidly shift competitive and manufacturing priorities from one set of goals to another, within the same manufacturing system. This principle challenges the traditional assumption about rigid trade-offs involving manufacturing performances.
2. *Integration*. This relates to production organisation from a macro-structural perspective. It entails a resolute process focus, and process integration pursued across the internal functions and with both customers and suppliers. The historical emphasis on functional optimisation should be abandoned in favour of a redesign of the company pivoted by the concepts of operating continuity, and process integrity, across the functional barriers.
3. *Process ownership*. This relates to production organisation, from a micro-structural perspective. It aims at involving all employees at any hierarchical level, in decision making and problem solving. Delegation, involvement and knowledge

of the process are embodied in this principle. The ultimate purpose is to develop at least some degree of local problem-solving capabilities, in order to detect and resolve process anomalies as soon as possible, and to avoid time consuming hierarchical referrals.

The implementation of these three principles should be approached as an integrated problem, in order to achieve the required external and internal consistency.

Having proposed a new paradigm, the research set out first to operationalise it and then to test it. A series of hypotheses were developed about its acceptance and use and its effectiveness. To do this data was analysed from the International Manufacturing Strategy Survey. This survey has proved to be a valuable resource for research into manufacturing strategy and policies and is still being run today.

The results of the empirical study were very interesting. First there were strong contrasts between the levels of adoption of the three elements of the new paradigm. Strategic multi-focusedness was widely adopted across the sample and across all regions. However, there were mixed results for integration and generally low levels of adoption of process ownership. In the latter two, a number of country differences stood out. First, Scandinavian countries had higher scores for all three elements. Cultural differences were evident, Japan scored highly on all except delegation, and companies from the Deutschmark (pre-Euro) area showed poor process ownership in particular. In addition, as might be expected, adoption was higher in larger companies and more developed countries. The data also indicated that those who adopt all three elements achieve superior performance to those with partial adoption who in turn achieve higher performance than non or low adopters.

The paper is partly framed in terms of going beyond Fordism. I feel that, although the concept of Fordism was widely used in behavioural management and economics, by the time the research was done the extant developments in manufacturing strategy were already moving "beyond Fordism", though process ownership can be seen as a further move away from Fordism.

This pattern of high and low adoption of the three elements of the paradigm raises interesting questions. It is argued that adoption of the paradigm may be a step-by-step process and that at the time of the research companies were in the early stages of adoption. A second possibility is that cultural barriers hold back process ownership. However, unfortunately the first of these cannot be easily tested in a cross-sectional study. Another possibility not discussed is that the multi-focused paradigm may not actually consist of these three elements and that although process ownership can be desirable, it is not a necessary component of strategically flexible production. The reference to the Udevalla plant as an example of simultaneous implementation of process integration and process ownership using, for example, semi-autonomous groups or self-managed team is interesting, but raises questions due to the subsequent failure and closure of the plant.

3.3 The Significance of the Paper

As discussed above, this paper is an important milestone in the development of the field of manufacturing strategy. At the time of its publication, the field of manufacturing strategy had begun to realise the importance of the dynamic nature of markets, but had taken a rather conservative approach to developing strategies to dealing with this. Flexibility was still seen as the opposite of focus and thus something that in the short term was a trade-off. This paper was the first to properly address this and to question the traditional trade-offs. The proposal that a manufacturing strategy for the emerging market and process context needed to be strategically flexible and that this in turn required multi-focusedness was a major step change for the area. That it had been empirically tested and found to impact performance gave it greater validity.

It has long been argued that flexibility is an important dimension in manufacturing. Slack (1983) both signalled this and provided a set of dimensions for flexibility in manufacturing. This in turn led to the increasing focus on flexibility as a manufacturing capability. The work of Spina et al. (1996) was a major step forward from this as it saw flexibility not just as a capability but as a key strategic element for manufacturing. As a result of this the focus of researchers on flexibility evolved. For example, building on Spina's work Oke (2005, p. 973) argued that "manufacturing flexibility had been heralded as a major competitive weapon for manufacturing organisations operating in increasingly uncertain environments and turbulent markets. It has been argued that manufacturing flexibility has the capability to change levels of production rapidly, to develop new products more quickly and respond more rapidly to competitive threats."

It is interesting to observe the continuing debates on flexibility, particularly when associated with technology. Initially these led to much consideration of "the factory of the future" (Jelinek and Goldhar 1984). The earlier development of flexible manufacturing systems had been hailed as a breakthrough, but subsequent research found that they actually did not greatly influence the overall flexibility of a manufacturing plant. A technology in isolation without the clear strategic flexibility view and elements proposed by Spina et al. (1996) may not fulfil its potential. Cagliano and Spina (2000) examined whether advanced manufacturing technologies were important for strategic flexible production. Data showed that while core adopters do not use stand-alone AMT more than the other groups, they have a higher level of computer integration, in particular in their forefront departments. However, the use of integrating technologies varies much within the core adopters, suggesting that Strategically Flexible Production does not necessarily require massive information technology support. This was further confirmed by the analysis of performance improvements. The mere adoption of stand-alone AMT per se did not provide companies with superior improvements in performance. Whereas, Strategically Flexible Production alone or combined with a higher level of integration of stand-alone AMT fostered increased time responsiveness.

Today we are seeing a repeat of these debates, but instead of flexible manufacturing systems or the factory of the future, the focus is on 3D printing. To the casual observer, much of the discussion of 3D printing seems over-hyped with claims similar to those put forward, decades before, for FMS and the factory of the future, without reference to markets or manufacturing strategy. Today's scholars should heed Spina et al.'s (1996) work before making all the claims that they are making about the latest technology.

The issue of trade-offs in manufacturing has been a long-running debate. There has been a natural feed-in from Spina et al.'s (1996) work to the debates around both lean production and trade-offs. An important element of the proposed paradigm was to challenge the traditional assumption about rigid trade-offs involving manufacturing performances. The notion of trade-offs in manufacturing go back to Skinner's (1969, p. 138) seminal article where he states: "a production system invariably involves trade-offs and compromises and so must be designed to perform a limited task well, with that task defined by strategic objectives." Rosenzweig and Easton (2010) point out that "a considerable debate exists in the operations strategy literature regarding whether manufacturing can focus on multiple competitive capabilities with sacrificing performance of another". Spina's work was one of the important precursor to this debate and was an input in the meta-analysis by Rosenzweig and Easton. The findings of this study were consistent with those put forward by Spina et al. (1996).

Lean production should be a contributor to flexibility and multi-focus. But as Lewis (2000) points out, there should be trade-offs involved in the use of lean production. However, his empirical work found that the expected trade-off between lean methods and innovation was not present. He argues that "A number of operations authors have suggested that it is possible to create a strategically flexible production model that accommodates this apparent contradiction (Spina et al. 1996). This requires substantial further investigation."

A number of subsequent research studies have focused on using or exploring some of the specific ideas from Spina et al. (1996). Beach et al. (2000) examine strategic flexibility. Takala et al. (2006) specifically examined multi-focused strategies. They state that competitive strategies—especially in manufacturing industry—changed dramatically from focused to multi-focused priorities. However, this change brings about a great challenge for the successful implementation of these strategies. They use the sand cone model to explore this.

3.3.1 Summary

The paper "Strategically flexible production: the multi-focused manufacturing paradigm", was an important milestone in the development of the field of manufacturing strategy. First, it was both timely and was the first to challenge the established paradigms of manufacturing strategy. Voss (1995) set out the paradigms of manufacturing strategy, but did not challenge them. In doings so Spina et al. (1996) put

forward a new paradigm that both reflected the evolution of manufacturing and challenged our view of trade-offs and the assumptions behind some of the core concepts such as the focused factory. Importantly, it was not just conceptual, but the paradigm was operationalised and empirically tested both for adoption and impact. It would be good if many of the conceptual papers that we read today would do the same. It was the first research to fully recognise the major changes in technology, markets, the organisation and management of manufacturing. Subsequent empirical research has proved to be supportive of the new paradigm. As such it has been a platform for future work in and the evolution of the field. There is a need today to remember the themes from this research in areas such as 3D printing.

References

Beach, R., Muhlemann, A. P., Price, H. R., Patterson, A., & Sharp, J. A. (2000). Manufacturing operations and strategic flexibility: Survey and cases. *International Journal of Operations & Production Management, 20*(1), 7–30.

Cagliano, R., & Spina, G. (2000). Advanced manufacturing technologies and strategically flexible Production. *Journal of Operations Management, 18*, 169–190.

Hayes, R. H., Wheelwright, S. C., & Clark, K. (1988). *Dynamic manufacturing*. New York: Collier Macmillan.

Jelinek, R., & Goldhar, J., (1984). The strategic implications of the factory of the future. *Harvard Business Review*, 24–37 (Summer).

Lewis, M. A. (2000). Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management, 20*(8), 959–978.

Oke, A. (2005). A framework for analysing manufacturing flexibility. *International Journal of Operations & Production Management, 25*(20), 973–992.

Rosenzweig, E. D., & Easton, G. S. (2010). Tradeoffs in manufacturing? A meta-analysis and critique of the literature. *Production and Operations Management, 19*(2), 127–141.

Skinner, W. (1969). Manufacturing—Missing link in corporate strategy. *Harvard Business Review*, 136–145 (May–June).

Skinner, W. (1974). The focused factory. *Harvard Business Review*, 113–121 (May–June).

Slack, N. (1983). Flexibility as a manufacturing objective. *International Journal of Operations & Production Management, 3*(3), 4–13.

Spina, G., Bartezzaghi, E., Bert, A., Cagliano, R., Draijer, D. & Boer, H. (1996) Strategically flexible production: The mult-focused paradigm. A review and outlook. *International Journal of Operations and Production Management, 16*(11), 20–41.

Takala, J., Leskinen, J., Sivusuo, H., Hirvelä, J., & Kekäle, T. (2006). The sand cone model: Illustrating multi-focused strategies. *Management Decision, 44*(3), 335–345.

Voss, C. A. (1995). Alternative paradigms for manufacturing strategy. *International Journal of Operations and Production Management, 15*(4), 5–16.

Chapter 4
Advanced Manufacturing Technologies and Strategically Flexible Production. A Review and Outlook

Harry Boer

Abstract This Chapter discusses the key problem of integrating the use of advanced manufacturing technologies (AMTs) together with the change in the strategic and organizational approach to manufacturing in order to build superior capabilities, especially strategic flexibility and continuous innovation. In the original paper AMTs were analysed within the context of the Strategically Flexible Production (SFP). The use and effectiveness of various technologies and their computer-based integration were investigated in the light of the emerging paradigm. Data from the International Manufacturing Strategy Survey have shown that the use of integrating technologies varied much within the core adopters of the paradigm, suggesting that SFP did not necessarily require massive information technology support. However, SFP alone or combined with a higher level of integration of stand-alone AMT fostered increased time responsiveness. The commentary suggests that today very similar hypotheses to the ones tested in the original paper could be explored in relation to the currently emerging technologies, such as Industry 4.0 or Smart Factories. In particular we need to ask questions and test propositions around the need of alignment between today's advanced technologies and work organization practices, and around the relative importance of technology compared to organization in building superior capabilities.

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4.1 Original Paper[1]

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1. Introduction

During the 1980s, Western manufacturers were attracted by the potential of computer technology to increase productivity through the improvement of quality and the reduction of costs and lead times. However, most investments aimed at exploiting the benefits of Computer Integrated Manufacturing (CIM) led to only partial results, and were often abandoned or scaled down. At the same time, a number of *soft* organizational and managerial approaches and improvement programs, mostly derived from Japan, began to spread in response to the dramatic changes in the competitive environment that seemed to require new rationales to organize and manage production systems. However, the compatibility and coherence between changing organizational paradigms and CIM approaches were not extensively explored nor understood. This paper aims to investigate the interactions between the implementation and integration of Advanced Manufacturing Technologies (AMT) and the adoption of new managerial and organizational principles.

The study is organized as follows. Section 2 presents research background, including the decline of CIM, the shift in the rationales of production management, and the need to rethink the use of AMT; Section 3 details research hypotheses; Section 4 illustrates the methodology and the sample; and Section 5 reports the data analyses and discusses the major findings. Finally, Section 6 summarizes and considers future research.

[1]Reprinted with permission from: Cagliano R, Spina G (2000) Advanced manufacturing technologies and strategically flexible production. *Journal of operations Management* 18(2), 169-190.

2. Research background

2.1. The rise and fall of CIM

The introduction into manufacturing of computers as a source of competitive advantage has received scholarly attention for quite some time now. Early interest focused on the cost advantages of AMT — see e.g., Gerwin (1982), Zuboff (1982), Rosenthal (1984) — including various hardware-based and software-based approaches ranging from numerical control machine tools (NC) to machining centers, flexible manufacturing cells and systems (FMC/ FMS), computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided process planning (CAPP), automated storage and retrieval systems (AS/RS), material resources planning (MRP II) and others. Once stand-alone AMT could be integrated into unified systems, the concept of CIM arose and was credited with the potential to provide not only improvements in efficiency, but also greater operational flexibility, higher quality products, a shorter time-to-market, and a faster response to changing customer needs (see e.g., Nemetz and Fry, 1988; Somers and Gupta, 1991).

The quest for such benefits caused CIM to evolve in order to integrate new applications and enlarge the set of business processes involved. Its turbulent growth in the 1980s and the perspective of a company-wide integrated information system also contributed to the creation of the myth of the so-called *unmanned factory.* In the early 1990s, however, this myth started to decline, as CIM had not kept its promises. Many CIM projects yielded only partial results (Jaikumar, 1986; Babbar and Rai, 1990), while others were given up completely, at times because of the difficulties in paying back the huge investments that were often required (Kaplan, 1986). Initially, two reasons were given to explain these failures. First, it was argued that, due to their poor understanding of the strategic potential of information technology (IT), most companies missed the opportunity to shift strategy from mere cost-leadership to differentiation based on quality, flexibility and service (Scott Morton, 1991). Second, the poor implementation of CIM projects, particularly in managing cultural and organizational change, was cited as a major cause of failure (Hirschhorn, 1984; Beatty and Gordon, 1988). In particular, firms often failed to understand that the implementation of CIM considerably alters organizational structure, even to the extent of changing reporting channels and responsibilities (Meredith, 1987).

These arguments basically refer to the poor understanding and use of CIM approach, which was, however, still considered to be effective. In addition, inherent and structural shortcomings of CIM were also identified. Duimering et al. (1993) observed that CIM may simply automate bad practice and institutionalize poor business processes, and thus suggested that the redesign of organizational structures and coordinating mechanisms should precede the implementation of technology. Gunn (1987) remarked on the lack of coherence between CIM projects and other approaches to manufacturing innovation that were becoming

popular in industry, e.g., Just-in-Time, Total Quality Management, Concurrent Engineering, and Business Process Re-engineering (BPR). In general, it has been recognized that the concept of CIM as a multi-layer and hierarchical model to integrate AMT is inconsistent with the new rationales for production systems (Boer et al., 1990; Spina and Verganti, 1993).

2.2. Changes towards Strategically Flexible Production (SFP)

In response to environmental changes, there have been dramatic changes over the last two decades in the basic ideas of production system design, organization and performance indicators. Evident examples are the current emphasis on empowerment, learning organizations and local autonomy (rather than the mere automation of narrow tasks and the use of information systems to enforce hierarchical control); on project teams and cross-functional integration (rather than automation of compartmentalized procedures); on networking and virtual organizations (rather than the integration of internal applications into unique systems maintaining clear company boundaries). The shifts towards such new issues have involved an increasing number of companies from various industries and countries, and have been highlighted by a number of authors — see e.g., Roobeek (1987) Hayes et al. (1988), Drucker (1990), Karlsson, 1996. These changes have been analyzed from macro-institutional, socio-economical, organizational and managerial perspectives. World Class Manufacturing (Schonberger, 1986), Lean Production (Womack et al., 1990), Innovation-mediated Production (Kenney and Florida, 1989), Agile Manufacturing (Goldman et al., 1995), SFP (Spina et al., 1996) and others are all concepts that embody new principles to design and manage production systems. Such proposals overlap to a large extent, though they differ in their accents and nuances. On the whole, they highlight that today's external consistency seems to demand: multiple simultaneous performance, rapid priority changes, responsiveness and timeliness, greater quality in working life and, in general, more involving and motivating tasks for an increasingly educated workforce. To match these requirements, internal consistency is also needed, which may be provided in various ways: e.g., global optimization, a process focus in organizational design, a perspective beyond rigid company boundaries, the development of internal capabilities and local problem solving, and the alignment of the manufacturing and new product development processes.

Of the various theoretical approaches, this paper focuses on SFP, which benefits from the availability of a validated methodology to measure its adoption in real manufacturing units (see Section 4 and Appendix A; Spina et al., 1996). SFP is based on three principles: multi-focusedness and strategic flexibility, process integration and process ownership. These are discussed below together with the details of the sub-principles in multi-focusedness and process ownership, and the areas in which process integration can be implemented (see Fig. 1).

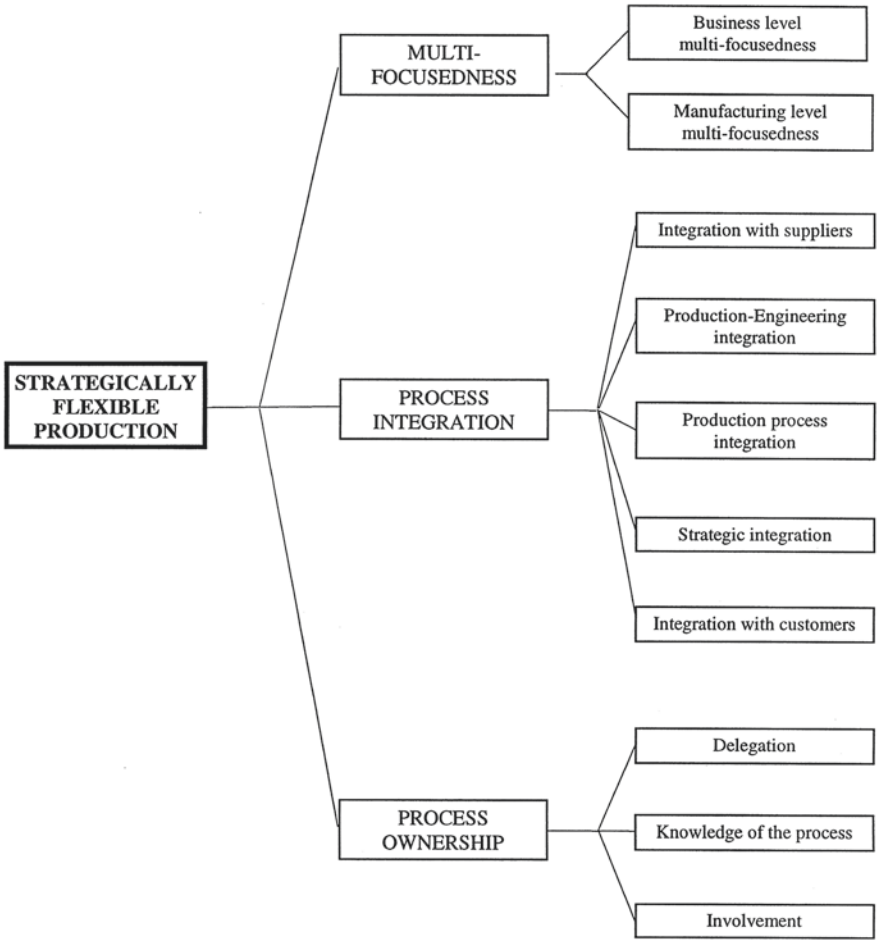

Fig. 1. The basic principles of SFP.

(1) Multi-focusedness and strategic flexibility drive companies to pursue simultaneously a number of different objectives traditionally regarded as in conflict, rather than focusing on single goals (Dean and Susman, 1989). Multi-focused competition has been found in many industries. For example, Abernathy et al. (1983) noticed that at the beginning of the 1980s car manufacturers were already trying to increase quality while expanding product range and customization, not increasing costs, and even cutting prices. Multi-focusedness challenges the consolidated theory of rigid trade-offs between manufacturing performances and suggests that these should be regarded as changing and dynamic (Hayes and Pisano, 1996). Strategic flexibility, i.e., the ability to shift competitive and manufacturing priorities rapidly from one set of goals to another within the same manufacturing system, is also needed. Gerwin (1993) refers to this concept as strategic adaptability.

(2) Process integration relates to organization from a macro-structural perspective. It calls for the redesign of organizational units, coordinating mechanisms and the overall structure of operations in terms of operational continuity and process integrity across functional barriers (Zeleny et al., 1990). It is therefore crucial to identify core processes (Kaplan and Murdock, 1991) by mapping customer needs to define outputs, activities, inputs, resources, skills and the interdependencies between activities. BPR (Hammer, 1990; Davenport, 1993) has been regarded as a radical approach which unfreezes and re-shapes the organization through process integration. At first sight, BPR is highly biased towards the exploitation of IT, and is thus relevant to the present paper. However, the nature of BPR is organizational, and it has a very strong operations management content, as properly noted by Armistead et al. (1995). Merging various contributions (Hammer and Champy, 1993; Davenport, 1993; Johansson et al., 1993), the salient characteristics of process integration include: customer focus, organization by outcomes not by tasks, the elimination of non value-added activities, the setting of decision points, information processing, checks and controls where activities are performed, linking and combining parallel activities instead of integrating results ex-post, capturing information once only at its very source, and minimizing reconciliation. Direct and continuous contact between and among customers, marketing, engineering, manufacturing, research and development, and part suppliers are also increasingly important (Griffin and Hauser 1992; De Meyer, 1992). Integrative issues therefore become critical when a single manufacturing system is required to cope with increasing variety and uncertainty (Susman, 1992). Fig. 1 shows that process integration is pursued across internal functions and primarily concerns the manufacturing/development interface, alignment with marketing strategy and competitive positioning, and integration between various manufacturing departments. Also, process integration expands across company boundaries to both customers and suppliers (Davenport and Short, 1990; Harrington, 1991).

(3) Process ownership addresses to production organization from a micro-structural perspective. It concerns job design and the role of individuals. Schonberger (1990) introduced the concept of process ownership with reference to the involvement of all employees at any hierarchical level in decision making and problem solving. Process ownership is necessary to ensure process integration: decision making is moved down the organization and vested in the people most familiar with operations and related problems (Huber and McDaniell, 1986). Interdependent activities that require diverse skills are grouped, and more authority and control must be given to the job incumbent (Hirschhorn, 1984; Walton and Susman, 1987). In turn, the expansion of job responsibilities demands shared knowledge and cross-training. As underlined by Van de Ven (1986), cross-training aims to give workers that holistic view of the ''whole in the part'' which is essential to process integration. Thus, process ownership is a multi-faceted concept that requires: delegation, involvement and knowledge of the process — see Fig. 1. The ultimate objective is to develop local problem solving capabilities in order to detect and resolve process anomalies as soon as possible, so avoiding time-consuming hierarchical referrals.

2.3. Rethinking the use of AMT

SFP principles are quite generic and can be implemented by various techniques, approaches and managerial practices, including the use of several AMT and different methodologies drawn from Just-in-time, Concurrent Engineering, Total Quality Management and other popular approaches. These and other techniques and technologies comprise a reservoir from which managers can select, customize and integrate a set of practices and approaches according to their internal and external environments. As a consequence, companies can achieve SFP through various patterns in which AMT may have different emphasis and application. However, most of the literature agrees on the complementary role of AMT and "soft" innovation within the context of the new production management rationales. Several contributions have suggested how to implement AMT effectively in the light of the paradigmatic changes in organizational and managerial principles. For example, in response to emerging competitive challenges and the need for corporate strategic responses, Jaikumar (1986) advocated new mission statements for AMT implementation. Spina and Verganti (1993) derived implications for AMT implementation from general principles that underpin various organizational and managerial innovations. Beatty (1992) proposed "rules of the road" for implementing AMT in the context of the emerging managerial practices and organizational structures. Furthermore, there is some empirical evidence of the joint effects of AMT and infrastructural improvement programs (Boyer et al., 1997) or organizational integration (Vonderembse et al., 1997) on company performance. More in general, differences in managerial practice and organizational forms explained variations in the competitive performance of AMT users (Brynjolfsson and Hitt, 1995; Parthasharty and Yin, 1996). Again, these studies show that companies that want to squeeze performance improvement from AMT need to adapt technology to new organizational forms and emerging managerial practices.

In summary, there is now evidence and agreement that successful changes in companies over the past few years were more organization-driven than technology-driven, though AMT often provided strategic support for organizational restructuring. Recently, this line of argument has gained widespread approval, even among policy makers. The OECD (1996) report on "Technology, Productivity and Job Creation" recognizes and summarizes the paradigmatic changes for production systems and sets the pre-requisites to capture benefits from technology *given* the emerging organizational and managerial contexts:

> . . . technology provides new opportunities for expanding the range of goods and services, increasing productivity, and increasing employment, but the organization of firms and the institutional context for the introduction of organizational change determines the effectiveness and the impact of the adoption of new technologies (OECD, 1996, p. 91).

Summarizing our argument, the decline of CIM and the need to rethink the use of AMT in the light of the changes in the rationales of production management and organization (SFP or similar theoretical approaches) provide the background for detailed hypotheses on the interactions between such organizational and managerial issues and AMT implementation which can be tested empirically.

3. Research aims and hypotheses

This study addresses the use and the effectiveness of AMT within the context of the shift in the organizational and managerial principles of production systems, using SFP as the reference framework. Previous research has proved that strategic multi-focusedness, process integration and process ownership — i.e., SFP as a whole — are increasingly adopted by manufacturing companies worldwide and enable significant improvements in manufacturing performance (Spina et al., 1996). This paper uses a survey methodology to investigate how much and how effectively AMT are used by firms in function of their orientation towards SFP. In the conceptual model we propose (see Fig. 2), this degree of orientation to SFP is taken as an independent variable that might explain the use and integration of various AMT. This is a quite different approach from that used in other research in the field, in which technology is taken as an independent variable and the organizational conditions under which the potential benefits of computer-based technologies can be achieved and exploited in competition are examined (see e.g., Parthasharty and Sethi, 1992; Brynjolfsson and Hitt, 1995; Parthasharty and Yin, 1996; Udo and Ehie, 1996). Fig. 2 illustrates the conceptual model we use to develop detailed hypotheses.

The first concern of the paper is to explore the level of adoption of AMT within the context of SFP. As previously argued, various contributions support the idea that organizational and managerial innovations are necessary to exploit technological opportunities, or are even crucial per se. As a consequence, we expect that SFP is not necessarily technology-intensive. In other words, we do not expect a higher adoption of stand-alone computer technologies within companies that are oriented to SFP. However, we do expect that SFP implies a higher level of computer integration (CI) between stand-alone AMT, since it requires greater focus on process integration across activities in different functions and departments, and even across company boundaries. This is in line with recent contributions (e.g., Vonderembse et al., 1997) contending that in the post-industrial era, integration is the major driver of innovation, whereas in the industrial age, focus was on automation which occasionally led to integration.

In summary, we formulate the following two hypotheses:

H1A *SFP does not lead firms to a higher use of stand-alone AMT*;

H1B *SFP leads firms to a greater integration of AMT*.

In Section 2.3, we pointed out that SFP is a generic concept that might embrace different manufacturing strategies in terms of practices and technologies. Since companies have to find their own way in adapting SFP to their competitive and internal contexts, the use of AMT — as well as of ‘‘soft’’ practices — might differ significantly within manufacturers oriented to SFP. Hence, we formulate the following hypotheses:

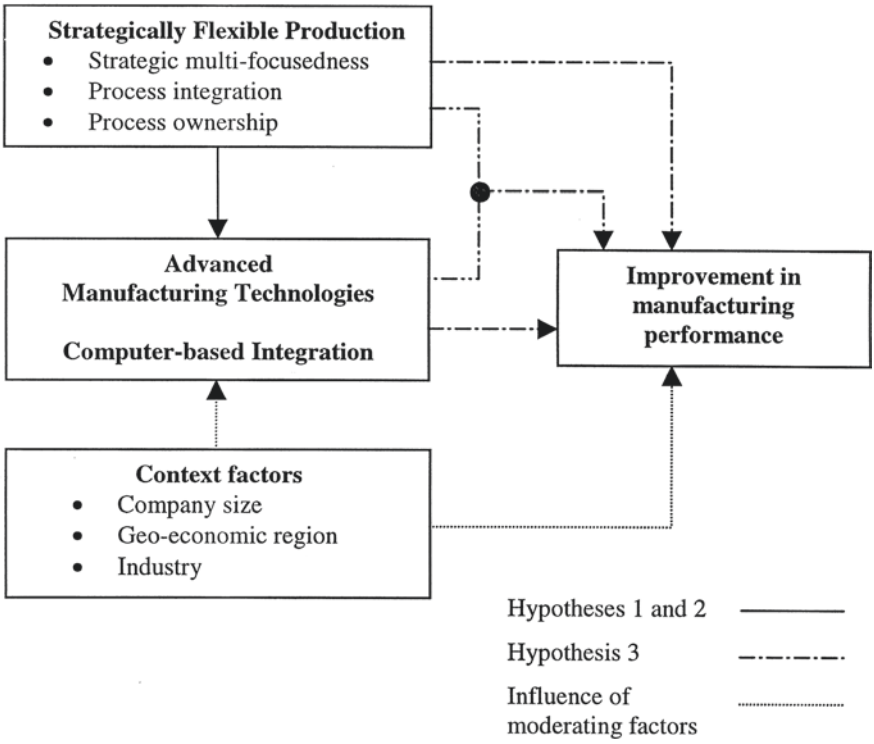

Fig. 2. Conceptual model.

H2A *The use of stand-alone AMT varies considerably within companies that are highly oriented towards SFP*;

H2B *The level of integration of stand-alone AMT varies considerably within companies that are highly oriented to SFP*.

Finally, the impact of SFP and AMT implementation on manufacturing performance is considered, the general question being: is technology alone, apart from the adoption of SFP, able to improve manufacturing performance? On the basis of recent studies, the answer should be no. Investments in AMT and CI by themselves have not led to greater improvements in performance at business level (Boyer et al., 1996). Infrastructural investments in worker empowerment, quality management and organizational coordination have been seen to catalyze the potential benefits of technological investment (Parthasharty and Yin, 1996; Boyer et al., 1997). Similarly, a wide body of literature has contended that AMT must be complemented with adequate organizational and managerial change in order to be effective (e.g., Meredith, 1987; Duimering et al., 1993; Udo and Ehie, 1996). Small and Yasin (1997) found that firms adopting integrated technologies and making a significantly greater effort in the development of human factors and

team-based project management have achieved better results on various performance measures.

This study seeks further confirmation of the limited independent effect of AMT adoption and integration on improvement in manufacturing performance. We predict that the adoption of SFP is the main driver of performance improvement. In particular, both the adoption of SFP alone and the joint implementation of SFP and CI are expected to provide companies with greater improvement, since the implementation of the three principles of SFP should unlock the potential of AMT. The above expectations are summarized in the following hypotheses:

H3A *Stand-alone AMT per se do not provide companies with greater improvement in manufacturing performance.*

H3B *Both SFP and the integration of AMT provide companies with greater improvement in manufacturing performance; the joint adoption of SFP and CI is expected to further improve performance.*

Of course, all the links presented above might be influenced by contextual factors such as company size, geo-economic region, and industry. The models we use to test the above set of hypotheses therefore also include such variables as potential explanatory factors.

4. Sample and methodology

4.1. Sample

In order to explore the relations between the use of AMT and the adoption of SFP, empirical evidence was drawn from the International Manufacturing Strategy Survey (IMSS), a worldwide research project involving 600 manufacturing units from the metal-working industry (ISIC 38) operating in 20 countries in Europe, North and South America, and Japan. Data were collected during 1993 by the national research groups within the global network using a standard questionnaire. The latter investigated: competitive strategies, goals and cost structure, current manufacturing practice, integration of manufacturing with other functions, customers and suppliers, past and planned improvement programs, and, finally, performance at both business and manufacturing level. The 10-page questionnaire was built on consolidated tools in the field and circulated among a panel of scholars and practitioners for refinement. It was also pre-tested in a small sample of Swedish companies. In most of the countries, the questionnaire was translated from English to the local language and then back-translated for validation.

The questionnaire was sent to plant managers or manufacturing executives in a sample of manufacturing units with more than 100 employees, and could, in theory, be self-completed by a single respondent. In practice, however, contact people often circulated the questionnaire through the various departments of the company, while researchers provided any necessary support by phone or even by personal visit.

Altogether, 1788 firms were contacted, and 600 were included in the final database giving an average response rate of 33.5%. Response rate varied across countries, ranging from 100% in Denmark to 17% in Norway.

From the original database of 600 companies, we restricted our analysis to 392 units which provided enough data for the evaluation of their orientation to SFP. We discarded companies for which the methodology could not provide a reliable measure of the orientation to the SFP because data were incomplete. This restriction did not significantly affect the sample distribution. Tables 1 and 2 show the distribution of the 392 manufacturing units by industry and country.

4.2. Measurement of AMT use

In order to explore the hypotheses presented in Section 3, we considered both the use of stand-alone AMT and the level of CI between the technologies.

On the one hand, we looked at various computer-based equipment, i.e., Numeric Control Machines, Machining Centers, Fabrication Robots and Assembly Robots. The use of such stand-alone AMT was evaluated as the current number of such machines per 100 salaried employees. On the other hand, we investigated different classes of computer software, including CAD and CAM systems, and planning and control packages (MRP and MRP II). The use of such technologies was measured on 5-point Likert-like scales ranging from 1 (no use) to 5 (high degree of use) which have become common in the assessment of AMT implementation (see e.g., De Meyer, 1987; Ward et al., 1994; Boyer et al., 1996, 1997).

Companies were also asked to indicate the extent to which production processes and equipment are integrated across manufacturing departments and with other functions. Respondents indicated the level of CI on an ordinal scale ranging from 1 to 10, as reported in Table 3.

Table 1
Distribution of the 392 processable companies by industry (number and percentage of total sample)

ISIC	Description	Respondents
381	metal products (except machinery)	123 (31.4%)
382	machinery (except electrical)	62 (15.8%)
383	electrical machinery apparatus, appliances and supplies	80 (20.4%)
384	transport equipment	49 (12.5%)
385	measuring and controlling equipment, optical goods	
-	not specified or other	42 (10.7%)

Table 2
Geographical distribution of the 392 processable companies

EUROPE	220
Sweden	41
Norway	9
Finland	15
Denmark	12
Great Britain	24
Germany	17
Austria	13
The Netherlands	16
Belgium	1
Italy	29
Spain	21
Portugal	22
NAFTA	95
USA	32
Canada	12
Mexico	51
MERCOSUR	42
Argentina	20
Brazil	20
Chile	2
PACIFIC RIM	35
Japan	13
Australia	22

Table 3
Ordinal scale for the level of CI

Level	Computer control	Description of computerized control for level
1	None	
2	Stand alone machine	Instructions for machine control
3	Machining center	level 2 + Instructions for changing tools
4	Machining cell	level 3 + Multiple machining control
5	FMS — type 1	level 4 – Scheduling
6	FMS — type 2	level 5 + Loading/unloading, storage
7	FMS — type 3	level 6 + Inspection, sorting
8	Automated factory — 1	level 7 + Computerization of functional modules, e.g., MIS, MRP, CAD, CAM, CAPP
9	Automated factory — 2	level 8 + Linkage of MIS, MRP, order processing, scheduling and cost analysis
10	Automated factory — 3	level 9 + Linkage of CAD, CAPP, CAE and CAM

The nine levels describing automation were grouped into three categories of increasing integration: (i) island automation — including levels 2 to 4, i.e., stand alone machines or machining centers up to work cells; (ii) production integration — including levels 5 to 8, i.e., integration of automated equipment and computer software in cells or flexible manufacturing or assembly systems; (iii) cross-functional integration — including levels 9 and 10, i.e., integration of equipment and software throughout different functions and computerized modules, e.g., the integration between demand management and production scheduling and control, or design/engineering functions.

The level of CI was assessed at both the general level, i.e., the average within the company, taking account of differences between departments, lines, cells, etc., and the highest level, i.e., that found in the most advanced department in the plant. Both measures were considered in the analyses.

The use and integration of AMT were analyzed in the large IMSS sample in function of the degree of adoption of SFP.

4.3. Measurement of the orientation to SFP

The concepts of strategic multi-focusedness, process integration and process ownership can hardly be measured directly by a survey, as they constitute a complex, multidimensional issue. Clearly, when using a mail questionnaire, information is limited and standardized, while, obviously, the data cannot be considered a direct and synthetic measure of the orientation to such principles. Starting from the information provided by the IMSS questionnaire, we therefore needed to build a generic model of the manufacturing system that operationalizes the concept of SFP. In particular, the methodology should combine and aggregate a set of standard data in a hierarchy of concepts and thereby evaluate in a formal way the orientation of a generic unit in the database to the basic principles of SFP.

The usual method to measure constructs in operations management is to build multidimensional scales that average the values of a set of items considered, providing, in general terms, a proxy of the concept evaluated (see e.g., Nunnally 1978; Flynn et al., 1990). This methodology was not used in this study for two main reasons. First, the principles and sub-principles of SFP are not additive, but rather are needed *simultaneously* to reach a complete orientation to the overall concept. In addition, to meet a principle, a company can use both alternative or complementary levers. These two aspects are hardly captured by a simple average of the values. A valid tool to cope with this kind of problem is *fuzzy set theory*, which ‘‘provides a strict mathematical framework in which vague conceptual phenomena can be precisely and rigorously studied’’ (Zimmermann, 1993). The basic idea of the fuzzy set theory is that the membership of a certain set is not decided in a binary — yes or no — way, but is stated by a continuous function (membership function) that varies between 0 and 1. In this way, the theory ‘‘provides a natural

way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables'' (Zadeh, 1965). Goguen (1981) contends that ''fuzzy sets without some sort of elaboration are inadequate for use in analyzing natural language'' and illustrates how fuzzy theory can represent hierarchical concepts through the use of multi-sets which are hierarchies of sets. Hierarchical trees of sets have also been suggested, in which the leaves represent the simple concepts that combine to give the complex ones. Zimmermann and Zysno (1983) propose similar representations for complex concepts or subjective categories.

Cagliano and Spina (1996) and Spina et al. (1996) fully describe the operationalization of SFP through fuzzy sets (the model is summarized in Appendix A) and its application to the IMSS sample. The methodology was in fact used to process the individual data and to measure the orientation of each unit to multi-focusedness, process integration and process ownership, respectively, on a scale — a fuzzy number — ranging from 0 (no adoption) to 1 (full adoption).

This use of fuzzy set theory assesses the concepts of multi-focusedness, process integration and process ownership, as previously defined (e.g., Spina et al., 1996), by sub-dividing them into categories that can be measured directly in reality with a survey tool. Once the measures of these three concepts had been obtained, companies were classified into categories of adoption by a cluster analysis on the standardized values of the three variables.

Standardization is often suggested in cluster analysis when variables have different ranges to ensure that no variable can influence the grouping procedure more than any other (Ketchen and Shook, 1996). In this case, process ownership has the smallest range (0.79), and multi-focusedness the largest (1.0).

A K-means clustering procedure was used that divided companies into seven clusters. This number was chosen both in the light of Lehmann's suggestion to limit cluster number to $n/30$ and $n/60$, where n is the sample size (Lehmann, 1979), and to guarantee greater interpretability (for a similar application in Operations Management, see e.g., Miller and Roth, 1994).

Table 4
K-means clustering procedure: cluster centers for multi-focusedness, process integration, process ownership

Cluster	Number of companies	Multi-focusedness (standardized value)	Process integration (standardized value)	Process ownership (standardized value)
1	78	0.514	0.997	0.413
2	91	0.593	0.180	–0.786
3	71	0.186	–0.295	0.572
4	35	0.438	0.646	1.949
5	42	–0.085	–1.924	–0.384
6	53	–0.711	0.150	–0.629
7	21	–2.62	0.389	0.438

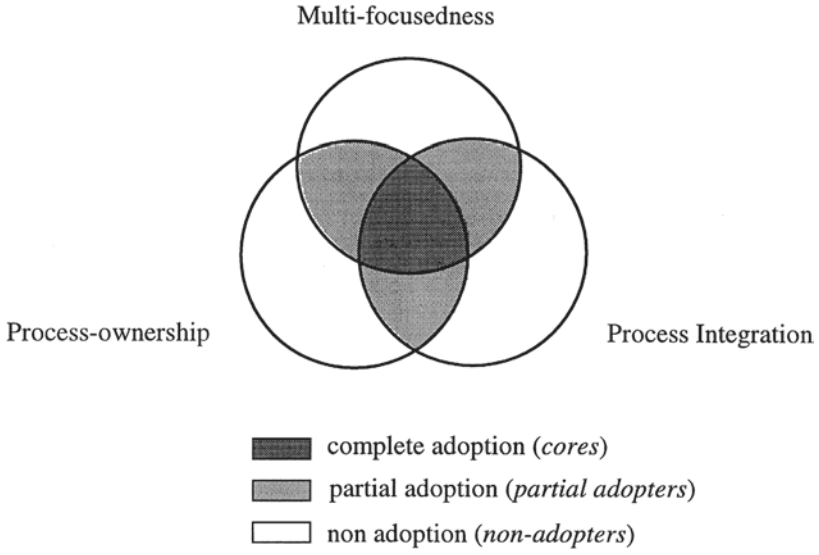

Fig. 3. Stages in SFP adoption.

The results of the cluster analysis are reported in Table 4, which shows the cluster centers and the number of companies in each cluster.

Looking at these clusters, companies can be further grouped into three main classes.

Clusters 1 and 4 both include companies with a strong orientation to all three principles (the standardized value of the three variables is above zero). We will refer to these companies as ‘‘core adopters’’ of SFP, since they show above average orientation for all three principles. On the other hand, clusters 5 and 6 group companies that are weakly oriented to all three principles (the standardized value of the three variables is below or close to zero). These companies are labeled ‘‘non adopters’’. Finally, clusters 2, 3 and 7 are in some way similar, in that they group companies who have adopted two out of three principles massively, while they lack the remaining factor. Units in cluster 2 lack process ownership, units in cluster 3 process integration, and units in cluster 7 multi-focusedness. All these units are comparable, in view of their incomplete — but at least partial — orientation to SFP. We refer to these companies as ‘‘partial adopters’’.

Fig. 3 clearly shows the concept underlying this further classification: the orientation of a company to the overall concept grows with the number of principles that are fully adopted.

Of the 392 units in the sample, 113 units (29%) were classified as core adopters, 184 units (48%) as partial adopters, and 95 units (24%) as non adopters.

4.4. Measures of performance improvement

Most of the studies of AMT based on survey methodology analyze performance at business level, such as profit and growth, but manufacturing performance only at aggregate level (e.g., Boyer et al., 1996, 1997). In contrast, we focused exclusively on manufacturing performance, considering a wide set of quantitative improvements rather than qualitative evaluations. In particular, we considered the percentage variation over a 3-year period in the following performance measures:

- unit manufacturing costs;
- conformance to specification;
- inventory turnover;
- delivery lead time;
- on-time deliveries;
- manufacturing lead time;
- time-to-market;
- product variety.

4.5. Contextual factors

As mentioned in Section 3, the analyses performed to test the influence of SFP adoption on the level of automation and CI and on manufacturing performance should include contextual variables, in order to assess their impact on the relationships analyzed. The following contextual variables were considered:

- company size, measured by the number of employees;
- the economic region in which the company operates; four regions were considered, i.e., Europe, NAFTA, MERCOSUR, and the Pacific Rim;
- the industrial sector, as defined by the ISIC code specified by the company in the questionnaire (ISIC codes from 381 to 385 — see Tabte 2).

5. Empirical results

5.1. AMT, CI and SFP

Table 5 gives the average use (and standard deviation) of computerized equipment and software applications among core, partial and non adopters of SFP. The data show that the intensity of automation is not related to the adoption of SFP, since numeric control machines and fabrication and assembly robots are used almost to the same extent in the three classes, while machining centers are even more extensively implemented by non adopters. On the other hand, a certain

Table 5
Average use of AMT and the adoption of SFP

	Core adopters		Partial adopters		Non adopters	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
NC[a]	7.1	(19.23)	7.0	(15.73)	5.0	(9.45)
Machining centers[a]	1.8	(4.17)	1.4	(2.77)	2.9	(20.57)
Fabrication robots[a]	1.7	(5.20)	1.1	(3.35)	0.5	(1.71)
Assembly robots[a]	0.6	(1.75)	1.2	(7.87)	0.2	(0.76)
MRP[b]	3.27	(1.62)	3.32	(1.59)	3.03	(1.45)
MRPII[b]	2.90	(1.69)	2.50	(1.56)	2.88	(1.50)
CAD[b]	3.74	(1.26)	3.96	(1.25)	3.31	(1.27)
CAM[b]	2.64	(1.37)	2.70	(1.34)	2.59	(1.27)

[a]Units per 100 salaried employees.
[b]Use on a Likert-like scale (from 1 to 5).

degree of adoption of SFP is weakly related to a greater use of software applications, as non adopters are less concerned than partial and core adopters, except in the case of MRPII.

The data in Table 5 also show that the standard deviation of measures for stand-alone AMT is generally high, especially in the core adopters class. This means that the adoption of SFP does not necessarily entail massive and company-wide computer support.

These preliminary observations are further confirmed by a General Factorial Analysis of Variance, in which the explanatory factors considered are SFP adoption, company size, region and industry. These variables were added to the model in order to control for contextual influences. The results are shown in Table 6.

The level of automation and the use of software applications do not differ significantly among the SFP adoption classes, while in some cases the differences found can be explained by contextual variables. For example, numeric control machines and fabrication robots are more frequent in some industry sectors than in others. In particular, NC is more used in the metal products and machinery industries ($p = 0.000$), and fabrication robots in the metal products and electrical machinery industries ($p = 0.046$). On the other hand, the use of assembly robots is explained by company size, with greater adoption in larger companies ($b = 0.00058$; $p = 0.019$).

The use of software applications is generally explained by economic region. Planning tools are more frequently used in the NAFTA area (average use: MRP = 3.66; MRPII = 3.44), followed by Europe (average use: MRP = 3.12; MRPII = 2.50), the Pacific Rim (average use: MRP = 3.05; MRPII = 2.16) and MERCOSUR (average use: MRP = 2.43; MRPII = 2.08). Significance levels are $p = 0.022$ and $p = 0.000$ for MRP and MRPII, respectively.

As far as the use of CAM systems is concerned, NAFTA (average use = 2.96) and Pacific Rim countries (2.77) precede Europe (2.43) and the MERCOSUR region (2.30). The significance level is $p = 0.044$.

The above findings support hypotheses H1A and H2A, in that the adoption of SFP does not lead to a more intense use of computerized equipment or software applications (stand-alone AMT), while the use of these technologies varies considerably within companies that adopt SFP massively. This means that the orientation to the emerging principles in production systems management does not necessarily require a massive use of AMT. At least in part, contextual factors may explain the differences in the use of computerized technologies.

A similar analysis was performed to test the influence of the orientation to SFP on the general and highest levels of CI. A preliminary General Loglinear Analysis tested the independence of the level of CI, SFP adoption and contextual factors. The probability of the Pearson Chi-squared test ($\chi^2 = 166.37$, $p = 0.499$) fully supported the independence of the variables, thus allowing independent analyses to study the link between CI and the orientation to multi-focusedness, process integration and process ownership. Of course, this does not mean that contextual variables do not affect the level of CI: CI is, for example, greater in European countries and in medium-sized companies. However, a deeper analysis of these

Table 6
Effects of SFP adoption and contextual factors on AMT use

AMTs	Corrected model			Intercept		Region		Industry		Size		SFP	
	n	*F*	Significance	*F*	Significance	*F*	Significance	*F*	Significance	*F*	Significance	*F*	Significance
NC	342	2.861	**0.002**	23.43	**0.000**	0.478	0.698	5.579	**0.000**	2.219	0.137	1.194	0.304
Machining centers	342	0.994	0.448	6.907	**0.009**	1.246	0.293	0.889	0.471	0.208	0.649	0.486	0.616
Fabrication robots	342	1.916	**0.042**	8.422	**0.004**	1.590	0.192	2.444	**0.046**	0.568	0.451	2.720	0.067
Assembly robots	342	1.889	**0.046**	0.325	0.569	1.057	0.368	1.676	0.155	5.592	**0.019**	1.283	0.278
MRP	251	1.549	0.123	340.144	**0.000**	3.256	**0.022**	0.475	0.754	0.783	0.377	0.970	0.381
MRPII	229	3.076	**0.001**	231.76	**0.000**	6.702	**0.000**	0.659	0.621	2.389	0.124	1.991	0.139
CAD	312	1.468	0.150	926.891	**0.000**	1.686	0.170	0.700	0.592	2.389	0.123	1.447	0.237
CAM	186	1.127	0.342	341.22	**0.000**	2.746	**0.044**	0.291	0.884	0.932	0.335	0.129	0.879

effects is beyond the scope the present paper, which concentrates on the effects of SFP orientation on AMT and CI.

Tables 7 and 8 report the proportion of units implementing increasing CI (''island'' automation, production integration and cross-functional integration) as a function of increasing levels of SFP adoption. Both at the general and the highest level within the factory, many companies integrate their processes cross-functionally via computer, moving from non adopters towards core adopters. However, the differences are not significant at the general level (Table 7, Pearson-χ^2 test: $p = 0.270$). On the other hand, when considering the highest level of CI in a given department (Table 8), the differences are significant both between core adopters and partial adopters and between partial adopters and non adopters (Pearson-χ^2 test: $p = 0.021$). In particular, the forefront departments in core adopter factories show significantly higher cross-functional CI, as 22.2% of this group (vs. 12.7% of partial adopters and 7.5% of non-adopters) has at least one cross-functionally integrated department. In other words, the higher level of organizational integration required for a complete orientation to SFP often goes along with greater computer-based integration. This finding supports hypothesis H1B.

Table 7
General level of CI and the adoption of SFP
Percentages of units that achieve a growing level of integration. Pearson-χ^2: $p = 0.270$.

General level of CI	Core adopters, N = 72	Partial adopters, N = 128	Non adopters, N = 75
Island automation	62.5	71.9	77.3
Production integration	34.7	26.6	22.7
Cross-functional integration	2.8	1.5	0
Total	*100*	*100*	*100*

Table 8
Highest level of CI and the adoption of SFP
Percentages of units that achieve a growing level of integration. Pearson-χ^2: $p = 0.021$ (significance at 95%).

Highest level of CI	Core adopters, N = 63	Partial adopters, N = 118	Non adopters, N = 66
Island automation	22.2	34.7	47.0
Production integration	55.6	52.6	45.5
Cross-functional integration	22.2	12.7	7.5
Total	*100*	*100*	*100*

H2B is also confirmed. The level of CI varies much within core adopters: one third only implement ''island'' automation, while more than half do not go beyond production integration.

This conclusion is further confirmed by results in previous research which demonstrated that core adopters do not implement AMT and CI as independent and autonomous manufacturing strategies but in a broader context of innovation. Spina (1998)

empirically identified several alternative manufacturing strategies for core adopters of SFP, showing differences in the level of stand-alone AMT utilization and CI.

Overall, the above findings support the hypotheses formulated in Section 3, in that the adoption of SFP is not related to a more intense use of computerized equipment or software applications (stand-alone AMT). In contrast, the increasing adoption of SFP is linked to a parallel process of computer-based integration within factories and across functional boundaries.

5.2 AMT, SFP and performance improvements

The hypotheses H3A and H3B were tested by two subsequent analyses. Table 9 illustrates the results of a correlation analysis between each performance criterion and the computer equipment and software analyzed. Data show that the adoption of AMT has only limited effects on performance improvements, as few of the correlation coefficients are high, positive, or statistically significant. The only positive, significant correlations are between the use of assembly robots and manufacturing quality, and between the use of MRPII software and improvement in manufacturing lead time. These findings support hypothesis H3A, i.e., there is no independent effect of AMT on performance improvements. This result is substantially consistent with previous literature on the subject (e.g., Boyer et al., 1996, 1997), in that technology alone seems unable to improve manufacturing performance.

In order to test the separate and joint effect of SFP adoption and CI, i.e., hypothesis H3B, we performed a General Factorial Analysis of Variance, assessing the main effects of SFP adoption and the use of CI, and their interaction. Contextual factors were also included in the model to correct the analysis for contingent influences. The use of AMT was not entered into the model, since, as mentioned before, we have demonstrated that these variables do not significantly influence performance.

Each performance measure was tested in the following overall model:

$$\begin{aligned}\text{Performance Improv.} = \text{constant} &+ \alpha\text{Size} \\ &+ \beta\text{Region} + \gamma\text{Industry} \\ &+ \delta\,\text{SFP} + \varepsilon\text{CI} \\ &+ \xi\,\text{SFP} \times \text{CI}\end{aligned}$$

Table 10 shows the results of the analysis for the general level of CI, i.e., the average level of integration in the plant.

The adoption of SFP drives most of the improvements in time performance, since its main effect is significant for delivery lead time and manufacturing lead time. The effect of SFP orientation on delivery lead time is further reinforced by

Table 9
Performance improvement and adoption of AMT
Correlation coefficient and significance between the percentage performance improvement (in a 3-year period) and the use of AMT.

Performance criteria	NC[+]	Machining centers[+]	Fabrication robots[+]	Assembly robots[+]	MRP[++]	MRP II[++]	CAM[++]	CAD[++]
Unit cost	−0.016	0.022	−0.063	0.080	0.059	0.069	0.048	−0.023
Manufacturing conformity	−0.034	0.002	−0.060	**0.133**[a]	−0.028	0.038	−0.058	−0.016
Inventory turnover	**−0.109**[a]	−0.102	−0.057	0.045	0.009	−0.023	−0.032	**−0.120**[a]
Delivery lead time	−0.014	0.051	−0.056	−0.022	0.090	0.046	−0.059	−0.103
On time deliveries	0.015	−0.025	**−0.106**[a]	−0.016	0.105	0.046	−0.082	0.011
Manufacturing lead time	0.004	−0.006	−0.052	0.096	0.114	**0.146**[a]	0.106	0.036
Time to market	0.004	−0.017	−0.010	−0.046	−0.003	0.077	0.074	0.041
Product variety	−0.024	−0.057	−0.050	−0.025	0.066	0.067	**−0.142**[a]	0.063

[+] Units per 100 salaried employees.
[++] Use on a Likert-like scale (from 1 to 5).
[a]Significanct at 90%.

Table 10
Effects of SFP, CI and contextual factors on performance improvement

Manufacturing performance	N		Corrected model	Intercept	Region	Industry	Size	SFP	CI	SFP × CI	R^2
Unit cost	227	Σ^2	7113.98	4336.66	2041.21	2173.44	10.11	1323.76	312.66	491.53	0.104
		F	1.639	14.99	2.352	1.878	0.035	2.288	0.540	0.566	
		Significance	**0.066**	**0.000**	0.073	0.115	0.638	0.104	0.583	0.638	
Manufacturing conformity	215	Σ^2	41 480.88	22 295.47	16 510.11	7885.90	242.92	4754.40	2789.62	3648.93	0.187
		F	3.049	24.579	6.067	2.173	0.268	2.621	1.538	1.341	
		Significance	**0.000**	**0.000**	**0.001**	0.073	0.605	0.075	0.217	0.262	
Inventory turnover	213	Σ^2	32 535.87	36 947.34	8167.19	6514.42	1394.97	4704.32	4886.15	3699.06	0.115
		F	1.712	29.156	2.148	1.285	1.101	1.856	1.928	0.973	
		Significance	0.051	**0.000**	0.095	0.277	0.295	0.159	0.148	0.407	
Delivery lead-time	210	Σ^2	24 434.10	40 032.99	1509.57	1026.92	2160.53	12 326.46	6347.30	7288.47	0.193
		F	3.095	76.062	0.956	0.488	4.105	11.710	6.030	4.616	
		Significance	**0.000**	**0.000**	0.415	0.745	**0.044**	**0.000**	**0.003**	**0.004**	
On time deliveries	219	Σ^2	15 204.15	19 372.20	6572.40	4807.63	2009.09	1490.66	54.160	1805.75	0.046
		F	0.653	12.477	1.411	0.774	1.294	0.480	0.017	0.388	
		Significance	0.828	**0.001**	0.241	0.543	0.257	0.619	0.983	0.762	
Manufacturing lead-time	220	Σ^2	38 793.40	43 000.52	7265.80	5002.99	5928.70	9426.68	2099.714	3196.09	0.121
		F	1.881	31.273	1.761	0.910	4.312	3.428	0.764	0.775	
		Significance	**0.027**	**0.000**	0.156	0.459	**0.039**	**0.034**	0.467	0.509	
Time-to-market	203	Σ^2	15 917.79	13 783.44	2769.19	3153.04	396.78	1769.14	2054.54	153.30	0.083
		F	1.129	14.667	0.982	0.839	0.422	0.941	1.093	0.054	
		Significance	0.333	**0.000**	0.402	0.502	0.517	0.392	0.337	0.983	
Product variety	200	Σ^2	15 595.26	11 930.64	4204.92	1087.69	831.29	254.63	7970.21	1327.353	0.063
		F	0.827	9.494	1.115	0.216	0.661	0.101	3.171	0.352	
		Significance	0.646	**0.002**	0.344	0.929	0.417	0.904	**0.044**	0.788	

the use of CI, as both the main effect of CI and the interaction between the two variables are significant. In contrast, CI is the main influence on significantly higher improvements in product variety. The differences in the other performance improvements are not significantly driven by the variables in the model.

A deeper analysis of the results of the data reported in Table 10 also allows tentative conclusions to be drawn on the relative importance of SFP and CI in explaining greater performance improvements even when differences are not significant. For most performance measures, the effect of SFP adoption — measured through sum of squares associated with the variable — and the joint effects of SFP and CI prevail over the separate effect of CI. Two exceptions are Time to market and Product variety, where the effect of CI is greater than that of SFP. We can thus conclude that operational manufacturing performances are in part related to, and explained by, the adoption of the emerging principles of multifocusedness, process integration and process ownership, while product innovation performance (product range and time-to-market) is affected more by CI.

Even if the main focus of our analysis is the study of the effects of SFP orientation and the use of CI on performance improvements, it is interesting to note some significant effects of contextual variables. In particular, company size explains higher levels of performance improvement in both manufacturing and delivery lead time. In each case, improved performance is related to a smaller company size *(*$b = 0.0064$, $p = 0.039$; and $b = 0.004$, $p = 0.044$ for manufacturing lead time and delivery lead time, respectively). It is important to remember that companies in the sample have more than 100 employees. This means that within our sample, smaller, i.e., medium-sized, units proved to be more able to reduce their lead time than larger companies. Finally, manufacturing quality improvements are significantly related to the economic region in which the company is located. These are highest in the Pacific Rim area (average improvement = 51.5%), followed by MERCOSUR (30.8%), NAFTA (22.2%) and Europe (20.0%).

The overall results of this analysis are coherent with hypothesis H3B, proving that both SFP and CI alone support performance improvements. The two variables reinforce each other in generating improvements in delivery lead time, since the effect of their interaction is statistically significant. A further conclusion is that SFP alone has a greater effect on manufacturing performance improvements than CI or the joint effect of the two, while product innovation performance is driven more by CI across functions.

6. Summary and conclusions

This paper is centered on the broad debate of the role of AMT within the paradigmatic changes in manufacturing systems. In an attempt to extend knowledge in this field further we have conducted an extensive empirical study of the intensity of use and the effectiveness of AMT with respect to the adoption of three emerging principles in manufacturing systems organization and management: (i)

multifocusedness and strategic flexibility; (ii) process integration across functions; and (iii) process ownership. Together, these are referred to as SFP.

A vast body of literature supports the idea that the adoption per se of different computer-based technologies does not provide companies with greater ability to improve manufacturing performance. This finding is also supported by the present study. Obviously, this does not mean that world-class manufacturing can be achieved without any computer-based support. Rather, it provides indirect confirmation of the need to re-shape the concept of CIM as it evolved in the eighties and early nineties in line with emerging organizational and managerial rationales that have proved to be effective.

In this paper we have investigated how the adoption of SFP influences the use and the effectiveness of various AMT and their integration. Our data show that while core adopters of SFP do not use computerized equipment and sofware applications more than other units, they show a greater level of CI, in particular in their forefront departments. However, the use of integrating technologies varies considerably within core adopters. This suggests that firms that implement advanced organizational practices not always perceive extensive automation and IT-based integration as the primary source of innovation, even though various AMT, together with organizational innovations, are often adopted successfully within the broader context of different manufacturing strategies.

This finding is also confirmed by the analysis of performance improvements. Technology alone does not provide companies with better overall performance, as revealed by the data in Table 10, but the joint use of technological and organizational innovation can have an effect on several performance measures. However, high levels of performance improvement are not necessarily reached through extensive automation and IT-based integration.

Clearly, such findings do not provide a complete understanding of the way emerging organizational principles for manufacturing systems re-shape the use of AMT. A major limitation of our research is that the available data do not allow detailed analysis of whether core adopters of SFP arrange AMT differently with respect to key issues, such as IT architecture, data management and access, change management, and the empowerment of the workforce. However, some managerial implications do emerge, such as the following.

• Massive automation alone is not necessarily required in order to achieve performance improvements, since there are excellent manufacturers who effectively pursue strategic multi-focusedness, integrate their business processes and develop process ownership without relying on company-wide use of computerized applications.

• Integration of stand-alone AMT should be accompanied by an orientation towards SFP; in fact, CI alone has a limited independent effect on performance improvements and only on product variety. It would appear that networking stand-alone AMT should be implemented in the light of SFP, i.e., with (i) a ‘‘process view’’ rather than functional perspective and (ii) the development of process ownership (delegation, empowerment, involvement, re-skilling, etc.) in order to support (iii) strategic multi-focusedness and flexibility. This is consistent with recent

findings linking the efficacy of CIM investments to customer focus (Brynjolfsson and Hitt, 1995) and recognizing that CIM effectiveness is moderated by the integration of jobs, strategies and partners within the supply chain (Parthasharty and Yin, 1996), or by infrastructural improvement programs, such as quality leadership, worker empowerment and soft integration (Boyer et al., 1997).

Further research is needed to overcome the major limitations of this study. In particular, investigation of the qualitative aspects of AMT implementation which go beyond the mere quantitative measure of companies' ''technological intensity'' will support a deeper understanding of how SFP and AMT combine and interact to provide superior performance. Such work should substantiate the above recommendations, which at present are still tentative. Research based on case studies has recently addressed this issue, and guidelines and interpretation have been proposed (e.g., Vonderembse et al., 1997). However, these preliminary findings should be extended with broader evidence from survey studies.

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Appendix A

The orientation to SFP was measured by a methodology based on fuzzy set theory. The model was built as follows:

1. stepwise disaggregation of the original, complex concept — SFP — into categories of decreasing complexity and increasing measurability;
2. stepwise aggregation of the measures at the lowest level of the tree into synthetic indicators of the orientation to the three principles of multifocusedness, process integration and process ownership;
3. definition of classes of adoption according to the orientation to the three principles.

The first step in the process took account of the literature on the principles of multi-focusedness, process integration, process ownership (see Section 2.2). Each principle was disaggregated into sub-principles (i.e., the application of the principles to different areas or parts of the organization); sub-principles were then disaggregated into necessary attributes with which a production system must comply in order to be oriented to the single sub-principle; attributes were then linked to

various managerial levers or operational conditions (required to meet the above attributes); finally, indicators of both the use of levers and the operational conditions were determined. Fig. 1 shows the first two levels of the hierarchical tree, i.e., the principles and sub-principles. Indicators considered for each principle ranged from nominal to interval (Likert-like) or ratio scales. These are listed below (for a detailed description of the whole tree, see Cagliano and Spina, 1996).

Multi-focusedness:

- number of top business priorities
- number of top manufacturing priorities
- relevance of reduction in manufacturing lead time (as a way to shift trade-off between different manufacturing performance measures)

Process Integration

- cooperation in the development process
- proportion of JIT deliveries
- participation of manufacturing in the design process
- use of line layout
- proportion of cellular manufacturing in total activities
- proportion of workforce working in teams
- proportion of multi-skilled operators
- frequency of job rotation
- influence of manufacturing in defining competitive strategy

Process Ownership

- number of employees per foreman
- number of hierarchical levels
- responsibility for shop-floor scheduling and control
- hours of training per year for regular workforce
- hours of training for new workers
- proportion of preventive quality costs
- proportion of preventive maintenance
- payment system type and base
- short-term absenteeism rate
- number of suggestions per employee
- personnel turnover rate

A second step calculated synthetic indicators based on the above variables. First, all the variables were translated into a degree of membership of a given principle, ranging from 0 to 1, by defining a membership function $\mu(X)$ for each basic variable (see e.g., Zimmermann, 1993). The shape of the membership functions was assessed using reasonableness criteria and theoretic guidelines. Two main types of functions were used, following Zimmermann (1993): discrete membership functions, where the variables are measured on nominal scales (Type A

— Membership Model), and simplified, S-shaped curves, as in the case of Likert-like and numerical scales (Type B — Membership Model). In both cases, the definition of the functions required assessment of the degree of membership corresponding to different levels of the original variable. This process was primarily based on the literature discussing worldwide best practice in the assembly industry (e.g., Womack et al., 1990), since most of the indicators are frequently used in case studies. A degree of membership equal to 1 was set as the highest level of performance, while a degree of membership equal to 0 was set as the minimum ''industry standard'', i.e., the level in companies with a traditional approach to production system management and organization. These values were checked against the upper and lower quartiles of the distribution of each indicator in the IMSS sample.

Subsequently, the degrees of membership expressed by the membership functions were aggregated into a synthetic measure. Variables at the same hierarchical level were linked by either an *and* or an *or* logical operator. The *and* aggregation represents the co-presence of the items in order to meet the concept of the upper level. The *or* aggregation is used when single mechanisms can be regarded as alternatives. The list below shows the aggregating operators used in the model.

- AND: min $\{\mu_a(X), \mu_b(X)\}$
- FUZZY AND: $\alpha * \min \{\mu_a(X), \mu_b(X)\} + (1 - \alpha) * \text{average } \{\mu_a(X), \mu_b(X)\}$
- FUZZY OR: $\alpha * \max \{\mu_a(X), \mu_b(X)\} + (1 - \alpha) * \text{average } \{\mu_a(X), \mu_b(X)\}$
- OR: max $\{\mu_a(X), \mu_b(X)\}$

The outcome of these operations is a synthetic indicator of the degree of orientation to each principle of SFP, ranging from 0 (non orientation) to 1 (complete orientation). With these measures, the third step in the process built a framework to categorize companies according to their adoption of the overall SFP concept. The methodology for this step is described in Section 4.3. Three classes of adoption were defined: (1) complete adoption, referring to the companies using all three principles (core adopters); (2) partial adoption, i.e., companies using two of the three basic principles (partial adopters); (3) non adoption, i.e., companies using only one principle or not using any principle (non adopters).

Obviously, the above classification of the adoption of SFP embodies much subjectivity in the selection of the indicators, the definition of the membership functions and the aggregation logic. Some of these aspects, e.g., the aggregation logic and the shape of membership functions, are hypotheses within the model. Others, such as the parameters of the curves, require that the robustness of the model be verified.

A sensitivity analysis verified that when the parameters of the model altered (i) the ranking of the companies by degree of orientation would not suffer significant change, and (ii) the membership to the three classes of the model (see Fig. 3) would not be significantly affected.

References

Abernathy, W.J., Clark, K.B., Kantrow, A.M., 1983. Industrial Renaissance: Producing a Competitive Future for America, Basic Books, New York, NY.

Armistead, C., Harrison, A., Rowlands, P., 1995. Business process re-engineering: lessons from operations management. International Journal of Operations and Production Management 15 (12), 46-58.

Babbar, S., Rai, A., 1990. Computer integrated flexible manufacturing: an implementation framework. International Journal of Operations and Production Management 10 (1), 42-50.

Beatty, C.A., 1992. Implementing advanced manufacturing technologies. Sloan Management Review 33 (4), 47-60.

Beatty, C.A., Gordon, J.R.M., 1988. Barriers to the Implementation of CAD/CAM Systems. Sloan Management Review 29 (4), 25-33.

Boer, H., Hill, M.R., Krabbendam, J.J., 1990. FMS implementation management: promise and performance. International Journal of Operations and Production Management 10 (1), 32-40.

Boyer, K.K., Ward, P.T., Leong, G.K., 1996. Approaches to the factory of the future — an empirical taxonomy. Journal of Operations Management 14 (4), 297-313.

Boyer, K.K., Leong, G.K., Ward, P.T., Krajewski, L.J., 1997. Unlocking the potential of advanced manufacturing technologies. Journal of Operations Management 15 (4), 331-347.

Brynjolfsson, E., Hitt, L., 1995. Information technology as a factor of production: the role of differences among firms. Economy of Innovation and New Technologies 3, 183-199.

Cagliano, R., Spina, G., 1996. Assessing the orientation of factories to the emerging manufacturing paradigm. A fuzzy based research methodology, Proceedings of 3rd Congress of SIGEF, Buenos Aires, Paper no. 2.5, pp. 1 -26.

Davenport, T.H., 1993. Process Innovation: Reengineering Work through Information Technology, Harvard Business School Press, Boston, MA.

Davenport, T.H., Short, J.E., 1990. The new industrial engineering: information technology and business process redesign. Sloan Management Review 31 (4), 11-27.

Dean, J.W., Susman, G.I., 1989. Organizing for manufacturable design. Harvard Business Review 67 (1), 28-36.

De Meyer, A., 1987. The integration of information systems in manufacturing. Omega 15, 229-238.

De Meyer, A., 1992. The Development/Manufacturing Interface: Empirical Analysis of the 1990 European Manufacturing Futures Survey. In: Susman, G.I. (Ed.), Integrating Design of Manufacturing for Competitive Advantage, Oxford Univ. Press, New York, pp. 69-81.

Drucker, P.F., 1990. The emerging theory of manufacturing. Harvard Business Review 68 (3), 94-102.

Duimering, P.R., Safayeni, F., Purdy, L., 1993. Integrated manufacturing: redesign the organization before implementing flexible technology. Sloan Management Review 34 (4), 49-56.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A., Flynn, E.J., 1990. Empirical research methods in operations management. Journal of Operations Management 9 (2), 250-284.

Gerwin, D., 1982. Do's and don'ts of computerized manufacturing. Harvard Business Review 60 (2), 107-116.

Gerwin, D., 1993. Manufacturing flexibility: a strategic perspective. Management Science 39 (3), 395-410.

Goguen, J.A., Jr., 1981. Concept representation in natural and artificial languages: axioms, extensions and applications for fuzzy sets. In: Mamdani, E.H., Gaines, G.R. (Eds.), Fuzzy Reasoning and Its Applications, Academic Press, London.

Goldman, S.L., Nagel, R.N., Preiss K., 1995. Agile Competitors and Virtual Organizations, Van Nostrand Reinhold, New York, NY.

Griffin, A., Hauser, J.R., 1992. Patterns of communications among marketing engineering and manufacturing. Management Sciences 38, 360-373.

Gunn, T.G., 1987. Manufacturing for Competitive Advantage. Becoming a World Class Manufacturer, Ballinger Publ., Cambridge, MA.
Hammer, M., 1990. Re-engineering work: don't automate, obliterate. Harvard Business Review 68 (4), 104-112.
Hammer, M., Champy, J., 1993. Re-engineering the Corporation, Free Press, New York, NY.
Harrington, H.J., 1991. Improving Business Process, Total Quality Management, February, 39-41.
Hayes, R.H., Pisano, G.P., 1996. Manufacturing strategy: at the intersection of two paradigm shifts. Production and Operations Management 3 (1), 25-41.
Hayes, R.H., Wheelwright, S.C., Clark, K.B., 1988. Dynamic Manufacturing. Creating the Learning Organization, The Free Press, New York, NY.
Hirschhorn, L., 1984. Beyond Mechanization: Work and Technology in a Postindustrial Age. MIT Press, Cambridge, MA.
Huber, G.P., McDaniell, R.R., 1986. The decision making paradigm of organizational design. Management Sciences 32, 572-589.
Jaikumar, R., 1986. Postindustrial manufacturing. Harvard Business Review 64 (6), 69-76.
Johansson, H.J., McHugh, P., Pendlebury, A.J., Wheeler, W.A., III, 1993. Business Process Reengineering — Breakpoint Strategies for Market Dominance, Wiley, New York, NY.
Kaplan, R.S., 1986. Must CIM be justified by faith alone. Harvard Business Review 64 (2), 87-95.
Kaplan, R.S., Murdock, L., 1991. Core process redesign. The McKinsey Quarterly 2, 27-43.
Karlsson, C., 1996. Radically new production systems. International Journal of Operations and Production Management 16 (11), 8-19.
Kenney, M., Florida, R., 1989. Japan's role in a post-Fordist age, Futures, April, 136-151.
Ketchen, D.J. Jr., Shook, C.L., 1996. The application of cluster analysis in strategic management research: an analysis and critique. Strategic Management Journal 17, 441-458.
Lehmann, D.R., 1979. Market Research and Analysis, Irwin, Homewood, IL.
Meredith, J.R., 1987. Automating the factory: theory versus practice. International Journal of Production Research 25 (10), 1493-1510.
Miller, J., Roth, A., 1994. A taxonomy of manufacturing strategies. Management Science 40 (3), 285-304.
Nemetz, P.L., Fry, L.W., 1988. Flexible manufacturing organizations: implications for strategy formulation and organization design. Academy of Management Review 13, 627-638.
Nunnally, J.C., 1978, Psychometric Theory, McGraw-Hill, New York, NY.
OECD, 1996. Technology, Productivity and Job Creation, DSTI/IND/STP/ICCP, Paris, Chap. 6 ''Technology and the changing nature of jobs: organisational changes and the nature of jobs''.
Parthasharty, R., Sethi, S.P., 1992. The impact of flexible automation on business strategies and organizational structure. Academy Management Review 17 (1), 11-86.
Parthasharty, R., Yin, J.Z., 1996. Computer-integrated manufacturing and competitive performance. Moderating effects of organization-wide integration. Journal of Engineering and Technology Management 13, 83-110.
Roobeek, A., 1987. The Crisis in Fordism and the Rise of a New Technological Paradigm, Futures, April, 129-154.
Rosenthal, S., 1984. Progress towards the factory of the future. Journal of Operations Management 4 (3), 203-229.
Schonberger, R.J., 1986. World Class Manufacturing. The Lesson of Simplicity Applied, Free Press, New York, NY.
Schonberger, R.J., 1990. Building a Chain of Customers. The Free Press, New York, NY.
Scott Morton, M.S., 1991. The Corporation of the 1990s: Information Technology and Organizational Transformation. Oxford Univ. Press, New York, NY.
Small, M.H., Yasin, M.M., 1997. Advanced manufacturing technology: implementation policy and performance. Journal of Operations Management 15 (4), 349-370.

Somers, T., Gupta, Y.P., 1991. Factory automation: US versus Japanese experiences. Manufacturing Review 3 (4), 157-166.

Spina, G., 1998. Manufacturing paradigms versus strategic approaches: a misleading contrast. International Journal of Operations and Production Management 18 (8).

Spina, G., Bartezzaghi, E., Bert, A., Cagliano, R., Draaijer, D., Boer, H., 1996. Strategically flexible production: the multifocused manufacturing paradigm. International Journal of Operations and Production Management 16 (11), 20-41.

Spina, G., Verganti, R., 1993. Designing and implementing CIM to support the lean production paradigm. In: Kooij, C., MacConnail, P.A., Bastos, J. (Eds.), Realizing CIM's industrial potential, IOS Press, pp. 268-278.

Susman, G.I., 1992. Integrating Design and Manufacturing for Competitive Advantage. Oxford Univ. Press, New York, NY.

Udo, G.J., Ehie, I.C., 1996. Advanced manufacturing technologies — determinants of implementation success. Intemational Journal of Operations and Production Management 16 (12), 6-26.

Van de Ven, A.H., 1986. Central problems in the management of innovation. Management Sciences 32, 590-607.

Vonderembse, M.A., Raughunathan, T.S., Subba Rao, S., 1997. A post-industrial paradigm: to integrate and automate manufacturing. International Journal of Production Research 35 (9), 2579-2599.

Walton, R.E., Susman, G.I., 1987. People policies for the new machines. Harvard Business Review 65 (2), 98-106.

Ward, P., Leong, G.K., Boyer, K.K., 1994. Manufacturing proacliveness and performance. Decision Science 25 (3), 337-358.

Womack, J.P., Jones, D.T., Ross, D., 1990. The Machine that Changed the World. Macmillan, London.

Zadeh, L.A., 1965. Fuzzy sets. Information and Control 8, 338-353.

Zeleny, M., Cornet, R., Stoner, J.A.F., 1990. Moving from the era of specialization to the era of integration. Human System Management 9, 153-171.

Zimmermann, H.J., 1993. Fuzzy Set Theory and its Application, 6th edn. Kluwer Academic Publishers, London.

Zimmermann, H.J., Zysno, P., 1983. Decision and evaluations by hierarchical aggregation of information. Fuzzy Sets and Systems 10, 243-266.

Zuboff, S., 1982. New worlds of computer-mediated work. Harvard Business Review 60 (5), 142-152.

4.2 Review and Outlook

4.2.1 Strategically Flexible Production Anno 2000

Around and after the year 2000, when Raffaella Cagliano and Gianluca Spina published their paper entitled *Advanced Manufacturing Technologies and Strategically Flexible Production* (Cagliano and Spina 2000), a range of new production concepts started to emerge, including agile manufacturing (Goldman et al. 1995), Enterprise 2.0 (McAfee 2006), Factories of the Future (origin not entirely clear, but adopted by the EU in its Horizon 2020 program; e.g. EU 2013), Industry 4.0 (Kagermann et al. 2013) and the Smart Factory (origin not clear either; a keystone in Industry 4.0).

According to Google Scholar, the Cagliano and Spina paper has been cited around 100 times since it was published in 2000. However, the paper is much more important than what that number suggests.

The paper does two important things. First, building on Spina et al. (1996), it reemphasises the importance of strategic flexibility, "… the ability to rapidly shift competitive and manufacturing priorities from one set of goals to another, within the same manufacturing system. This principle challenges the traditional assumption about rigid trade-offs involving manufacturing performances" (Spina et al. 1996, p. 24). In that sense, strategic flexibility is akin to the capability to balance exploration and exploitation excellence effectively (March 1995), or what Boer (2001) calls continuous innovation capability, which builds on strategic, innovation and operational excellence.

Second, Cagliano and Spina (2000) draw attention to the important role of technology in combining these forms of excellence, which many authors, either implicitly or quite explicitly, have long considered as antithetical (e.g. Burns and Stalker 1961; Skinner 1974; Porter 1980), and which March (1995) describes as a balance which "… organizations persistently fail to maintain …" (March 1995, p. 433).

As Stacey already foresaw in 1992, in today's global competition, "… you do not see 'either/or' choices. Instead you see 'both/and' choices. Successful organizations—that is, continually innovative organizations—cannot choose between tight, formal control systems and structures on the one hand and loose, informal systems that provoke learning on the other … they must do both at the same time" (Stacey 1992, p. 19).

Spina et al. (1996) analyse data collected through the first International Manufacturing Strategy Survey (IMSS-I) and show that 83 (19 %) of the 443 companies considered are strategically flexible companies. These companies combine multi-focusedness, process ownership and process integration which, taken together, provide Strategically Flexible Production (SFP) capability. Compared to firms that have adopted none or only one or two of the three characteristics, strategically flexible companies have a consistently better:

- Improvement capability on a wide range of operational performance criteria;
- Capability to rapidly shift competitive and manufacturing priorities from one set of goals to another.

Cagliano and Spina (2000) build on the SFP concept and focus on the role of technology in supporting strategic flexibility capability. In view of the analysis and outlook developed further on in this contribution, it is important to report how they operationalise their core constructs.

According to Spina et al. (1996), strategic flexibility requires a combination of:

- Multi-focusedness, i.e. the pursuit of a number of different objectives simultaneously;
- Process integration, across the internal functions and with both customers and suppliers;
- Process ownership, by involving all employees at any hierarchical level, in decision-making and problem solving.

Technology is operationalised as:

- The use Advanced Manufacturing Technology (AMT) in the form of:
  - Stand-alone equipment—numerically controlled machines, machining centres, fabrication and assembly robots;
  - Computer software—CAD, CAPP, CAE and CAM systems, MRP[2];
- The extent to which production processes and equipment are integrated across manufacturing departments and with other functions, grouped to form the following Computer Integration (CI) scale:
  - Island automation—stand-alone machines of machining centres, work cells;
  - Production integration—integration of automated equipment and computer software in cells or flexible manufacturing or assembly systems;
  - Cross-functional integration—integration of equipment and software across different functions, e.g. integration of demand management and order processing and production scheduling and control (through MRP) or the design/engineering functions (through CAD, CAPP, CAE and/or CAM).

Using the same IMSS-I sample as Spina et al. (1996), Cagliano and Spina (2000) identify 392 companies that provided enough data for the evaluation of their hypotheses. They adopt the same methodology as Spina et al. (1996), fuzzy logic, which is based on fuzzy set theory (see Appendix A in Cagliano and Spina 2000) to analyse the data.

Based on a range of considerations, reported in detail in the paper, they hypothesise:

H1A SFP does not lead firms to a higher use of stand-alone AMT.
H1B SFP leads firms to a greater integration of AMT.
H2A The use of stand-alone AMT varies considerably within companies that are highly oriented towards SFP.

[2]CAD: Computer Aided Design; CAP: Computer Aided Process Planning; CAE: Computer Aided Engineering; CAM: Computer Aided Manufacturing; MRP: Manufacturing Resource Planning.

H2B The level of integration of stand-alone AMT varies considerably within companies that are highly oriented to SFP.
H3A Stand-alone AMT per se does not provide companies with greater improvement in manufacturing performance.
H3B Both SFP and the integration of AMT provide companies with greater improvement in manufacturing performance; the joint adoption of SFP and CI is expected to further improve performance.

The analyses reported in the paper support all these hypotheses. In their discussion of the findings, Cagliano and Spina (2000, p. 186) conclude:

- The research provides "… indirect confirmation of the need to re-shape the concept of CIM as it evolved in the eighties and early nineties in line with emerging organizational and managerial rationales that have proved to be effective".
- "… firms that implement advanced organizational practices not always perceive extensive automation and IT-based integration as the primary source of innovation, even though various AMT, together with organizational innovations, are often adopted successfully within the broader context of different manufacturing strategies".
- "Technology alone does not provide companies with better overall performance […], but the joint use of technological and organizational innovation can have an effect on several performance measures. However, high levels of performance improvement are not necessarily reached through extensive automation and IT-based integration".

4.2.2 Strategically Flexible Production Anno 2015

This was the picture in 2000, at the turn of the century. What happened since?

First, the business and societal world is much more global today and has really become the global village, which the Canadian philosopher of communication theory Marshall McLuhan predicted as early as the 1960s. China opened its economy more than ever and has become a formidable player in the world economy. Traditional investment targets such as the BRICS[3] countries now represent around 20 % of the world gross product and have started investing in Western countries. In effect, strategic flexibility has become even more important, certainly for industries in the old industrialised countries.

Second, and at the same time, enormous progress has been made in manufacturing and operations management technology. Today, we talk about concepts such as Enterprise 2.0, the Factory of the Future, Industry 4.0 and the Smart Factory. Let us look at each of these concepts in more detail.

[3]Brazil, India, China, Russia and South Africa.

The term Enterprise 2.0 was coined by McAfee (2006). It refers to the use of social software platforms within companies, or between companies and their partners or customers, which enable people to meet, connect or collaborate through computer-mediated communication and to form online communities. McAfee uses the acronym SLATES to indicate the six components of Enterprise 2.0 technology: Search, Links, Authoring, Tags, Extensions and Signals. While Enterprise 2.0 is targeted at knowledge workers, the three other concepts are rather focused on industrial production.

The Factory of the Future is a concept launched by the European Union (e.g. EU 2013). For 2016 and 2017, €278 million are available for research projects. One of the topics in the 2016 call of the Horizon 2020 "Factories of the Future" program is "continuous adaptation of work environments with changing levels of automation in evolving production systems". Whereas the other topics are largely technological, this topic recognises the continued importance of the human factor, saying: "In the past, and due to human flexibility, workers were expected to adapt to machine requirements. However, today's machines increasingly allow these roles to be reversed with automation systems becoming ever more adaptable to the capabilities of workers, and work organization [becoming] more flexible in terms of time and place. Furthermore, higher levels of product customization and variable requirements, call for new adaptive human-centred automation approaches, complementing the cognitive capabilities of humans by advanced sensing and the higher precision of machines. Modern manufacturing system design builds on an optimal and continuous distribution of tasks between humans and machines for higher performance, adaptability and quality" (EU 2015).

Some words and phrases describing the intention of the research falling under this topic are: adequate levels of automation, optimal flexibility, agility, competitiveness of highly customized production, accommodation to the worker's skills and flexibility needs, adaptation of workplaces to the physical, sensorial and cognitive capabilities of workers, safety and health at work, worker satisfaction, engagement of workers in the design and adaptation of their workplace, virtual and/or augmented reality to support process and workplace simulations, industrial social networking with rich user experience for knowledge capture and decision support with a strong focus on usability, user acceptance and training (EU 2015).

Industry 4.0, the 4th phase in industrial development,[4] got its name from a project initiated by the German government. Kagermann et al. (2013) report the project as follows. Integrating cyber-physical systems into manufacturing and logistics and deploying the Internet of Things and Services in industrial processes, key characteristics of Industry 4.0 are the strong customisation of products supported by highly flexible production processes and equipment. The required automation technology includes methods of self-optimisation, self-configuration,

[4]The first three phases are water/steam power, followed by electrical power and, next, information/computing power.

self-diagnosis, cognition and intelligent support of workers in their increasingly complex work. Keystones in Industry 4.0 are (Kagermann et al. 2013, p. 5):

- Cyber-physical systems comprising "… smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently".
- Smart factories with:
  - "Smart products [that] … know their own history, current status and alternative routes to achieving their target state".
  - Manufacturing systems [that] "… are vertically networked with business processes within factories and enterprises and horizontally connected to dispersed value networks that can be managed in real time—from the moment an order is placed right through to outbound logistics … [and] … both enable and require end-to-end engineering across the entire value chain".

The potentials of Industry 4.0 include meeting individual customer requirements, last minute production changes, responding flexibly to disruptions and failures in supply, end-to-end transparency and new business models enabling new ways of creating values. Finally, Industry 4.0 "will address and solve … challenges … such as resource and energy efficiency, … release workers from … routine tasks … [and enable] them to focus on creative, value-added activities … [and] … create [flexible forms of] work organization … [that] … enable workers to combine their work, private lives and … professional development more effectively …" (Kagermann et al. 2013, p. 5).

The origins of the term Smart Factory are not quite clear. However, experts (e.g. Zühlke 2010; Hessman 2013; Alessi and Gummer 2014) agree on a range of characteristics of which connectedness seems to be the most important one. In Smart Factory environments, entire production chains—from suppliers to logistics to the life cycle management of a product—are closely connected across corporate boundaries. Similarly, individual production steps are seamlessly connected, from product development, production planning, engineering and scheduling, actual fabrication and assembly processes, production control, including quality control, through to logistics. All kinds of technologies are used, including control technologies, sensors and actuators, to provide machinery and equipment with the ability to improve processes through self-optimisation and autonomous decision-making.

Changes in work and work organisation are often mentioned in Industry 4.0 and Smart Factory publications. However, these publications either predict these changes or raise questions for future research. Kagermann et al. (2013, pp. 6–7), for example, write: "In smart factories, the role of employees will change significantly. Increasingly real-time oriented control will transform work content, work processes and the working environment. Implementation of a socio-technical approach to work organization will offer workers the opportunity to enjoy greater

responsibility and enhance their personal development". As workers' job and competence profiles will be radically different, "[i]t will … be necessary to implement appropriate training strategies and to organize work in a way that fosters learning, enabling lifelong learning and workplace-based [continuing professional development]". Richter et al. (2015) predict that workers at factories of the future gain autonomy, competence, connectedness and work variety through new forms of ICT. Based on an explorative literature study, Lampela et al. (2015) note that the smart factory will require "… tasks that are typically regarded as knowledge work: information and knowledge processing, decision-making and problem-solving. However, the factory context, the tasks performed at the production line and the physical environment differ considerably from the typical office environments designed for knowledge workers". Advanced technologies "… provide process, job, and task level information to employees in a personalized form to support their daily work … enhance knowledge sharing, communication and collaboration" but require "new types of incentives, feedback mechanisms and training through … mobile devices, 3D-simulations and virtual environments with personalized learning content". Lampela et al. (2015) also raise a couple of issues for further research, including the role of different knowledge environments in manufacturing, a mapping of the possibilities of new knowledge work tools on knowledge sharing processes and practices amongst factory workers.

4.2.3 So, What Are We Heading For?

Since Cagliano and Spina's study, published in 2000 but based on data collected in 1994, obviously many things have changed and some of these changes are rather dramatic. The need for strategic flexibility capability is larger than ever, especially in Western economies. The four technological concepts addressed above promise a lot. However, the opportunities and also the challenges for workers and work organisation are equally large.

If we put Cagliano and Spina's (2000) conclusions in the perspective of the current smart technologies, some interesting questions emerge.

First, Cagliano and Spina indirectly confirm "… the need to re-shape the concept of CIM as it evolved in the eighties and early nineties in line with emerging organizational and managerial rationales …". Well, CIM is not what it used to be before the turn of the century. We see much higher levels of autonomy, including self-optimisation, self-configuration and self-diagnosis, and integration all the way from multi-technology machines,[5] through seamlessly connected production steps and the technologies used to perform and control these steps, to entire, closely connected, production chains reaching across company boundaries. It would seem

[5]Note that the autonomy of machines in the Smart Factory, in the form of self-optimisation, self-configuration and self-diagnosis, is due to the *integration* of actuators and sensors into the machines.

that today, perhaps, the conclusion should go the other way around, namely that there is a need to reshape organisational and managerial rationales to the emerging characteristics of smart technology.

Second, Cagliano and Spina conclude that "… firms that implement advanced organizational practices not always perceive extensive automation and IT-based integration as the primary source of innovation …". Here the role of the current smart technologies is less clear. The literatures referred to above do refer to customisation, adaptability, flexibility, innovation, and development of new business models and new ways of creating value. The most likely effect of technology is that it enables these dynamic capabilities, especially if it comes to the actual implementation and launch of innovations. The creation of innovations, from the fuzzy front-end ideation phase through to the design of new products, processes, technologies or business models, will largely remain the domain of human ingenuity.

Finally, Cagliano and Spina put forward that "[t]echnology alone does not provide companies with better overall performance […], but the joint use of technological and organizational innovation can have an effect on several performance measures. However, high levels of performance improvement are not necessarily reached through extensive automation and IT-based integration". It would seem that the former is still very true. Many authors mention changes in work and work organisation as a consequence and often as a benefit of smart technology. As to the latter, the jury is out. In Industry 4.0 and its (Smart) Factories of the Future, with Enterprise 2.0 knowledge workers, performance excellence is probably highly dependent on smart technology.

4.2.4 Further Research

The above analysis suggests the following hypotheses, some of which are similar to, some the opposite of Cagliano and Spina's (2000) versions, see Table 4.1.

Some, mostly case-based, research on the "oldest" of the four concepts introduced above, Enterprise 2.0, has been reported (e.g. Corso et al. 2008). No rigorous research has so far been conducted on the reality of Industry 4.0, the Factory of the Future, the Smart Factory. There are some state-of-the-art studies (e.g. Deloitte 2015) and case descriptions or references to existing Smart Factories (e.g. Siemens' Electronic Works facility, Amberg; BASF's pilot plant at the German Research Center for Artificial Intelligence, Kaiserslautern; Robert Bosch GmbH, Homburg; Audi's A4*/A5*/Q5 assembly facility, Ingolstadt). The total sample is simply too small to do large-scale studies. That should not stop us, though, to start exploring the hypotheses formulated in Table 4.1, which represents just a few of many possible directions of research. Consider for example the influence of contextual factors such as process type—e.g. high volume car manufacturing versus low volume airplane production, and company size—is smart manufacturing indeed something for medium-sized companies, as suggested by Papadopoulou

Table 4.1 The 2000 hypotheses versus the 2015 hypotheses

	The 2000 hypotheses	The 2015 hypotheses
H1A	SFP does not lead firms to a higher use of stand-alone AMT	SFP does not lead firms to a higher use of stand-alone smart technology
H1B	SFP leads firms to a greater integration of AMT	Smart technology is a prerequisite for SFP
H2A	The use of stand-alone AMT varies considerably within companies that are highly oriented towards SFP	Companies that are highly oriented towards SFP use smart, i.e. highly autonomous and integrated, technology
H2B	The level of integration of stand-alone AMT varies considerably within companies that are highly oriented to SFP	
H3A	Stand-alone AMT per se does not provide companies with greater improvement in manufacturing performance	Companies that are highly oriented towards SFP do not use stand-alone AMT, as it does not provide them with adequate levels of manufacturing performance and improvement thereof
H3B	Both SFP and the integration of AMT provide companies with greater improvement in manufacturing performance; the joint adoption of SFP and CI is expected to further improve performance	Both SFP and smart technology provide companies with greater improvement in manufacturing performance; the joint adoption of SFP and smart technology is expected to further improve performance

(2014)? Will the smart factory provide the breakthrough to "operations management heaven" and enable companies to seriously get off the diagonal in the product-process matrix (Hayes and Wheelwright 1984), and achieve the benefits of low and high volume production, flexibility and efficiency, simultaneously, indeed? And, finally, is there a future for unskilled, semi-skilled or even skilled labour in Industry 4.0 Smart Factories of the Future, or will production work of the future require Enterprise 2.0 knowledge workers educated and trained at higher vocational or even academic level? If the latter appears to be the case, what will be the societal consequences if smart production becomes the dominant paradigm?

How much would Gianluca have loved taking up some of these research challenges, and how much would we, his friends and colleagues, have loved doing that together with him. We will miss him.

References

Alessi, C., & Gummer, C. (2014). Germany bets on 'smart factories' to keep its manufacturing edge. *The Wall Street Journal* (October 26).

Boer, H. (2001). *And [Jethro] said … Learning: The link between strategy, innovation and production. Inaugural lecture*. Aalborg: Aalborg University, Center for Industrial Production.

Burns, T., & Stalker, G. M. (1961). *The management of innovation*. London: Tavistock.

Cagliano, R., & Spina, G. (2000). Advanced manufacturing technologies and strategically flexible production. *Journal of Operations Management*, *18*(2), 169–190.

Corso, M., Martini, A., & Pesoli, A. (2008). Enterprise 2.0: What models are emerging? The results from a 70 case-based research. *International Journal of Knowledge and Learning, 4*(6), 595–612.

Deloitte. (2015). *Industry 4.0. Challenges and solutions for the digital transformation and use of exponential technologies*. Zürich: Deloitte.

EU. (2013). Factories of the future. *Multi-annual roadmap for the contractual PPP under Horizon 2020*. Retrieved on November 5, 2015, http://effra.eu/attachments/article/129/Factories%20of%20the%20Future%202020%20Roadmap.pdf

EU. (2015). *Continuous adaptation of work environments with changing levels of automation in evolving production systems*. Retrieved on October 31, 2015, http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2370-fof-04-2016.html

Goldman, R. L., Nagel, R., & Preiss, K. (1995). *Agile competitors and virtual organizations*. New York: Van Nostrand Reinhold.

Hayes, R. H., & Wheelwright, S. C. (1984). *Restoring our competitive edge. Competing through manufacturing*. New York: Wiley.

Hessman, T. (2013, February 14). The dawn of the smart factory. *Business Week*, pp. 15–19.

Kagermann, H., Wahlster, W., & Helbig, J. (Eds.). (2013). *Securing the future of German manufacturing industry. Recommendations for implementing the strategic initiative Industrie 4.0. Final report of the Industrie 4.0 working group*. Frankfurt am Main: Acatech e.V.

Lampela, H., Heilmann, P., Hurmelinna-Laukkanen, P., Lämsä, T., Hyrkäs, E., & Hannola, L. (2015). Identifying worker needs in implementing knowledge work tools in manufacturing. In: *17th ILERA World Congress*, Cape Town, 7–11 September.

March, J. G. (1995). The future, disposable organizations and the rigidities of imagination. *Organization, 2*, 427–440.

McAfee, A. P. (2006). Enterprise 2.0: The dawn of emergent collaboration. *MIT Sloan Management Review, 47*(3), 21–28.

Papadopoulou, D. (2014). *Industrie 4.0—Smart factory: Also something for medium size companies*? Retrieved on November 7, 2015, https://www.linkedin.com/pulse/20140715201857-54916794-industrie-4-0-smart-factory

Porter, M. E. (1980). *Competitive strategy. Techniques for analyzing industries and competitors*. New York: The Free Press.

Richter, A., Heinrich, P., Stocker, A., & Unzeitig, W. (2015). Der Mensch im Mittelpunkt der Fabrik von morgen. *HMD Praxis der Wirtschaftsinformatik, 52*, 690–712.

Skinner, W. (1974). The focused factory. *Harvard Business Review, 52*(3), 113–121.

Spina, G., Bartezzaghi, E., Bert, A., Cagliano, R., Draaijer, D. J., & Boer, H. (1996). Strategically flexible production: The multi-focused manufacturing paradigm. *International Journal of Operations & Production Management, 16*(11), 20–41.

Stacey, R. D. (1992). *Managing the unknowable: Strategic boundaries between order and chaos in organizations*. New York: Wiley

Zühlke, D. (2010). Smart factory. Towards a factory-of-things. *Annual Reviews in Control, 34*(1), 129–138.

Part II
Supply Chain and Purchasing Strategy

Chapter 5
A Model of Codesign Relationships: Definitions and Contingencies. A Review and Outlook

Alberto De Toni and Guido Nassimbeni

Abstract The original paper investigated, with a case study method, the different forms of co-design, i.e. the joint development of products and processes by customer and supplier. Four types of co-design are identified, according to the type of knowledge transferred (product or process) and the degree of interaction between the parties (loose or tight). Results show that the success of co-design depends on the fit between the type of relationship adopted and two contextual factors: the uncertainty of the design endeavour and the relational capabilities. The commentary highlights the original contribution at the time, in terms of both theoretical and methodological approach: the paper proposes a situational approach, showing the need to adapt the type of co-design to the context, and adopts a qualitative method, investigating four co-design projects within the same buying company. Research in this field has been rich in the subsequent years and this paper can be seen as a precursor of the relevance of the relational environment and the eco-system concept, widely adopted today to analyse innovation and product development.

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5.1 Original Paper[1]

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1 Introduction

Buyer-supplier relationships have grown in importance, since ever more firms tend to concentrate investments and resources on their 'core capabilities' and to outsource an increasing amount of product components and subsystems. As a consequence a firm's competitive performance increasingly relies on suppliers' performance in terms not only of cost/productivity, but also of quality, flexibility, timeliness and innovation. In many industries cooperation and partnership started from operating issues, concerning deliveries, inventory and capacity management, logistics and order management [1]. But, cooperation increasingly extends to new product development.

Indeed, in the ever more turbulent business environment, customers ask for higher customisation and innovativeness of products. Thus, the frequency of product innovation endeavours is increasing and the complexity of technologies calls for deep and advanced knowledge. Therefore there is a growing demand for resources and diversified competencies to carry on product development projects. Facing this challenge, firms often resort to suppliers as sources of customised innovation [2,3]. Hence, there is an increasing interest in co-design practice, that is early supplier involvement in the New Product Development process.

[1]Reprinted with permission from: Spina G, Verganti R, Zotteri G (2002) A model of codesign relationships: definitions and contingencies. International Journal of Technology Management 23(4), 304-321.

A wide and heterogeneous literature has recognised the strategic relevance of codesign and has described its practice [4–6] and the related performance improvements regarding cost, quality and development time (see e.g., [7]). However, risks and drawbacks associated with co-design have also been highlighted and poor or even negative impact on product development process performance have been illustrated, thus questioning the general applicability and effectiveness of co-design [8,9]. Finally others have tried to highlight the conditions under which the potential benefits of co-design outweigh its costs [9–12,2]. Such contributions focused mainly on the relational conditions and suggested that mutual trust and frequent exchanges of information are needed to gain the potential benefits of co-design. However, most of them consider buyer-supplier collaboration in product development as a matter of 'shades of grey'. Therefore, the 'intensity' of co-design is often related to performance improvements, disregarding the fact that different kinds of co-design activities can be developed according to different situations. Of course, most popular classifications of buyer supplier collaboration in product development implicitly consider various practices. For example, Kamath and Liker [13] in an evolutionary perspective of such relationships identified four stages of supplier role – contractual, child, mature, partner – characterized by different practices and an increasing level of collaboration. Almost the same early descriptions of co-design practice (e.g., [4,14]) focus on the level of autonomy of suppliers in accomplishing the design tasks up to the so-called 'black box development'. According to such approaches, firms choose the proper degree of co-design depending on the objectives and environmental conditions they are facing (i.e., they choose the proper shade of grey according to the context they are working in). Indeed, Clark and Fujimoto [14] and Lamming [15] suggest that 'grey-box' parts can be distinguished as black-box parts where the auto manufacturer has more influence on the parts internal functioning.

On the whole there is lack of analysis and discussion about the different types of codesign relationships, that are not necessarily characterised by an increasing intensity of collaboration. Rather, it seems that co-design is a 'matter of colours', and not just a matter of shades of grey. Thus, a contingent model is needed to help practitioners to select the type of co-design that suits their situation best, i.e. to select the proper mix of colours.

In the light of the above considerations the aim of this paper is therefore twofold:

1. To provide a classification – a taxonomy – of different kinds of co-design relationships based on empirical in-depth analyses.
2. To discuss contingencies (when and what) under which certain types of co-design are successful, i.e., they produce high performance in the product development process.

In particular, to meet such aims this research assumes the perspective of the decision making process of the customer. Indeed literature often considers the new product development process as a series of inter-connected decision making processes and defines co-design as the involvement of suppliers in those processes. However, so far classifications have mainly focused on the phases of the new

product development processes during which the supplier is involved (e.g. [14]) and the kind of supplier involved in the co-design relationship [13]. In this paper, we will mainly focus on the roles of the suppliers and customers in the decision making processes performed when designing new products. Though it is clear that the decision making process is affected by several contingent factors, in our study we mainly focus on the uncertainty of the transaction which has been highlighted by both the transaction cost theory [16,17] and the theory of managerial decisions [18,19].

The remainder of the paper is organised as follows. Section 2 briefly discusses the methodology. Section 3 introduces a conceptual framework that guides the analysis of the empirical evidence from four in-depth case studies presented in Section 4. Section 5 introduces the different forms of co-design relationships, while Section 6 investigates the domain of applicability of different solutions, in the light of the model presented in Section 4. Finally, Section 7 draws some conclusions and discusses future developments.

2 The model of co-design

On the basis of the literature reviewed we provide a definition of co-design to identify the scope of analysis of this paper. Firstly, a co-design relationship involves the supply of customised innovation (see Figure 1). In this perspective, the transacted good shall be specific. That is, the innovation shall be performed in order to satisfy the specific needs of the customer. Moreover, in co-design relationships the supplier is a source of complementary knowledge. That is, customers look for the know-how needed to properly design the product and do not simply look for a supplier of components they do not want to design (since they are not relevant or they are available on the marketplace). Hence, the transacted good is the know-how and not just the manpower needed to perform relatively standard and non-specific tasks.

Given the above definition, to support the analysis of the rich information gained through case studies, we developed a conceptual framework that identifies co-design relationships in terms of inputs and outputs of a single co-design project.

Seminal works on partnership and co-design highlight that cooperation with suppliers can have many positive outputs [20]. Moreover, most of the previous work in this area identifies a wide set of managerial levers suitable for implementing partnership and codesign (e.g., trust, exchange of information, specific assets) [21,22]. However, the literature lacks a coherent classification of inputs (managerial levers) and outputs (objectives, results) of a co-design relationship.

We classified the levers of co-design into two clusters. A first cluster of levers characterises the technical and organisational situation of the relationship (e.g., prototyping policies, degree of involvement in the project, and innovativeness of the component). These levers can be easily deployed according to the needs of each single project and their effect is bound to the single project (hence they are

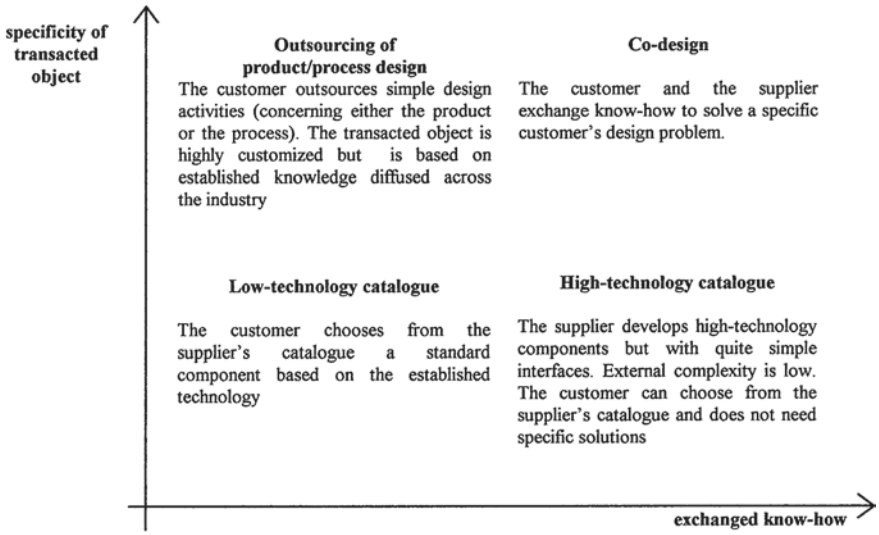

Figure 1 A definition of co-design relationships

named single-project levers). For example, an innovative project might require a close interaction between the customer and the supplier, while, for projects that require only minor improvements of the component a lower level of interaction might be required. Thus the extent to which the customer and the supplier jointly make decisions can be changed according to the needs of each single co-design project and can be considered a single-project lever.

On the other hand, a second cluster of levers has a wider impact on the relationship. These levers are set '*una tantum*' (once for many projects) since they have a longer-term orientation; hence, they tend not to be modified for each single project. For example, the customer typically chooses its vendor-rating criteria according to the general purchasing strategy rather than to a single co-design project. In other words, although the customer checks the quality of the transacted good (i.e., the output of the co-design relationship) at the end of each single project, the performance criteria of a co-design relationship are defined '*una tantum*'. Indeed, metrics shall be common in order to compare results of different projects and decide whether to undertake co-design projects with that supplier in the future or not. This second group of levers has a direct impact on many projects (therefore they are named multi-project levers). They also increase trust since they often give the partner important signals of commitment on the development of the relationship. For example, in one of the cases described later in the paper, the supplier increased its production capacity to respond to the actual and future demand for components from the customer. The capacity is not '*strictu sensu*' component-specific and can be used to manufacture various components from the same family. Obviously, this decision is not related to one single new component, rather it relates to the expectation of future contracts for the purchase of similar

components from the same customer. Although the supplier invests because he expects future purchases from the customer it is worth noticing that this investment is a signal of mutual commitment '*per se*' which dramatically improves mutual trust and the relational environment.

Both single-project and multi-project levers are deployed according to the final goals of the company. In other words, they should depend on the strategy of the firm. In particular, the purchasing and the new product development strategies play a crucial role in defining a co-design relationship [23]. Indeed, in the customer firm, both the Engineering and the Procurement functions cooperate in co-design projects. This highlights a remarkable warning for co-design: an inconsistency between new product development practices (which often tend to involve suppliers to rely on their capabilities and to act in a win-win logic) and purchasing function (which often tends to play a zero sum game) can lead the co-design relationship to fail. In addition, given the strategic objectives the choice of the appropriate coordination levers clearly depends on some contingent variables such as, for example, the characteristics of the component (e.g., innovativeness) and the relational environment (e.g., level of trust).

As previously mentioned both multi-project and single-project levers influence the outputs of the co-design project. The outputs of the project are various and can be clustered according to the clusters of levers. The first, direct performance of the project is the new component. In more detail, the performance criteria are the time and cost spent in the project and the quality of the new component [14]. Both the customer and the supplier are interested in this output since, on the one hand, the competitiveness of the supplier depends on the performance of the component (which is the supplier's product). On the other hand, the competitiveness of the customer depends on the performance of the final product that is influenced by the performance of the component (in terms of time, cost, product performance).

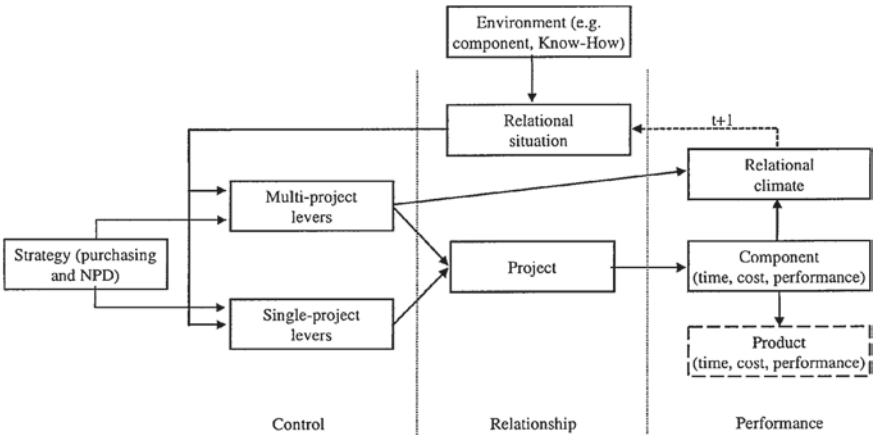

Figure 2 The model of co-design relationships

Furthermore, the output of the single project influences also the relational environment and, thus, contributes to the multi-project level of cooperation between the two firms. The ongoing results of the customer-supplier relationship influence relational variables such as trust, the expectation of relationship duration, organizational behaviours, and conflict resolution policies. For example, we might expect that a customer is not willing to cooperate in the future with a supplier that designed a poorly performing, expensive product and did not meet the deadline of the project. Neither the supplier nor the customer are interested in this relational output '*per se*', since the relational environment generated by the co-design project is not a direct performance improvement. However, this is a crucial output since it influences future projects. In this perspective, the outputs of a co-design project are the inputs for the successive decisions concerning multi-and single-project levers (they describe the status of the relationship before the new project starts). This loop clearly highlights the path dependencies of the relationship. Future developments depend on the actual performance of today's projects to a large extent. Hence, both the supplier and the customer shall consider the effects of their decisions on the relational environment when setting their strategies. Although a good relational environment is not an objective '*per se*', in the long run it can significantly improve the performance of both the customer (product performance) and the supplier (component performance).

3 Methodology

The research presented in this paper stems from a conceptual model presented in Section 2. Indeed this conceptual model introduces the variables at stake in a co-design relationship and represents the conceptual background for the empirical part of the study. In the model the variables are defined, clustered, and their dynamic interactions are discussed. Obviously this model is not the only contribution of the paper but it supports the empirical analyses discussed in the following paragraphs.

Given the exploratory objectives, this research adopts the case study methodology since it provides the great depth of information that is needed in the early phases of research on organisational issues. Indeed, though surveys can help to validate research hypotheses they can hardly provide the depth of information which is needed to identify and define research hypotheses. In addition, when studying customer-supplier relationships in general, and co-design in particular, the research focus should be on the relationship and not on a single firm (though often literature focuses on the customers' side). Thus in each case study, both the supplier and the customer of a given transacted good were investigated. In particular, the four case studies presented in this paper describe the relationships between a major international producer of white goods located in northern Italy and four of its first tier suppliers. For the sake of confidentiality hereinafter the producer of white goods will be named Customer. Customer is a large multi-brand manufacturer with several plants in Europe and the USA. Its European headquarters are located in northern Italy. Customer has several business units (including refrigerators, kitchens,

microwaves) characterised by significantly different products in terms of internal complexity (e.g., number of components and number of different technologies), market share of the firm, volumes. We chose to study four cases from a single business unit (Refrigeration – i.e., refrigerators, freezers, etc.). This makes the four case studies easily comparable. Indeed they belong to the same industry, and there are no differences in terms of the vertical integration and purchasing strategy of the customer. Thus, the differences between the cases are due either to the features of the transacted good, or to the characteristics of the supplier, or to the relational environment. Finally, the case studies were performed at the same time. Thus, time discrepancy of data is avoided (given the high rate of changes in multi-national organisations it might have made the projects hardly comparable).

4 Case studies

This section describes four cases thus providing the empirical data that support the empirical taxonomy discussed in the following sections. Since this paper focuses on codesign relationships, when performing case studies, we selected four cases that fit our definition of co-design (i.e., the supplier provides the customer with the know-how to respond to a specific customer need). Thus the relationships investigated in this paper are in the upper-right portion of Figure 1. Moreover, since this paper aims to identify different forms of co-design we looked for rather different relationships (e.g., in terms of success, innovativeness of the component and of the end-item). Cases A to C involve the development of components for a new chest freezer while case D concerns the development of a component for a one door free-standing refrigerator. This sampling procedure is not suitable for providing any evidence about success rates or average performance of co-design relationships. However, it enables the authors to study both successful and unsuccessful relationships and, thus, discuss which characteristics of the project (in terms of inherent features of the project, fit with the characteristics of the component, the relational and strategic environment) lead to performance improvements and strengthen the customer-supplier relationship. In addition, the authors selected four co-design relationships that were performed at about the same time in order to avoid time discrepancy. Finally, the authors studied four non-standard components that were customer-specific (according to the definition of co-design provided in Figure 1). However, different degrees of innovativeness were considered to investigate whether this feature of the single project has a relevant impact on the organisation of the co-design relationship.

4.1 Case A: lamp-holder

In case A, the supplier (hereinafter called Supplier A) provided Customer with the lamp holder. The lamp-holder is a part of a more complex sub-system consisting

of the lamp, the light switch, the thermostat and some electric connections. The lamp-holder is not very relevant in terms of costs (it accounts for about 1% of the overall cost of the chest freezer). However, it has a relevant impact on the reliability of the final product. Indeed, several electrical connections are co-stamped [24] in the plastic and can provoke reliability problems (for example because of the heat generated by electrical currents). In addition, the lamp-holder has very complex functional and geometrical relationships with the sub-system. Thus, there is a need for great integration between the development of the lamp-holder and other components of the sub-system. In the past, Customer and Supplier A jointly developed a new family of lamp-holders that exploits the potential benefits of the co-stamping technology. So, this relationship could benefit from previous developments both from a technical and a relational perspective. Indeed, on the one hand, only minor design improvements and customisations were needed. On the other hand, the cooperation between the customer and the supplier was relatively easily managed: the successes of past projects helped in building trust and, although the relationships between the component and the sub-system are quite complex, they were identified in previous projects. In other words, the two parties had in the past identified the technical specifications that are needed to describe the component and its interactions with the final product and were able to define them with relatively little organisational effort and within a limited time frame. This enabled the supplier to develop the component and the process with very little interaction with Customer whose role was just to deliver design specifications. In this case the relationship was very successful since it brought about some marginal improvements to the component that contributed to the design of a better final product. Moreoever, the relational environment of the relationship was excellent and further improved by the successful development of this component.

4.2 Case B: hinge

In case B the supplier (hereinafter called Supplier B) tried to develop a new hinge for the external door of the chest freezer. In the past Supplier B had supplied hinges to other business units (e.g., the cooking business unit) of Customer. However, Supplier B had never supplied any hinge to the Refrigeration Business Unit. This unit used to buy standard hinges from the hinge-market leader. In this project, Customer was looking for a completely new hinge, since the strategic marketing function felt that customers were looking for a very thin chest freezer thus asking for a very thin door hinge (the hinge usually juts out from the chest freezer, so it exacerbates the problem). Supplier B and Customer signed a long-term contract and agreed to co-design the ‘thin hinge’. However, several problems occurred in this relationship. First, some re-thinks took place since Supplier B proposed some new concepts for the component that were not consistent with the freezer door. Indeed, Customer took for granted some technical specifications, that Supplier B was not aware of, simply because they had never worked

with the Refrigeration Business Unit before. In other words, the two parties were simply not aware of the information their counterpart needed to perform their task and thus failed to provide it. This resulted in several re-thinks and extra costs. Finally, Customer and Supplier B agreed on a new concept. However, Supplier B failed to meet the technical specifications (in terms of reliability of the component) they had committed to. Indeed, Supplier B had not designed similar products (in terms of final product and environmental condition of usage) in the past and was not able to figure out whether the technical specifications were feasible or not. As a consequence, Customer decided to switch to another supplier both because the component did not match technical specifications and because the development of the hinge would have significantly delayed the launch of the freezer. Moreover, Refrigeration's Strategic Marketing came to consider the thinness of the chest freezer as a minor order winner and so a very specific and thin hinge was no longer needed. This project was a failure since component specifications were unstable, the supplier was not able to supply the component, and the product introduction was delayed. In addition, this project had negative effects on the customer-supplier relationship. Customer did not purchase any hinges from Supplier B. Consequently, the bad results of the project caused the final failure of the relationship.

4.3 Case C: packaging

In this case the supplier (hereinafter called Supplier C) provided Customer with the packaging for the chest freezer. The package has a relatively low impact on overall costs (3% of the overall cost) but significantly influences logistics costs. In addition, in the past the poor design of the packaging caused some damage to the final product which led to some product rejections and damage to the image of the firm. To reduce damage to the product, the engineering function decided to develop a new packaging concept that has very complex geometric relationships with the end-product, in effect tightening the end product to protect it from damage. The packaging was designed by Customer's engineering function. However, Customer decided to design the process for the production of the packaging with its suppliers since its engineering function was not very aware of the process technologies required. The plant that produces freezers is located in central Italy and, since the transportation cost of polystyrene packaging is very high, Customer selected Supplier C in central Italy as the producer for the packaging. Unfortunately, Supplier C had relatively low technical skills. So, Customer chose to develop the process for the packaging with a more skilled supplier located in northern Italy (near Customer's engineering function), while Supplier C was in charge of the production of the packaging. So the local supplier's and Customer's engineering functions, located in northern Italy, were co-designing the packaging that Supplier C (located in central Italy) was supposed to manufacture and Customer's plant (located in central Italy) was supposed to assemble. Customer

designed the new packaging and the local supplier developed the process on the basis of its technical capabilities. Unfortunately, though the component and process designs were consistent with the local supplier's machines, they were completely inconsistent with Supplier C's machines and Customer's assembly lines. It is interesting to note that in this case four organizations were involved and this provoked a weak link between the engineering functions (of Customer and the local supplier) and the production units (of Supplier C and Customer). This seems to be a major concern since on the one hand co-design aims to integrate different skills but, on the other hand, it aims to strengthen the relationships between Component specifications and the production process. Thus the packaging had to be completely re-designed to fit with the production plants at Supplier C and Customer in central Italy. In this case, the outputs of the co-design relationships were negative, indeed neither the component nor the products gained their initial goals (the defect rate was far higher than initial targets). In this case, though Customer kept a good relationship with both suppliers, Customer's managers recognised that the complex organizational structure of the relationship (four organisational units were involved – Customer's engineering function, Customer's plant, Supplier C, and the local supplier) caused significant problems. Thus, though the managers expect to develop partnership agreements with the two suppliers, they do not plan to adopt such a complex organization in the future.

4.4 Case D: freezer door

In case D the supplier (hereinafter called Supplier D) provided Customer with the internal freezer door which lies within the refrigerator. In this case the component is not very relevant in terms of costs (the freezer door accounts for about 2–3% of the overall cost of the refrigerator). However, it has a relevant impact on the technical performance of the final product. Indeed, it influences the insulation of the refrigerator and through that energy consumption, the temperature of the freezer, and ice generation. In addition, the design of the door is not independent from the design of the whole refrigerator. Not only does it influence several relevant performance criteria but it also has several geometrical relationships with the system (in terms of width, length, depth of the door, etc.). In this case the supplier provided the customer with the new process expertise (co-injection technology) that enabled them to change the concept of the freezer door and radically improve its performance. Once the new technological opportunity was identified, and process technology bounds were made explicit to Customer, the engineering function designed the new component. However, Supplier D technicians were often involved to verify the manufacturability of design features. In this case the Supplier was involved from the concept phase of the component, indeed the technological opportunity played a crucial role in defining the component concept.

The relationship was fruitful both for Supplier D and Customer. Customer was able to develop a new, cheaper, and better performing component. Moreover, the

new component development project was completed before the deadline. Thus the component contributed to the development of a good final product (the one door free-standing refrigerator). Consequently, Supplier D got a long-term contract. In addition both the supplier and the customer increased their mutual trust and relation-specific skills, so much so that they both think that they will be able to undertake better co-design projects in the future.

5 A taxonomy of co-design relationships

On the basis of the four case studies we found that co-design relationships can be quite heterogeneous. Although a wide array of variables characterise the co-design relationship, we focus our attention on two single-project levers that can have a significant impact on other features of the relationship (see Figure 3).

Know-how delivered in the relationship. The supplier might deliver either process know-how or product and process know-how. For example, while in the case of the 'freezer door' the supplier basically supplies process know-how (Customer's technicians design the product), in case A the supplier designs and produces the lamp-holder on the basis of Customer's functional specifications (thus providing both product and process know-how). Thisvariable might be relevant since it influences the roles of the two parties and the time when the supplier is involved in the decision making process (e.g., see [14]). In addition, this variable is relevant since it determines the nature of the information exchanged between customer and supplier. In the case of process know-how, it relates to the component's technical specifications and/or the process. In the case of product know-how, this relates instead to the functional specifications of the component. Finally different flows of information are supported by rather different exchange processes (in terms, for example, of frequency of the exchange of information, media, number and level of people involved) and different relationships (in terms, for example, of agreements, level of trust, ability to work together on partial information from the counterpart).

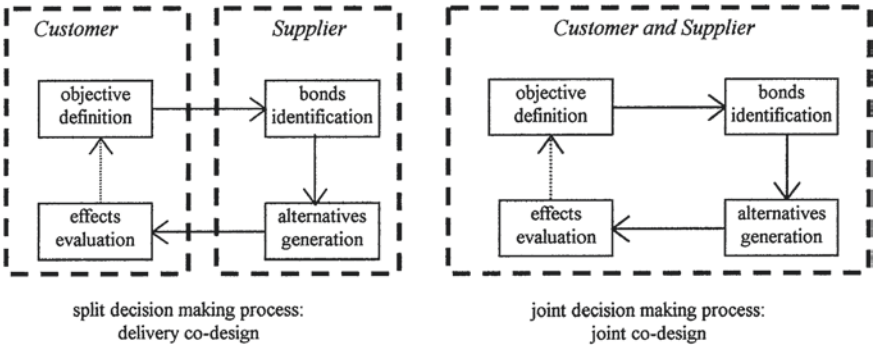

Figure 3 Different decision making processes in co-design relationships

Characteristics of the decision making process. The New Product Development process may be considered as a series of decision making processes. Nevertheless, as pointed out in the introduction, the literature has devoted little attention to the dynamics of decision making in co-design. In particular, co-design relationships may be classified according to the extent to which customers and suppliers jointly manage the different phases of the decision making process. In some cases, decision making is split and thus the supplier *delivers* the solution the customer has asked for. On the other hand, customers and suppliers may share all the phases of the decision making process (*joint* co-design). This variable can be very relevant when defining different kinds of co-design relationships [25]. Indeed, a joint decision making process asks for some pre-conditions about the relational situation such as mutual trust, and similar approaches to project management. In addition, a shared decision making process often requires a shared language, and a common knowledge (often built on previous experiences, see the model presented in Figure 2). For example, in case B the prototylpe for the new hinge was completely unsuccessful since Supplier B failed to identify the technical bonds that the customer had taken for granted. In this case, the lack of a shared language and knowledge instigated re-thinks in the project.

The *exchange of information* is very different in the two cases. In the *delivery relationships* the information tends to be codified. This often concerns technical specifications for the component and/or for the process, and the exchange of information tends to be relatively sporadic. In the case of *joint development relationships* there is a more continuous exchange of information that often is not completely codified. As a consequence, the method of communication changes accordingly. Indeed, a shared decision making process tends to require personal meetings to support a very comprehensive exchange of information (see case D and the first project for the development of a completely new lamp-holder platform). Delivery relationships, conversely, could rely on media such as telephone calls and e–mail (see the project for the marginal improvement and the customisation of the lamp-holder – case A).

The two previous single-project variables identify the following four different types of co-design relationships. Thus we suggest a classification that relies on the model presented in Section 3. As previously stated in our view these are all co-design relationships since in all of these cases the supplier provides the customer with customised know-how. However, we believe that recognising the differences in this relationship is a key point. On the one hand the deployment of managerial levers (especially single-project ones) can differ significantly. On the other hand, as discussed in the next section, different kinds of co-design relationships may suit different environmental and strategic conditions.

6 The role of uncertainty and of the relational environment: a contingent analysis

The previous section shows how co-design relationships may actually occur in different forms: four classes of co-design relationships have been proposed. One

might therefore investigate in which situation and context a given type of co-design relationship is most suitable. In particular, while the first dimension (characteristics of the know-how delivered) is an immediate consequence of the specific customer requirements (i.e., a new component or a new process technology), the second dimension (characteristics of the decision making process) calls for an explicit analysis of consistency. Indeed, choosing between a tight interaction (joint decision making) and a loose one (split decision making) is not simply a matter of intensity. Both types of relationships involve a co-design process and both of them may lead to success or failure depending on the design problem dealt with and on the implementation approach. As a matter of fact, in the case studies we observed both success (cases A and D) and failure (cases B and C). What is the reason behind these different outcomes of the co-design relationships? Our hypothesis is that failures are due to a mismatch between the type of co-design and the context of the relationship.

In this respect, the literature investigates the prerequisites and contextual factors that may support a tight or loose logistics integration (as opposed to new product development integration, i.e., co-design) within a partnership, including the degree of appropriability of the innovation, the complementary assets, the risk of imitation, etc. The four cases discussed in this paper shed light on the role played by two specific factors: the degree of uncertainty and the relational capabilities. The role of these factors is illustrated in Figure 5.

Uncertainty plays a major role in defining the intensity of interaction between the customer and the supplier. This uncertainty may be due to two major factors:

The novelty of the solution to be designed. This is related to the degree of innovation of the component (or the process technology) designed by the supplier and to the novelty of the end product in which the component has to be embedded. Uncertainty increases as new technological solutions are looked for and novel

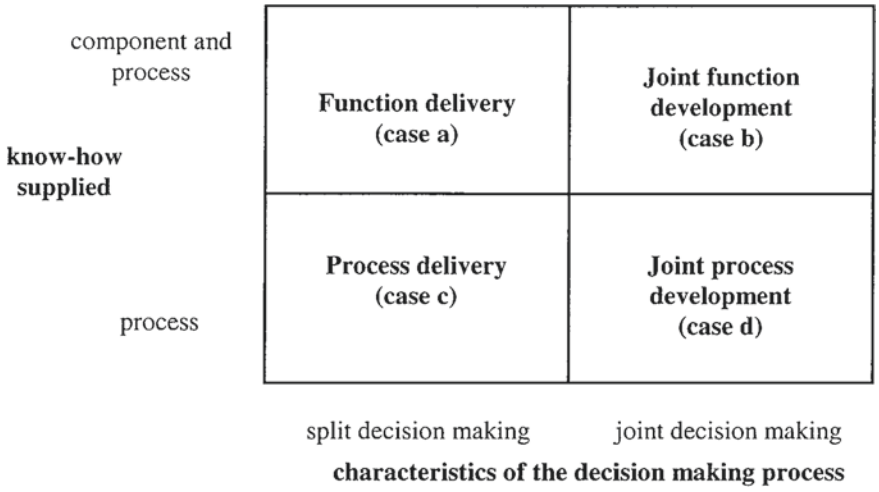

Figure 4 A taxonomy of co-design relationships

interfaces are developed between the component and the product architecture, thus requiring a tighter interaction between the partners.

Environmental turbulence. This is related to the dynamics of the project environment (the extent to which the requirements for the final customers are changed during the project; the chance that new technologies for the end product may emerge; requests for changes in the product architecture) and usually results in a significant instability in the technical specifications of the component. In highly turbulent environments therefore, the customer and the supplier must continuously adapt their design and have to continuously interact (see for example case B, where the concept evolved during the development of the hinge).

Our cases suggest that if partners enter into a co-design relationship in a highly uncertain context, a joint approach to co-design is required. Consider for example case B (hinge) and case D (freezer door). In both these cases the customer was looking for a major improvement in the component performance, on the basis of a fairly new design. Hence, complementary resources were jointly used and while setting the component specifications the customer considered the new opportunities that the supplier's technologies could offer. In other words, as already suggested in Figure 5, a joint decision making process was followed to deal with the high levels of uncertainty. In these cases, a delivery relationship would not have provided the necessary depth of interaction to master the turbulence of the environment and develop radically new solutions.

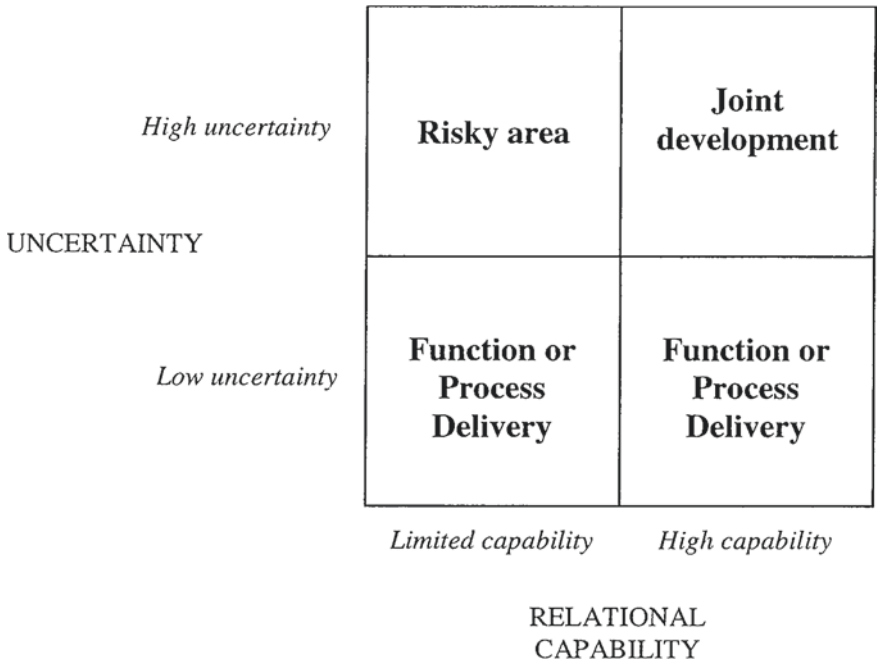

Figure 5 A contingent model of co-design relationships

The hypothesis that joint co-design is consistent with major innovations is further supported by case C, which was an unsuccessful undertaking. A major reason for design problems was that even though the customer was looking for a major re-definition of the packaging of the chest freezer, a split decision making process was undertaken. The local supplier from northern Italy was not able to anticipate the bonds of the process technologies of Supplier C, making the component design inconsistent both with the production process of the customer and with the assembly line of Supplier C.

On the other hand, case A (lamp-holder) shows that, when incremental improvements are sought, a split decision making process may be successful. In this case, the tight coordination and interaction of joint development is an unnecessary cost for achieving minor innovations or improvements. In addition, it would divert the project team and management support from more crucial and risky co-design undertakings.

Uncertainty is not the only contextual factor to be considered when choosing the co-design approach. Indeed, while both projects D and B followed a joint development approach, the former turned into a success and the latter failed.

The reason for the failure of project B has to be found in the second dimension of our model: the relational capability. As previously said, a joint decision making process asks for higher capabilities, in terms of relational knowledge, mutual trust, project management skills, teamwork and dedicated assets. These capabilities are a prerequisite for making a close interaction between customer and supplier successful. Project B lacked these prerequisites. Supplier B had never worked with the refrigeration business unit, and new behavioural patterns had to be developed, which did not happen quickly enough. Put simply, the customer and the supplier did not have the necessary basis to work closely together. In other words, case B is located in the upper left area of the matrix in Figure 4. This case suggests that though the joint approach might seem to be a more promising alternative, it does not always guarantee better performance than the delivery relationship. The former is much more complex and calls for careful implementation and for high relational capabilities.

Relational capabilities depend mainly on the relational environment and practices, which is often a consequence of previous co-design undertakings (see Figure 2). They are therefore generated through multi-project levers (such as dedicated technologies and investments, or the knowledge of the mutual patterns of communication). These capabilities evolve over time and are specific to a particular relationship (in other words, they vary as different pairs of customer-suppliers are considered). The dynamic growth (or atrophy) of the relational capabilities make the joint development approach a viable option in cases of radical improvements in the design.

However, it may happen that a novel design is needed, therefore requiring joint development even though relational capabilities are poor. This occurred for example in case D. This project is located in the upper left corner of our model as well (see Figure 5). The customer and the supplier had never cooperated before. Indeed, while the managers of both companies recognised the need for joint development (given the novelty of the solution to be developed) they also acknowledged the lack of relational capabilities required for this approach. This explicit understanding of the relational environment led the managers to invest

in coordination and integration not only to properly design the component, but also to build up a new relationship. In other words, they acted on single-project levers (such as dedicated supplier engineers, top management support, additional resources when needed) to compensate for the lack of relational capabilities at the project outset.

Cases B, C and D therefore show that high uncertainty calls for a joint approach, which is a viable option if outstanding relational capabilities have already been developed, or a risky option (i.e. it requires much more attention and effort) if these capabilities are initially weak. As a consequence, a joint approach may be adopted only in a limited number of situations, given the amount of resources and support from the top management it requires.

On the other hand, case A shows that once high relational capabilities are achieved (in a previous project the customer and Supplier A re-designed the overall family of lamp-holders for the Refrigeration Business Unit), a wider set of options are disclosed, ranging from split problem solving (when uncertainty is low) to joint problem solving (when uncertainty is high).

7 Conclusions

This paper shows that co-design relationships may occur in different forms and that the success of supplier involvement in product development mainly depends on the proper choice of the type of relationship according to the contingencies to be dealt with.

In particular, by adopting a decision making perspective to investigate design processes, we have identified four different approaches to co-design, depending on the type of knowledge transferred from the supplier to the customer (product knowledge or process knowledge) and the degree of interaction between the partners. In this latter regard, a co-design relationship may occur with a loose interaction (when the customer defines the component specifications and the supplier designs the solution that better fits those specifications) or a tight interaction (when the problem solving process is not split between the partners).

We have also shown how the choice between a joint or split co-design approach depends (among others) on two contextual factors: the uncertainty of the design endeavour (i.e., the novelty of the component to be developed and the turbulence of the environment) and the relational capabilities (i.e., the capabilities to manage the information flows occurring between the two patterns). High uncertainty calls for a joint co-design process, which, however, requires high relational capabilities (or, if these are lacking, a great deal of coordination effort being deployed). High relational capabilities, on the other side, allow a wider set of design approaches to be adopted, according to the design context to be dealt with.

Two major implications emerge from the findings and models discussed in this paper The first one is a managerial implication, which concerns the choice and implementation of a co-design relationship. In this regard most product development management models (and most managerial practices) are mainly focused on

whether to implement a co-design relationship or not, assuming this relationship may take a unique form the major problem is how far to push the partnership. In other words, most models assume that there is an 'intensity' in a co-design relationship, and the more intense the relationship is the better. This paper, instead, shows that there are actually different forms of co-design relationships, and neither of them could be considered 'the best way'. All of these forms may be equally successful or unsuccessful depending on their fit with the project context and their implementation. For example, while apparently a joint relationship could seem a better choice, since it implies a closer interaction and exchange of information between the partners, it also involves a far larger amount of resources and effort, calls for dedicated and specific assets and, most of all, asks for higher relational capabilities. In several cases a split decision making process is more suitable, efficient and effective.

As far as implications for theory and research are concerned, this paper demonstrates that co-design relationships must be investigated (and managed) dynamically: the success of a given co-design project depends on previous experiences, which are an intrinsic characteristic of a relationship (i.e., they are not a characteristic of a single partner). There is therefore a feedback linkage between co-design performance and design management levers (especially at the multi-project level). Scholars have often overlooked these dynamics in co-design relationships since their models are mostly based on static observations (i.e., data on a co-design project at a given moment in time). Instead, this feedback effect calls for a deeper investigation and understanding of the factors of success in co-design relationships considering also the influence of previous relational experiences. This, however, requires a different approach to empirical investigation, one with more observations based on longitudinal studies.

References and Notes

1 Cusumano, A.M. and Takesishi, A. (1991) 'Supplier relation and management: a survey of Japanese transplant, and US auto plants', *Strategic Management Journal*, Vol. 12, pp.563–588.
2 Ring, P.S. and Van de Ven, A.H. (1992) 'Structuring cooperative relationships between organisations', *Strategic Management Journal*, Vol. 13, No. 7, pp.483–498.
3 Da Villa, F. and Panizzolo, R. (1996) 'Buyer-subcontractor relationships in the Italian clothing industry. An interpretative framework', *International Journal of Operations and Production Management*, Vol. 16, No. 7, pp.38–61.
4 Clark, K.B. (1989) 'Project scope and project performance: the effect of parts strategy and supplier involvement on product development', *Management Science*, Vol. 35, No. 10, pp.1247–1263.
5 Stalk, G. Jr. and Hout, T.M. (1990) 'Competing against time', *Research Technology Management*, Vol. 66, pp.19–24.
6 Liker, J.L., Kamanth, R.R., Wasti, S.N. and Nagamachi, M (1996) 'Supplier involvement in automotive component design: are there really large US Japan differences?', *Research Policy*, Vol. 25, pp.59–89.

7 De Toni, A. and Nassimbeni, G. (1999) 'Buyer-supplier operational practices, sourcing policies and plant performance: results of an empirical research', *International Journal of Production Research*, Vol. 37, No. 3, pp.597 619.
8 Eisenhardt, K.M. and Tabrizi, B.N. (1995) 'Accelerating adaptive process: product innovation in the global computer industry', *Administrative Science Quarterly*, Vol. 40, pp.84–100.
9 Littler D., Leverick, F. and Bruce, M. (1995) 'Factors affecting the process of collaborative product development. A study of UK manufacturers of information and communications technology products', *Journal of Product Innovation Management*, Vol. 12, pp.16–32.
10 Ragatz, L.G., Handfield, R.B. and Scannel, T.V. (1997) 'Success factors for integrating suppliers into new product development', *Journal of Product Innovation Management*, Vol. 14, pp.190–202.
11 Bruce, M., Leverick, F. and Littler, D. (1995) 'Complexities of collaborative product development', *Technovation*, Vol. 15, No. 9.
12 Hartley, J.L., Meredith, J.R., McCutcheon, D. and Kamath, R.R. (1997) ''Suppliers' contributions to product development: an exploratory study', *IEEE Transactions on Engineering Management*, Vol. 44, No. 3, August.
13 Kamath, R.R. and Liker, J. (1994) 'A second look at Japanese product development', *Harvard Business Review*, November–December, pp.154–170.
14 Clark, K.B. and Fujimoto, T. (1991) *Product Development Performance: Strategy, Organization, and Management in the World Auto Industry*, Harvard Business School Press, Boston.
15 Lamming, R. (1993) *Beyond Partnership: Strategies for Innovation and Lean Supply*, Prentice Hall, London.
16 Williamson, O.E. (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press, New York.
17 Williamson, O.E. (1991) 'Comparative economic organization', *Administrative Science Quarterly*, Vol. 36, pp.269–296.
18 Knight, F.M. (1921) *Risk Uncertainty and Profit*, Houghton Mifflin, Boston.
19 Simon, H. (1957) *Rationale Choice and the Structure of the Environment*, Wiley, New York.
20 Akacum, A. and Dale, B.G. (1995) 'Supplier partnering: case study experiences', *International Journal of Purchasing and Materials Management*, January.
21 Ellram, L.M. (1995) 'Partnering pitfalls and success factors', *International Journal of Purchasing and Materials Management*, Spring, pp.10–16.
22 Stuart, F.I. and McCutcheon, D. (1996) 'Sustaining strategic supplier alliances', *International Journal of Operations and Production Management*, Vol. 16, No. 10, pp.5–22.
23 Leandro L., Spina, G. and Zotteri, G. (1998) 'Co-design in Italy: internal consistency and strategic fit', *Proceedings of the 5th EIASM Product Development Management Conference*, Como, Italy, 25–26 May.
24 In the co-stamp technology the electrical connections are stamped in the plastic component. Thus there is no need to add wires while assembling the product.
25 It is worth noting that this variable is not completely overlapping at the time when the supplier is involved (which was suggested by prior literature on this topic). Indeed, both a split and a joint decision making process might take place even at the early phases of the project.

5.2 Review and Outlook

5.2.1 The Context

This work dates back to the early 2000s and is part of a debate that has involved academic scholars for over two decades. Within this debate on co-development we can recognize several investigative streams that have gradually converged.

The first stream relates to the studies on just-in-time purchasing (JIT-P) in the mid-80s, described mainly by Schonberger (1982, 1986), Hall (1983) and Ansari and Moddarres (1988). These studies focused on the logistics process: the JIT approach requires rigorous control and synchronization of entry flows and therefore reconfigures the customer–supplier connection. The "early involvement of the supplier in the design and product/process development" was mentioned amongst JIT-P practices, as well as some other related aspects ("information sharing", "joint value analysis programmes" and "standardized packaging"). According to this perspective, however, co-development was considered to be little more than a specific management practice, which enabled cutting the time required to get goods to the market place and speeding up the flow of materials.

The second stream—mainly based on the works of Clark (1989), together with Fujimoto (1991) and Wheelwright (1992) in the late '80s—focused on the product development process. These authors regarded new product development as a set of problem-solving and information-processing scenario activities, within which the management challenge was to establish organizational structures and practices to ensure the adequate integration of diverse skills, including providing information and knowledge to—and between—suppliers and customers. Each supplier would be involved at different levels, based on the amount of design content, the complexity and technology of a specific item and the kind of the information shared.

These two streams of study, the first focused on the (synchronous) logistical links and the second focused on the (a-synchronous) collaboration in product development, converged in the '90s. During this decade, the Toyota model and "new" management systems dominated scientific debate in the field of operations. JIT, total quality management (TQM) and concurrent engineering (CE)—key pillars of the Toyota Production System—are all approaches that modified and extended traditional customer–supplier interactions ("lean supply"). In this context, co-development was framed as a set of management practices and tools not (only) related to a single process or to some functional interfaces, but forming part of an operations model extending beyond the plant boundaries.

In addition, the relevant relational implications of co-development began to be investigated in greater depth. The co-development process is bi-directional and interactive, at least partially tacit and intangible and cannot entirely be codified ex-ante and therefore measured ex-post. In addition, it involves a variety of specific assets. Thus, such kind of exchange requires relational forms and contractual arrangements quite different when compared to the traditional (antagonistic) ones.

Ultimately, this third line of enquiry examined co-development within that cluster of interdependent, cross-functional and inter-organizational methodologies and tools conventionally called *lean* management.

5.2.2 The Study

Notwithstanding the considerable amount of research on co-development emerging from studies on lean issues, a number of questions were still under discussion at the beginning of this millennium. The concept of co-development was still rather vague at that time and continued to be considered—as Gianluca Spina, Roberto Verganti and Giulio Zotteri wrote—as *shades of grey* rather than *a matter of colours*. Feasible forms of co-development were still unclear. In addition, the associated contingencies—that is, the contextual factors that signposted specific forms of co-development—were still largely unexplored. As a result, co-development tended to be described as a sort of "best practice", independent of the context in which it was applied. Moreover, the most relevant experiences documented in the literature concerned the automotive industry, in which there was great need for experimentation and analysis, as was the case in other sectors.

As far as methodology is concerned, the instruments used for empirical investigation—in particular, surveys—reflected these conceptual weaknesses. The co-development construct was usually operationalized via few dimensions, which were in turn translated into perceptual and rather elementary items. The point of view of the supplier was often given little consideration due to the difficulty of defining consistent criteria for measurement. Taking into account this gap in the literature, the objectives of this study were precisely to provide a taxonomy of co-developmental relationships and to identify contingencies that would influence the implementation of specific forms of such relationships.

The theoretical and methodological framework of the study merits some remarks.

The conceptual background starts with the definition of co-development. The authors used two variables—the know-how exchanged and the specificity of the transacted good (Fig. 1)—to identify a first broad range of design solution exchanges. The co-development construct is thus delimited to the quadrant characterized by an innovative and specific exchange ("the supply of customised innovation"): here the authors wished to explore in greater depth possible forms of exchange. Then, the dimensions of analysis and the hypothesized relationships are pointed out (Fig. 2). The conceptual framework uses input variables (single and multi-project levers), output variables (product/component performance and relational climate) and contextual factors (strategy and environment). Compared to previous lever-performance models, this framework is characterized by the variety and nature of the levers considered (to characterize "the technical and organizational situation") and the classification of these ("una tantum" and single project levers). In addition, the "relational climate" is considered here to be both the result

(output) and the premise (input) of subsequent projects. In this way, the relational context is analysed in a dynamic and at least partially longitudinal (retrospective) approach. To better identify and qualify some of these contextual variables, specifically those related to decision making in situations governed by uncertainty, the theories of transaction cost analysis and managerial decision making are used.

The exploratory nature and the complexity of the topic did not permit the application of "standard" investigation tools. The object of analysis was not merely practices, but also the non-material content ("the transacted good is the know-how and not just the manpower needed"), as well as the business and relational environment, which evolves over time and which cannot be codified a priori. Therefore, the study adopted a case study methodology. The unit of analysis was the single co-development project. The choice of the research population—companies in which such projects could be analysed—would have been quite challenging. The choice had to include an adequate variety of situations as compared to the number of research dimensions, but also needed to enable contrast between different situations. Four different projects belonging to a business unit of a (multinational) firm were selected. These projects differed in terms of transacted goods, the characteristics of suppliers and the relational environment, but their commonality in terms of the organization made it possible to control the results against a multiplicity of possible intervening factors (industry, level of vertical integration, purchasing strategy, etc.).

The industry was also carefully selected. The appliance industry is characterized by large-scale manufacturing and parts assembly, as in the automotive industry. Unlike the latter, however, the appliance industry exhibits a much wider variety of products and a shorter life cycle. It is therefore particularly suited to gaining insight into issues in co-development.

5.2.3 The Contribution

The cross-case analysis points to a taxonomy of co-design relationships structured in four types according to two variables: the know-how supplied and the characteristics of the decision-making process. The first variable, already used to define the co-development concept, is also useful for identifying specific additional forms. The second variable refers to the intensity (content) and kind of interaction (split or joint decision making). Based on the results of the projects analysed (two successes and two failures), the authors formulated a further hypothesis: failures are due to a mismatch between the type of co-design and the context of the relationship. The latter can in turn be characterized in terms of uncertainty and relational capability.

Because of its unconventional theoretical and methodological approach, this work has been able to make a significant contribution to the advancement of knowledge in various directions. First, the concept of co-design is defined and distinguished from similar forms. In addition, the authors have identified some

contextual variables either ignored or underestimated by previous research. Among these variables, the relational environment, its evolution and the resulting effects of path dependency play a key role.

Over the inter-temporal horizon of analysis, the most important decisions during the product development process are tracked and their consequences are evaluated. While previous research often provided static and stylized descriptions of the product development process, here a broad investigative perspective strongly anchored to the context and to the dynamics of the situation has been adopted.

Finally, on the basis of the contextual variables identified, the authors describe four approaches to co-design. There is therefore no longer "*a unique form*", a best way, but rather a way that depends on the specific circumstances. Thus, the fit between the characteristics of the project and the relational modalities becomes even more important to achieve matches between all the relevant technological, organizational and managerial aspects. The theme of fit is central in almost every management ambit. It is due to the work of these authors that this theme was relaunched in the co-development field.

In conclusion, this study demonstrates that co-development relationships may take many forms and "that the success of supplier involvement in product development mainly depends on the proper choice of the type of relationships according to the contingencies to be dealt with". In so doing, it opens up the way for extensive future research.

5.2.4 The Heritage

The work of Spina et al. has been adopted and cited by several other studies that have tested and expanded the contingencies and the typologies proposed here. In addition to the studies that explicitly cite this work, a more implicit but perhaps more relevant cultural heritage can be pointed out.

The work clearly shows the need for a situational understanding of the product development process, in other words, the need to explain the "phenomenon" from a situational point of view. Companies operate in different environments and exhibit peculiar organizational characteristics with unique histories. This is especially true in product development: each project has its own genesis and development, combining different knowledge and skills, which are variously distributed amongst internal and external organizational units. Each project constitutes a synthesis between market needs, technological opportunities and economic and constructive constraints. All these factors in turn depend on the specific inter-organizational context, as well as on time requirements. Thus, product development, a process that is structurally non-repetitive, exhibits strong idiosyncratic features.

This apparently obvious statement has important consequences, both for research methodology and management practice. On the methodological side, the study reinstated a qualitative, longitudinal, in-the-field research approach,

strongly oriented towards situational factors. On the managerial side, it follows that there is no one way to look at product development and collaboration processes. Companies need to adapt to the most relevant aspects of their environments to adopt those management approaches and organizational structures that better achieve this fit. This is the key message of the study.

If we look at the evolution that product development has undergone in recent years, we can better appreciate the great importance that the authors accorded the main situational feature: the relational environment. Today, the environment in which co-design takes place has dramatically expanded. It no longer merely involves suppliers, but also direct and indirect customers, complementary businesses, service providers, even communities of practice. All these groups are players and web-based interaction between them is the norm nowadays, with constant real-time connections provided by mobile communications technology enabling co-development from inception right through to the final consumption stage.

This open-to-innovation habitat co-evolves together with the businesses and the actors who inhabit it. A metaphor that recurs in current literature is "eco-system". At a biological level, an eco-system is a community of different species in a given space, which in turn works as an active support for the community itself. In this space, companies co-evolve through a dense network of cooperative and competitive relationships, different technologies converge and product and service development is—to some extent—the combined effort of a varied population of professionals, users and service providers. The most direct example is probably that of the computing eco-system, which includes the software and significant segments of the hardware industries, but extends into many other industries.

It is within such a composite relational platform that product development processes take place today. The management of this platform is not just a matter of practices and technicalities, but rather a matter of construction and co-evolution of the social and technological environments.

In a nutshell, these aspects can be recognized in the work of Spina et al. The co-design context that the authors describe is a relational environment populated not only by suppliers and customers, but also manufacturers, distributors and final consumers, all operating in various industries. This environment is explored in its breadth, its complexity and in its evolution, precisely in order to gain a better understanding of the phenomenon under study. After 15 years, this work remains topical and continues to be a methodological reference.

References

Ansari, A., & Modarress, B. (1988). JIT purchasing as a quality and productivity centre. *The International Journal of Production Research, 26*(1), 19–26.

Clark, K. B. (1989). Project scope and project performance: The effect of parts strategy and supplier involvement on product development. *Management Science, 35*(10), 1247–1263.

Clark, K. B., & Fujimoto, T. (1991). *Product development performance: Strategy, organization, and management in the world auto industry*. Boston: Harvard Business Press.

Hall, R. W., & American Production and Inventory Control Society. (1983). *Zero inventories*. Homewood, IL: Dow Jones-Irwin.
Schonberger, R. (1982). *Japanese manufacturing techniques: Nine hidden lessons in simplicity*. New York: Simon and Schuster.
Schonberger, R. (1986). *World-class manufacturing. The lessons of simplicity applied*. New York: The Free Press.
Wheelwright, S., & Clark, K. (1992). *Revolutionising product development*. Cambridge, Mass: Harvard Business School Press.

Chapter 6
E-Business Strategy: How Companies Are Shaping Their Manufacturing and Supply Chain Through the Internet. A Review and Outlook

Ann Vereecke and Matteo Kalchschmidt

Abstract The original paper investigated, on a large sample of manufacturing firms, the adoption of Internet-based tools to support supply chain processes. Four strategies are identified, according to the level of adoption of e-commerce, e-procurement and e-operations. The four strategies are subsequently analysed according to contingent factors and supply chain integration mechanisms. Results show a clear relationship between the use of Internet-based tools and the adoption of integration mechanisms. The commentary shows that the paper has been widely cited in both operations, supply chain and ICT literature, recognizing its seminal contribution to the analysis of the impact of Internet technologies on supply chain processes, their relation with supply chain integration and their impact on performance. The research directions suggested in the original paper are discussed analysing the subsequent literature, including the replication studies performed by the original authors. The importance of investigating emerging topics, as well as observing their evolution over time, is highlighted.

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6.1 Original Paper[1]

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Introduction

It is widely acknowledged that companies are increasingly facing the challenge of e-business, that is, the use of Internet-based tools to support their business processes. In fact, the evolution of Information and Communication Technology has fostered the development of powerful tools that are expected to improve supply chain performance dramatically, through higher levels of process efficiency and integration. Despite the initial enthusiastic expectations, it is still not completely clear how relevant these technologies are for companies and what actual benefits can be obtained. In fact, there is still poor evidence of actual implementation and effectiveness of e-business practices. Some results of existing research in the field, although preliminary, seem to highlight as a success factor of e-business choices their coherence with the overall strategy of the company. Following this line of reasoning, it is interesting to study how e-business practices are used and integrated in the operations strategy as a whole, in order to understand their coherence and the consequent potential benefits. However, operations management research still lacks empirical results that examine the relationship between e-business and supply chain strategies.

This paper aims at addressing the above issues, providing some evidence of the use of Internet tools by a sample of European manufacturing companies. Such

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tools aim at supporting different supply chain processes, in relationship with different supply chain strategies.

Research background

The use of electronic communication links between firms has been considered as a key tool for at least 20 years. Malone et al. (1987) argue that electronic communication along with supply chain allows the reduction of both the costs of coordinating economic transactions and the costs of coordinating production. EDI was the first tool that was widely diffused and enabled this kind of communication, while more recently Internet-based applications seem to overcome most of its original limitations.

The increasing importance and role of web-based technologies to support company operations (e-business) is widely acknowledged both by practitioners (e-business reports have been published by all of the more important consulting firms – such as Forrester Group, Gartner Group, Morgan Stanley, KPMG, Accenture, etc.) and academicians (Evans and Wurster, 1999; Skjoett-Larsen, 2000). The efficiency of information transfer, the timeliness of information availability, the openness and transparency of relevant business information are only a few of the benefits provided by the Internet to support supply chain integration. E-business is particularly important for the supply chain literature as a consequence of the increasing need to integrate activities and information flows and to optimize the processes not only at the single company level, but also at the level of inter-company processes (Stevens, 1989). In fact, an increasing amount of activities are externalized, thus their impact on company processes should be managed through adequate integration mechanisms in order to foster superior performance (Hakansson and Snehota, 1995).

In the previous years, a surprising number of studies appeared in the management literature, trying to describe and better understand the e-business phenomenon, mainly exploring the potential advantages, the changes required in current management and organization of the companies, the possible business models of adoption of Internet tools. Most of these studies were explorative in nature, and mainly conducted through case study approaches (Van Hoek, 1998, 2001a). However, they helped to provide a more mature view of relevant features and potential of the Internet, compared to the first, enthusiastic claims on the "miraculous" effects of the "new economy".

One of the points that was clarified is that the concept of e-business itself is rather wide, since it includes a number of different applications and uses of the Internet technology.

Among the possible classification dimensions, a relevant one is based on the process supported by Internet tools. In fact, supply chain management refers to the management of different processes, such as customer relationship management, customer service, demand management, order management, production and material flows and purchasing (Lambert et al., 1998). In this light, Internet tools can be classified as: e-commerce (Brynjolfsson and Smith, 2000) – support to sales, distribution

and customer service processes, e-procurement (De Boer et al., 2002) – support to sourcing, procurement, tendering, and order fulfillment processes, and e-manufacturing (Kehoe and Boughton, 2001) – supporting demand and capacity planning, forecasting and internal supply chain integration. Another classification is suggested by Lee and Whang (2001), who distinguish between e-commerce, e-procurement and e-collaboration. The last category refers to the use of the Internet to strengthen the relationships along the supply chain, exchanging data and making joint decisions. Frohlich and Westbrook (2002) classify web-based supply chain integration strategies according to two dimensions, namely Internet-based demand and supply integration. The resulting categories are low integration, demand integration (similar to e-commerce), supply integration (similar to e-procurement) and demand chain management integration (which is the joint application of the previous two strategies).

Moreover, different tools and solutions have been implemented through the use of Internet technologies, each with different goals, benefits and drawbacks. For example, relevant differences exist between auctions, exchanges, marketplaces, catalogues, e-collaboration tools, etc. (Kalakota, 2000; Kaplanand Sawhney, 2000; Wise and Morrison, 2000). Finally, distinctions between tools have been made also on the basis of the connectivity model, i.e. between private and public tools (Whitaker et al., 2001).

The attention of the companies and the literature was first concentrated on the use of the Internet to support sales and customer service to end-users (Van Hoek, 2001b), e.g. business-to-consumer e-commerce. However, much greater potential has been expected from the business-to-business applications, especially the ones aiming at automating, speeding-up and facilitating information flows along the supply chain (Feeny, 2001). Van Hoek (2001a) suggests that the supply chain dimension of e-business has been neglected so far, as poor basic operational performance is hampering the implementation and success of such applications.

Given this variety of tools and applications, the literature highlighted that companies can draw benefits from the use of Internet tools only by defining a clear e-business strategy.

The concept of e-business strategy has been introduced to address the issue of how the Internet can reshape companies and provide competitive advantage. Contributors covered different perspectives of the problem, ranging from business models to organization, and from marketing to operations (Brynjolfsson and Urban, 2001, for a review). In the specific context of Supply Chain Management, e-business strategy refers to the way Internet tools are selected and used in relation to the needs of integration. A coherent e-business strategy concerns both the right choice of tools and solutions according to the specific aims, goals and context of the application (Soliman and Youssef, 2001), and the coherence of these choices with other organizational and managerial tools used to integrate the company's processes (Graham and Hardaker, 2000). The need to integrate organization and technology is relevant, in general, for most technological innovations, in particular those related to information technology. Just to give an example we remind here what happened with the introduction of computer integrated manufacturing (CIM), whose results did not match expectations, often due to the lack of understanding of the strategic, cultural and organizational changes that were required to achieve its potential (Cagliano and Spina, 2000).

Finally, the company and the whole supply chain may require or take advantage of relevant structural changes concurrent with e-business adoption, such as streamlining, reduction in number of tiers, changes in power structure, etc. (Croom, 2001; Malone *et al.,* 1987; Sampler, 1998). Consequently, a successful e-business implementation requires both a coherent set of different tools and relevant structural changes, leading to an integrated approach that involves both the physical and the virtual supply chain, as shown by very few successful cases studied so far (Graham and Hardaker, 2000; Van Hoek, 1998, 2001a).

Although these points are reasonably well established, the discipline is still in its early stages, thus requiring further investigation and fine-tuning. In particular, large empirical studies are needed that try not only to describe the current behaviors of companies when facing the Internet, but also studying relationships among the relevant variables of the problem (Van Hoek, 2001b).

Considering the above-mentioned points, some relevant matters should be addressed:

- Do companies adopt Internet in different processes across the supply chain through a comprehensive e-business strategy, or do they focus on the most relevant ones in their contingent situation?
- Which contingent variables are relevant to explain higher or lower use of the Internet, or different e-business strategies?
- Are companies adopting e-business strategies in coherence with their overall supply chain strategy? In other words, is there coherence between the e-business strategies adopted and the integration mechanisms used across the supply chain?

The understanding of these aspects is very important for the development of a new theory of supply chain management that includes Internet tools as relevant variables, rather than studying them separately.

Research aims and propositions

The aim of this paper is to investigate the use of the Internet by manufacturing companies to integrate processes along the supply chain, and to analyze the relationships among Internet adoption, contingent factors and integration mechanisms. The underlying assumption is that effective use of Internet technologies to support the current business takes place only when it is integrated in coherent strategies of supply chain management.

The first research objective is to understand the extent to which the Internet is currently adopted by European manufacturing firms in the operational processes along the supply chain. The second is the identification of the contingencies that affect the use of the Internet currently, in order to investigate in which contexts the expected benefits are higher. Finally, to better understand if specific relationships exist, this paper analyses which coordination mechanisms are coherent with the use of the Internet within the supply chain.

The following research propositions will be explored.

P1. The Internet is adopted by manufacturing firms to integrate different processes along the supply chain; different e-business strategies can be identified according to the process in which Internet is used.
P2. The e-business strategy selected by the company is influenced by contingent factors such as industry, size and the position within the supply chain.
P3. E-business strategies are related to the mechanisms used to coordinate the supply chain; in particular, coherent patterns of technological and managerial integration can be identified.

The relationships among the variables hypothesized in the above propositions are shown in Figure 1. The dotted line represents a relationship between contingent factors and integration mechanisms, which could exist, although it is not considered in the present work, since it is not relevant for the purpose of the research.

Research methodology and sample

The sample

This study is based on survey data collected within the third release of the International Manufacturing Strategy Survey (IMSS III), a research carried out by a global network aimed at exploring practice and performance in manufacturing and supply chain management (see the Appendix for an extract from the questionnaire) (Lindberg *et al.,* 1998).

Data were collected during 2001 by national research groups using a standard questionnaire, developed by a panel of experts on the base of the state-of-the-art of both research and practice, exploiting also the experience of the previous editions of the research. In nations where English is not commonly used, the questionnaire

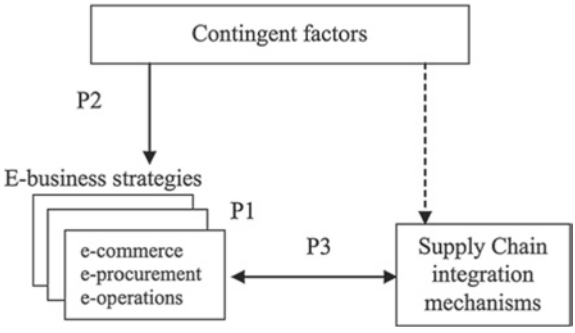

Figure 1. Framework of the research propositions

was translated into the local language by OM professors familiar with manufacturing and supply chain strategy.

This study is based on the European sample of IMSS III; the average response rate in the various countries was 34 percent. Among the 338 companies of the sample, only 276 provided enough information for the purpose of this study. Companies in the sample operate in the engineering industry (ISIC 38 classification) and employ more than 15 persons.

Small companies (from 15 to 250 employees) account for 48.9 percent of the sample, medium-sized companies (from 251 to 500 employees) account for 20.3 percent, while large companies (more than 500 employees) account for 30.8 percent.

The distribution of the sample by country and industry is shown in Tables I and II.

The variables included in the analysis

As mentioned in the previous section, this study focuses on the impact of the Internet on supply chain strategy, and in particular on operational integration. In order to obtain an overall supply chain perspective, the variables used address both up- and downstream operations.

Three categories of variables have been considered for the analysis:

(1) the degree of use of the Internet to integrate processes along the supply chain;
(2) the coordination mechanisms along the supply chain; and
(3) the contingent variables.

Table I. Geographical distribution of the sample

Country	*n*	Percent
Denmark	34	12.3
Germany	28	10.1
Hungary	53	19.2
Ireland	27	9.8
Italy	55	19.9
Norway	20	7.2
Spain	17	6.2
UK	42	15.2

Table II. Industry distribution of the sample

ISIC	Industry	*n*	Percent
381	Fabricated metal products	77	27.9
382	Machinery except electrical	75	27.2
383	Electrical machinery apparatus, appliances and supplies	73	26.4
384	Automotive and transportation equipment	30	10.9
385	Measuring and controlling equipment	21	7.6
	Total	276	100.0

While the first of these three categories of variables was used to identify configurations based on the use of the Internet, contingent variables and coordination mechanisms were used *a posteriori* to describe the configurations detected and to study external consistency. The specific variables were chosen according to classifications commonly accepted in the literature both for the processes that can be supported by the Internet and for the coordination mechanisms.

Most variables were measured on Likert-like scales from 1 to 5. Some variables are categorical (industry - ISIC code, country) or numerical (e.g. company size). The original questions from the IMSS questionnaire can be found at the end of this paper.

Research methodology and constructs

The first step of the analysis has been the reduction of the many variables available through factor analysis, in order to highlight the main underlying constructs. The second step has been the classification of the sample into groups through cluster analysis, in order to highlight different e-business strategies, thus testing *P1.* Finally, the third step has been the analysis of the relationships among e-business strategies, contingencies and coordination mechanisms, in order to investigate both *P2* and *P3.*

Factor analysis has been performed within both the areas of adoption of the Internet and the coordination mechanisms. In particular, a Principal Components Analysis with Varimax Rotation has been performed in order to minimize inter-factor correlation. This methodology helped to reduce the problem of multicollinearity among variables, which can decrease the significance of cluster analysis on the variables (Ketchen and Shook, 1996; Punj and Stewart, 1983). The number of factors has been determined according to the analysis of the combination of components' eigenvalues, percentage of variance explained and orthogonality of the solution obtained (Norusis, 1993). Cronbach's Alpha coefficient is used to measure construct reliability (Fullerton and McWatters, 2001; Nunnally, 1978).

Measure for Internet adoption within the supply chain. The Internet adoption within the supply chain has been assessed by asking companies the following question: "To what extent do you use Internet to integrate the activities of the following processes along the supply chain?". The answers to this question were given on a five-point scale ranging from "no use" (1) to "high use" (5) and have been grouped in three factors, explaining 77 percent of the total variance.

Generally, only components with eigenvalues greater than 1 are chosen, but in this case only one component presented such a value. This is because only a limited number of companies in the sample (123 out of 276, i.e. 44.6 percent) did adopt e-business. Consequently, at a first analysis, the processes involved in Internet adoption could be considered as a single factor. However, since the purpose of the present work is to investigate the different strategies of adopters, a three factors solution has been chosen, according to both interpretability

and orthogonality criteria, thus allowing to explain a greater amount of the total variance (77 percent compared to 56 percent). This solution, as shown in Table III, presents factors with loadings greater than 0.6 and no variable has loadings greater than 0.45 on more than one factor (Bagozzi and Yi, 1988). The value of Cronbach's Alpha is greater than 0.7 for all factors, showing high reliability of the constructs.

The emerging factors concerning the use of the Internet have been labeled *e-commerce, e-procurement* and *e-operations*. The first refers to sales and customer service and support, thus representing the adoption of e-business in downstream relationships. The second factor refers to the use of the Internet in purchasing activities, including procurement of both strategic and standard parts. In this case, the Internet is adopted to manage upstream relationships with suppliers. The third factor, finally, refers to the use of the Internet in the operational activities across the company value chain, including order processing and tracking, production planning and scheduling, inventory management and transportation planning. This factor represents the adoption of the Internet in all those processes which, although dealing with physical and information flows along the supply chain, are mainly focused on internal operations. These three factors are consistent with the constructs used in the literature (Brynjolfsson and Smith, 2000; De Boer *et al*., 2002; Frohlich and Westbrook, 2002; Kehoe and Boughton, 2001; Lee and Whang; 2001).

Measure for coordination mechanisms. The use of the coordination mechanisms has been investigated both up- and downstream, coherently with what has been done for Internet adoption, through the following question: "How do you coordinate planning decisions and flow of goods?". Respondents used a five-point scale ranging from "no use" (1) to "high use" (5). Factor analysis has been performed separately for the variables related to the interface between customers and suppliers. The variables considered are consistent with those used to measure

Table III. Factors measuring Internet adoption to integrate processes in the supply chain

Variables	Factor loadings E-commerce	E-procurement	E-operations	Mean
Customer service and support (CRM)	0.87	–	–	1.92
Sales	0.76	–	–	2.06
Procurement of strategic parts	–	0.90	–	1.90
Procurement of standard parts	–	0.85	–	1.97
Order processing and tracking	–	–	0.80	1.74
Production planning and scheduling	–	–	0.79	1.49
Inventory management	–	–	0.69	1.49
Transportation planning	–	–	0.62	1.72
Cronbach's Alpha	0.74	0.86	0.85	–
Average use	1.94	1.90	1.60	–
Standard deviation use	1.04	1.07	0.84	–
Average payoff (adopters)	2.98	2.84	2.88	–
Standard deviation payoff (adopters)	1.00	1.07	0.91	–

Note: Factor loadings in excess of 0.45 are shown

supply chain integration in other studies (Frohlich and Westbrook, 2001). The results, as can be seen in Table IV, show two factors in each case, very similar in their composition. The first factor, named *information sharing*, refers to the exchange of information on production plans, delivery frequencies and inventory levels. The average use of these mechanisms is quite high, although the standard deviation suggests some differences in adoption. The second factor, *system coupling,* consists of the adoption of tools and techniques, such as VMI, kanban and co-location, aimed at coupling the interface between customer and supplier. The average use of these mechanisms, instead, is quite low, but there are a few firms that adopt them to a much greater extent, as shown by the high standard deviation. Although the two factors are not identical up- and downstream, they have been named in the same way, since the relevant content is very close.

In the second step of the analysis, the sample has been subdivided into clusters based on the three factors, corresponding to the areas of adoption of e-business, in order to highlight different patterns of adoption of the Internet. The approach is similar to the one adopted in literature on *strategic configurations*, which aims at individuating groups of companies whose strategies are very similar within the same cluster and different from those of the rest of the sample (Bozarth and McDermott, 1998; Frohlich and Dixon, 2001; Miller and Roth, 1994). Given the aim of the present study, the most appropriate variables to identify e-business strategies are the different approaches to Internet adoption within the supply chain.

Hierarchical cluster analysis using Ward's partitioning method and squared Euclidean distance allowed the determination of the most suitable number of clusters, while a non-hierarchical technique (the K-means algorithm) was chosen to assign each company to a cluster, through an iterative process. This two-step approach is suggested to exploit the advantages of both techniques (Ketchen and Shook, 1996). The number of clusters was determined considering both the increase in the agglomeration coefficient while reducing the number of clusters and

Table IV. Factors related to coordination mechanisms with suppliers and customers

	Coordination with suppliers			Coordination with customers		
Mechanisms	Info. sharing	System coupling	Mean	Info sharing	System coupling	Mean
Production plan	0.832	–	3.33	0.849	–	3.13
Delivery frequency	0.738	–	3.77	0.745	–	3.54
Inventory levels	0.677	–	2.89	0.706	–	2.75
VMI	–	0.754	2.30	–	0.832	2.21
Co-location	–	0.636	1.78	–	0.682	1.78
Std packages	–	0.571	2.80	0.555	–	2.87
Kanban	–	0.537	2.24	–	0.611	1.90
Cronbach's Alpha	0.680	0.559	–	0.749	0.614	–
Mean	3.36	2.27	–	3.12	2.02	–
Standard deviation	0.91	0.83	–	1.02	0.96	–

Note: Factor loadings in excess of 0.45 are shown

the interpretability of the solution obtained. The greatest increase in the coefficient corresponds to the aggregation of all cases from two to one cluster, thus collapsing together adopters and non-adopters of e-business. This means, as mentioned earlier, that the most significant difference between the companies in the sample is between these two macro categories. However, in order to explore different e-business strategies, a four-cluster solution was chosen, corresponding to the second highest increase in the difference between the agglomeration coefficient in two consecutive solutions. Also the interpretability criterion confirmed the choice, since passing from five to four clusters, two quite similar groups merged, while passing from four to three the merging involved two dissimilar groups. To validate the four-group solution, a test of equality of group means (ANOVA) was performed, showing that all variables differ significantly across the clusters. Discriminant analysis was run to ensure that the groups were correctly classified: the analysis shows very good differentiation among the groups (Miller and Roth, 1994).

Finally, ANOVA, *Post Hoc* and Pearson Chi-squared tests have been used to detect the links between e-business strategies, contingent settings and coordination mechanisms.

Results

The use of the Internet in manufacturing firms

As mentioned earlier, the first step of the analysis has been the investigation of e-business adoption. As seen in Table III, the average use of the Internet is very low, due to a high number of companies not adopting it at all, and a limited number of companies adopting it to a high extent (as shown by the high standard deviation). This is consistent with the literature, which shows that only some firms have actually adopted the Internet (Van Hoek, 2001b). In particular, one can see that the adoption of the Internet is higher in downstream and upstream processes (e-commerce and e-procurement), while is lower within the company (e-operations).

For the firms that do use the Internet, the payoff is, on average, on intermediate values (almost 3 on a five-point scale), but with a certain variability (standard deviation around 1). This means that there is a sub-set of firms that actually use the Internet and have obtained rather good results from it, although they are a minority of the sample.

E-business strategies

The above results suggest that there are different degrees of adoption of the Internet and, besides that, it can be used to integrate different processes.

Consequently, firms were grouped in four categories using cluster analysis, in order to highlight different e-business strategies, each one characterized by the adoption of the Internet in different areas. The discriminant analysis showed that the clustering algorithm classified 98.9 percent of the companies correctly, indicating very good differentiation among the clusters. The Post Hoc test, using the Scheffé method, showed that the difference between each pair of cluster is statistically significant for each of the three factors, with only one exception. The results of the cluster analysis are shown in Tables V and VI.

The four clusters obtained through the analysis are discussed in the following sections.

Traditionals. This is the largest group in our sample, with no relevant use of Internet-based technologies within the supply chain. In fact, the three e-business factors are significantly lower than in every other cluster. Having detected that this group is coherent with the preliminary results about e-business adoption and with the common understanding that the Internet has generated considerable discussion and promised much, but, as yet, has only been adopted by a relatively small number of firms. The data were collected during 2001, thus it is possible that in the subsequent years, more companies within this group have adopted e-business. However, given the end of the "new economy" hype and the economic downturn, the situation is not likely to have dramatically changed. In our sample, this group accounts for about 55 percent of the companies.

Table V. Clusters obtained on the base of Internet adoption factors

	Clusters				
Factor	1 Traditionals	2 E-sellers	3 E-purchasers	4 E-integrators	ANOVA Sig.
E-commerce	1.30	2.99	1.74	4.18	0.00
Pairwise difference	(2, 3, 4)	(1, 3, 4)	(1, 2, 4)	(1, 2, 3)	–
E-procurement	1.31	1.81	3.43	3.99	0.000
Pairwise difference	(2, 3, 4)	(1, 3, 4)	(1, 2, 4)	(1, 2, 3)	–
E-operations	1.15	1.96	1.76	3.60	0.000
Pairwise difference	(2, 3, 4)	(1, 4)	(1, 4)	(1, 2, 3)	–
No. of firms	153	64	39	20	–
Percent	55.4	23.2	14.1	7.3	–

Note: Pairwise differences shown are significant at the 0.05 level (*Post Hoc* test using the Scheffé method)

Table VI. Payoff of the adoption of the Internet

	E-commerce	E-procurement	E-operations
E-sellers	3.18	–	–
E-purchasers	–	3.38	–
E-integrators	4.12	3.67	3.83

Note: The difference in the e-commerce payoff between e-integrators and e-sellers is statistically significant at the 0.01 level

E-sellers. This cluster contains 64 firms adopting the Internet mostly for sales and customer care. The e-commerce factor is in fact significantly higher than traditionals and e-purchasers. This group is fairly large (23 percent of the sample) and this is in line with indications provided by the literature. The use of the Internet mainly for sales and customer care has been seen, especially at the beginning of the "new economy", as the most frequent approach to the adoption of the Internet (Van Hoek, 2001a, b). Anyway, we cannot conclude that this is necessarily the best strategy for companies; it will be interesting to observe whether firms in this group will go on in this direction or if they will instead move to other strategies. A first indication in this direction comes from the fact that, while the e-procurement factor is lower than in any other group except traditionals, e-operations is higher (even if not significantly so) compared to e-purchasers. This fact suggests that these companies are also integrating their internal processes related to e-commerce.

E-purchasers. This group includes 39 firms (14 percent of the sample) adopting the Internet to a significant extent only for one upstream process within the supply chain, namely purchasing. In fact, e-procurement is significantly higher than in every other group, except e-integrators, the other factors being significantly lower. This means that e-procurement is seen as a practice with which companies can start introducing the Internet, without relevant investments in other areas.

E-integrators. This cluster includes 20 firms adopting the Internet in all the processes of the supply chain, from procurement to sales, including internal operations. This is the smallest group (7 percent), and includes the most advanced firms as far as Internet adoption is concerned, since they adopt web-based solutions to a high extent along the whole supply chain (the value of the three factor is significantly higher than in every other group). Internet adoption in this cluster seems to be most coherent, since technology supports the integration of the whole supply chain. Clearly, only a limited number of companies have adopted this integrated approach as yet, which is in line with the suggestions provided in the literature for achieving the best results (Van Hoek, 2001a, b).

General comments. It is interesting to note that, as could be expected, the companies which actually use the Internet have also quite higher payoffs in the processes involved, compared to non-adopters. Besides, e-integrators also have a higher payoff than e-sellers from e-commerce, suggesting the higher effectiveness of a fully integrated strategy.

As a general comment, it is interesting to note that the use of the Internet to support internal operations is only used together with both e-commerce and e-purchasing, to obtain overall supply chain integration, while it is only used in a limited way to support integration downstream. One can expect some sequence or path of Internet adoption, depending on the ease or benefits obtained by each strategy.

Further insights on this subject can be derived from Table VI, which shows the declared future adoption of the Internet.

The first impression is of a general tendency towards an increase in Internet adoption, in particular, each group seems to go on in the same direction followed

so far; the three strategies, in fact, are still clearly the same. The comparison of the values, however, could also suggest that both e-purchasers and e-sellers tend to widen their strategies, investing also on other processes, suggesting the possibility of an evolutionary path towards e-integrators. Considering the differences between future and current adoption, indeed, some interesting observations can be made. The greatest increase is declared by e-purchasers in the e-commerce area (+1.19), while the second greatest by e-sellers in e-procurement (+0.90), and both groups are also similarly planning to adopt e-operations (+0.63 for e-purchasers and +0.66 for e-sellers). This means that those companies, who have so far adopted e-business in limited areas of the supply chain, are trying to close the gap with e-integrators, who however are not standing still, since they are planning to strengthen all the areas, in particular e-operations (e-commerce +0.44, e-procurement +0.30, e-operations +0.51). Firms belonging to the traditionals group are also moving, declaring higher adoption, in particular for e-commerce (+0.76) and e-procurement (+0.62). It seems likely that new adopters are starting from one single area (e-commerce or e-procurement), to move subsequently to wider adoption strategies.

The effect of contingencies on the adoption of the Internet

The clusters presented in the earlier section have been analyzed, considering contingent factors, such as industry, size and position in the supply chain. The results presented in Tables VII-X highlight some interesting differences among the groups, although only the industry factor is statistically significant (Pearson Chi-Squared test).

The contingencies that characterize each cluster are discussed in detail.

The companies that are not using Internet technologies in the supply chain are rather dispersed, there is no contingent setting without a relevant presence of this group of firms. This approach seems to be still very diffused, irrespective of industry, size or position in the supply chain. Anyway, traditional firms are more concentrated in the automotive and transportation (384) and less in the measuring and control equipment industry (385), compared to the sample distribution. As far as size is concerned, this group of companies does not differ significantly from the total sample. Considering the position in the supply chain, finally, the firms that do not use the Internet are more concentrated upstream and less downstream.

Table VII. ANOVA of the future adoption of the Internet

	Traditionals	E-sellers	E-purchasers	E-integrators	Sample mean	Sig.
E-commerce	2.06	3.73	2.94	4.63	2.80	0.000
E-procurement	1.93	2.71	4.01	4.29	2.61	0.000
E-operations	1.53	2.62	2.39	4.11	2.13	0.000

Table VIII. Industry distribution of the clusters

ISIC	Traditionals (%)	E-sellers (%)	E-purchasers (%)	E-integrators (%)	Sample (%)
381	30.1	20.3	38.5	15.0	27.9
382	26.1	35.9	23.1	15.0	27.2
383	24.2	28.1	17.9	55.0	26.4
384	15.0	6.3	2.6	10.0	10.9
385	4.6	9.4	17.9	5.0	7.6
Sig.	0.004	–	–	–	–

Table IX. Size distribution of the clusters

Size	Traditionals (%)	E-sellers (%)	E-purchasers (%)	E-integrators (%)	Sample (%)
Small	51.6	48.4	53.8	20.0	48.9
Medium	19.6	20.3	20.5	25.0	20.3
Large	28.8	31.3	25.6	55.0	30.8
Sig.	0.170	–	–	–	–

Table X. Distribution of the position in the supply chain of the clusters

Position	Traditionals (%)	E-purchasers (%)	E-sellers (%)	E-integrators (%)	Sample (%)
Upstream	34.6	25.6	31.3	20.0	31.5
Intermediate	9.2	5.1	9.4	5.0	8.3
Downstream	54.9	64.1	56.3	75.0	58.0
Missing	1.3	5.1	3.1	0.0	2.2
Sig.	0.656	–	–	–	–

Note: *Upstream*: 70 percent or more of sales to component manufacturer or product assembler; *Downstream*: 70 percent or more of sales to distributors or end users; Intermediate: less than 70 percent of sales to both groups

E-sellers. Companies that adopt the Internet mainly in the selling process are concentrated in the machinery industry, while their presence is limited in both the metal products and the automotive and transportation industries. There are slightly more large firms than small ones, but the size distribution in this category is very similar to the total sample. No relevant differences with the sample can be found when considering the position in the supply chain either, although it seems that they are slightly more concentrated in intermediate positions.

E-purchasers. Companies that use the Internet mainly in the procurement process are strongly concentrated in the metal products and measuring and control equipment industries (381 and 385), with a very low presence in the electrical machinery and automotive and transportation ones (383 and 384). This group shows the highest concentration of small firms and the lowest presence of medium and large ones, which is a very interesting result, meaning that the Internet is both feasible and actually adopted by SMEs. Finally, e-purchasers are concentrated in the downstream stages of the supply chain. This is not surprising, since companies at these stages

rely strongly on their suppliers, and with purchasing consequently being a strategic process, the use of Internet technologies can provide relevant benefits.

E-integrators. The firms that use the Internet in all the supply chain processes are strongly concentrated in the electrical machinery industry, with a low presence in both the metal products and the machinery industries, although the limited dimension of this group (20 companies) does not allow to generalize this result. Also considering size there is a relevant polarization towards large firms, with a marginal presence of small ones; this result anyway is not surprising, given the investment required by such a pervasive use of e-business. The position in the supply chain, finally, is also strongly shifted downstream.

General comments. In synthesis, the analysis of contingencies shows that only industry has a statistically significant impact, but all the factors considered present differences among the clusters.

The companies in the sample belonging to the automotive industry are the ones with the lowest adoption of the Internet. This is rather surprising, since this industry is usually technologically highly developed and relies strongly on supply chain processes. Maybe the high diffusion of EDI has hampered the penetration of web-based technologies. The companies in the metal products and in the measuring and control equipment industries are mainly focused on the procurement process. Those in the machinery industry are focused on the selling process, while the electrical machinery is the industry with the highest rate of e-integrators.

Small firms either adopt the Internet for the procurement process or they do not use it at all, while large firms can more easily afford a pervasive use, involving all the three main processes.

Companies operating upstream in the supply chain generally show the lowest use of the Internet, while those operating downstream are more likely to adopt it, in particular for the procurement process, in some cases even for all processes together.

E-business strategies and supply chain integration mechanisms

The last step of the analysis has been the investigation of possible relationships between the adoption of e-business and the coordination mechanisms used to integrate the supply chain, which could be supported by the Internet, but could also be implemented through more "traditional" technologies. The factor analysis (see previous section) highlighted the same mechanisms both up- and downstream: *information sharing*, based on an intense exchange of information between the customer and the supplier, and *system coupling*, which consists of practices such as VMI, kanban, and co-location.

The use of these mechanisms by the different groups of firms has been investigated through ANOVA and Post Hoc tests, and the results are presented in Table XI.

Table XI. ANOVA of the factors related to coordination mechanisms

	Traditionals	E-sellers	E-purchasers	E-integrators	Sample	Sig.
Info sharing suppliers	3.19	3.48	3.53	3.84	3.36	0.004
Pairwise difference	(4)	–	–	(1)	–	–
System coupling suppliers	2.13	2.36	2.23	3.06	2.27	0.000
Pairwise difference	(4)	(4)	(4)	(1, 2, 3)	–	–
Info. sharing customers	3.06	3.09	3.14	3.55	3.12	0.271
Pairwise difference	–	–	–	–	–	–
System coupling customers	1.86	2.04	2.16	2.82	2.02	0.000
Pairwise difference	(4)	(4)	–	(1, 2)	–	–

Note: Pairwise differences shown are significant at the 0.05 level (*Post Hoc* test using the Scheffé method)

From the data, we can observe that information sharing is a common integration mechanism, used by all groups of firms, both adopters and non-adopters of the Internet. This clearly means that a lot of companies still rely on traditional tools and methods to exchange information with their customers and suppliers. However, the companies that do use the Internet show higher values of information sharing with suppliers, thus supporting the idea that the Internet enforces communication. The *Post Hoc* test shows that e-integrators use these mechanisms significantly more than the firms belonging to the traditional cluster. In general, e-integrators show the highest use of information sharing. This first result suggests that e-integrators are the companies that have closer relationships with their partners, and that the use of the Internet seems to be aimed at facilitating them.

System coupling, both up- and downstream, is lesser spread than information sharing. Some differences exist between traditionals and Internet adopters, even if they are not significant, with the exception of e-integrators. This result suggests that often Internet adoption is aimed at supporting market transactions, with tools such as auctions, catalogues and marketplaces, instead of collaboration. E-integrators, instead, employ system coupling at the highest level, suggesting a relationship between the adoption of advanced coordination mechanisms and the pervasive use of the Internet. The *Post Hoc* test shows that the adoption of system coupling with suppliers by e-integrators is significantly higher than any other group in the sample, and system coupling with customers is also significantly different from both traditionals and e-sellers. This result reinforces the idea that e-integrators are the companies that have developed close, collaborative relationships along the supply chain and are thus using the Internet along with traditional integration mechanisms to obtain better coordination and support collaboration. This interesting result should be further analyzed, since the limited number of firms in this group does not allow for generalization. The general characteristics of this cluster, which is made up mostly by large firms, seem to be relevant in explaining this strategy, which indeed requires considerable investments and significant process re-engineering.

Finally, the analysis has shown a relationship between e-business strategies and integration mechanisms, suggesting that integrated strategies do exist. In particular, e-business is adopted in at least one supply chain process by those companies that share information with partners, confirming the synergy between the two. Instead if we consider those companies that use the Internet throughout their supply chain (e-integrators), we notice that they both exchange information to a high extent and closely integrate their systems with their partners. This is a new supply chain strategy, which requires a radical redesign, but is also expected to provide the highest benefits, since it is based on a coherent set of choices, and not just on the automation of the existing processes.

Conclusions

The study presented in this paper highlighted the existence of different e-business strategies among those companies that have adopted web-based solutions to integrate their supply chains, strategies that differ in terms of the processes supported by Internet applications. A few studies have already proposed some classification of e-business applications, but they are generally based on conceptual categories or case studies of best practices. The present work, instead, is based on survey data, consequently the strategies identified are those currently adopted by a relevant European sample. These strategies have been explored both in terms of impact of contingent factors and relationship with other supply chain coordination and integration mechanisms. In this way each strategy has been defined considering not only the supply chain processes supported by e-business, but also the related use of information sharing and system coupling mechanisms with both customers and suppliers.

The value of the present study is twofold. On the one hand, it contributes to current research presenting a taxonomy of strategies based on-empirical data, on the other, it provides useful insights for managers.

The evidence discussed in this paper shows that both partial adoption of the Internet on a few processes and complete adoption throughout the supply chain are used by companies. The former strategies, although presenting satisfactory payoffs, seem to be a transition state. In fact, on average these companies plan to extend the use of the Internet to other processes. The study also showed how few companies that have implemented e-business solutions extensively, i.e. throughout the supply chain, are now achieving far better payoffs. This strategy thus seems to be superior in terms of effectiveness. Interestingly, the empirical evidence shows that this extensive adoption of the Internet is closely related to the considerable use of other mechanisms of supply chain integration, namely information sharing and system coupling. This result suggests that virtual integration is one of the different solutions used by these companies to collaborate and integrate processes across the company boundaries. In contrast, firms that use the Internet only in limited areas are doing so mostly to increase the effectiveness of information exchange along the supply chain.

To summarise, we can draw two main conclusions. First, Internet adoption generally follows incremental strategies that go from a limited to a wider use of e-business tools along the supply chain, starting from external processes and subsequently integrating internal ones. Second, extensive use of the Internet along the supply chain is expected to be coupled mainly with close collaboration relationships, while limited adoption is often simply related to information sharing effectiveness.

Based on these results, some managerial implications can also be drawn.

When facing decisions regarding the adoption of Internet tools within their supply chain processes, companies should consider the overall e-business strategy that is more suitable to their peculiar processes, together with a pattern of implementation. This is especially important for those small companies that cannot invest a large amount of money at one single moment. While integrated e-business strategies – up and downstream – seem to pay off considerably, this is not the best strategy for every company. Managers need to carefully consider the coherence between the Internet tools to adopt and choices in terms of integration with customers and suppliers. The Internet can support and facilitate information sharing, both in collaborative or in market-type relationships, or can be used to support closer integration (system coupling) with the partners.

The study suggests that future research efforts should be directed towards a deeper analysis of the types of relationship that can be supported by the different e-business strategies, in order to understand which benefits can be drawn by Internet-based solutions in each case. Related to this, further research should also quantify the impact of e-business on supply chain performance, in order to provide an objective measure of its highly proclaimed benefits. Finally the evolutionary path of e-business adopters is definitely worth studying, in order to understand if there are preferred steps or, instead, different paths can be followed. Only longitudinal evidence will support this research question.

References

Bagozzi, R.P. and Yi, Y. (1988), "On the evaluation of structural equation models", *Academy of Marketing Science*, Vol. 16 No. 1, pp. 787-802.

Bozarth, C. and McDermott, C. (1998), "Configurations in manufacturing strategy: a review and directions for future research", *Journal of Operations Management*, Vol. 16, pp. 427-39.

Brynjolfsson, E. and Smith, J. (2000), "Frictionless commerce? A comparison of Internet and conventional retailers", *Management Science*, Vol. 46 No. 4, pp. 563-85.

Brynjolfsson, E. and Urban, G.L. (Eds) (2001), *Strategies for e-business Success*, Jossey-Bass, San Francisco, CA.

Cagliano, R. and Spina, G. (2000), "Advanced manufacturing technologies and strategically flexible production", *Journal of Operations Management*, Vol. 18 No. 2, pp. 169-90.

Croom, S. (2001), "Restructuring supply chains through information channel innovation", *International Journal of Operations & Production Management*, Vol. 21 No. 4, pp. 504-15.

De Boer, L., Harink, J. and Heijboer, G. (2002), "A conceptual model for assessing the impact of electronic procurement", *European Journal of Purchasing and Supply Management*, Vol. 8, pp. 25-33.

Evans, P. and Wurster, T.S. (1999), "Getting real about virtual commerce", *Harvard Business Review*, pp. 85-94.

Feeny, D. (2001), "Making business sense of the e-opportunity", *MIT Sloan Management Review*.

Frohlich, M.T. and Dixon, J.R. (2001), "A taxonomy of manufacturing strategies revisited", *Journal of Operations Management*, Vol. 19, pp. 541-58.

Frohlich, M.T. and Westbrook, R. (2001), "Arcs of integration: an international study of supply chain strategies", *Journal of Operations Management*, Vol. 19, pp. 185-200.

Frohlich, M.T. and Westbrook, R. (2002), "Demand chain management in manufacturing and services: web-based integration, drivers and performance", *Journal of Operations Management*, Vol. 20, pp. 729-45.

Fullerton, R.R. and McWatters, C.S. (2001), "The production performance benefits from JIT implementation", *Journal of Operations Management*, Vol. 19, pp. 81-96.

Graham, G. and Hardaker, G. (2000), "Supply-chain management across the Internet", *International Journal of Physical Distribution & Logistics Management*, Vol. 30 No. 3/4.

Hakansson, H. and Snehota, I. (1995), *Developing Relationships in Business Networks*, Routledge, London.

Kalakota, R. (2000), "Next-generation B2B solutions", *Supply Chain Management Review*.

Kaplan, S. and Sawhney, M. (2000), "E-hubs: the new B2B marketplaces", *Harvard Business Review*.

Kehoe, D.F. and Boughton, N.J. (2001), "New paradigms in planning and control across manufacturing supply chains: the utilisation of Internet technologies", *International Journal of Operations & Production Management*, Vol. 21 No. 5/6, pp. 582-93.

Ketchen, D.J. and Shook, C.L. (1996), "The application of cluster analysis in strategic management research: an analysis and critique", *Strategic Management Journal*, Vol. 17, pp. 441-58.

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998), "Supply chain management: implementation issues and research opportunities", *The International Journal of Logistics Management*, Vol. 9 No. 2, pp. 1-17.

Lee, H.L. and Whang, S. (2001), "Supply chain integration over the Internet", in *CommerceNet*, 8 January, available at: www.commerce.net/research/ebusiness-strategies/2k1/2k1_2k1_r. html

Lindberg, P., Voss, C.A. and Blackmon, K. (1998), *International Manufacturing Strategies. Context, Content, and Change*, Kluwer Academic Publishers, Dordrecht.

Malone, T., Yates, J. and Benjamin, R. (1987), "Electronic markets and electronic hierarchies: effects of information technology on market structure and corporate strategies", *Communications of the ACM*, Vol. 30 No. 6, pp. 484-97.

Miller, J. and Roth, A. (1994), "A taxonomy of manufacturing strategies", *Management Science*, Vol. 40, pp. 285-304.

Norusis, M. (1993), SPSS *for Windows. Release 6.0*, SPSS Inc., Chicago, IL.

Nunnally, J. (1978), *Psychometric Theory*, McGraw-Hill, New York, NY.

Punj, G. and Stewart, D.W. (1983), "Cluster analysis in marketing research: review and suggestions for application", *Journal of Marketing Research*, Vol. 20, pp. 134-48.

Sampler, J.L. (1998), "Redefining industry structure for the information age", *Strategic Management Journal*, Vol. 19 No. 4, pp. 343-55.

Skjoett-Larsen, T. (2000), "European logistics beyond 2000", *International Journal of Physical Distribution & Logistics Management*, Vol. 30 No. 5, pp. 377-87.

Soliman, F. and Youssef, M. (2001), "The impact of some recent developments in e-business on the management of next generation manufacturing", *International Journal of Operations & Production Management*, Vol. 21 No. 5/6, pp. 538-64.

Stevens, G.C. (1989), "Integrating the supply chain", *International Journal of PhysicalDistribution & Materials Management*, Vol. 19 No. 8, pp. 3-8.

Van Hoek, R. (1998), "Logistics and virtual integration. Postponement, outsourcing and the flow of information", *International Journal of Physical Distribution & Logistics Management*, Vol. 28 No. 7, pp. 508-23.

Van Hoek, R. (2001a), "Epilogue: UPS logistics - practical approaches to the e-supply chain", *International Journal of Physical Distribution & Logistics Management*, Vol. 31 No. 6, pp. 463-8.

Van Hoek, R. (2001b), "E-supply chains - virtually non-existing", Supply Chain Management: *An International Journal*, Vol. 6 No. 1, pp. 21-8.

Whitaker, J.D., Murphy, M.D., Haltzel, A.H. and Dik, R.W. (2001), "Private exchanges: the smart path to collaboration", *Supply Chain Management* Review, global supplement, July/August.

Wise, R. and Morrison, D. (2000), "Beyond the exchange: the future of B2B", *Harvard Business Review*, November-December.

Appendix. Extract from the IMSS III questionnaire

T3. Please indicate to what extent do you use Internet to integrate the activities of the following processes along the supply chain

Degree of use None				High	Relative payoff None				High		Expected use within 1 year None				High
1	2	3	4	5	1	2	3	4	5	Procurement of standard parts	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Procurement of strategic parts	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Inventory management	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Production planning and scheduling	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Transportation planning	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Order processing and tracking	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Sales	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	Customer service and support (CRM)	1	2	3	4	5

SC5. How do you coordinate planning decisions and flow of goods?

	Level of adoption With your suppliers None				High	With your customers None				High
Share information about the inventory levels	1	2	3	4	5	1	2	3	4	5
Share information about production planning decisions and demand forecast	1	2	3	4	5	1	2	3	4	5
Co-location of plants	1	2	3	4	5	1	2	3	4	5
Use of standard packages and containers	1	2	3	4	5	1	2	3	4	5
Agreements on delivery frequency	1	2	3	4	5	1	2	3	4	5
Use of Kanban systems to deliver your products						1	2	3	4	5
Supply your customer through consignment stock and/or Vendor Managed Inventories						1	2	3	4	5
Use of Kanban systems to acquire materials	1	2	3	4	5					
Require your supplier to manage or hold inventories of materials at your own site	1	2	3	4	5					

6.2 Review and Outlook

6.2.1 Introduction

Our friend and colleague Gianluca Spina was the co-author of a remarkable sequel in the field of supply chain management published in the International Journal of Operations and Production Management. A first paper, "E-business strategy: How companies are shaping their supply chain through the Internet", by Raffaella Cagliano, Federico Caniato and Gianluca Spina was published in 2003 (IJOPM, Volume 23, Issue 10, pp. 1142–1162). It discussed the early adoption of Internet technology in the supply chain. An update of the paper was published in 2005 (IJOPM, Volume 25, Issue 12, pp. 1328–1332). And four years later, the initial study was replicated by the same authors, with the help of Matteo Kalchschmidt and Ruggero Golini (IJOPM, Volume 29, Issue 19, pp. 921–945).

In this paper, we reflect on the early study and we discuss its contribution to the field of operations and supply chain management. In a first section, we summarize the main findings of Cagliano et al. (2003). We then consider how the scientific community has evaluated the contribution of the paper. We do so by studying a set of papers in the literature that have cited the early work by Cagliano et al. (2003). In addition to this, we have reviewed the suggestions for future research that were put forward in the 2003-paper and we report some of the lessons that have been learned from this "future" research, carried out by the same team of authors as well as by other researchers in the field.

6.2.2 E-Business Supply Chain Strategies Anno 2003

The initial paper was published in 2003 when the Internet phenomenon was at its peak of expectations. It explores, using data from the International Manufacturing Strategy Survey, "how manufacturers started using the Internet to integrate processes across their supply chain. In particular, … linking the level of collaboration with customers and suppliers to the use of Internet applications to the supply chain processes" (Cagliano et al. 2005, p. 1328).

The authors identified four e-business strategies—*the Traditionals, the E-sellers, the E-purchasers and the E-integrators*—and they discussed the impact these strategies have on supply chain integration mechanisms.

- The *Traditionals* are characterized by a limited use of the Internet in their customer and supplier relationships. They are not very active in sharing information with suppliers and taking joint decision with suppliers or customers, when compared to the other companies in the sample.
- *E-sellers* are mainly interested in the application of Internet technologies towards their market. Interestingly they don't invest much in the relationship

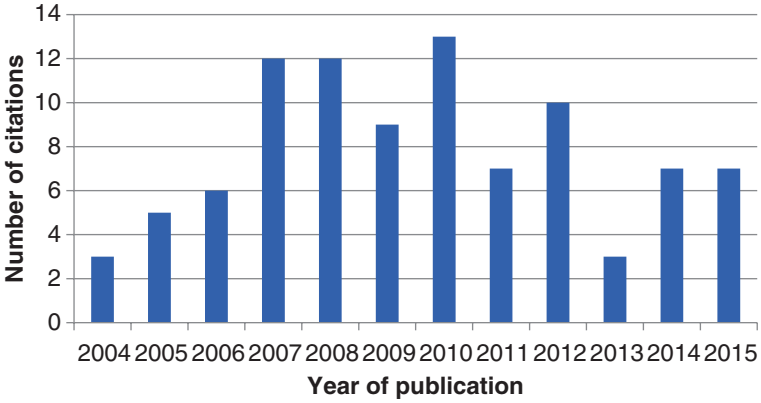

Fig. 6.1 Descriptive statistics of papers citing Cagliano et al. (2003)—Year of publication

with customers nor suppliers, which suggests that the tools are mainly used as a means for getting access to the customers rather than for cooperation.
– *E-purchasers* are characterized by a focused adoption of the Internet in supplier relationships and purchasing activities. They are typically positioned in the downstream stages of the supply chain.
– The *E-integrators* invest significantly in Internet applications both upstream and downstream in the supply chain. They exchange information to a high extent and they closely integrate their systems with both customers and suppliers.

6.2.3 Attracting Interest from the Research Community

The paper has attracted a lot of interest from the research community. With more than 90 citations[2] since its publication in 2003, it has clearly become a key reference paper. Even today, more than 10 years after its publication, the paper still draws the attention of researchers in the field, as can be seen in Fig. 6.1.

Table 6.1 classifies the papers citing Cagliano et al. (2003) according to their main area of research. As could be expected given that the paper was published in IJOPM and was theoretically grounded in Operations Management theory, many of the citations (26 %) are in the area of Operations Management. Another 20 % of the citations are in publications on Supply Chain Management, which is the specific area of investigation of the 2003-paper. Interestingly, 26 % of the considered papers are in the ICT area with publications in journals such as the European Journal of Information Systems, Information Systems Journal, International Journal of Information Management and Internet Research.

[2]We identified, through a Scopus search in January 2016, 94 papers citing Cagliano et al. (2003).

Table 6.1 Descriptive statistics of papers citing Cagliano et al. (2003)—area of research

Area	% of papers
Operations management	26
ICT	26
Supply chain management	20
E-business	13
Management and economics	9
Others	6

This indicates that the paper contributes to the integration of two distinct research perspectives: on the one hand the strategic role of ICT as a support system and on the other hand practices in operations and supply chain management as an application area.

From the list of papers citing Cagliano et al. (2003), we selected 19 papers for further analysis. The selection was essentially based on the impact of these papers (measured by the relevance of the journal of publication and the number of publications citing the paper) and on the relevance of the topic of the paper with respect to the topic of Cagliano et al. (2003). Among these, 8 papers have been published in Operations Management journals (e.g., IJOPM, JOM), 6 in ICT journals (e.g. Information Systems Journal, Internet Research, International Journal of Information Management) and 5 in Supply Chain Management journals (e.g., Supply Chain Management, Journal of Supply Chain Management, International Journal of Production Economics). Table 6.2 provides the list of the selected papers.

We studied these papers, focusing in particular on the reference they made to the 2003-paper and on the discussion they provided of the contribution of this paper. This allowed us to identify the impact that the early work of Cagliano et al. (2003) had on research in the decade that followed its publication. It also allowed us to see to what extent the suggestions for future research that were put forward by Cagliano, Caniato and Spina have been followed by other researchers. We will discuss this in the next two sections of this article.

6.2.4 The Paper's Contribution to the Field of E-Supply Chain

Several authors acknowledge the pioneering role of the 2003-paper by Cagliano et al. They refer to it as one of the first studies providing evidence of **the application of Internet technologies in the supply chain**. In 2007, Harland et al. confirmed the early observation made by Cagliano et al. (2003) that the adoption of e-business in the supply chain was slower than expected. In addition to observing and discussing the rate of adoption, Harland et al. also identified some barriers to

Table 6.2 Selected papers

Authors	Year	Journal
Folinas D., Manthou V., Sigala M., Vlachopoulou M.	2004	Internet Research
Croom S.R.	2005	International Journal of Operations and Production Management
Zheng J., Bakker E., Knight L., Gilhespy H., Harland C., Walker H.	2006	International Journal of Information Management
Cullen A.J., Webster M.	2007	International Journal of Operations and Production Management
Devaraj S., Krajewsky L., Wei J.C.	2007	Journal of Operations Management
Harland C.M., Caldwell N.D., Powell P., Zheng J.	2007	Journal of Operations Management
Power D., Singh P.	2007	Journal of Operations Management
Bakker E., Zheng J., Knight L., Harland C.	2008	International Journal of Operations and Production Management
Harrigan P.O., Boyd M.M., Ramsey E., Ibbotson P., Bright M.	2008	Management Decision
Smart A.	2008	Journal of Enterprise Information Management
Soto-Acosta P., Merono-Cerdan A.L.	2008	International Journal of Information Management
Caniato F., Cagliano R., Kalchschmidt M., Golini R., Spina G.	2009	International Journal of Operations and Production Management
Vanpoucke E., Boyer K.K., Vereecke A.	2009	International Journal of Operations and Production Management
Thun J.-H.	2010	Journal of Supply Chain Management
Vijayasarathy L.R.	2010	International Journal of Production Economics
Wei H.-L., Wang E.T.G.	2010	European Journal of Information Systems
Zhang X., van Donk D.P., van der Vaart T.	2011	International Journal of Operations and Production Management
Sila I., Dobni D.	2012	Industrial Management and Data Systems
Chang H.H., Tsai Y.-C., Hsu C.-H.	2013	Supply Chain Management

e-adoption, which were not only technical, but also cultural or business-related. Along the same lines, Power and Singh (2007) discussed the dilemma that managers face when considering investments in Internet technologies in the supply chain.

Moreover, the 2003-paper helps to understand how **Internet technologies and supply chain integration** processes are interconnected. Harland et al. (2007), amongst others, appreciate the paper for showing the link between the use of Internet technologies and integration mechanisms in the supply chain. Zheng et al. (2006) highlight that the paper provides evidence that "the degree of e-adoption through the supply chain is related to the level of integration with customers and suppliers" (p. 293). Similarly, Power and Singh (2007) highlight that the paper

contributes by linking the effective applications of Internet-based technologies with the degree to which processes are integrated with customers and suppliers. They conclude that the paper clearly shows "the importance of combining the practice of sharing information with trading partners, with the capability to share" (Power and Singh 2007, p. 1294). In turn, Thun (2010) recognizes that the paper demonstrates that supply chain integration can be achieved thanks to "the efficiency of information transfer, the timeliness of information availability and the openness and transparency of relevant business information" (p. 31), which come with Internet-based applications. We read similar comments on the interconnection of Internet-based technologies and supply chain integration in Zhang et al. (2011) and Folinas et al. (2004).

The paper has also contributed to the broader discussion on the **impact of information technology on supply chain performance**. Both Zhang et al. (2011)—in their review of the literature—and Vanpoucke et al. (2009)—in their empirical study on the impact of IT on supply chain alliances—refer to the 2003-paper since Internet-based technologies are a specific example of information technologies.

Finally, the 2003-paper goes beyond the observation of the relationship between e-adoption and supply chain integration as it also identifies some of the **contingent variables** (namely the size of the company and its position in the supply chain) that influence the effectiveness of Internet-based technologies in supply chain integration. Harrigan et al. (2008) report that the paper explains clearly how larger companies are more able to invest significant resources on strategic initiatives such as e-procurement. Zheng et al. (2006) and Zhang et al. (2011), express their appreciation for the paper because it shows "the influence of contextual factors such as competition, size and position in the chain on ICT, SCM, performance, and on their relationship" (Zhang et al. 2011, p. 1236). Bakker et al. (2008) clarify that two categories of contingent factors matter for e-adoption: the external context, such as the supply chain structure, and the internal context, such as the organization's readiness for IT.

6.2.5 The Impact on "Future" Research

More than 10 years after the publication of the paper by Cagliano, Caniato and Spina, we believe it is interesting to see to what extent the three main directions for future research that were put forward by the authors have been followed: (1) the need for a deeper analysis of the supply chain relationships that can be supported by e-business strategies, (2) the need for more research on the impact of e-business on supply chain performance, and (3) the need for more research on the evolutionary pattern of e-business adoption in the supply chain.

The call for a deeper analysis of the **relationships supported by different e-business strategies** has been answered by several researchers. Papers published since 2003 have addressed this topic along three main areas of development:

the context of the relationship, the role of people within the relationship and the transactions taking place within the relationship. Several researchers have studied the context of the supply chain relationship and have expanded the *contingency perspective of e-business* application in the supply chain that was offered by Cagliano et al. (2003). Power and Singh (2007) and Harland et al. (2007), for example, show that the hypothesis of one-size fits all is indeed not supported and that different solutions should be applied in different contexts, suggesting that contingent or configurational approaches are more suitable. Harrigan et al. (2008) provide evidence that larger companies are more keen to invest in Internet-based technologies. Sila et al. (2012) on the other hand focused on e-business in smaller companies, in particular on B2B e-commerce in SMEs: they confirm the implementation of different strategies for e-business. Bakker et al. (2008) identify internal competence maturity as an important contingency factor for the adoption of Internet-based technologies. Several authors also identified the important *role of people* in making e-business a positive opportunity for supply chain integration. Harland et al. (2007) identified the role of leadership in defining the best configuration of the chain and Harrigan et al. (2008) highlighted the importance of people's attitude toward e-systems in order to achieve tangible benefits. Cullen and Webster (2007) add to this that the impact of e-business on supply chain integration depends on the kind of *transaction between customer and supplier*. Thus, they shift the focus from the relationship to the single transaction between partners in the supply chain as the unit of analysis.

Following up on the second suggestion for future research, i.e. the call to provide a deeper understanding of the **impact of e-business on supply chain performance**, Harland et al. (2007) provide evidence that the largest benefit of e-business occurs when its application is fully integrated through the chain. Harrigan et al. (2008) show that the impact of e-procurement is higher when technical competencies and systems (e.g. ERP, CRM, SCM) are owned by both parties in the transaction. In turn, Devaraj et al. (2007) highlight that e-business per se doesn't contribute to operational performance. They argue that a proper set of competencies is needed in order to actually realize the benefits of Internet-based applications in customer and supplier integration. Chang et al. (2013), in their study on e-procurement in Taiwanese companies, add new insights on the relationship between e-business and supply chain performance. They show that different dimensions of e-procurement (e-design, e-sourcing, e-negotiation and e-evaluation) have a different influence on performance.

Thirdly, Cagliano et al. (2003) suggested that "the **evolutionary path of e-business adopters** is definitely worth studying, in order to understand if there are steps or, instead, different paths, that can be followed" (p. 1160). As mentioned earlier, Cagliano et al. (2003) stated that "Internet adoption generally follows incremental strategies" (p. 1159). Interestingly, in 2005 Croom came to a similar conclusion (Croom 2005). We remind the reader that both studies were carried out in the same period, that is, in the early 2000s, when the Internet was reaching the peak of inflated expectations and the adoption rate was still limited even if companies declared their willingness to invest. The question at that time was

what would happen when the Internet technology would become more mature. The team of authors—Cagliano, Caniato and Spina—took their own call for future research at heart and published two papers, following up on the evolutionary pattern of e-adoption. In their 2005-paper, they already identified that things were changing and they predicted that we would have seen different patterns of adoption of e-business in supply chain integration in the years to come. By 2009, they had completed a replication of their initial empirical study. This paper, published again in IJOPM (Caniato et al. 2009) compared the data used in the 2003-paper (IMSS III data) with data collected in 2005 (IMSS IV data). The paper reported two main findings. First, the level of adoption of Internet-based tools (i.e. e-procurement and e-commerce) by European companies showed a slight, but significant, growth. Firms seemed to have started to climb the "slope of enlightenment" (Gartner Group) by adopting e-business solutions with an incremental approach, as was expected by Cagliano et al. (2005), rather than a radically innovating approach. This finding seems to be confirmed by Sila et al. (2012), who reported that the group of low-adopters of e-business had proportionally become smaller. However, the four clusters identified in the 2003-paper (i.e. *Traditionals*, *E-sellers*, *E-purchasers* and *E-integrators*) were not confirmed. Companies had significantly changed their e-business strategy, in particularly those that in the first study in 2003 had invested mainly in a mono-directional strategy. Over time, firms had evolved towards a more balanced strategy that allowed them to exploit e-business benefits in all their supply chain relationships. These results were confirmed by a longitudinal analysis comparing 47 companies that participated in both research projects.

6.2.6 Conclusions

Clearly, the paper published in 2003 discussed an emerging phenomenon. It marked the beginning of an interesting journey: from the first seminal ideas on the usefulness of a new technology in a company's operations to the empirical assessment of its impact on the company's performance. As one could expect, some of the early insights offered by the 2003-paper have been confirmed in later research; other initial conclusions were revised over time as companies evolved in the adoption of e-business in their supply chain.

The authors—Cagliano, Caniato and Spina—deserve credit for having studied the phenomenon at such an early stage. They were asking questions about the willingness (or lack of willingness) of companies to adopt the new technology in their supply chain, the adoption strategies companies would follow and the impact this could have on performance. In doing so, they have demonstrated an eagerness to learn about something new and emerging. This curiosity for what is new is fundamental to academic research. We as researchers often feel the pressure to specialize, to focus our research on a well-defined and focused topic, and to study what is already known. Whilst this may lead to a good number of publications, it may not

lead to new and fresh insights. It may help us to understand what was, but not to see what may be. The Socratic belief that "the only true wisdom is in knowing you know nothing" has been a driving force for Gianluca Spina in his choice of new themes and unexplored topics for research. Those among us who had the opportunity to work with him will always remember and appreciate him for that.

As time moves on, new technologies emerge and existing technologies are improved. It is our task as researchers to spot these technological opportunities, to ask questions about their application and impact, and to embark on rigorous research to find some answers to these questions. Big data, additive manufacturing, the "cloud" are just a few examples of recent technologies and innovations that can change the way supply chains are structured and managed. In the footsteps of Gianluca Spina and his team, we hope to see many more pioneering studies of such innovations in the supply chain.

At the same time, we would like to applaud the team of researchers for having replicated their own research several years after the first study. It is our belief that our field could benefit from more replication studies. When done thoroughly, such research advances our understanding of phenomena in the supply chain. Either by confirming patterns and relationships, giving confidence in the validity of the earlier conclusions. Or by not-confirming them, which then leads to new research questions and potentially new insights.

References

Bakker, E., Zheng, J., Knight, L., & Harland, C. (2008). Putting e-commerce adoption in a supply chain context. *International Journal of Operations and Production Management, 28*(4), 313–330.

Cagliano, R., Caniato, F., & Spina, G. (2003). E-business strategy: How companies are shaping their supply chain through the Internet. *International Journal of Operations Management, 23*(10), 1142–1162.

Cagliano, R., Caniato, F., & Spina, G. (2005). Reconsidering e-business strategy and the impact on supply chains. *International Journal of Operations and Production Management, 25*(12), 1328–1332.

Caniato, F., Cagliano, R., Kalchschmidt, M., Golini, R., & Spina, G. (2009). Evolutionary patterns in e-business strategy. *International Journal of Operations and Production Management, 29*(9), 921–945.

Chang, H. H., Tsai, Y.-C., & Hsu, C.-H. (2013). E-procurement and supply chain performance. *Supply Chain Management, 18*(1), 34–51.

Croom, S. R. (2005). The impact of e-business on supply chain management: An empirical study of key developments. *International Journal of Operations and Production Management, 25*(1), 55–73.

Cullen, A. J., & Webster, M. (2007). A model of B2B e-commerce, based on connectivity and purpose. *International Journal of Operations and Production Management, 27*(2), 205–225.

Devaraj, S., Krajewsky, L., & Wei, J. C. (2007). Impact of eBusiness technologies on operational performance: The role of production information integration in the supply chain. *Journal of Operations Management, 25*(6), 1199–1216.

Folinas, D., Manthou, V., Sigala, M., & Vlachopoulou, M. (2004). E-volution of a supply chain: Cases and best practices. *Internet Research, 14*(4), 274–283.

Harland, C. M., Caldwell, N. D., Powell, P., & Zheng, J. (2007). Barriers to supply chain information integration: SMEs adrift of eLands. *Journal of Operations Management, 25*(6), 1234–1254.

Harrigan, P. O., Boyd, M. M., Ramsey, E., Ibbotson, P., & Bright, M. (2008). The development of e-procurement within the ICT manufacturing industry in Ireland. *Management Decision, 46*(3), 481–500.

Power, D., & Singh, P. (2007). The e-integration dilemma: The linkages between Internet technology application, trading partner relationships and structural change. *Journal of Operations Management, 25*(6), 1292–1310.

Sila, I., & Dobni, D. (2012). Patterns of B2B e-commerce usage in SMEs. *Industrial Management and Data Systems, 112*(8), 1255–1271.

Smart, A. (2008). eBusiness and supply chain integration. *Journal of Enterprise Information Management, 21*(3), 227–246.

Soto-Acosta, P., & Merono-Cerdan, A. L. (2008). Analyzing e-business value creation from a resource-based perspective. *International Journal of Information Management, 28*(1), 49–60.

Thun, J.-H. (2010). Angles of integration: An empirical analysis of the alignment of internet-based information technology and global supply chain integration. *Journal of Supply Chain Management, 46*(2), 30–44.

Vanpoucke, E., Boyer, K. K., & Vereecke, A. (2009). Supply chain information flow strategies: An empirical taxonomy. *International Journal of Operations and Production Management, 29*(12), 1213–1241.

Vijayasarathy, L. R. (2010). Supply integration: An investigation of its multi-dimensionality and relational antecedents. *International Journal of Production Economics, 124*(2), 489–505.

Wei, H.-L., & Wang, E. T. G. (2010). The strategic value of supply chain visibility: Increasing the ability to reconfigure. *European Journal of Information Systems, 19*(2), 238–249.

Zhang, X., van Donk, D. P., & van der Vaart, T. (2011). Does ICT influence supply chain management and performance? A review of survey-based research. *International Journal of Operations and Production Management, 31*(11), 1215–1247.

Zheng, J., Bakker, E., Knight, L., Gilhespy, H., Harland, C., & Walker, H. (2006). A strategic case for e-adoption in healthcare supply chains. *International Journal of Information Management, 26*(4), 290–301.

Chapter 7
Logistics and Supply Chain Management in Luxury Fashion Retail: Empirical Investigation of Italian Firms. A Review and Outlook

Pamela Danese, Pietro Romano and Andrea Vinelli

Abstract The original paper investigated which is the role of operations and supply chain management in luxury fashion companies' success. It presented the results of the exploratory stage of a research project carried out at Politecnico di Milano and dealing with supply chain management in the luxury fashion industry. In total, 12 Italian luxury fashion retailers were studied in order to describe the main features of operations and supply chain strategies in the luxury fashion segment and to identify their role with respect to the relevant critical success factors. After summarizing the key messages of the paper, the commentary note highlights three major contributions. First, the article sets the step from the old concept of luxury to the new concept of luxury, moving from the simple possession of the product to the delivery and consumer experience, strongly related to SCM activities. Second, the unit of analysis is not the single brand, product, or company, but the supply network overall, including a number of different actors. Third, the paper highlights how different supply chain configurations impact on the critical success factors depending on different contexts.

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7.1 Original Paper[1]

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1. Introduction

The industry of luxury goods, according to forecasts, has become in 2006 a $170 billion business worldwide (Egon Zehnder International, 2006), registering a growth of 7.3% compared to 2005 (Pambianco, 2006); Italian luxury brands represented in 2005 27.5% of the total luxury goods sold worldwide (Jucker, 2006), corresponding to about 40€ billion. In particular, as far as luxury fashion goods are regarded, the Italian market of fashion goods in the luxury segment accounted for about 26€ billion in 2006 (Il Sole 24ore, January 10, 2007) Despite the adverse economic cycle of the last few years, luxury goods experienced increasing demand: this is due in part to the increasing social relevance of owning luxury goods, in part to the strong commitment of the luxury companies in branding and communication management (Castaldo and Botti, 1999).

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As a consequence, entering the luxury segment is a very attractive way to expand a brand and build a sustainable business for the future (Danziger, 2005): markets are polarizing, with growth concentrated both at the lower price and at the high end, especially considering fashion-sensitive businesses.

Given this background, which is the role of operations and supply chain management in luxury fashion companies success? Which is the relative importance of superior product design, positive branding and communication action, and operational excellence in building and sustaining the competitive advantage of a fashion luxury company? Of course, as in any other manufacturing business, production and sourcing management is a key factor (Thomassey et al., 2005), and we know that balancing production and demand is one of the major challenges faced by fashion retailers (Nair and Closs, 2006). But when it comes to manufacturing fashion luxury goods, to what extent operations and supply chain strategies and techniques may affect the success of a luxury fashion company?

This paper presents some results of a wider research project launched by the Centre of Excellence in Supply Chain Management of Politecnico di Milano and named Supply Network Strategy (SNS—Brun et al., 2005). The programme aims at developing a framework model focused on critical decision areas in the strategy formulation process: strategy is studied in terms of goals (pursue of critical success factors), configuration choices and intra- and inter-firm management practices. The final goal is to provide a support for the definition of the suitable supply chain choices according to the competitive priorities of the supply chain: therefore, the unit of analysis is the complete network of companies and relationships involved.

Given this introduction, the paper is arranged as follows. Section 2 presents a literature review about the luxury segment of the fashion industry and supply chain strategy, showing what are the main limitations in applying the existing supply chain strategy models to the luxury fashion industry. Section 3 is devoted to better outline the research questions, whereas in Section 4 the research methodology is presented, introducing the main features of the companies involved in the performed case studies. Section 5 deals with the analysis of the results. Finally, Section 6 will draw some concluding remarks and suggest future research paths.

2. Literature review

Cigolini et al. (2004) and Miragliotta (2006) provided a comprehensive analysis of the most relevant supply chain management tools and techniques, as well as a conceptual model for efficient and stable product flow across the supply chain: the interested reader could refer to these papers for an introduction to the topic of supply chain strategy. This section will instead discuss two relevant topics for the forthcoming dissertation: first, a definition of the concept of ‘‘luxury’’ with respect to the fashion industry and, second, a review of the available supply chain strategy formulation models, in order to evaluate how these could fit to the luxury fashion industry.

2.1 Overview of the concept of "luxury" with regards to the fashion industry

The concept of "luxury" traces its roots back to the history of the great civilizations of the ancient world: luxury goods have always been associated to wealth, exclusivity and power, as long as it was identified with satisfaction of non-basic necessities. The term "luxury" itself comes from the Latin ''luxus", which means ''soft or extravagant living, sumptuousness, opulence'' (from the Oxford Latin Dictionary in Dubois et al., 2005) or from the Latin ''luxuria'', which means ''excess'' or ''extras of life'' (Danziger, 2005).

The modern industry of luxury goods was born in the XIX century in Europe when, thanks to the industrial revolution, some entrepreneurs established companies aimed at creating exceptional products that represented the elitist lifestyle of the time. Since the seminal works dealing with fashion as a social phenomenon (Blumer, 1969), it was observed that fashion trends affirm themselves in a spontaneous way in accordance to the *Zeitgeist,* i.e. the spirit of the age prevailing at a given moment. Traditionally, a polarization can be observed in the fashion industry: some companies choose to operate in the mass market, selling low-cost products that are available to a large number of consumers, whilst other companies are aiming at providing exclusive and expensive products to an elitist segment of consumer.

Luxury fashion used to be a geographically centralized industry where new trends were diffused from a single location—Paris in the past, Milan more recently—where the collections presented by a small network of couturier became the trends that everybody in the world imitated. Due to the limited local potential growth, these companies had to expand their sales outside the country of origin in order to reach a larger customer base. This put the basis for the present-day global luxury companies (Antoni et al., 2004). Nowadays luxury fashion originates from more sources, both in terms of design and production (Polhemus, 1994; Crane, 1994) and it is distributed all over the world.

This led to a deep change in the concept of luxury fashion, stemming from the idea of *luxury for the masses* (Silverstein and Fiske, 2003). As business grew, the customer base became broader—as the elites of the world became larger and more diverse— and the reputation for exceptional quality evolved into well-established brands: today the brand image and characterization have become one of the most relevant aspects in order to get a positioning into the luxury market. The emotional factors have been getting more and more importance, as customers are looking for goods that are characterized by reliable performances and perfection of details but at the same time they want to be emotionally involved and feel a complete and memorable shopping and ownership experience. In this regard, Reddy and Terblanche (2005) divided luxury brands into two categories: those which are primarily recognized for their technical features and those which, in the eyes of the customer, are primarily symbolic: people buy Ferrari, for instance, because of the vehicles' world-class performance and engineering, while other luxury brands, like Gucci, are valued more for the lifestyle they project than for the particular expertise or functionality they embody.

Today most authors agree that ‘‘luxury’’ does not actually identify a category of products rather than a conceptual and symbolic dimension, defined by values which are strongly related with the cultural elements that characterize a society in a particular historical period. A decade ago, Nueno and Quelch (1998) highlighted that the idea of ‘‘luxury’’ does not merely apply to premium priced products; it encompasses a set of distinctive characteristics, namely *consistent delivery of premium quality, heritage of craftsmanship, recognizable style and design, exclusivity, emotional appeal, global brand reputation, association with a country of origin, presence of elements of uniqueness and lifestyle of the creator.* Antoni et al. (2004) proposed a similar framework, drawing the attention on *excellence*, *brand aura* and *desirability*.

A further shift was thus ready to come: Silverstein and Fiske (2003) described the shift from *old luxury* to *new luxury*. Old luxury was about the attributes, qualities and features of the product, and much of its appeal was derived from status and prestige. New luxury defines the category from the point of view of the consumer, that focus on the experience of luxury embodied in the goods and services they buy, not in ownership or possession itself. Luxury products should communicate and delivery emotions and experiences to the consumer. Luxury brand’s role is hence to fulfil luxury fantasies of the customer (Danziger, 2005): performance—no matter what the product or service—is the key: the way the luxury brand delivers fulfilment in the emotional and physical realm of the consumer.

2.2 Brief overview on supply chain strategy literature

In the last two decades many authors dealt with the topic of supply chain management: some of them dedicated to the strategic level and developed models for a proper supply chain strategy, others focused on the identification of the available techniques and tools for supply chain configuration and management.

The concept of Supply Chain Strategy has been proposed as an evolution of the consolidated framework of Manufacturing and Operations Strategy proposed by Skinner (1969) and Hayes and Wheelwright (1984). Harland et al. (1999) proposed to extend the operations strategy framework to the supply chain (in terms of competitive priorities, structure and infrastructure). Other contributions expressed the need to focus supply chain strategy and align it towards the critical success factors of the considered product/market. Product features indeed influence supply chain configuration and management choices; a well-established classification is the one proposed by Fisher (1997): *functional* products and *innovativ*e products. Functional products match with a physically efficient supply chain management strategy, while innovative and fashion- sensitive ones (Aitken et al., 2003; Stratton and Warburton, 2003) match with a market-responsive strategy.

Many models have been proposed with the aim of matching the company goals and success factors to the most suitable supply chain strategy (Fisher, 1997; Lamming et al., 2000; Towill et al., 2002; Lee, 2002, 2004; Cigolini et al., 2004). However, such models are meant for companies operating in the mass segment

and they find low correspondence in the luxury segment of the fashion industry (Caniato et al., 2007).

For instance, luxury products cannot be considered as functional, since in the luxury segment cost issues are not as relevant as for Fisher's functional category; similarly the fashion component does not justify the inclusion of luxury products into innovative ones, where the stress is on reactivity performances due to their short lifecycle and highly volatile demand (Choi, 2006; De Toni and Mene- ghetti, 2000): in fact, in the luxury segment, some products could be classified as ''innovative'', while many others are not innovative at all. Reactivity is not the objective when products have hand made details which require very long manufacturing lead times, not when waiting lists are applied as happens for some super-expensive branded lady bags.

More recently, researchers introduced other categories for the purpose of identifying the most appropriate supply chain configuration and strategy. A relevant category could be that of *unique* products (Lamming et al., 2000): uniqueness is often caused by the reputation of its brand, especially in market segments (e.g. apparel/fashion industry) in which the brand name is a determinant of success (Bruce et al., 2004; Byrnes, 2004). Such uniqueness should be created, supported and maintained by managing in an appropriate way throughout the various steps of the supply chain (Bowman, 2004). Manufacturers of unique products may nurture them and also protect them from other parties in the network, fearing that their products, and the resources and competencies which provide their competitive advantage may be replicated by imitators. Therefore, as firms rely on and protect their unique resources in order to generate sustained competitive advantage, they may be expected to exercise caution in sharing them with other parties (Lamming et al., 2000).

As a matter of fact, the literature regarding the luxury goods industry is mainly focused on sociological, marketing and branding aspects, and little attention has been paid to the operations and supply chain strategy perspectives. Despite this, our research experience shows that such issues are not ancillary in the luxury segment: as recognized by Nueno and Quelch (1998) too, design and communication activities may be the main success drivers, but excellence has to be pursued also in product line management, service management and channel management.

Stemming from these consideration, a specific sub-area was opened in the SNS research programme to explore the relevance of operations and supply chain management in the luxury fashion industry. The above-mentioned research gap, together with the importance of the luxury industry in the Italian context, gives reasons for this subproject, which is the core topic of this paper.

3. Research questions

As already stated in the introduction, the overall research aims at exploring the role of operations and supply chain management in luxury fashion companies, and in particular to which extent operations and supply chain activities impact on the

success of luxury firms. In order to cope with this broad and ambitious topic it is necessary to take a step back, and focus on some preliminary questions regarding the critical success factors in the luxury industry and on the currently adopted operations and supply chain practices. Hence, the following research questions will be enquired in this paper.

1. Which is the relevance, as perceived by luxury firms, of the various critical success factors?
   By critical success factors the authors mean those features in terms of product or service design that allow a firm to succeed into a specific market segment: customers select the firm's product and not the competitors' ones because of those specific features (Rockart, 1986). Of course, a firm will not aim at excelling in the whole set of critical success factors that characterize the considered market segment: its competition will mainly focus on a selected subset of such factors, which can be addressed as the "niche area" of the brand.
   For the purpose of this research, the critical success factors proposed by Nueno and Quelch (1998) for the luxury goods industry have been taken as a reference.
2. Which supply chain configurations are currently adopted by luxury firms?
   Supply chain configuration is intended as a set of long-term strategic decisions taken by the company in terms of make-or-buy, supply base definition, localization and distribution channel (Harland et al., 1999).
3. Which are the key choices that need to be considered by those companies?
   It is important to assess which short- and medium-term decisions that need to be taken in order to manage the operational activities along the supply chain of the fashion luxury industry (i.e. decoupling point, inventory management, demand forecasting, supplier selection, etc.).
4. Does any relationship exist between critical success factors and the adopted supply chain configurations and management choices in the luxury fashion industry?
   This final question constitutes the definite step towards the overall aim of the research: it is important to understand whether luxury firms take specific supply chain strategic and operational decisions according to the critical success factors they declare to pursue.

4. Methodology

Given the above research goals and questions, the nature of the study is both explorative and explicative. In fact, we not only aim at describing the supply chain of Italian luxury fashion firms, but we also look at significant links between critical success factors and supply chain configuration and management choices.

For this purpose, the research is based on a multiple case study methodology, which involved a sample of 12 luxury fashion manufacturers in Italy (Table 1).

Table 1 Sample

Name	Managed brands (owned)	Turnover, employees	Main products	Accessories	Evergreen products	Collections per year
1	5 (5)	€ 30–40 million, 120 empl.	Beachwear, Lingerie	Handbags, scarves, pareos, beach related	Yes	2
2	1 (1)	€ 20–30 million, 20 empl.	Shoes in exotic leather	Belts	Yes	2
3	3 (1)	<€ 10 million, 40 empl.	Leather shoes	No	No	2
4	1 (1)	€ 50–60 million, 360 empl.	Knitwear, jackets, suits, apparel in cashmere wool	Leather accessories	Yes	2
5	1 (1)	>€ 100 million, 400 empl.	Handbags, leather wallets, shoes	Textile accessories	Yes	2
6	7 (1)	€ 20–30 million, 40 empl.	Handbags, wallets, belts, other leather accessories	No	Yes	No collections
7	9 (1)	€ 20–30 million, 50 empl.	Handbags, leather wallets,	No	No	2
8	1 (1)	>€ 100 million, 300 empl.	Shoes	Handbags, belts, wallets, gloves, umbrellas	Yes	2
9	3 (3)	€30–40 million, 160 empl.	Shoes	No	No	2
10	1 (1)	€30–40 million, 60 empl.	Handbags and suitcases	No	No	2
11	4(2)	€60–70 million, 200 empl.	Shoes	Key rings, bags	No	2
12	1(1)	>€100 million, 300 empl.	Handbags, leather wallets, shoes	Leather accessories	Yes	2

According to Yin (2004) and Eisenhardt (1989), this number can be considered sufficient to give an accurate account in an empirical research.

Our focus is on the worldwide renowned Italian fashion luxury products, whose brands have achieved international recognition and are facing today the challenge of developing supply chain strategies that can support them in competing globally. For this reason, the industries considered are those related to the traditional Italian products: shoes, apparel, accessories. In order to be eligible for inclusion in the sample (Fernie et al., 1997), the fashion firms were considered only if they:

- have an international profile by appearing in a major catwalk in the key fashion capitals;
- have been established in the fashion business for several years;
- produce merchandize for sale in two or more continents;
- have registered positive and increasing economic results in the last years, thus encouraging us to consider them as good examples of effective managerial practices, despite the differences among them.

Our sample is mainly made of small and medium firms, who usually face great challenges in building global supply chains. The sample also contains some large firms, who were Small-Medium Enteprises (SME) and have grown to support their market expansion. The choice of such a varied sample—as regard company size—makes it representative of the actual composition of the Italian fashion luxury mar ket, which is made of very few fashion giants with billionaire turnover (i.e. Gucci:

3.1€ billion; Armani: 1.4€ billion; Prada: 1€ billion), tens of—equally renowned—medium-sized firms (i.e. Diesel: 0.6€ billion; Geox: 0.5€ billion; Tod's: 0.4€ billion; Versace 0.3€ billion) and plenty of smaller player, some of which owning worldwide known luxury brands (i.e. Iceberg: 92€ million; Liu Jo: 91€ million; Guru: 86€ million; Aspesi: 45€ million; Marinella: 12€ million).

Most of the firms considered in this research manage their own brands, while others just manufacture products that are sold under leading brands; in some cases, the manufacturers have been acquired by the brand owner. Companies in the sample have one or more product lines, as well as complementary accessories that enrich the product offering, and generally launch two collections each year, corresponding to the main selling seasons (fall-winter and spring-summer). At the same time, they offer evergreen items or carry-over products. The choice of such a heterogeneous sample is due to the purpose of exploring different choices in terms of supply chain strategy and management. Moreover, we used in the selection phase the replication technique (Yin, 2004) in order to obtain both convergent (literal replication) and contrasting results (theoretical replication).

Information was collected in each case using semi-structured interviews and documentary analysis. Owners and General Managers (in the case of smaller firms) and Operations Managers (in the case of larger firms) were interviewed; when possible, multiple interviews were conducted in each company to achieve a broader perspective and perform data triangulation. Interviews were recorded and summary reports for each firm were prepared; cross-case synthesis technique was used to analyse and compare data from the research. Moreover, pattern matching and explanation building techniques were helpful in order to understand how the different critical success factors impact on supply chain strategy and management choices (Yin, 2004).

5. Findings

As anticipated, 12 Italian manufacturing companies from the luxury segment of the fashion industry have been studied, in order to identify the critical success factors of their business and to assess the configuration and management choices of their supply chain (Cigolini et al., 2004)

In order to obtain comparable descriptions of the different companies, the information obtained during the interviews was organized as referring to three macro-processes (namely: sourcing, manufacturing and retailing): supply chain configuration and management choices were described and analysed with respect to these three areas. In the following sections, the supply chain configuration of the companies will be presented; the supply management choices and tools will be analysed and the impact of critical success factors on such choices will be discussed.

5.1 Critical success factors in the luxury segment of the fashion industry

The first result to be obtained from the case studies was the identification of critical success factors for the luxury segment of the fashion industry. The interviewee was asked to identify, within those listed by Nueno and Quelch (1998), the critical success factors which more suitably applied to their business. Among the companies involved in the research, the following critical success factors were more frequently indicated (see Table 2) and therefore can be considered as most relevant:

- *Product quality:* this aspect is to be considered both in terms of product compliance with the specifications and in terms of superior manufacturing quality. Luxury brands are not just empty names: they have to stand for quality, so that it can be justified spending money on them.
- *Style and design:* superior material quality is not enough for the luxury segment of the fashion market; products must also convey emotions to the customer. Product design and aesthetics can make the product unique and they make customers associate emotions to the products.
- *Country of origin:* In most of the cases the value perceived by the customer is partly due to the country of origin of the product (i.e. *Made in Italy).*
- *Emotional appeal (mainly in terms of shopping experience*): this is to be considered both in terms of service level (time performances, product availability, product variety) and in terms of supporting the customer in the emotional elements of his/her shopping experience so that his/her luxury fancies are satisfied. Indeed marketing experts (Danziger, 2004) highlight that consumers look for a shopping experience that transcends the product to reach a new level of enhanced experience. Moreover, the aspects related to service level are becoming more and more important as the customer requirements increase, to the point that ''service level'' was indicated by some companies as a success factor to be pursued even beyond its contribution to creating an emotional appeal.
- *Brand reputation:* Brand related aspects emerge as a critical issue for fashion/luxury products. The customer has to feel he/she is part of the brand aura while buying the product as well as while using it.

Table 2 Critical success factors emerging from the case studies

Company	1	2	3	4	5	6	7	8	9	10	11	12
Creation of a lifestyle	X			X	X	X	X	X	X	X	X	X
Product quality	X	X	X	X	X	X		X	X	X	X	X
Made in Italy	X	X	X	X	X	X	X	X	X		X	X
Style and design	X					X		X	X	X	X	X
Shopping experience	X				X		X		X	X	X	
Brand reputation	X	X	X	X	X	X	X	X	X	X	X	X

- *Creation of a lifestyle:* this means a strong identification of the product and of the shopping experience to the values conveyed by the brand.

Only four of the interviewed companies indicated all the six factors as relevant for their business, while 11 companies over 12 highlighted the relevance of ''made in Italy''; the same is true for the factor ''product quality''.

It is interesting to notice that—talking to the interviewed people about costs as a critical aspects—none of the companies interviewed included *costs* within their critical success factors. Of course—when expressly asked for—they stated that costs are always relevant, but performance (in terms of combination of the factors listed above) comes first. This seems to be reasonable for companies operating in the luxury market, where price is not the priority in the customer's mind: luxury consumers can afford to pay a premium price (and they do it with pleasure!) but the condition is that such price is justified by the compliance with a certain set of performances (Danziger, 2005).

5.2 Supply chain configuration in the luxury segment of the fashion industry

During the case studies, several supply chain configuration choices have been investigated such as the geographical extension of the supply chain, the location of the actors, the number of echelons of the supply chain, the size and type of the actors in the various echelons, the level of upstream and downstream integration and the outsourcing choices (see Table 3).

It is important to remark that although the sample included 12 companies, the supply chains taken into account were much more than 12: in fact each company is managing different supply chains due to the fact that they manufacture a certain variety of products and that such products are distributed through different kinds of points of sale. Differences existing between products and different requirements from points of sale impact on supply chain configuration and management choices (e.g. company #4 chose to develop strategic know-how in cashmere technology and to consider clothes made of other kinds of fabric as a secondary product: this led to keep in-house cashmere manufacturing while outsourcing the rest to specialized companies).

All the companies involved highlighted that the most relevant core competences to keep in house are those related to the design phase, which defines material requirements, aesthetic aspect and style of the product. This is the reason why these companies rely on a qualified design team and often collaborate with external designers or brand owner's design team (when they are licensee for other brands), in order to create products which are compliant with brand image as well as with customers' requirements.

In the luxury segment high-quality products must be guaranteed; therefore, sourcing has to ensure high-quality raw materials and components and every phase of the manufacturing process must be compliant to the desired quality level.

Table 3 Supply chain configuration for the analyzed companies

Case study	Suppliers (localization)	Production (localization)	Retailing
1	Consumables (Italy and abroad) Fabrics (Italy) Accessories (Italy)	Cutting: in house. Outsourcing of labor-intensive phases (Italy)	Mono-brand boutiques Multi-brand shops Department store corners Worldwide
2	Leather and shoe components (Italy)	Outsourcing (Italy)	Multi-brand shops Europe, USA
3	Leather (Italy)	Inside (Italy)	Multi-brand shops Department stores Europe, USA, Japan
4	Raw material (abroad) Cashmere thread (Italy)	Cashmere products: in house. Clothes: outsourcing (Italy)	Mono-brand boutiques Multi-brand shops Department stores Worldwide
5	Leather and accessories (Italy)	Outsourcing to specialized companies (Italy)	Mono-brand boutiques (mostly) Department store corners Worldwide
6	Leather (Italy) Fabrics (Abroad) Special components (Italy)	In house (Italy and abroad)	Mono-brand boutiques Multi-brand shops Worldwide
7	Leather (Italy) Fabrics (Italy and abroad)	Outsourcing (Italy and abroad)	Mono-brand boutiques Multi-brand shops Department stores Worldwide
8	Leather (Italy)	In house Outsourcing of labor intensive phases (Italy)	Mono-brand boutiques Multi-brand shops Department store corners Worldwide
9	Leather (Italy) Special components (specific countries)	In house Outsourcing to specialized companies (Italy)	Mono-brand boutiques Multi-brand shops Department stores Worldwide
10	Leather (Italy) Other components (Abroad)	Abroad	Mono-brand boutiques Multi-brand shops Department stores Worldwide
11	Leather (Italy) Special components (specific countries)	In house Outsourcing to specialized companies (Italy for high-end lines, Romania for entry-level lines)	Mono-brand boutiques Multi-brand shops Department store corners Worldwide
12	Leather (Italy) Special components (specific countries)	Outsourcing to local excellent craftsmen (Italy)	Mono-brand boutiques Multi-brand shops Department store corners Worldwide

As a consequence, often materials have to be sourced in particular countries (e.g. leather in Italy, cashmere wool in India, crocodile leather in Australia, etc.) and from specialized suppliers. Likewise, the most critical production phases (e.g. the cutting phase) are to be kept in house while only the non-critical and most labour intensive phases (e.g. sewing) can be outsourced. Anyway even for those phases that do not take place in house, suppliers are carefully selected and the customer company usually applies some kind of control or monitoring on their operations.

In some cases (e.g. company #12) luxury firms outsource all phases of manufacturing to several neighbouring craftsmen or small companies, often belonging to the same industrial district, who are considered as their production department. The focal company performs all the planning and procurement activities and assign the work to the various suppliers, who are often completely dedicated and therefore cannot be left idle. This close relationship allows strict control over quality and avoid the creation of a grey market (i.e. suppliers manufacturing products that are sold through unauthorized channels). Moreover, such a supply base is very flexible, allowing to cope with a fluctuating and unpredictable demand; furthermore, in this way it is also possible to customize products to a great extent, since batch sizes are very small.

It is worth noticing that, in the cases where the critical success factor ''country of origin'' is relevant, production phases—even when operated in outsourcing—take place in Italy (with some exceptions for entry-level lines): in fact, the label ''made in Italy'' is still regarded worldwide as synonymous of high quality and original design, and this strongly contributes to justifying the premium price requested to consumers.

Regarding the upstream part of the supply chain, several sourcing and manufacturing echelons can be identified: apart from the focal companies, several tiers of suppliers and outsourcers exist. On the contrary, the downstream section of the chain is often very short: companies prefer (when possible) to sell their product directly to the final points of sale, so bypassing any kind of wholesaler or distributor. This allows companies to have a better control on the retailing echelon, which is critical in reaching the final customers. In fact, regardless the fact they own a direct operated retail network or not, virtually all the companies involved in the present research agreed on one point: it is essential to build a direct contact with the consumer and this could be obtained by means of some kind of downstream integration. Consequently many companies establish—at the retailing stage—a network of mono-brand boutiques, partly owned and partly in franchising. Such points of sale are preferably located in the city centre of worldwide renowned shopping capitals and they are characterized by an interior design that convey the style of the brand: this combination of design and exclusive location contributes to guarantee a strong coherence with brand image and values. Furthermore, this allows companies to better understand customers' needs and to improve the relationship with them, and it is also useful in order to obtain reliable sales information on which forecasting activities are based.

As mono-brand boutiques pursue the mission of protecting the values of the brand, multi-brand shops and department stores help to enlarge the potentially reached customer base, and are carefully selected to display the products in a proper way, following the guidelines provided by the focal company.

Another reason why companies pursue downstream integration through mono-brand boutiques is related to counterfeiting issues: having higher control and information exchange with the retail echelon, the manufacturing or brand-owner companies can guarantee that products sold in these shops are original and provide all the promised features.

This observed preference for internal control over distribution (company-owned retail network, shops in strategic locations, consistency of the retail environment) and over outsourcing confirms the statements by Moore and Birtwistle (2004) about trends in the luxury fashion retailing.

5.3 Supply chain management choices in the luxury segment of the fashion industry

Regardless of the specific configuration of their supply chain, the management choices and tools of the interviewed companies have been investigated so as to get a good understanding of their operations management approach (see Table 4).

For all the studied companies, demand is highly variable, influenced by fashion trends and the selling season is very short: this is the reason why design activities begin very early (on average 9–12 months before the product is available for the consumer) and the first production launch takes place soon after (7–8 months before the product is available in the points of sale).

As stated before, cutting production costs is not a priority for high-end companies; even so the finished product is manufactured starting from high-value materials (e.g. very expensive exotic leather) and the risk of obsolescence is very high. In order to avoid excessive stock, some companies in the sample prefer to produce only on the basis of order received by the point of sale, so pursuing a make-to-order strategy: this happens especially when the company cannot rely on past selling data obtained from the points of sale, when customization is high and postponed assembly cannot be applied.

The make-to-order strategy is not feasible when operations lead time is longer than the delivery lead time expected by the market. In the studied cases, this happens for two main reasons. On the one hand, a considerable part of collection time window is taken up either by the engineering phase or by the order collecting phase, so forcing sourcing, production and distribution phases to take place in a narrow time window. On the other hand, companies often cope with demand variability and uncertainty recurring to outsourcing, so increasing their production flexibility: this choice, besides requiring a strict quality control of outsourced materials, makes manufacturing lead time longer and more uncertain.

In order to reduce such risk, many companies chose to produce some lines (those supposed to be "best sellers") in advance. In particular, product lines which are regarded as "classics" are usually managed through a make to stock manufacturing strategy, as well as items outsourced in low-cost countries (provided that in the studied sample the choice of outsourcing in low-cost countries was really uncommon, and pursued only for non-critical products or process phases).

Overplanning technique (both of materials and of finished products) has been observed as an effective lever for facing demand uncertainty. In order to better match production and demand, information exchange on sell-out data and forecasts between manufacturers and retailers is very frequent: some companies

register very detailed information not only about the products but also about the customers, e.g. day and time of the transaction, sex and age of the customer, weather conditions.

On the retail side of the chain, the companies involved in the research expressed a wish for downstream integration, as this is universally recognized as a critical aspect for success in the considered segment. In many cases, retailers can access a reserved area of the company website and put replenishment orders that will be registered online. Major efforts are aimed also at creating a direct relationship between the consumer and the company through the redesign of the retailing system: this means creating a network of mono-brand controlled (owned or franchised) boutiques as well as improving the service to this kind of retailing channel in terms of delivery lead times, product availability, direct communication with the focal company, replenishment programs, support to the sales people and information sharing.

Finally, it is worth highlighting the role of the factory outlet channel, allowing companies to ''absorb'' the mistakes of the planning and manufacturing processes (poor quality, wrong demand forecasts, etc.). Sometimes the outlet channel is used to keep the utilization of production system to high values, and the outlet collection (if exists) keeps the production lines running during the ''hiatus'' between the regular collections.

Information exchange is less frequent in the upstream part of the supply chain where production plans are made by the focal company and communicated to suppliers and outsourcers only through specific orders: this is due to the fact that outsourcers and suppliers are mainly small or craftsman companies, and the focal company believes they are not ready to look at the business from a wider point of view, and dealing with integrated supply chain planning and management. Anyway some of the interviewed companies are introducing some collaboration programs in order to increase the level of integration with their first tier suppliers and improve coordination with outsourcers (see details in Table 4): e.g. company #5 coordinates a large network of small leather manufacturing companies by means of a detailed collaborative forecasting and planning programme which includes frequent information exchange about production plans and execution progress. In some cases the presence of collaboration programs gave rise to a performance measurement system which overcomes the boundaries of the company and includes key performance indicators related to the logistic performances of the supply, outsourcing and retailing network as a whole.

However, the presence of small companies and craftsmen in the investigated supply chains is almost a constant element, and can be justified considering three reasons. First, according to cultural and historical reasons, the Italian economic system is mainly composed of small (family run) enterprises,and so it is easier to find suppliers and outsourcers of small size; second, as documented by the related literature (Naylor et al., 1999; Lee, 2004), supply chain flexibility is a key performance nowadays: outsourcing to a large number of small enterprises allows supply chain to be more flexible (especially in terms of volumes and variety) than outsourcing to a few large companies; third, all the interviewed companies deal

with products which often require *hand-made* quality details, and specialized craftsman companies can easily guarantee such excellence in manufacturing; furthermore, *hand-making* contributes to make each item a unique piece, so increasing its exclusiveness.

The role of suppliers and outsourcers is critical also in terms of innovation and new product development, since in many cases products are co-designed. In this way focal companies can access the innovative competences of the various suppliers specialized on different technologies and materials. Case #1 is very interesting

Table 4 Supply chain management choices in the investigated companies

Case study	Decoupling point	Information sharing	Sourcing choices	Manufacturing choices	Retailing choices
1	Make to stock 70% Make to order 30%	Forecasts and sell-out data (with retailers) On-line connection with points of sale	Codesign with suppliers also from other industries Long-term partnership Vendor selection based on quality	Coordination through structured contracts and informal processes Cellular batch manufacturing Flexibility through overtime Internal quality control	Training and support to sellers Downstream integration: mono-brand boutiques No intermediaries Weekly replenishment allowed
2	Make to order	Production plans (with outsourcers)	Co-design with outsourcers Long-term partnership Parallel sourcing Relationship with second-tier suppliers	Outsourcers development Reserving upstream capacity and stock Internal quality control	Exclusive locations Selected multi-brand shops No intermediaries
3	Purchase to order	None	Vendor selection based on quality and reliability	In-house manufacturing	Selected multi-brand shops No intermediaries
4	Make to order 80% Make to stock 20%	Forecasts (with retailers and raw materials suppliers)	Co-design with outsourcers Vendor selection based on experience Reserving upstream material stock	Combine tradition and technology	Downstream integration: company-owned boutiques No intermediaries when possible Exclusive locations Replenishment allowed
5	Make to order 80% Make to stock 20%	Forecasts (with retailers) Production plans (with outsourcers)	Vendor selection based on quality and flexibility Relationship with second-tier suppliers	Joint forecasting and production planning Parallel sourcing Coordination of supply and outsourcing network Coordination of retailing network	Downstream integration: mono-brand boutiques No intermediaries Wide range of products available in the shops Replenishment allowed Retailing system redesign
6	Make to order 40% Make to stock 60%	Design specifications (with brand owners)	Vendor selection based on quality Parallel sourcing Long-term partnership	Tracking of logistics transactions	Introducing mono-brand boutiques No intermediaries when possible
7	Make to order	On-line ordering system Real-time monitoring of sell-out data	Co-design Parallel sourcing	Continuous replenishment program Tracking of logistic transactions	Downstream integration: company-owned boutiques Replenishment allowed

(continued)

Table 4 (continued)

Case study	Decoupling point	Information sharing	Sourcing choices	Manufacturing choices	Retailing choices
			Low cost countries for fabric items	Supply chain key performance indicators (KPI) system	Retailing system redesign
					Customized packaging
8	Make to order 80%	Forecasts and sell-out data (with retailers)	Parallel sourcing	Reserve upstream capacity and stock	Downstream integration: mono-brand boutiques
	Make to stock 20%		Long-term partnership		No intermediaries
					Exclusive locations
9	Make to order	Sell-out data and customer's history (with retailers)	Parallel sourcing	Coordination of the supply and outsourcing network	Downstream integration: mono-brand boutiques
			Long-term partnership Co-branding with branded suppliers Relationship with second-tier suppliers	Internal quality control	No intermediaries Exclusive locations
10	Make to stock 75%	Daily communication of sell-out and shop's stock	Materials sourced in Italy (high quality)	Coordination of the supply and outsourcing network	Delivery priority to mono-brand shops
	Make to order 25%	On-line ordering system	Labor sourced in low cost countries	Logistic effectiveness	Market penetration through specialized and non specialized shops
				Tracking of logistic transactions Supply chain key performance indicators system	
11	Make to order	Sell-out data and customer's history (with retailers)	Materials sourced in Italy (high quality)	Manufacturing system redesign	Delivery priority to leading customers and flagship stores
			Vendor selected on quality and reliability	Coordination of the supply and outsourcing network	Exclusive locations
			Internal quality control	Parallel sourcing Internal quality control	No intermediaries Retailing system redesign Customized packaging
12	Make to order	Production plan (with outsourcers)	Materials sourced where quality is best (e.g. crocodile from Australia) All component suppliers are from Italy	Outsourcers located in the Tuscany leather district	Direct operated showrooms in high end shopping districts all over the world
				Strong quality control	Some exclusive multi-brand retailers in the USA
				Order overplanning as a lever for coping with materials shortage New manufacturing planning IT system	

from this point of view: despite products appear very simple (lingerie and beachwear), the company worked with various suppliers from both the same industry (i.e. textile) and other industries (e.g. biomedical) to jointly develop innovation in materials (e.g. new fabrics) and functionalities (e.g. air pressure pushup bras).

5.4. Impact of critical success factors on supply chain configuration and management

The supply chain configuration and management choices described in the previous sections clearly reflect a coherence with the critical success factors declared by the companies. The following consideration are summarized in Table 5. For the sake of convenience, the factors named ''lifestyle creation'' and ''brand reputation'' have been put together into a single paragraph, since they produce analogous implications on supply chain choices.

Table 5 Critical success factors and supply chain processes

Critical success factor	Sourcing	Manufacturing	Retailing
Brand reputation and creation of lifestyle	Collaboration programs Integration	Ensuring product quality to sustain brand reputation	Retailing network redesign (mono-brand boutiques) Coordination of retail network Shop location Training and support to salespeople Delivery priority to mono-brand shops
Product quality	Vendor selection Coordination of the supply network	In-house manufacturing Coordination with subcontractors in order to assure high-end quality of manufacturing	No intermediaries Information exchange.
	Information exchange Parallel sourcing Long-term partnership Quality control	Internal quality control Subcontractors development and training Combine tradition (craftsmanship) and technology	Tracking of sales
Country of origin	Suppliers localization	Subcontractors located in Italy or even in the same district In-house manufacturing	Emphasize country of origin in store design
Style and design	Co-design with suppliers, also from other industries	Preserve elements of craftsmanship	Shop location
	Extraordinary/exotic materials		Shop interior design Information exchange on customers preferences
Emotional appeal (and service level)	Co-branding with branded suppliers	Coordination with subcontractors and among suppliers and subcontractors in order to have good time-performances (timeliness, punctuality)	Exclusive locations
	Allow customization Information exchange	Supply chain KPI measurement system Increasing production flexibility by means of cellular batch manufacturing, overtime, seasonal workers, subcontractors	Shopping environment Behaviour of shop assistants
	Tracking of logistic transactions	Order overplanning as a lever for coping with materials shortage	Product availability
		Joint forecasting and production planning with subcontractors Continuous replenishment programs	Communication with the maison Logistic effectiveness Fidelity programs Tracking of logistics transactions Continuous replenishment program Supply chain KPI measurement system

- The requirements of superior product quality leads to a careful selection of material suppliers and outsourcers and to the creation of long-term partnerships in order to ensure a reliable quality over time and to make collaborative improvement possible on both sides. Also, the use of parallel sourcing strategies—i.e. outsourcing each specific product or activity from a single companies, but having different suppliers for similar products or activities—is due to quality matters: this can guarantee uniformity within a single product line, while maintaining a broad supply base. In many cases the search for high product and process quality leads to pursue a ''made in Italy/source in Italy'' strategy.
- Also supply chain coordination, control and monitoring are critical issues in order to ensure the required superior quality. For instance, company #9 is an Italian manufacturer specialized in high-quality shoes which was acquired by a famous Italian fashion *maison* that wanted to enter the shoe manufacturing industry; in fact the latter—after a series of unsuccessful attempts to outsource the whole supply chain, decided to increase its control over the supply chain and to internalize the shoe design and shoe-making know how by means of such acquisition.
- *Style and design* excellence are achieved by keeping in house the design activities and, at the same time, collaborating with experienced external designers and stylists. Suppliers are also critical for finding new materials, technologies and solutions that bring innovation and are appreciated by final customers. Co-design is often used also to transform the ideas of designers and stylists into real product, often adopting or even inventing new technologies and manufacturing processes. Finally, the style and the aesthetic requirements of the company drives also the design of mono-brand boutiques, thus drawing a link from manufacturing to retailing.
- When the *country of origin* is a key competitive factor, the supply chain configuration is baldly affected by constraints on location of the country-sensitive phases; for instance, for a company aiming at manufacturing high-end fashion leather products, leather tanning must be located in Tuscany.

- Providing a complete *shopping experience* (design of point of sale, assistance from the shop personnel, availability of some exclusive products, etc.) conveys the appropriate *emotional appeal* and contributes to reach customer satisfaction as well as the feeling of a direct contact with the manufacturing company. Downstream integration towards points of sale (mono-brand boutiques and flagship stores) is a way to satisfy luxury consumers who are seeking new experiences. Some of the interviewed companies resort to fidelity programs, other go further and allow full product customization in order to assure the uniqueness of the bought item. Also, providing a special design packaging is a way of enhancing shopping experience. Finally, companies have experienced that product shortage, which in some cases contributed to create a sense of exclusivity, is no more sustainable in the long term: the case studies have shown that higher and higher attention is devoted to increasing production flexibility in order to rapidly ramp up production of hit products; in particular, the shifting of manufacturing organi-

zation from job shops to cells has proven to be an effective lever in this regard.
- The need of creating a *lifestyle* coherently with the *brand values and reputation* influences most of the choices in the design and retailing phases: design activities are often performed in collaboration with designers and brand owners in order to enhance and maintain the established brand style. On the retailing side the creation of a mono-brand retailing network allows the identification of the shop (strongly characterized in terms of layout and interior design) with the brand image; even the behaviour of shop assistants should convey the brand values and help the customer in feeling a complete shopping experience. Equally, the shops location in exclusive town centres contribute to the creation of a luxury lifestyle. Sometimes also marketing activities are performed together with suppliers who might contribute to create the main brand lifestyle: this is the case of suppliers with a strong and recognizable brand, which can be associated to the brand of the final product in the advertising campaign, so as to strengthen other brands.

6. Conclusion and further devolopments

In this paper, we have investigated the relationship between supply chain management strategies and practices and the luxury segment of Italian fashion industries. The topic is rather innovative *per se,* since managerial literature so far has mainly dealt either with supply chain management in mass markets, or with other aspects of luxury, such as marketing and branding. The case studies analysed have shown that operational issues are nevertheless relevant also for luxury fashion firms in order to build and support their brands, deliver their products and satisfy their very demanding customers. In particular, we have shown how supply chain configuration and management decision can impact the critical success factors of luxury fashion firms, thus supporting them to achieve a competitive advantage.

It is also interesting to highlight that the company included in the sample shares a deep commitment as regards excellent product quality; at the same time they generally state that controlling or reducing costs is not the main objective. This reveals the presence of actual material quality beyond the care for superior brand image: supply chain configuration and management choices are therefore often directed towards creating and preserving such quality excellence.

The results of our study suggest that a major trend is taking place within this industry: in order to maintain control on both the supply and the distribution side of the chain, brand owners are either integrating or increasing their control over the supply chain. On the supply side this is due to the need to ensure product quality and availability, while on the distribution side this is even more important in order to achieve a direct relationship with the final customer.

A further emerging issue is the heterogeneity of approaches in terms of configuration and management choices among the sample: in fact the range goes from vertically integrated companies to complete outsourcing of manufacturing processes; from absence of information exchange to extremely detailed flow

of information from end to end of the supply chain; from simple craftsman-based businesses to companies with a very structured strategic plan.

In this scenario, SMEs are either growing and trying to evolve their traditional role of specialized manufacturers, e.g. by developing their own brands and distribution channels, or they are becoming part of larger groups or networks of firms. The cases have shown that also traditional Italian SMEs have developed supply chain management competencies that allow them to manage a supply base, manufacture their products at extremely high-quality levels and distribute them all over the world.

We are confident that this research project, whose early results are published in this paper, will provide useful insights both for researchers and practitioners: for researchers, since it highlights an interesting business segment where many of the consolidated supply chain management models seem to fail or be inadequate, therefore claiming for further investigation; for practitioners, since it highlights the relationship between critical success factors and supply chain strategies and practices, targeting complementary management actions and guidelines with respect to well-acknowledged efforts in marketing and design. This can be of great help for those firms in the luxury fashion segment that are now facing the challenge of an increasingly fierce competition, on a global playground.

We see several directions to enrich this first research pattern. First, in our study we have considered successful companies in order to evaluate their supply chain strategies and practices, under the hypothesis that such choices have contributed to the company success, but further investigation is needed to better understand causal relationships between supply chain management and company performance. Second, although Italy is globally recognized as one of the countries where luxury fashion is created, there are other countries playing a fundamental role in this segment; therefore, the study presented in this paper has to be replicated in other key countries. This represents the future research being carried out as a result of this first study.

References

Aitken, J., Childerhouse, P., Towill, D.R., 2003. The impact of product life cycle on supply chain strategy. International Journal of Production Economics 85, 127-40.

Antoni, F., Burgelman, R.A., Meza, P., 2004. LVMH in 2004: The challenges of strategic integration. Harvard Business School Case.

Blumer, H., 1969. Fashion: From class differentiation to collective selection. The Sociological Quarterly 10, 275-291. Bowman, R.J., 2004. Using Supply Chain excellence to build brand reputation. Global Logistics and Supply Chain Strategies <http://www.glscs.com/archives/08.04.brands.htm? adcode=10).

Bruce, M., Daly, L., Towers, N., 2004. Lean or agile. A solution for supply chain management in the textile and clothing industry. International Journal of Operations and Production Management 24 (2), 151-170.

Brun, A., Cagliano, R., Caniato, F., Fahmy Salama, K., Sianesi, A, Spina, G., 2005. Supply chain performance measurement systems: How to evaluate their performance? In: Proceedings of the Second European Forum on Market Driven Supply Chain, Milan, April, pp. 5-6.

Byrnes, J., 2004. Supply Chain Management in a Wal-Mart World. HBS Weekly Publication, August.
Caniato, F., Caridi, M., Castelli, C., Golini, R., Spina, G., Sianesi, A., 2007. Supply chain strategy in the luxury industry: Do consolidated models fit? In: Proceedings of the 16th IPSERA Conference, Bath, April 1-4, 2007.
Castaldo, S., Botti, S., 1999. The emotional dimension of shopping: Explorative research about the role of the point of sale. Economia & Management 1, 17-37 (in Italian).
Choi, T., 2006. Pre-season stocking and pricing decisions for fashion retailers with multiple information updating. International Journal of Production Economics 106, 146-170.
Cigolini, R., Cozzi, M., Perona, M., 2004. A new framework for supply chain management: Conceptual model and empirical test. International Journal of Operations and Production Management 8, 1-13.
Crane, D., 1999. Diffusion models and fashion: A reassessment. Annals of the American Academy of Psychology and Social Sciences 566, 13-24.
Danziger, P.N., 2004. Why People Buy Things They Don't Need. Dearborn Trade Publishing, Chicago.
Danziger, P.N., 2005. Let them Eat the Cake: Marketing Luxury to the Masses as Well as the Classes. Dearborn Trade Publishing, Chicago.
De Toni, A., Meneghetti, A., 2000. The production planning process for a network of firms in the textile-apparel industry. International Journal of Production Economics 65, 17-32.
Dubois, B., Czellar, S., Laurent, G., 2005. Consumer segments based on attitudes towards luxury: Empirical evidence from twenty countries. Marketing Letters 16 (2), 115-128.
Egon Zehnder International, 2006. Luxury goods: Fashion houses are adapting executive recruitment to new consumer trends. Available online at <http://www.egonzehnderknowledge.com/knowledge/content/articles/index.php?article = 23), 0-s (visited on January 23, 2007).
Eisenhardt, K.M., 1989. Building theories from case study research. Academy of Management Review 14 (4), 532-550.
Fernie, J., Moore, C., Lawrie, A., Hallsworth, A., 1997. The internationalization of the high fashion brand: The case of Central London. Journal of Product and Brand Management(3), 151-162.
Fisher, M.L., 1997. What is the right supply chain for your product? Harvard Business Review March-April, 105-116.
Harland, C.M., Lamming, R.C., Cousins, P.D., 1999. Developing the concept of supply strategy. International Journal of Operations and Production Management 19, 650-673.
Hayes, R.H., Wheelwright, S.C., 1984. Restoring our competitive edge: competing through manufacturing. Wiley, NY.
Jucker, C., 2006. I marchi del made in Italy leader nei consumi di lusso. Il Sole 24Ore, June 9, 2006 (in Italian).
Lamming, R., Harland, C., Zheng, J., Johnsen, T., 2000. An initial classification of supply networks. International Journal of Operations and Production Management 20, 675-694.
Lee, H.L., 2002. Aligning supply chain strategies with product uncertainties. California Management Review 44, 105-119.
Lee, H.L., 2004. The triple—A supply chain. Harvard Business Review October, 102-112.
Miragliotta, G., 2006. Layers and mechanisms: A new taxonomy for the Bullwhip Effect. International Journal of Production Economics 104 (2), 365-381.
Moore, C., Birtwistle, G., 2004. The Burberry business model. International Journal of Retail and Distribution Management 32 (8), 412-422.
Nair, A., Closs, D.J., 2006. An examination of the impact of coordinating supply chain policies and price markdowns on short lifecycle product retail performance. International Journal of Production Economics 102, 379-392.
Naylor, J.B., Naim, M.M., Berry, D., 1999. Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. International Journal of Production Economics 72, 107-118.
Nueno, J.L., Quelch, J.A., 1998. The mass marketing of luxury. Business Horizons November-December, 61-68. Pambianco, 2006. <www.pambianconews.com).

Polhemus, T., 1994. Street Style: From Sidewalk to Catwalk. Thames and Hudson, London.
Reddy, M., Terblanche, N., 2005. How not to extend your luxury brand. Harvard Business Review, May.
Rockart, J.F., 1986. A primer on critical success factors. In: The Rise of Managerial Computing: The Best of the Center for Information Systems Research. Irwin Professional Publication.
Silverstein, M.J., Fiske, N., 2003. Trading Up: The New American Luxury. Portfolio/Penguin Group, New York.
Skinner, W., 1969. Manufacturing-missing link in corporate strategy. Harvard Business Review 47 (3), 136-145.
Stratton, R., Warburton, R.D.H., 2003. The strategic integration of agile and lean supply. International Journal of Production Economics 85, 183-198.
Thomassey, S., Happiette, M., Castelain, J., 2005. A global forecasting support system adapted to textile distribution. International Journal of Production Economics 96, 81-95.
Towill, D.R., Childerhouse, P., Aitken, J., 2002. Analysis and design of focused demand chains. Journal of Operations Management 20, 675-689.
Yin, R.K., 2004. Case Study Research. Sage Publications, Beverly Hills, CA

7.2 A Review and Outlook

7.2.1 A Critical Review

This study aims to investigate the role of operations and supply chain management in luxury fashion companies. In particular, it provides an original contribution by analysing the fit between critical success factors (CSFs) and supply chain management configurations and decisions. The research is based on a multiple case study methodology, which involved a sample of 12 luxury fashion manufacturers in Italy. The industries considered are those related to the traditional Italian products: shoes, apparel and accessories. All the companies analysed are established businesses in the luxury arena, with an international profile and positive and increasing economic results. These companies agree on the importance of a common set of CSFs, namely: product quality, style and design, emotional appeal, country of origin (i.e. "made in Italy"), brand reputation, creation of a lifestyle. Interestingly enough, the most relevant CSFs are product quality and country of origin, whereas no company indicated costs among the critical factors.

Consistently with these CSFs, the paper provides an in-depth description of supply chain management configurations. Some common trends that emerge are: preference for internal control over distribution (company-owned retail network, flagship shops in strategic locations, consistency of the retail environment) and outsourcing. Companies pursue overall control of the whole supply chain, which is a necessary condition for excellence in the aforementioned CSFs. Another trend concerns the downstream chain, which is often very short: companies prefer (where possible) to sell their products directly to the final points of sale, thus bypassing any kind of intermediaries and providing better support for brand awareness. Consequently, many companies establish—at the retailing stage—a

network of mono-brand boutiques, partly owned and partly in franchising. Such points of sale are preferably located in the city centres of worldwide renowned shopping capitals and they are characterized by an interior design that conveys the style of the brand. This combination of design and exclusive location contributes to guaranteeing a strong coherence with brand image and values. Another reason why companies pursue downstream integration through mono-brand boutiques is related to counterfeiting issues. Having greater control and information exchange with the retail echelon, the manufacturing or brand-owner companies can guarantee that products sold in these shops are original and provide all the promised features.

A following important section of the paper is dedicated to supply chain management choices. Here, the authors argue the implications of long lead times in the luxury fashion sector, in which the first production launch generally takes place 7–8 months before the product is available at the points of sale. This exposes companies to a high risk of obsolescence and prevents the use of a "make to order" production approach. In this context, information exchange on sell-out data and forecasts between manufacturers and retailers are critical to align production resources rapidly with market trends. Compared to downstream, information exchange is less frequent in the upstream supply chain. Here, production plans are made by the focal company and communicated to suppliers and outsourcers only through specific orders. Upstream companies are high in number, small in dimension and not structured in the organization. This configuration of the upstream network complicates the implementation of supply chain tools in aligning production, procurement and shipments, but supports the strategic aim of supply chain flexibility and innovation, coherent with the CSFs.

In the final part of the paper, the authors link these supply chain configurations and management choices with the CSFs pursued by the sampled companies. The requirements of superior product quality lead to the careful selection of material suppliers and outsourcers and the creation of long-term partnerships to ensure reliable quality over time and make collaborative improvements possible on both sides. Also, the use of parallel sourcing strategies—i.e. outsourcing each specific product or activity from a single company, but having different suppliers for similar products or activities—is due to quality matters. This can guarantee uniformity within a single product line while maintaining a broad supply base. In many cases, the search for high product and process quality leads to the pursuit of a "made in Italy/sourced in Italy" strategy. Style and design excellence is achieved by keeping design activities in house and at the same time collaborating with experienced external designers and stylists.

In conclusion, the paper notes the pivotal role of horizontal control over the supply chain, both upstream and downstream—although with rather different approaches—and the vertical alignment between strategic and operational choices.

7.2.2 Key Messages and Findings

In our opinion, the paper provides several contributions, thorough and meaningful per se from both the academic and the practitioner perspectives.

First, the study has the distinction of proving the fundamental role played by supply chain management in determining companies' competitiveness and customer satisfaction. Indeed, companies' competitive priorities are supported by excellent performance in terms of high product quality, innovative design, strategic purchasing, streamlined manufacturing, on-time distribution and excellent customer service. Even in an ephemeral industry, as the luxury sector is often perceived, this performance is the plain result of a well-run supply chain, in which the main processes—new product development, purchasing, production and logistics and physical distribution to the final customer—are efficaciously managed throughout the network. In this way, brand owners either integrate or increase their control over the whole supply chain, both on the supply side to ensure product quality and availability and on the distribution side to achieve a direct relationship with the final customer.

A relevant contribution of the study is to show precisely how the CSFs identified are supported by different supply chain configurations and management decisions. Before this contribution, the literature on the luxury goods industry focused primarily on sociological, marketing and branding issues, paying scant or no attention to the role played by operations and supply chain management in buttressing companies' competitiveness. All in all, the paper clearly indicates first that companies need to align and fit these alternative supply chain management choices to their own strategies and second that there are distinct avenues in achieving competitive advantage.

Another important finding of the paper regards the critical role performed by suppliers and outsourcers in driving new product development and ultimately product innovation. This is particularly true and vital in the luxury fashion industry, in which product innovation often stems from innovative fabrics, yarns, finishes and the use of leather, materials and accessories that enable brand companies to propose new styles and/or product functionalities. However, the importance of having robust and collaborative relationships with suppliers and outsourcers to nurture innovation is a key message that other ensuing studies have then strongly confirmed as pertinent and crucial in many sectors.

A fourth key message of the paper is that supply chain processes are relevant when they are finalized to offer practical answers to final customer's needs and expectations. From this perspective, world-class companies are able to excel on both the *high-tech* and the *high-touch* sides, operating lean and innovative production processes on the one hand, but also listening to the "voice of the customer" on the other. The point of view of the customer is well synthesized by the service (luxury) experience, with the hard attributes, qualities and features of the product being blended and balanced with the soft issues, such as emotions and

experiences, "to eventually deliver fulfilment in the emotional and physical realm of the consumer".

Finally, an essential lesson of the paper emerges from the heterogeneity of approaches implemented by the companies analysed in terms of supply chain configurations and management choices. Indeed, the range goes from fully vertically integrated companies to the complete outsourcing of manufacturing processes; from the absence of information exchange to extremely detailed information flows from end to end along the supply chain; from small and simple craftsman-based businesses to large international companies operating with structured strategic plans. Moreover, as all the companies sampled have registered positive and increasing economic results over the years and can be considered good examples of effective managerial practices, the powerful lesson learned is easy to see: good management and strategic decision-making can still make the difference in terms of success. In the luxury industry, as in any industry, there is no one best way to compete. Different companies can implement distinct and effective business models, but what is ultimately relevant in determining competitive advantage is the fit and alignment between operational and supply chain management configurations, the choices made and the CSFs.

7.2.3 Advancement in the Specific Field of Study

When it was published in 2008, this paper represented a seminal contribution in the field of research on supply chain management in the luxury fashion industry. The basic assumption of this study was that the fashion industry was witnessing a polarization of sales, with growth concentrated at both the lower price and high ends. Given this scenario, the authors remarked the need for "momentum" in studying the role of operations and supply chain management in the success of luxury fashion companies. This was an urgent and compelling issue at the time when the paper was published, given that existing supply chain management models did not provide academics and practitioners with adequate guidelines on how to design and manage supply networks in the luxury fashion industry. At the same time, the authors noted that most supply chain management models focused on the mass market sector and there was no correspondence with the luxury segment of the fashion industry. Also, Fisher's (1997) well-known model, which classifies products as functional and innovative and and suggests an efficient and reactive supply chain management strategy for each respectively for each respectively, fails to provide useful insights in the case of luxury goods. Indeed, classifying these products as innovative is too reductive given the number of attributes linked to the emotional experience inherent in luxury goods.

A further original contribution of this paper compared to previous studies lies in the concept of "new luxury" mentioned and explained in the paper. To our

knowledge, this is one of the first papers in the supply chain and operations management field that explicitly addresses this concept and its implications in terms of supply chain management strategies. As noted by the authors, "Old luxury was about the attributes, qualities and features of the product, and much of its appeal was derived from status and prestige. New luxury defines the category from the point of view of the consumers, that focus on the experience of luxury embodied in the goods and services they buy, not in ownership or possession itself. Luxury products should communicate and deliver emotions and experiences to the consumer". Luxury brand's role is hence "to fulfil luxury fantasies of the customer: performance—no matter what the product or service—is the key: the way the luxury brand delivers fulfilment in the emotional and physical realm of the consumer". Due to this shift from old to new luxury, in 2008 luxury fashion companies witnessed a deep change in the concept of luxury fashion, with important consequences for the CSFs of the luxury segment and consequently for the supply chain management strategies pursued by companies. For example, in terms of supply chain management configurations and choices, several efforts should be dedicated to the careful management of the retailing channel, which is the place where the customers' shopping experience begins.

In addition to this, an original and distinctive feature of this paper regards the unit of analysis, i.e. the whole network of companies involved in the process of manufacturing and delivering luxury fashion goods. This perspective, which was quite new when the paper was published, allows the authors to provide a more complete picture of the phenomenon than would otherwise be the case by investigating supply chain management configurations and choices from upstream to downstream. Even today, studies in the fashion and luxury industry adopting this perspective are rare.

Last but not least, the picture of the luxury industry at the beginning of the 21st century this paper provides is extremely heterogeneous in terms of supply chain configuration and management choices. Notwithstanding this complex scenario, the authors wished to propose two directions for SMEs. The first was to grow and evolve from the traditional role of specialized manufacturers, for instance by developing own brands and distribution channels. The second was to become part of larger groups or networks of firms. We think that this dichotomy is still valid and deserves further investigation as the two alternative patterns are likely to require different supply chain management choices and competences.

7.2.4 Main Developments in the Literature

This paper opened up an interesting debate on the luxury sector and inspired much later research on the topic investigated. This paper focused on a narrow issue, i.e. the luxury segment, and thus it is surprising that over the years it has attracted 50[2]

[2]Scopus database, January 2016.

citations. This testifies to the fact that this research was able to stimulate reasoning in different ways.

First of all, it contributed to the development of a stream of research on supply chain management in the luxury sector. Starting from the main findings of the paper, some works developed the issue of supply network strategies in the luxury sector further, embracing a supply chain management perspective (Caniato et al. 2009, 2011; Macchion et al. 2015). Within this field, some other papers instead took a narrower perspective, looking at focused tiers and processes of the luxury supply chain. For instance, Luzzini and Ronchi (2010) investigated purchasing management in the luxury industry, Amatulli and Guido (2012) focused on retail strategies and Brun and Moretto (2014) on quality management, to cite just a few. In addition, inspired by Luca et al.'s paper, some articles focused on supply chain management in the luxury industry, looking at the luxury jewellery segment (Brun and Moretto 2012) and the yacht industry (Ponticelli et al. 2013).

In line with the innovative definition of the luxury product attributes reported in Luca et al.'s paper, a further interesting research stream developed based on the concept of "new luxury". Liu et al. (2011) analysed consumers' behaviours and psychology to provide guidelines for the development of market strategy for luxury products in China, while Li et al. (2012) investigated willingness to pay for luxury fashion brands depending on consumers' fashion lifestyle and perceived social and emotional value.

Besides having a great impact on the development of further papers and studies, in 2011 the Politecnico di Milano, based on the experiences and competences acquired in the fashion luxury sector by Luca and his team, co-funded with the University of Padova the "*Osservatorio Sistema Moda*", a research centre focusing on the fashion industry, aimed at supporting fashion companies and starting from their needs, developing empirical research on different cutting edge issues in the sector, such as sustainability, internationalization, e-commerce, communication strategies, etc.

7.2.5 Final Remarks

We would like to conclude this contribution by remembering some memories we shared of Luca.

Andrea Vinelli

> My first memories of Luca date back to early nineties in Bressanone, where we were young post docs and research fellows gathered to attend the Management and Engineering Summer School. I still have a vivid memory of a question Luca posed at the end of a lecture. A full professor's question, we joked, but one could already perceive some distinctive aspects of Luca's personality: leadership and clear ideas.
>
> Our friendship blossomed and strengthened during the organization of EurOMA Conference in Venice in 1999. Working closely together for more than one year,

eventually we found in each other trusting friendship. From then on, he started to call me by the affectionate nickname *Vino*. Organizing the Conference also gave me the opportunity to appreciate some of Luca's other distinguishing characteristics: precision for operational details and a strategic view.

Then came the time when we sat together on the EurOMA Board. For six years, we had a regular appointment—a tradition—drinking beers together at Brussels airport before taking our flights back home. That was time dedicated to our families and to us. Luca's love for his family, his pride and tenderness in talking about his children and wife are always in my mind.

My mind is also full of many happy and cheerful times spent together during national and international conferences. The last was in Palermo, at the EurOMA Conference in June 2014. After a full day of sessions, Luca came to my hotel and just the two of us walked and talked, looking around Palermo for a couple of hours before the Gala dinner. As always in these cases, I completely relied on Luca. Luca was always equipped with a guide and fully prepared in terms of where to go and what to see! His intellectual curiosity, genuine passion and boundless energy were also impressive.

I really enjoyed our dear friendship. I miss Luca so much. I only regret having missed my last opportunity to see him. Because of my knee injury, I could not attend the Italian Management & Engineering Association Board meeting on the last 17th of February in Milan. On that occasion, Luca said to Pietro: "Tell Vino to slow down skiing. Tell him he is not young anymore!" and his joking and affectionate farewell words to me are in my heart.

Pamela Danese

I first met Luca in Parma in November 2001 during the Annual Scientific Meeting of the Italian Management & Engineering Association. On that occasion, Luca was the discussant of a paper on product modularity, which at that time was my field of research and thus I attended his presentation. I immediately realized that he was not a common researcher, not only because of his competence, but also his ability to go beyond common views and conventional theories. Although the content of his speech was very serious, Luca made his presentation amusing, alternating between serious content and funny examples. This was a peculiarity of Luca: being very keen and ironic at the same time.

Afterwards, I had the opportunity to meet Luca on several other occasions and get to know him better, especially during the organization of the EurOMA-POMS Conference in Como in 2003. I remember his precision, enthusiasm and attention to detail in the organization, as well as his ability to play down difficulties and encourage the team.

Luca simply represented the point of reference for our Italian OM community, a leader able to build and guide an extraordinary team of researchers at the Politecnico di Milano. I will remember him for his passion, charisma, irony and clear vision. Ciao Luca.

Pietro Romano

I had the good fortune and honour of working with Luca especially on three occasions: the organization of the EurOMA conference in Venice (1999), the first joint EurOMA-POMS conference in Como (2003) and more recently, the board of the Italian Management & Engineering Association (AiIG). In my heart, I have special memories of Luca related to all three occasions. As regards the Venice conference, I retain a clear image in my mind of the funny (or rather astonished) face Luca made when, the

day before the conference, the Guardian Grande of the *Scuola Grande di San Giovanni Evangelista*—the Chairman of the historic Venetian institution that provided the venue for the conference—said that he no longer wanted to allow the use of the Scuola Grande. Fortunately, also thanks to Luca's *savoir faire*, the problem was resolved. As regards the Como conference, Luca was really impressed when Pamela and I confessed that we had decided to postpone our marriage to guarantee our contribution to the organization of the conference. Frankly speaking, I cannot say if he was positively or negatively impressed… In terms of the AiIG board, Luca was simply great! He was able to mix in his original and inimitable way rough with wise speaking and his reasoning was always witty and aimed at solving rather than setting problems (a rare virtue in the academic world and more widely). I conclude with a final memory. A couple of days before Luca's departure, I was in Milan and I took a picture of the Duomo. It was a sunny day and the Duomo square was crowded with masked boys and girls: it was carnival. I use that picture as the screen-saver on my mobile: it reminds me of Luca and the best of Milan.

References

Amatulli, C., Guido, G., (2012). Externalised vs. internalised consumption of luxury goods: Propositions and implications for luxury retail marketing, *International Review of Retail, Distribution and Consumer Research*, *22*(2), 189–207.

Brun, A., & Moretto, A. (2012). Contract design and supply chain management in the luxury jewellery industry. *International Journal of Retail and Distribution Management, 40*(8), 607–628.

Brun, A., & Moretto, A. (2014). Organisation and supply chain for quality control in luxury companies. *Journal of Fashion Marketing and Management, 18*(2), 206–230.

Caniato, F., Caridi, M., Castelli, C. M., & Golini, R. (2009). A contingency approach for SC strategy in the Italian luxury industry: Do consolidated models fit? *International Journal of Production Economics, 120*(1), 176–189.

Caniato, F., Caridi, M., Castelli, C., & Golini, R. (2011). Supply chain management in the luxury industry: A first classification of companies and their strategies. *International Journal of Production Economics, 133*(2), 622–633.

Fisher, M. L. (1997). What is the right supply chain for your product? *Harvard Business Review, 75*, 105–117.

Li, G., Li, G., & Kambele, Z. (2012). Luxury fashion brand consumers in China: Perceived value, fashion lifestyle, and willingness to pay. *Journal of Business Research, 65*(10), 1516–1522.

Liu, X. Y., Chen, Y., & Zhang, L. L. (2011). Research on the marketing of fashion luxuries in China. *Advanced Materials Research, 175–176*, 843–848.

Luzzini, D., & Ronchi, S. (2010). Purchasing management in the luxury industry: Organization and practices. *Operations Management Research, 3*(1), 7–21.

Macchion, L., Danese, P., & Vinelli, A. (2015). Redefining supply network strategies to face changing environments. A study from the fashion and luxury industry. *Operations Management Research, 8*(1–2), 15–31.

Ponticelli, S., Mininno, V., Dulmin, R., & Aloini, D. (2013). Supply chain implications for one-off luxury products: Cases from the yacht industry. *International Journal of Retail and Distribution Management, 41*(11), 1008–1029.

Chapter 8
Past, Present and Future Trends of Purchasing and Supply Management: An Extensive Literature Review. A Review and Outlook

Finn Wynstra

Abstract The original paper aimed to evaluate the state of the art of Purchasing and Supply Management (PSM). This was carried out through an in-depth analysis of 1055 papers published in 20 peer-reviewed journals, providing a snapshot of PSM research. Other literature reviews related to PSM were conducted in the past but focused primarily on specific topics and/or considering a narrower set of publications. Furthermore, the authors defined a framework useful to analyse the PSM literature and outline the state of the art of PSM research from a content-specific perspective. The commentary note starts remembering the beginning of the International Purchasing Survey project (IPS), a wide and longitudinal research project initially conceived by the Italian PSM team at Politecnico di Milano, in which the team from Rotterdam played a crucial role since the beginning. The note focuses then on methodological strengths and areas of improvement of the presented literature review. Finally, three key research contributions are highlighted: the in-depth analysis of the use of existing theory in PSM papers, the useful classification of PSM contents in existing research studies, and the multidisciplinary approach that might further open PSM research to be published in non-PSM journals in the future.

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8.1 Original Paper[1]

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1. Introduction

This study aims to assess the current state of the art and the trends of Purchasing and Supply Management (PSM) by conducting a broad and structured examination of peer-reviewed journal articles in recent years.

Following Monczka, Handheld, Guinipero, and Patterson (2010), we refer to PSM as the "strategic approach to planning for and acquiring the organization's current and future needs through effectively managing the supply base." We therefore make a distinction between PSM and the broader concept of Supply Chain Management (SCM), which is commonly referred to as "a process-oriented approach to managing product, information, and funds flows across the overall supply network, from the initial suppliers to the final end consumers" (Metz, 1998). In other words, we focus on the source side of the well-known SCOR model promoted by the Supply Chain Council (SCC, 2008), and we exclude topics dealing with planning, production, distribution, and logistics. As a matter of fact, all these processes require specific tools and techniques. As a consequence production planning, distribution, logistics and others have consolidated as stand-alone,

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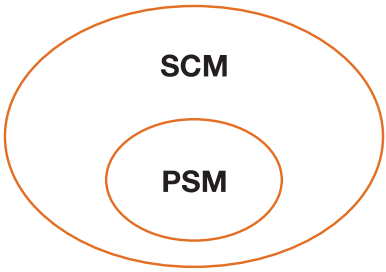


Fig. 1. Unionist perspective about PSM and SCM. Adapted from Larson and Halldorsson (2002).

though interconnected academic disciplines. Similarly, PSM increasingly gained its autonomy over the years both in research and practice. On the one hand academic journals explicitly address PSM issues; on the other hand, companies increasingly design specific PSM organizational roles and responsibilities. In the end, we look at PSM as a stand-alone academic discipline within the broader field of SCM. This is in line with what Larson and Halldorsson (2002) define as the *unionist* perspective over this issue (see Fig. 1).

There are few doubts about the increased relevance of PSM for companies of various industries including manufacturing and services. Business organizations have experienced rapid external environmental and internal organizational changes due to increasing i) outsourcing, ii) globalization, and iii) e-business. Massive outsourcing has occurred in many sectors; as a result, companies tend to spend more money on procurement and to buy not just commodities but also more specialties and customized services. Globalization in trade, commerce and finance has stressed the need to seek opportunities for global sourcing and, in many cases, to revisit make-or-buy strategic decisions, thus combining offshoring and outsourcing. Finally, the advent of the Internet in all business functions and processes has posed challenges and created opportunities for e-procurement, e-auctions and other practices in the field of PSM. The combined effect of outsourcing, globalization and e-business has raised several critical issues for PSM as a function within organizations as a process that spans organizational boundaries and as a profession. Both companies and the purchasing professional face new challenges as PSM becomes more strategic and complex.

Moreover, PSM has gained growing attention among business schools, where the subject is increasingly taught in both open enrollment programs and corporate training courses. Several handbooks and textbooks have appeared over the last twenty years - e.g. Van Weele, Monczka, and Lysons - thus corroborating the perception of PSM as an institutionalized field of management.

However, from a research perspective, supply management can hardly be considered an established discipline in its full maturity. “Supply management: is it a discipline?” is the evocative title of an article by Harland et al. published by IJOPM in 2006. At that time, and based on a relatively small sample of 41 papers, the authors concluded that although the internal coherence of the field was high,

there was not enough evidence of a theoretical debate to support the identification of supply management as a fully established discipline. Instead, PSM was identified as an emerging discipline in an early stage of its evolutionary cycle. Before and following Harland et al. (2006), others have proposed systematic literature reviews (LR) not primarily to answer the crucial question about the disciplinary status of PSM but with the purpose of identifying emerging issues, trends and gaps - for example, Giunipero, Hooker, Matthews, Yoon, and Brudvig (2008) - or to analyze and summarize the history of specific distinguished journals - for example, Wynstra (2010), who focuses on the Journal of Purchasing and Supply Management and Carter and Ellram (2003), who focus on the thirty-five-year history of the Journal of Supply Chain Management. Other recent reviews show a narrow scope as they focus on specific issues. For example, Johnsen (2009) reviews 30 key papers on suppliers' involvement in new product development, and Miemczyk, Johnsen, and Macquet (2012) address sustainable purchasing and supply management analyzing a sample of 73 contributions.

A careful analysis of all major LRs on PSM left us with the opinion that previous reviews are not extensive enough either in source coverage or in their breadth of topics to provide a fresh and comprehensive picture of the entire domain of PSM or to determine whether it should be considered an established discipline or one still fighting to emerge. In addition, for the most part, LRs of the past have been mainly descriptive - offering statistics for topics addressed - or normative - suggesting in which direction research should be developed. Finally, some of the most valuable reviews concern Supply Chain Management (SCM) at large, including PSM as well as other issues, such as demand management and distribution networks.

The purpose of this article is twofold. First, we are going to extend previous analyses by providing a refreshed and comprehensive review of PSM academic literature that is broader and deeper than previous reviews. Therefore, we examine a large number of papers - over one thousand - covering a wide set of highly qualified academic journals over a large time span. We examine how overall research production has evolved over time, considering units of analysis, research methods, and topics under investigation. Along with this goal, we aim to focus on Purchasing and Supply Management (PSM), omitting other SCM-related topics.

Second, we intend to assess the theoretical foundations of the PSM literature and how they have changed and possibly strengthened over time. We also aim to position PSM research in its evolutionary cycle, as it appears at the beginning of the current decade. We intend to outline the nature of the contributions, as they are exploratory, theory-building, or theory-testing.

In general, we aim to offer an analytical perspective regarding the discipline's origins and trajectory. We hope that by meeting the above two goals, we will enable scholars already active in the field and new researchers to potentially i) gain a clearer understanding of where PSM currently stands and ii) find some support in designing cutting-edge research that allows PSM to advance and consolidate as a discipline.

The article is structured as follows: the next section investigates past LRs about PSM to assess the need for further research in this direction and establish our objectives. We then describe the methodology followed to deliver a systematic LR,

which comprises four stages: source identification, source selection, source evaluation, and data analysis. Next, we analyze the database obtained and provide key statistics. Finally, we critically discuss the results in light of our objectives and provide main conclusions.

2. Previous literature reviews on PSM

LRs on PSM may be classified in two groups: generic and specific. Generic LRs reflect our own approach: they consist of broad overviews of the discipline focusing on a comprehensive set of subject areas. They answer the need for an analysis of the main research topics and methods in the field in general (e.g., Giunipero et al., 2008) or on a single journal. Given the breadth of the scope, this type of LR is not common, as it requires much effort to collect sufficient knowledge about the discipline. As a matter of fact, most authors decide to set some boundaries on either the time span, the number of sources considered, or the number of papers analyzed (e.g., Carter & Ellram, 2003; Wynstra, 2010; Zheng, Knight, Harland, Humby, & James, 2007).

Specific LRs are less of an issue because reviewing existing research on a narrower subject (e.g., supplier involvement in new product development– Johnsen, 2009 – or global purchasing – Quintens, Pauwels, & Matthyssens, 2006) is less problematic. Consequently, this second type of LR is much more common than generic reviews. Nonetheless, some boundaries for the analysis may be necessary to make it feasible, especially in the case of very popular topics.

Table 1 reports the list of PSM-related LRs that we have been able to find. Whereas the set of generic LRs is – to the best of our knowledge exhaustive, the set of specific LRs is intended to be only a partial selection, given that very many articles dealing with a subset of PSM are available. It is not pragmatic (and most likely not interesting) to build a list of any LR published on any topic that might be related to PSM.

The information collected on past LRs includes authors' names, the year of publication, the type of LR, the specific domain (in case of specific LRs), the

Table 1
Generic literature reviews on PSM and SCM.

Authors	Year	Domain	# Articles	# Journals	Time range (years)	Keyword-based	Description
Ellram and Carr	1994	PSM	20	n.a.	30	n.a.	Review of the purchasing strategy literature in the past 30 years. More quantitative studies are required to determine the role of the purchasing function in corporate strategy.
Carter and Ellram	2003	SCM	764	1 (JSCM)	35	No	Full review of the JSCM track of publications, including an analysis of research methods, subject categories, research designs, and individual/institutional contributions.
Burgess et al.	2006	SCM	100	31	1985–2003 (19)	Yes	Review of randomly selected SCM articles to clarify conceptual and methodological characteristics of the domain.
Zheng et al.	2007	PSM	42	13	9	Yes	Review of PSM publications to identify hot topics (strategy, structure, systems, and tasks) and run cross-sectional analyses (size, sector, working time, geographic focus).
Giunipero et al.	2008	SCM	405	9	10	Yes	Review focusing on the existing trends and gaps in the SCM literature, covering an analysis of content categories, supply chain levels, sample populations, industry, and research methods.
Wynstra	2010	PSM	351	1 (JPSM)	15	No	Full review of the JPSM track of publications, including an analysis of authorship, content, and impact.

Table 2
Examples of literature reviews on specific PSM-related topics.

Authors	Year	# Articles	# Journals	Time range (years)	Keyword-based	Focus
Gunasekaran and Ngai	2005	n.a.	n.a.	n.a.	Yes	Build-to-order SCM, including material procurement, e-procurement and partnership with suppliers
Gosling and Naim	2009	91	36	n.a.	Yes	Engineer-to-order SCM
Quintens et al.	2006	123	14	15	Yes	Global purchasing
Dubois and Araujo	2007	n.a.	n.a.	Not explicit	n.a.	Case research in PSM
Jiang et al.	2007	144	31	1980–2005 (26)	Yes	China-related POM research, including purchasing/sourcing systems
Johnsen	2009	30	n.a.	30	Yes	Supplier involvement in NPD
Pagano	2009	47	31	1995–2006 (12)	Yes	Relational capabilities and international sourcing
Bygballe et al.	2010	87	Not explicit	Not explicit	Yes	Partnering relationships in construction
Sarac et al.	2010	142	n.a.	1958–2009 (52)	n.a.	Impact of RFID on SCM, including the impact on vendor/supply management
Wu and Barnes	2011	140	12	2001–2011 (11)	Yes	Partner selection in agile supply chains
Marra et al.	2012	58	n.a.	2000–2010 (11)	Yes	SC knowledge management, including outsourcing and procurement
Miemczyk et al.	2012	113	29	n.a.	Yes	Sustainable PSM

number of articles analyzed, the number of journals considered, the time range of articles, and the use of keyword-based research. Please note that in most cases, not all articles published in a given time range are scanned; rather, it is more common to adopt a keyword-based research, meaning that authors usually search for articles through academic search engines (e.g., Scopus, Google Scholar) and some selected keywords. Such an approach is certainly appropriate when shared and standard terms exist, whereas it becomes an issue when a commonly accepted set of keywords is missing.

Among the generic LRs, we can identify some studies explicitly dedicated to PSM (Ellram & Carr, 1994; Wynstra, 2010; Zheng et al., 2007); other studies focus on the broader domain of supply chain management (SCM) (Burgess, Singh, & Koroglu, 2006; Carter & Ellram, 2003; Giunipero et al., 2008).We considered the latter as well because they investigate contents that are, to a great extent, relevant to PSM. A couple of studies, Wynstra (2010) and Carter and Ellram (2003), focus on all articles published in the Journal of Purchasing and Supply Management and the Journal of Supply Chain Management, respectively. All the others are keyword-based LRs considering multiple journals (even though it is not explicit, we might reasonably assume that the study by Ellram and Carr does so).

With regard to specific LRs, they usually consider multiple journals and – given the narrower scope – a lower number of articles. The topics reviewed are heterogeneous, as shown in Table 2.

We considered all the different types of LRs in terms of both content (e.g., to develop our classification framework) and methodology (e.g., to define the necessary steps for a systematic LR).

Without describing in detail the content of each study, we may note that almost all existing LRs are keyword-based: the few exceptions are those focusing on a specific journal. Considering multijournal LRs, all studies reported range between 42 and 144 articles considered, with the exception of Giunipero et al. (2008) with 405 articles, which can be considered the most comprehensive LR so far, spanning a decade and including articles from 9 different journals.

In summary, the major limitations of existing LRs on PSM that we aim to overcome with our study are as follows:

- Existing reviews are mostly based on a very limited set of publications and journals, thus providing only a partial overview of research in the field and leaving space for a more comprehensive one.
- Most reviews are quite dated, whereas PSM has encountered relevant growth in the last years; therefore, an up-to-date analysis would be beneficial.
- To identify trends and trajectories, assuming a longitudinal perspective would also be beneficial.
- The debate on the positioning of PSM as a discipline has been initiated but is far from concluded; also, given the dynamism of the field, an update may provide a significant contribution.

3. Research methodology

Given the limitations of existing LRs about PSM, we believe that there is room for further investigations, aiming essentially at understanding past and current research, planning future studies, and therefore advancing PSM in the process of becoming an established discipline. Such a purpose imposes, in our view, several requirements. First, the analysis requires a relatively broad time span to fill the gap between existing LRs and present times. Second, a large set of publications should be taken into consideration to have a representative picture of PSM research. For the same reason, we decided to scout as many articles as possible, thus avoiding a keyword search, which may prevent the identification of patterns and topics named with different labels in different times. As a matter of fact, several areas of the PSM domain continue to use different terms, sometimes intended to be synonymous, sometimes not (e.g., “purchasing”, “procurement”, “supply management”, “sourcing”). Certainly, clear criteria for publication selection should be stated directly to clarify advantages and disadvantages of a given choice. Finally, all aforementioned choices must be framed into a properly structured methodology, which is essential to ensure the reliability and representativeness of results.

Although these requirements, selected one by one, appear easy to meet, they are instead a challenge when considered altogether: a generic, long term, multi-journal, keyword-free approach is not easy to achieve. This is the reason why most PSM LRs tend to focus on specific topics and use a keyword search criteria to scout articles, whereas generic reviews have a broader scope but – to be feasible – narrow down the research to few journals and/or a few articles.

To define a structured LR methodology, we worked in two directions. On the one hand, we collected basic textbooks and conceptual articles explaining the step-by-step procedure for a systematic LR. Quite surprisingly, we did not find very detailed guidelines, in comparison to other research methodologies, such as survey or case studies. Other disciplines (e.g., psychology or medicine) exploit

meta-analytic approaches to LRwith specific purposes, such as determining the efficacy of a given drug by comparing the results of several published trials. A similar approach has been very rarely replicated by management scholars and, in any case, does not offer us a comprehensive indication regarding how to perform a LR.

On the other hand, past generic LRs explicitly targeting PSM (i.e., Ellram & Carr, 1994; Wynstra, 2010; Zheng et al., 2007) set the starting point of our study. In addition, we considered SCM LRs to be important references (Burgess et al., 2006; Carter & Ellram, 2003; Giunipero et al., 2008). Next, we examined specific PSM LRs (see Table 1) because despite the different focus, they do offer valuable input regarding the research methodology. Ultimately, we also consulted extant LRs in different fields (e.g., Social Sciences and Medicine; see, for instance, Stuck et al., 1999; Tseng et al., 2008).

As a result of this investigation, we were able to define a systematic LR methodology as being composed of four steps: (1) source identification, (2) source selection, (3) source evaluation, and (4) data analysis (e.g., Bryman, 2012; Hart, 1998). As a preliminary step for such analysis, the investigator should acquire some knowledge about the domain of interest. This allows the investigator to identify the correct perspective as well as possible gaps or extensions to previous studies. Source selection consists of the scouting of data and corresponding sources (paper or electronic), which will be selected according to objectives and views on the topic investigated. Given that it is impractical to read everything that has been written on a given subject (unless emerging ones) (Seuring & Muller, 2008), this is an important step, as it establishes the boundaries of the analysis (Mayring, 2000). Once selected, sources should be classified and further evaluated. Data may be cataloged through technological tools, such as databases (Mayring, 2000), which facilitate the recollection and analysis of information (Ferfolja & Burnett, 2002). Classification dimensions should be found, either inductively or deductively, possibly with a clear connection with the existing theory. Once collected, data may be processed and critically interpreted. Therefore, the last step of data analysis aims to organize data to obtain useful information. Because the LR is by definition the analysis of another author's contribution, it is extremely important to maintain a clear perspective throughout such an analysis. As a matter of fact, in the management field, the traditional narrative LRs have been widely criticized for the lack of relevance due to authors' use of a personal and usually subjective and biased methodology (Fink, 2009; Hart, 1998). To mitigate this gap, Tranfield, Denyer, and Smart (2003) propose the application of specific principles of the systematic review methodology used in the medical sciences, which is a rigorous, replicable, scientific and transparent process (Cook, Mulrow, & Haynes, 1997). However, a systematic review is different from a meta-analysis in that it does not use statistical and econometric procedures to synthesize findings and analyze data (Tranfield et al., 2003). The main purpose of a systematic review is to identify key scientific contributions to a field or question, and its results are often descriptively presented and discussed.

From this point forward, we will be describing the four-stage process undertaken for this study. It is worth mentioning that all authors are experienced researchers (ranging from post-doc to full professors) in the area of PSM; thus, we meet the requirement of having knowledge on the subject.

3.1. Source identification

We adopt as the unit of analysis papers published in English peer-reviewed journals that can be accessed directly through journal websites or electronic providers. Journals are likely the broadest and most common knowledge base for the research community, generally used to validate research results (through the review process) and release new findings. Therefore, conference papers, master's theses, doctoral dissertations, textbooks, news reports, and unpublished working papers, which are referred to as "gray literature" (Bryman, 2012), are excluded. This is of course a limitation due to practical reasons but also is in line with the scope of the study: we intend to investigate rigorous academic research about PSM. This is a common approach in similar studies (e.g., Giunipero et al., 2008).

Considering recent PSM LRs (e.g., Zheng et al., 2007), a time span of at least 5-10 years appears appropriate; therefore, the period 2002-2010 is chosen.

3.2. Source selection

Source selection consists of the identification of journals relevant to PSM and the extraction of relevant articles. With regard to journal selection, we considered the entire SCOPUS database, focusing, on the one hand, on journals close to PSM and, on the other hand, journals with a high impact on the scientific community.

3.2.1. Journal selection: content criteria

In terms of content, we elect to define topics that are part of the PSM domain and to select journals accordingly. First, we ground ourselves in the most common PSM textbooks (e.g., van Weele; Monczka; Lysons). Examining the detailed tables of contents, it is possible to appreciate the variety of topics that are part of the PSM domain. Furthermore, it is also possible to obtain an idea of a hierarchical classification of different topics, with each author adopting his own logic. For instance, Monczka et al. (2010) adopt a process-oriented scheme, initially focusing on "sourcing" processes inside the company and later on critical activities from a supply chain perspective. Van Weele (2009), instead, distinguishes "strategy and planning" from "implementation" and groups purchasing processes, tools, and organizational principles according to these two broad concepts. These seminal textbooks inspire the initial backbone of the classification framework, which

has been validated through several cycles of review. In particular, we isolate the "what" (i.e., PSM processes, such as portfolio management and network configuration), the "how" (i.e., PSM practices, organization, and relationship management), and the "why" (i.e., competitive priorities in relation to PSM).

As a result of this effort, we are able to choose among three sets of journals. We first include in the analysis international journals with an explicit focus on PSM (i.e., Supply Chain Management: an International Journal; Journal of Supply Chain Management; Journal of Purchasing and Supply Management). Second, we also scout journals in two other fields close to PSM that frequently publish manuscripts related to purchasing and supply: namely, Marketing and Operations Management. Marketing journals often analyze the customer-supplier relationship from a vendor perspective, and Operations Management journals often analyze supply management-related topics. Third, we also consider general management and economics journals that have recently shown an interest in PSM topics by publishing at least 3 papers in this field in 2010.

3.2.2. Journal selection: quality criteria

In terms of impact on the scientific community, we select journals with a Source Normalized Impact per Paper (SNIP) above the mean of the SCOPUS database (Moed, 2010). SNIP is defined as the ratio of the journal's citation count per paper and the citation potential in its subject field. It aims to allow a direct comparison of sources in different subject fields. Citation potential is shown to vary not only between journal subject categories - groupings of journals sharing a research field - or disciplines (e.g., journals in mathematics, engineering and social sciences tend to have lower values than titles in life sciences) but also between journals within the same subject category. As a matter of fact, the SNIP, in comparison with other indicators such as the SCImago Journals Rank (SJR), corrects for such differences.

3.2.3. Paper extraction

This journal selection process leads us to consider 20 international peer-review journals (Table 3). A unique feature of our effort to deploy a comprehensive PSM LR is to avoid the use of keywords to find articles. PSM is certainly gaining momentum and may be considered to be almost an established discipline (Harland et al., 2006). However, it is rather difficult to define a set of overarching concepts - corresponding to univocal keywords that enable one to spot all relevant papers. Therefore, we explore any paper published in the 20 journals shown in Table 3 by considering the title, the abstract, and in some cases the full text to clarify ambiguities. Only papers that could be related to any PSM topic mentioned above (i.e., what, how, and why) are analyzed in detail and included in the final database. Overall, the database comprises 1055 articles relating to PSM out of 14,943 articles that have been published in 2002-2010.

3.3. Source evaluation

The same criteria used to extract and select the articles are also used to evaluate and classify all articles in the database. In addition to using fields related to PSM topics, we also classify articles according to general metadata (e.g., authors, year of publication, journal, volume, issue) as well as study characteristics from a conceptual and methodological perspective (e.g., research approach, research method, theory used).

To perform source evaluation, in the first place, five researchers jointly define a merged framework based on PSM textbooks and openly discuss a lack of consistency and disagreements. Next, the revised draft of the framework is described in detail through a codebook. Three independent researchers contribute to the codebook validation, as this is crucial for the coding activity. In particular, the three researchers conduct two cycles of reliability analysis: they independently classify all papers published in 2010 by the Journal of Purchasing and Supply Management; then, classifications are compared; and finally, the codebook is revised until the reliability is sufficient. We obtain a final reliability of 96.3%, calculated as the number of fields coded in the same way by all three researchers over the total number of fields in the codebook. Some changes to the codebook only lead to a better explanation of existing fields, whereas others lead to a revision of the overall framework. Finally, the researchers code all the articles in the time frame; to avoid any bias depending on the coder-journal combination, each researcher codes a certain number of issues from all journals in the sample. In the initial coding phase, the emergence of a wider variety of topics allows fine-tuning of both the codebook and the framework. Each researcher highlights possible issues and discusses them with the other researchers to agree on any changes.

The final classification framework is reported in Table 3. First, the framework considers the research characteristics in terms of methodology and purpose.

Table 3
Journals included in the analysis.

N	Identified Journals	SNIP 2010	Papers on PSM in 2010	Total papers on PSM 2002–2010	Total papers
PSM related journals					
1	Journal of Supply Chain Management	2.640	8	81	165
2	Supply Chain Management: an Int. Journal	2.621	20	105	393
3	Journal of Purchasing and Supply Management	1.637	25	142	215
Marketing and Operations Management journals					
4	Journal of Operations Management	6.556	15	59	407
5	Int. Journal of Production Economics	2.927	32	145	1986
6	Journal of Marketing Research	3.921	3	8	487
7	Int. J. of Operations and Production Management	2.756	12	67	544
8	Industrial Marketing Management	2.666	23	123	799
9	Int. Journal of Production Research	1.801	30	97	2497
10	Production Planning and Control	0.911	8	27	566
General Management and Economics journals					
11	Strategic Management Journal	5.780	3	19	579
12	Organization Science	4.307	6	8	480
13	Research Policy	3.921	4	15	952
14	Journal of Management Studies	3.856	7	16	565
15	Technovation	3.624	5	15	799
16	Management Science	3.745	7	55	1210
17	Journal of Product Innovation Management	3.406	7	16	337
18	Decision Science	2.900	8	25	230
19	European Economic Review	2.258	6	14	674
20	Harvard Business Review	1.951	5	17	1058
	Total		234	1055	14,943

Subsequently, the research subject is considered in terms of the sector, type of purchase, company size, geographical scope and unit of analysis. Them, we move to the content of the paper, i.e., the topics investigated, in terms of the competitive priorities, processes, practices, organization, and relations.

3.4. Data analysis

Finally, we build a Microsoft Access database that reflects the research framework and upload data regarding all 1055 papers. This step is the starting point in conducting the analyses presented in the next section. We conduct several types of analyses, including calculations of the absolute cumulative number of papers focusing on a given topic; longitudinal analyses of the topic trends over the time span; and cross-sectional analyses among different topics.

4. Results

4.1. Overall research output

We now provide a general overview of the set of papers analyzed to convey a high-level picture of the evolution of scientific production in the PSM field in recent times. Fig. 2 shows the absolute growing trend of PSM papers in the journals considered: since 2002, there has been a 163% increase (from 68 to 179 papers). Even in comparison to the total number of papers published in the selected journals (see Fig. 3), the percentage of PSM papers more than doubled (from 4.7% to 9.6%). This finding is particularly relevant when considering that the sample includes several general management and economics journals.

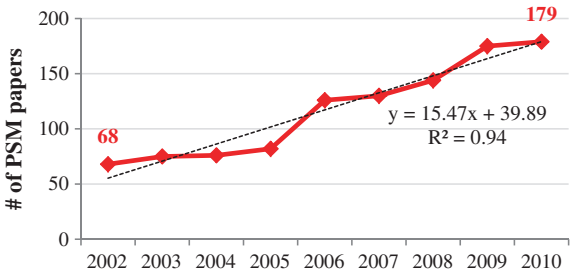


Fig. 2. Absolute trend of PSM papers.

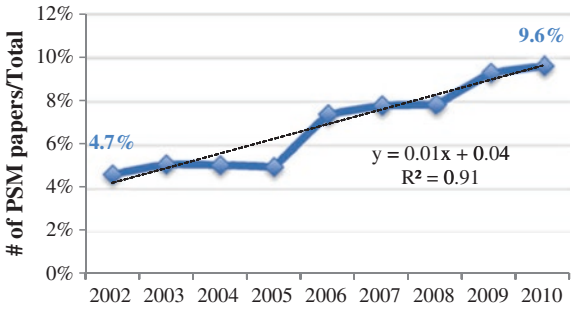
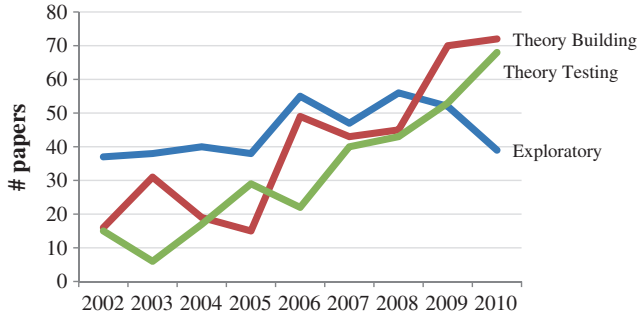


Fig. 3. Relative trend of PSM papers (percentage of the total # of papers).

4.2. Research type

Fig. 4 shows the trend in terms of the type of research conducted by scholars, distinguishing among exploratory, theory building, and theory testing. At the beginning of the decade, the most frequent case is that of exploratory papers, followed by theory-building and theory-testing ones. However, during the decade, exploratory papers have remained quite stable. In contrast, theory-building and theory-testing papers grow quickly: the former increases by 450% (from 16 to 72 papers), and the latter increases by 453% (from 15 to 68 papers), overcoming the others and becoming dominant.



Research type	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Exploratory	37	38	40	38	55	47	56	52	39	**402**
Theory building	16	31	19	15	49	43	45	70	72	**360**
Theory testing	15	6	17	29	22	40	43	53	68	**293**
Total	**68**	**75**	**76**	**82**	**126**	**130**	**144**	**175**	**179**	**1055**

Fig. 4. Absolute trend of research type (absolute # of papers).

4.3. Unit of analysis

With regard to the unit of analysis, Table 5 shows that papers focusing on the buyer's perspective represent the largest group (421 papers), followed by those focusing on the supply network (347) and dyadic relationships (233). Papers focusing on the supplier perspective are only a minority (54). However, the topic of supply networks has recently overcome all the other perspectives, representing 53.6% of the total output in 2010.

4.4. Research method

Table 6 shows how the three most frequent methods such as surveys (which clearly dominate, with 427 papers), followed by conceptual studies (318), and case studies (249) are used. These three methods consistently proved to be the most popular over the period under study. All the other methods (i.e., experiment, simulation, literature review, collaborative research, Delphi) are marginal in comparison. On the whole, the growing trend of survey and case studies appears more robust than that of conceptual papers.

4.5. Theoretical background

We investigate the extent to which PSM studies refer to consolidated theories that are borrowed from other fields of economics and management studies and are possibly adapted or developed for PSM. Only 10% of papers make explicit reference to theories, meaning that the vast majority of articles are not grounded in consolidated theories. Furthermore, transaction cost economics (TCE) is by far the most adopted theoretical perspective, followed by the resource-based view (RBV). Examining the evolutionary trend, we observe a significant increase in the last 5 years of theoretically grounded papers. In fact, in 2010, almost 11% of the total production is theoretically grounded.

4.6. Research topics

Moving from the general overview to the main content of papers, we classify the latter according to five groups of topics (one paper may fall into one or more groups). In Table 8, we report the evolution of the research topics according to the framework introduced in Table 4. In particular, Table 8 displays the overall research production with regard to:

Table 4
Classification framework.

Variable	Values
Methodology	Literature review, case study, survey, simulation, experiment, Delphi, collaborative research, conceptual
Type	Exploratory, theory building, theory testing
Sector	Manufacturing, services, public administration, health care
Type of purchase	Goods, services Direct, indirect, Capex
Company size	SME, large
Geographical scope	Continent, country
Unit of analysis	Buyer, supplier, buyer–supplier, supply network
Why (competitive priorities)	Cost, time, quality, flexibility, innovation, sustainability
What (processes)	Portfolio management (purchase classification, spending analysis), network configuration (sourcing strategy), reverse marketing (market intelligence), supplier management, vendor rating, specs definition, negotiation, contracting, execution (order, expediting, invoicing, payment)
How (practices)	Centralization, cooperative purchasing, outsourcing/make or buy, local/global sourcing, lean procurement, efficiency (pricing methods, batch sizing, learning curves, requirements), e-Purchasing (e-Sourcing, e-Procurement, e-Auctions), supply base reduction, supplier collaboration (supplier development, early supplier involvement, suppliers association), risk management
How (organization)	Macro-structure (organizational units), micro-structure (job definition, competences), performance of the purchasing department
How (relation)	Partnership, power, trust

Table 5
Absolute trend of unit of analysis (absolute # of papers).

Unit of analysis	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Buyer	27	39	38	26	80	58	48	67	38	421
Supplier	6	2	4	5	7	5	16	1	8	54
Dyadic	13	14	14	17	29	28	42	39	37	233
Supply network	22	20	20	34	10	39	38	68	96	347

- purchasing processes/activities (i.e., the what);
- practices, organization, and relationship management (i.e., the how);
- motivation and competitive priorities (i.e., the why).

Practices consistently comprise the most frequent content (547), closely followed by competitive priorities (461), relations (372), and processes (363). Organization is the least investigated topic (134). We also note that almost one third of the papers address partnership.

Table 6
Absolute trend of research methods (absolute # of papers).

Research method	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Survey	28	29	26	30	41	57	60	77	79	427
Conceptual	26	29	24	25	49	35	40	44	46	318
Case study	11	13	20	21	33	33	31	44	43	249
Experiment	0	2	2	2	2	5	5	6	8	32
Simulation	2	1	4	3	1	1	7	5	6	30
Literature review	0	2	1	1	3	3	2	4	8	24
Collaborative research	1	0	1	1	0	2	0	1	4	10
Delphi	0	0	0	2	0	0	0	0	1	3

Table 7
Absolute trend of theories (absolute # of papers).

Theory	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Transaction-cost economics	3	4	1		9	9	7	11	15	59
Resource-based view of the firm	2	2			3	3	6	3	8	27
Knowledge-based theory of the firm					1		2	2	7	12
Contingency theory	1					1	6	1	1	10
Game theory					2	1	1	3	1	8
Resource dependency theory				1	1	2	1	1		6
Social exchange theory					1			3	1	5
Agency theory					1	1		1	1	4
Institutional theory						1		2	1	4
Social network theory					1	1	1			3
Information processing theory					1	1				2
Critical realism theory								1		1
Dynamic capabilities							1			1
Multi-attribute utility theory						1				1
Organizational culture theory						1				1
Real options theory							1			1
Social capital theory							1			1
Total	6	6	1	1	20	22	27	28	35	146

Table 8
Papers content (absolute # of papers).

W	Framework variable	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
What	**Processes**	**17**	**33**	**27**	**19**	**48**	**51**	**36**	**60**	**72**	**363**
	Reverse marketing	9	9	8	6	25	22	18	16	24	137
	Contract management	2	5	7	2	9	9	7	15	18	74
	Supply network configuration	0	11	3	6	7	2	7	17	14	67
	Negotiation	3	6	2	3	3	7	6	11	8	49
	Vendor rating	3	4	2	2	6	3	6	7	4	37
	Supplier management	2	0	4	2	4	9	6	0	7	34
	Execution	2	1	3	2	3	1	7	1	7	27
	Portfolio management	2	3	0	2	1	1	0	2	4	15
	Requirement definition	0	1	0	0	2	2	1	1	1	8
How	**Practices**	**23**	**41**	**44**	**41**	**67**	**65**	**69**	**89**	**108**	**547**
	Outsourcing	4	14	7	9	17	19	24	36	41	171
	E-purchasing	3	15	16	23	13	17	15	11	14	127
	Local/global	3	4	7	2	12	9	7	18	20	82
	Risk management	5	1	8	3	13	8	4	17	21	80
	Efficiency	4	3	2	3	8	9	15	9	17	70
	Supplier involvement	4	3	4	4	9	9	5	12	13	63
	Lean	1	4	2	1	2	5	3	2	4	24
	Centralization	1	1	1	0	3	0	1	1	1	9
	Cooperative purchasing	0	1	0	0	0	1	0	1	2	5
	Supply base reduction	0	0	0	0	1	0	0	0	4	5
	Organization	**13**	**18**	**10**	**6**	**17**	**21**	**14**	**24**	**11**	**134**
	Micro structure	4	13	5	3	9	14	6	14	6	74
	Macro structure	10	9	4	3	8	11	8	7	7	67
	Performance of purchasing dept.	1	1	2	2	3	2	4	7	1	23
	Relations	18	23	27	26	47	43	53	67	68	372
	Partnership	16	20	25	21	44	33	48	54	61	322
	Trust	1	9	7	8	18	10	10	19	21	103
	Power	2	0	2	4	2	7	4	7	6	34
Why	**Competitive priorities**	**33**	**34**	**27**	**31**	**54**	**50**	**59**	**94**	**79**	**461**
	Cost	18	28	15	15	32	31	35	55	40	269
	Innovation	14	6	5	9	13	10	12	23	21	113
	Quality	11	9	5	8	16	15	9	23	14	110
	Time	4	5	6	1	11	9	10	10	18	74
	Sustainability	1	0	8	3	6	4	7	21	13	63
	Flexibility	2	4	5	1	4	10	3	12	14	55

5. Discussion

5.1. State of PSM research

The first goal of our LR is to extend previous analyses by providing a refreshed and comprehensive review of the PSM academic literature and to examine how the overall production has evolved over time, in terms of research methods, units of analysis, and topics.

By examining 20 scientific journals and over one thousand articles published from 2002 to 2010, we certainly extend and refresh previous LRs in the field of PSM. As noted in the Results section, the number of papers related to PSM has increased consistently in the last decade in both absolute and relative terms. In particular, PSM contributions have increased in journals related to general management and economics topics and not just in those focused on PSM. By extending and refreshing the dataset compared to the past LRs, two different trends emerge in terms of research output. In the first period, from 2002 to 2005, the trend is quite stable or slightly increasing. In 2006 a leap in terms of the number of published papers occurs, and from 2006 to 2010, the growing trend appears to be more robust than in the past. Although scholars have long been debating over PSM, it appears that this field has changed pace in the last five years. This trend is also consistent with the industry: companies are increasingly considering purchasing and supply activities as a source of competitive advantage (CAPS, 2012).

As already noted in the Results section, the fundamental emerging trend in terms of the unit of analysis is the shift from the buyer perspective to the supply network one. It appears that the reason for this shift may be related to the widespread impact of outsourcing and globalization. In fact, companies that have outsourced more operations and sourced globally have an increasing need for control and coordination over a multi-echelon network of suppliers worldwide. It is also intuitive that the focus on supplier has been quite limited in the past, as PSM papers naturally adopt a buying firm perspective. However, as it is an underdeveloped theme, there are further opportunities for research studies focused on the supplier perspective in the boundary between the PSM and Marketing literatures (e.g., the concept of customer attractiveness, Schiele, 2012).

Examining the research method, as shown in Table 6, most of the total production in PSM is either survey-based, conceptual, or case- based. Therefore, we observe an opportunity to develop genuine research exploiting different methods. For example, compared to other fields of management studies, experimental as well as collaborative research appear to be quite under-exploited. Among the other methods, it is interesting to note the increase in literature reviews in 2010. All of these elements suggest an overall growing maturity of the PSM field, as pure conceptual papers are being slowly substituted by more empirically based ones, especially survey-based ones, and literature reviews reveal the need to rationalize a broad existing knowledge base. Further considerations about the maturity stage of PSM are provided in the final section.

Moving from the general overview to the topics of the papers, we observe that practices is constantly the most frequent topic group, demonstrating strong attention of the academic community to the main activities and programs adopted by companies to manage and improve their purchasing and supply performance. Practices are closely followed by competitive priorities, showing a clear attention to the motivation and the impact ofPSM practices, as well as a strategic orientation of research. PSM processes and relations are also popular and show similar patterns. The above four groups are all growing with the overall growth of the number of papers. Organization instead is by far the least frequent group, with a flat trend, indicating proportionally declining attention to this group, despite (or perhaps due to) its being a very traditional one.

5.1.1. The what: purchasing processes

Table 8 also focuses on an analysis of the groups of topics, dividing them into individual topics. As far as processes are concerned, 9 topics are considered. The most popular is reverse marketing, which had a boost in 2006 and has remained high since then. The second most frequent process, although substantially less so than the previous, is contract management, which shows a very consistent growing trend. The supply network configuration is the third most popular process, with an isolated peak in 2003, followed by slow growth and then a step up in 2009 and 2010. These three processes demonstrate the strategic orientation of PSM research. Negotiation, vendor rating, supplier management and execution have lower frequencies but appear to follow the overall trend on average. Finally, portfolio management and requirement definition are the least frequent processes considered and have not even shown signs of growth. This result suggests that the category strategy approach entailed by portfolio management, despite the debate that followed Kraljic's (1983) seminal work, has not been developed much further in the last decade. A similar consideration may be made for the definition of requirements, which is almost neglected, despite its key role in determining the possibility of obtaining strategic advantages from PSM, e.g., by collaborating with R&D in new product development to standardize materials and avoid bottlenecks.

5.1.2. The how: purchasing practices, organization, and relations

Moving to practices, this group includes 10 individual topics according to our framework. We observe that outsourcing is the most frequent one, with an initial peak in 2003 and later constant growth, becoming the most frequent practice by far at the end of the decade. This is not surprising if we consider the tremendous impact of this practice on all industrial sectors and its implications for PSM. The second practice in terms of cumulated frequency is ePurchasing, which was the most popular at the beginning of the decade but then declined and stabilized at an intermediate position. When considering the natural time lag of research and publication, this pattern appears to mirror the enthusiasm of the Internet boom first at the end of the 1990s and the subsequent disillusionment after the fall of the

NASDAQ. However, the long-term impact of this topic in both research and practice, after the initial fad, is relevant. The following four practices, i.e., local/global sourcing, risk management, efficiency and supplier involvement show a very similar pattern of growth, with the same step up in 2006 also seen for other topics. Local/global sourcing and risk management in particular have become quite popular recently, coherently with the growing globalization, which provide opportunities as well as challenges, including a higher exposure to risks. On the contrary, lean, centralization, cooperative purchasing and supply base reduction have been very low for the entire period, despite the emphasis applied to these topics in managerial practice.

The organization group comprises 3 topics, with the macro and micro structure being the most frequent and relatively stable, although with lower values compared to other categories. The performance of the purchasing department has instead received very limited attention in the period, although this is becoming a very relevant issue in managerial practice today.

In addition, the relations groups comprises 3 topics, with partnership being by far the most popular and fastest growing, with the usual step up in 2006, although this cannot be considered a new topic. Although scholars have been writing about partnership for the last thirty years, it remains the most popular topic. This finding is most likely explained by the fact that partnership is even more necessary and difficult to implement. Trust is far lower in terms of the total number of papers, although this topic has been growing very significantly, again with a step up in 2006, suggesting increasing attention to soft and behavioral issues. Finally, power is the least common (and almost flat) topic, although this can be considered a traditional issue in the negotiation literature.

5.1.3. The why: purchasing competitive priorities

Moving to the last group, i.e., competitive priorities, we observe that cost is by far the most popular, with an initial spike in 2003, a step up in 2006 and another peak in 2009, confirming the traditional focus of PSM research on efficiency. All other priorities, although much less frequent, follow a similar trend but with a slower growth compared to cost. Innovation and quali ty have very similar values, suggesting an attempt by the academic community to shift the focus from efficiency to effectiveness and strategic contribution. Time follows with lower values but also a peak in 2010, suggesting that at the end of the decade, this competitive priority has become relevant. In addition, sustainability, which was almost absent at the beginning of the decade, has grown to reach similar values as innovation and quality, in line with the recent emphasis of both research and practice on this rather new topic. Finally, flexibility is the least frequent priority, although in the last years, its values are not far from those of the other priorities; we can conclude that priorities other than the classical triad (cost, quality, and time) are still a minority in the academic literature, but they are gaining momentum.

5.2. PSM position in the research life cycle

As mentioned in the Introduction, Harland et al. (2006) raised the crucial issue of whether PSM should be considered a fully established discipline. Their argument at that time was only preliminary, and they concluded tentatively that PSM may be regarded as an emerging and not fully established discipline because it continues to lack high- quality standards of theoretical development and discussion. Our empirical analyses do not allow us to answer their crucial issue. However, the amplitude of the production we have surveyed and the evolution of the nature of the papers we have detected provide us the opportunity to profile the evolutionary pattern of PSM as an academic field, thus shedding further light onto the legitimacy of the emerging discipline.

The dynamics displayed in Fig. 4 clearly shows how research on PSM has progressively evolved from a dominant exploratory focus to theory building and theory testing. Referring to the generic life-cycle for scientific research conceptualized by Wallace (1971), the initial stage of such a cycle is featured by empirical exploration and observation with the primary goal of observing phenomena and describing them. The second stage requires a shift to theory building, even borrowing concepts and linkage from other fields, whereas methods often combine empirical observation as well as theoretical reflection. Finally, in the third stage, research is mostly empirical and is aimed at theory testing to confirm, refine, enrich or even discard previously developed theories.

According to this model, we clearly observe how PSM is shifting away from stage 1 and has entered stages 2 and 3, thus providing the argument for a certain consolidation of the discipline. This pattern is also reinforced by four complimentary observations. First, the growing presence of PSM research in non-PSM top journals provides external legitimacy to the field (see Table 3). Second, the growing number of empirical papers and literature reviews testifies to a more consolidated and robust approach to research. Third, the evidence from Table 7 indicates a growing diffusion of the theoretically grounded research papers over the years. Fourth, the array of theories used, which began mostly around transaction cost economics and a resource-based view, evolved to include a number of emerging theories adapted on purpose.

On the whole, such evidence gives us the room to conclude that PSM, though not fully consolidated, has entered a more mature stage compared to a few years ago. The quantity, quality and credibility of the sources certainly appear to be higher than they were ten years ago.

6. Conclusion, limitations, and future developments

Having the chance to classify 1055 papers from 20 journals enabled us to meet the objectives of this study, i.e., expanding previous LRs about PSM and discussing the research state of the art.

Given the breath and the scope of our analysis, we believe that this effort will certainly benefit the research community. We defined a framework to scout PSM-related studies and provided a longitudinal analysis of the research production according to several perspectives, including the overall amount of PSM studies, the unit of analysis, the research method adopted, the theory used, and the main content of the articles. The PSM field has grown dramatically in the last decade and has recently matured in terms of its theoretical background as well as its breath of research methods applied. Such a review had been lacking; now, both within and outside the PSM community, it is possible to obtain a comprehensive understanding of how the field has evolved, which topics have been explored most and least frequently, and how mature research has become thus far. PSM scholars will be able to position their work in the literature and easily grasp the relevance and complexity of a given topic. Despite the overall growing trend, PSM research remains under development: few theories account for the majority of studies, and few methodologies prevail. We believe that PSM has expanded its boundaries through the exploitation of new theories and new methods that have proven to be effective in other disciplines, such as collaborative research or experimentation.

Although such a contribution is oriented primarily toward an academic audience, we believe that it may also be interesting and useful for practitioners, who will be able to obtain an understanding of what research is focusing on, identifying sources of valuable information as well as listing the relevant topics (and issues) for practice.

This study is not meant to provide in-depth comments on specific PSM topics, even though this would certainly be useful to researchers. Future studies might ground on this snapshot and analyze peculiar characteristics of PSM research, such as dominant theoretical perspectives and most common methodologies that are suitable to address specific phenomena. In addition, it would be interesting to provide definitions and theoretical frameworks about consolidated (e.g. reverse marketing or partnership) as well as emerging topics (e.g. sustainability or global sourcing).

A further limitation of the study is that we only deal with PSM academic peer-reviewed literature, leaving out a heterogeneous set of publications. For example, it would be interesting to compare scholars' and managers' perspectives by looking at professional magazines or by involving practitioners in the review and interpretation of the literature.

Finally, a very large set of analyses is possible on the base of our database of papers, and only a limited subset has been presented in this paper, also due to space limitations. We hope that other scholars further expand and update this study, possibly grounding their efforts on a shared research protocol. Future

updates of this paper will thus provide additional details and deeper analysis by enlarging the time-frame and the set of journals/papers as well as by validating/ updating the research framework.

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References

Bryman, A. (2012). *Social Research Methods*. USA: Oxford University Press.

Burgess, K., Singh, P. J., & Koroglu, R. (2006). Supply chain management: A structured literature review and implications for future research. *International Journal of Operations and Production Management*, *26(7)*, 703-729.

Bygballe, L. E.,Jahre, M., & Sward, A. (2010). Partnering relationships in construction: A literature review. *Journal of Purchasing and Supply Management*, 16(4), 239-253.

CAPS (2012). Snapshot of the CPO role shows significant change. *Inside Supply Management*, *23(8)*.

Carter, C. R., & Ellram, L. M. (2003). Thirty-five years of the Journal of Supply Chain Management: Where have we been and where are we going? Journal of Supply Chain Management, *39(2)*, 27-39.

Cook, D. J., Mulrow, C. D., & Haynes, R.B.(1997). Systematic reviews: Synthesis of best evidence for clinical decisions. *Annals of Internal Medicine*, *126(5)*, 376-380.

Dubois, A., & Araujo, L. (2007). Case research in purchasing and supply management: Opportunities and challenges. *Journal of Purchasing and Supply Management*, *13(3)*, 170-181.

Ellram, L. M., & Carr, A. (1994). Strategic purchasing: A history and review of the literature. *Journal of Supply Chain Management*, *30(2)*, 9-19.

Ferfolja, T., & Burnett, L. (2002). *Getting started on your literature review*: *A general guide for postgraduate research students*. UNSW.

Fink, A. (2009). *Conducting research literature reviews*. Sage Publications, Incorporated.

Giunipero, L. C., Hooker, R. E., Matthews, J. S., Yoon, T. E., & Brudvig, S. (2008). A decade of SCM literature: Past, present and future implications. *Journal of Supply Chain Management*, *44(4)*, 66-86.

Gosling, J., & Naim, M. M. (2009). Engineer-to-order supply chain management: A literature review and research agenda. *International Journal of Production Economics*, *122(2)*, 741-754.

Gunasekaran, A., & Ngai, E. (2005). Build-to-order supply chain management: A literature review and framework for development. *Journal of Operations Management*, *23(5)*, 423-451.

Harland, C. M., Lamming, R. C., Walker, H., Phillips, W. E., Caldwell, N. D.,Johnsen, T. E., et al. (2006). Supply management: Is it a discipline? *International Journal of Operations and Production Management*, *26(7)*, 730-753.

Hart, C. (1998). Doing a literature review. : Sage Publications Limited.

Jiang, B., Frazier, G. V., & Heiser, D. (2007).China-related POM research: A literature review and suggestions for future research. *International Journal of Operations and Production Management*, *27(7)*, 662-684.

Johnsen, T. E. (2009). Supplier involvement in new product development and innovation: Taking stock and looking to the future. *Journal of Purchasing and Supply Management*, *15(3)*, 187-197.

Kraljic, P. (1983). Purchasing must become supply management. *Harvard Business Review*, *61(5)*,109-117.

Larson, P. D., & Halldorsson, A. (2002). What is SCM? And, where is it? *Journal of Supply Chain Management*, *38(4)*, 36-44.

Marra, M., Ho, W., & Edwards, J. S. (2012). Supply chain knowledge management: A literature review. *Expert Systems with Applications*, *39(5)*, 6103-6110.

Mayring, P. (2000). Qualitative content analysis. *Forum Qualitative Sozialforschung/Forum*: *Qualitative Social Research*, *1(2)*.

Metz, P. J. (1998). Demystifying supply chain management. *Supply Chain Management Review*, 46-55.

Miemczyk, J., Johnsen, T. E., & Macquet, M. (2012). Sustainable purchasing and supply management: A structured literature review of definitions and measures at the dyad chain and network levels. *Supply Chain Management*: *An International Journal*, *17(5)*, 1-42.

Moed, H. F. (2010). Measuring contextual citation impact of scientific journals. *Journal of Informetrics*, *4(3)*, 265-277.

Monczka, R. M., Handfield, R. B., Guinipero, L. C., & Patterson, J. L. (2010). *Purchasing and supply chain management*. Cengage Learning EMEA.

Pagano, A. (2009). The role of relational capabilities in the organization of international sourcing activities: A literature review. *Industrial Marketing Management*, *38(8)*, 903-913.

Quintens, L., Pauwels, P., & Matthyssens, P. (2006). Global purchasing: State of the art and research directions. *Journal of Purchasing and Supply Management*, *12(4)*, 170-181.

Sarac, A., Absi, N., & Dauzere-Peres, S. (2010). A literature review on the impact ofRFID technologies on supply chain management. *International Journal of Production Economics*, *128(1)*, 77-95.

SCC (2008). Supply-chain operations reference-model: SCOR overview version 9.0. available at. http://supply-chain.org/resources/scor

Schiele, H. (2012). Accessing supplier innovation by being their preferred customer. *Research-Technology Management*, *55(1)*, 44-50.

Seuring, S., & Muller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16(15)*, 1699-1710.

Stuck, A. E., Walthert, J. M., Nikolaus, T., Bula, C. J., Hohmann, C., & Beck, J. C. (1999). Risk factors for functional status decline in community-living elderly people: *A systematic literature review*. *Social Science & Medicine*, *48(4)*, 445-469.

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14(3)*, 207-222.

Tseng, T. Y., Dahm, P., Poolman, R. W., Preminger, G. M., Canales, B.J., & Montori, V. M. (2008). How to use a systematic literature review and meta-analysis. *The Journal of Urology*, *180(4)*, 1249-1256.

Van Weele, A.J. (2009). *Purchasing and supply chain management*. Cengage Learning EMEA.

Wallace, W. L. (1971). *The logic of science in sociology*. Aldine De Gruyter.

Wu, C., & Barnes, D. (2011). A literature review of decision-making models and approaches for partner selection in agile supply chains. *Journal of Purchasing and Supply Management*, *17(4)*, 256-274.

Wynstra, F. (2010). What did we do, who did it and did it matter? A review of fifteen volumes of the (European) Journal of Purchasing and Supply Management. J*ournal of Purchasing and Supply Management*, *16(4)*, 279-292.

Zheng, J., Knight, L., Harland, C., Humby, S., & James, K. (2007). An analysis of research into the future of purchasing and supply management. *Journal of Purchasing and Supply Management*, *13 (1)*, 69-83.

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8.2 Review and Outlook

8.2.1 The Background

In 2013, in Industrial Marketing Management, Gianluca Spina, Federico Caniato, Davide Luzzini and Stefano Ronchi, all from Politecnico di Milano, presented an overview of purchasing and supply management research as published in international academic journals. This overview was in many ways a remarkable undertaking, as it encompassed not only a wide range of journals (20 in total, across different management research disciplines) but also it spanned almost a decade of research 2002–2010. Indeed, the review ultimately covers 1055 articles, which are subsequently analysed in terms of methods, research subject and detailed contents.

Before commenting on the article in more detail, let me briefly discuss the wider context of the work of Gianluca and his colleagues in the area of purchasing and supply management, and how our team in Rotterdam (including Erik van Raaij, Melek Akın Ateş and myself) came to collaborate with Politecnico—and others—in this area.

In my perception, much of the work of Gianluca and his colleagues in purchasing and supply management got a strong impetus when they initiated what later became known as the International Purchasing Study. In February 2007, Gianluca and Stefano Ronchi approached us with the idea to start an international consortium to collect data on purchasing strategies and performance. With our combined networks, we were able to set up a network of 10 universities, spread over Europe and North America. A first round of survey data collection took place in 2009, and ultimately, this research led to a number of publications in a variety of journals (Akın Ateş et al. 2015; Karjalainen and Salmi 2013; Kauppi et al. 2013; Knoppen et al. 2015; Luzzini et al. 2012, 2015a, b; Bengtsson and von Haartman 2015).

In this collaborative project, one central focus was on studying strategies and performance at an intermediate level; at the level of so-called purchasing categories or commodity groups. Many studies in the field have either studied individual or sets of supplier relations, or the purchasing strategy at the level of the entire organisation.

Another key idea, which turned out to be quite difficult in practice, was that the survey would be used to collect a form of panel data, in which the same firms would participate in the survey on multiple occasions.

The Politecnico team had earlier experience in international surveys on manufacturing, such as the International Manufacturing Strategy Survey and the Offshoring Research Network. These experiences proved quite valuable in setting up the International Purchasing Survey (IPS). At the same time, the project obviously had its own challenges. For instance, how to deal with the fact that in some countries, we could collaborate with the national purchasing management association in distributing the survey, but not in some other countries? How to agree on the sectors to be studied, particularly if some sectors were better represented in some countries than in others? And, much later in the project, how to agree on

co-authorship rules: for instance, under what conditions could a project member use the data collected in other countries?

With Italian charm and a pragmatic approach, Gianluca, Stefano, Federico and Davide helped resolve a lot of potential conflicts. Gianluca became less directly involved as the project moved along, but on important occasions, he was a productive "mediator", by looking at the overall picture and carefully analysing the pro's and cons of each option and investigating the possibilities for a compromise that would be acceptable to everyone.

Speaking on behalf of the Rotterdam team, I can safely say that the project was a great experience for all of us. Particularly in terms of organizing and managing such a consortium project, we have learned a great deal. Obviously, there are the various important publications on the issue of category sourcing strategy and performance, an area which I would argue would still benefit from more research.

But also, we have identified and applied improved methodological aspects of international survey data collection, such as in the area of measurement equivalence (Knoppen et al. 2015). If Gianluca and his team had not started this, and had not invited us to join, we would have missed out on a great learning opportunity and opportunity to contribute to purchasing and supply management research.

And we would have missed the great meetings; at Schiphol Airport, in Paris, Stockholm … but above all, in lovely Milan!

8.2.2 The Paper

In my view, the review in Industrial Marketing Management has been kind of inspired by the International Purchasing Survey. All the discussions on category sourcing, purchasing organisation and purchasing capabilities must have encouraged Gianluca and his team to create a solid overview—for themselves, but also for others—of previous research in the field. And being management researchers at a technical university, they were more than appreciative of the fact that the field of purchasing and supply management (PSM) research is multidisciplinary. Hence, their scope not only included PSM and Operations Management journals, but also economics, marketing and general management journals. One of the key assets of the review is that, at the time, there were only a few generic PSM literature review studies that encompassed such as wide range of journals.

Another salient aspect of the set-up is that the authors did not use a keyword search in the typical databases such as Web of Science or Business Source Premier, such as commonly done. Instead, they went through the title and abstract of each article published in the 2002–2010 period in each of the 20 journals. This amounted to reading 14,943 abstracts—a real impressive achievement already just by itself!

The argument for selecting the articles in this way is, in the words of the authors, that "it is rather difficult to define a set of overarching concepts—corresponding to univocal keywords—that enable one to spot all relevant papers" (p. 1206).

In my opinion, however, there would be one possible alternative, and that is to use rather broad key words, such as "purchasing", "sourcing", "procurement", "supply" (and all varieties thereof). The downside of that approach, however, is that one ends up with a lot of non-relevant articles in terms of PSM, for instance because they deal with "sources of competitive advantage". Therefore, there will have to be a follow-up analysis of each article, by reading the abstract at least and sometimes the entire article, and this may be equally time consuming.

Besides time investments, the key question is obviously which of the procedures is better in avoiding false positives or Type 1 errors (picking up an article that is not about PSM) and false negatives or Type 2 errors (not picking up a PSM article).

For illustration, therefore, it may be useful to compare the approach in this paper with a similar study that we are currently conducting. We are looking at PSM research articles published in the period 1996–2014, across 18 different journals. The set of journals largely overlaps with the set of the study by Spina and colleagues. In total, these journals have published around 18,300 articles in this given period, and using a search with broad keywords as above, we identify some 5800 articles. After reading these abstracts, we find that about 2600 of these really concern PSM research; in other words, about 14 % of the total number of articles published.

Spina and colleagues, by their "manual" approach, find 1055 PSM articles out of a total of 14,943, which is about 7 %—roughly half the number of articles we find through the keyword-plus-filtering approach.

This is a marked difference, but one word of caution applies. We clearly see that more and more journals are publishing a relatively growing share of PSM research. Thus, if the study of Spina and colleagues were extended to the four more recent years, it is likely their ratio of PSM articles to total articles would have gone up.

Still, this difference is too big to be due to this factor alone, so it seems the method by Spina and colleagues is more susceptible to false negatives or Type 2 errors. The explanation could be that in some abstracts, the words purchasing etcetera are not used prominently so that a visual inspection misses out on some of the articles that are in fact about PSM research.

Despite this possible criticism on the method applied, I believe the article delivers a number of important messages.

First of all, as briefly noted earlier, Gianluca and his co-authors approach PSM as a multi-disciplinary research field, albeit somewhat implicitly. They explicitly decide to first "define the topics that are part of the PSM domain and to select journals accordingly" (p. 1205). This results in identifying three baskets of journals: those with an explicit focus on PSM, Marketing and Operations Management journals, and General Management and Economics journals.

I wholeheartedly agree with the notion that purchasing and supply management should not be seen as a single discipline (see also Wynstra and Knight 2004). This perspective was echoed a long time ago by Williams (1986) who argued that, at that time, the multidisciplinary background of purchasing and supply management

had not sufficiently been leveraged. Purchasing and Supply Management in its very essence is a multidisciplinary research field, united by it study object: the design, initiation, control and evaluation of activities within and between organizations, aimed at acquiring products and services from suppliers (Wynstra 2006).

Second, Gianluca and his colleagues provide an interesting assessment of the use of theory in these publications. What becomes clear is that PSM research, since 2006, is increasingly using an explicit, established theoretical framework to ground a new study. In the decade prior to that, several researchers have claimed that PSM research was not yet as rigorous and coherent as other disciplines of management research (Buvik 2001; Carter and Ellram 2003; Das and Handfield 1997; Olsen and Ellram 1997). Explicitly, Buvik (2001) claimed that "When we compare current literature and research within the purchasing and marketing disciplines, one striking observation is the scant use of references in the purchasing research field" (p. 439).

Gianluca and colleagues follow up on this claim and, fortunately, demonstrate that PSM researchers have increasingly heeded this call for better theoretical grounding. Still, in their analysis, only some 20 % of the articles use such explicit theoretical grounding. Surely, this can and should improve further (Van Weele and Van Raaij 2014), but it is worth pointing out that most of the modelling-based PSM research that is rooted in the Operations Research (and partly also in the Operations Management) discipline, traditionally has used very little management and economic theory, as its main aim is not to advance this theory but to develop or improve analytical methods, and applications thereof. Such studies are also found in the journals encompassed in the current studies (including International Journal of Production Economics, International Journal of Production Research, Management Science and Decision Sciences).

A third important achievement of the study is that it provides a fine-grained classification of the contents of PSM studies, including the different (strategic) processes and objectives and the means to achieve these objectives (practices/tactical processes, and organisational forms). Wynstra (2010) provides a framework, which is largely similar although the strategic and tactical processes are defined and grouped somewhat differently. As such, the current study also helps in consolidating a common frame of reference for any subsequent overviews of the field.

8.2.3 The Legacy

What has happened since? As mentioned, the paper has been published in 2013, and the paper has been cited six times since then (as of July 2015). The most interesting citation comes from a study in the British Journal of Management (BJM), which refers to the Spina study to provide support for the claim that the purchasing function has become an important source of competitive advantage (Wilhelm et al. 2015). This citation is interesting because it may be indicative of the type of future citations one could expect—from non-PSM journals (BJM is a generic

management research journal)—as field reviews such as this one are useful sources particularly for relative outsiders, or "outside" journals. Time will tell, but reviews like these, demonstrating the breadth and depth of the field, will not only be a useful reference point for PSM researchers themselves, but hopefully also a wider range of management researchers in neighbouring fields. As such, it is one of several inspiring legacies that Gianluca has left behind.

References

Akın Ateş, M., Wynstra, J. Y. F., & Van Raaij, E. M. (2015). An exploratory analysis of the relationship between purchase category strategies and supply base structure. *Journal of Purchasing and Supply Management, 21*, 204–219.

Bengtsson, L., & von Haartman, R. (2015). The impact of global purchasing and supplier integration on product innovation. *International Journal of Operations and Production Management, 35*(9), 1295–1311.

Buvik, A. (2001). The industrial purchasing research framework: A comparison of theoretical perspectives from micro economics, marketing and organization science. *Journal of Business and Industrial Marketing, 16*(6/7), 439–451.

Carter, C. R., & Ellram, L. M. (2003). Thirty-five years of the journal of supply chain management: Where have we been and where are we going? *Journal of Supply Chain Management, 39*(2), 27–39.

Das, A., & Handfield, R. B. (1997). A meta-analysis of doctoral dissertations in purchasing. *Journal of Operations Management, 15*(2), 101–121.

Karjalainen, K., & Salmi, A. (2013). Continental differences in purchasing strategies and tools. *International Business Review, 22*(1), 112–125.

Kauppi, K., Brandon-Jones, A., Ronchi, S., & van Raaij, E. M. (2013). Tools without skills: Exploring the moderating effect of absorptive capacity on the relationship between e-purchasing tools and category performance. *International Journal of Operations and Production Management, 33*(7), 828–857.

Knoppen, D., Akın Ateş, M., Brandon-Jones, A., Luzzini, D., Van Raaij, E., & Wynstra, F. (2015). A comprehensive assessment of measurement equivalence in operations management. *International Journal of Production Research, 53*(1), 166–182.

Luzzini, D., Amann, M., Caniato, F., Essig, M., & Ronchi, S. (2015a). The path of innovation: Purchasing and supplier involvement into new product development. *Industrial Marketing Management, 47*, 109–120.

Luzzini, D., Brandon-Jones, E., Brandon-Jones, A., & Spina, G. (2015b). From sustainability commitment to performance: The role of intra-and inter-firm collaborative capabilities in the upstream supply chain. *International Journal of Production Economics, 165*, 51–63.

Luzzini, D., Caniato, F., Ronchi, S., & Spina, G. (2012). A transaction costs approach to purchasing portfolio management. *International Journal of Operations and Production Management, 32*(9), 1015–1042.

Olsen, R. F., & Ellram, L. M. (1997). Buyer-supplier relationships: Alternative research approaches. *European Journal of Purchasing and Supply Management, 3*(4), 221–231.

Van Weele, A. J., & Van Raaij, E. M. (2014). The future of purchasing and supply management research: About relevance and rigor. *Journal of Supply Chain Management, 50*(1), 56–72.

Wilhelm, H., Schlömer, M., & Maurer, I. (2015). How dynamic capabilities affect the effectiveness and efficiency of operating routines under high and low levels of environmental dynamism. *British Journal of Management, 26*(2), 327–345.

Williams, A. J. (1986). Doctoral research in purchasing and materials management: An assessment. *Journal of Purchasing and Materials Management, 22*(1), 13–16.

Wynstra, F. (2006). Inkoop, Leveranciers en Innovatie: Van VOC tot space shuttle. Inaugural addresses research in management series EIA-2006-027-LIS. Rotterdam: Erasmus Research Institute of Management ("Purchasing, Suppliers and Innovation").

Wynstra, F. (2010). What did we do, who did it and did it matter? A review of fifteen volumes of the (European) journal of purchasing and supply management. *Journal of Purchasing and Supply Management, 16*(4), 279–292.

Wynstra, F., & Knight, L. (2004). Editorial vision: JPSM—Foundations and future development, 2004–2007. *Journal of Purchasing and Supply Management, 10*(6), 227–231.

Gianluca Spina (1964–2015)

Biographical Notes

Gianluca Spina was born on the 6th January 1964, was married to Francesca Bodini and had two children, Pietro and Annachiara. He graduated in Electronic Engineering at Politecnico di Milano, where he soon embarked upon his academic career.

Gianluca Spina was Professor of Business Management and Supply Chain Management at the Department of Management, Economics and Industrial Engineering of Politecnico di Milano and Dean and President of MIP, the Graduate School of Business of Politecnico di Milano.

He will primarily be remembered for his great contribution to the development of Management Engineering and Management education in Italy.

Since 2001, he was involved in the management of the Business School, first as MBA Director, with Emilio Bartezzaghi as President. He then took the helm of MIP, as Director of the School from 2004 and then, from 2011, in the role of President. Latterly, he was behind the strong growth and internationalisation process of the School, being instrumental in it obtaining EQUIS accreditation from the European Foundation for Management Development, AMBA accreditation from the Association of MBAs and in establishing many partnerships with prestigious business schools in Europe, Asia and America. Under his guidance, MIP entered the Financial Times rankings among the top 100 business schools in the world. One of the many recent projects completed with great success was the launch of Flex EMBA, the first Executive MBA programme in Italy in the Smart Learning format.

Gianluca Spina contributed significantly to the strategic orientation and development of the Italian Association of Management Engineering (Associazione Italiana di Ingegneria Gestionale—AiIG), of which he was President for 2011–2013.

E. Bartezzaghi et al. (eds.), *A Journey through Manufacturing and Supply Chain Strategy Research*, DOI 10.1007/978-3-319-31104-3

He was an internationally acclaimed researcher for his innovative contributions in the field of Operations and Supply Chain Management. Gianluca started his research work in the early 1990s, focusing on JIT, Lean Production and New Manufacturing Paradigms. Later, his interests gradually shifted towards customer-supplier collaborations, purchasing management and supply chain management strategies. He collaborated on these topics with many scholars from top universities in Europe and the world and played a central role in the most important international networks and associations of the field.

He belonged to the founding groups of both IMSS (International Manufacturing Strategy Survey) and IPS (International Purchasing Strategy) and was a member of the European Operations Management Association (EurOMA), serving on the Board for a number of years, and organising—together with other Italian colleagues—two very successful EurOMA Annual Conferences, in Venice in 1999 and in Como (jointly with POMS) in 2003.

In terms of authorship, he co-authored about 180 publications, including six books and over 30 articles in international scientific journals. His contributions are widely cited in major international journals and some have been honoured, receiving awards of excellence. Gianluca Spina also helped in forming a lively research group in Operations and Supply Chain Management at Politecnico di Milano and was mentor and guide for many young researchers and PhD students.

Lastly, he was a consultant to many national and multinational corporations, developing for them training programmes for talented management employees. He was also an independent council member of Arcadia SGR, a private equity fund specialised in small cap companies. One of the traits that have distinguished the work of Gianluca Spina most was his attention and appreciation of the relationship between University and Industry, as a key driver for economic development and a key ingredient for the education of future generations of managers.

Main Publications

Papers in International Journals

Bartezzaghi, E., Spina, G., & Turco, F. (1992). The impact of the just-in-time approach on production system performance: A survey of Italian industry. *International Journal of Operations & Production Management, 12*(1), 5–17.

Bartezzaghi, E., Spina, G., & Verganti, R. (1994). Lead-time models of business processes. *International Journal of Operations & Production Management, 14*(5), 5–20.

Bartezzaghi, E., Spina, G., & Verganti, R. (1997). Strategically flexible production and the extra-firm infrastructures: How regions become attractive. *Integrated Manufacturing Systems—The International Journal of Manufacturing Technology Management, Special Issue on Manufacturing Strategy, 8*(5), 333–347.

Brun, A., Caniato, F., Caridi, M., Castelli, C., Miragliotta, G., Ronchi, S., et al. (2008). Logistics and supply chain management in luxury fashion retail: Empirical investigation of Italian firms. *International Journal of Production Economics, 114*(2), 554–570.

Cagliano, R., Caniato, F., Corso, M., & Spina, G. (2005). Collaborative improvement in the extended manufacturing enterprise: Lessons from an action research process. *Production Planning & Control, 16*(4), 345–355.

Cagliano, R., Caniato, F., Golini, R., Kalchschmidt, M., & Spina, G. (2008). Supply chain configurations in a global environment: A longitudinal perspective. *Operations Management Research, 1*, 86–94.

Cagliano, R., Caniato, F., Golini, R., Kalchschmidt, M., & Spina, G. (2009). Evolutionary patterns in e-business strategy. *International Journal of Operations and Production Management, 29*(9), 921–945.

Cagliano, R., Caniato, F., Longoni, A., & Spina, G. (2014). Alternative uses of temporary work and new forms of work organization. *Production Planning and Control, 25*(9), 762–782.

Cagliano, R., Caniato, F., & Spina, G. (2003). E-business strategy: How companies are shaping their supply chain through the Internet. *International Journal of Operations & Production Management, 23*(10), 1142–1162.

Cagliano, R., Caniato, F., & Spina, G. (2004). Lean, Agile and traditional supply: How they impact manufacturing performance? *Journal of Purchasing and Supply Management, 10*(4–5), 151–164.

Cagliano, R., Caniato, F., & Spina, G. (2005). Reconsidering e-business strategy and the impact on supply chains. *International Journal of Operations & Production Management, 25*(12), 1328–1332.

E. Bartezzaghi et al. (eds.), *A Journey through Manufacturing and Supply Chain Strategy Research*, DOI 10.1007/978-3-319-31104-3

Cagliano, R., Caniato, F., & Spina, G. (2006). The linkage between supply chain integration and manufacturing improvement programmes. *International Journal of Operations & Production Management, 26*(3), 282–289.

Cagliano, R., & Spina, G. (2000a). How improvement programmes of manufacturing are selected: The role of strategic priorities and past experience. *International Journal of Operations & Production Management, 20*(7), 772–791.

Cagliano, R., & Spina, G. (2000b). Advanced manufacturing technologies and strategically flexible production. *Journal of Operations Management, 18*(2), 169–190.

Cagliano, R., & Spina, G. (2002). A comparison of practice-performance models between small manufacturers and subcontractors. *International Journal of Operations & Production Management, 22*(12), 1367–1388.

Cagliano, R., Spina, G., Verganti, R., & Zotteri, G. (1998). Designing BPR Support Services for Small Firms. *International Journal of Operations & Production Management, 18*(9), 865–885.

Caniato, F., Caridi, M., Moretto, A., Sianesi, A., & Spina, G. (2014). Integrating international fashion retail into new product development. *International Journal of Production Economics, 147*(part B), 294–306.

Caniato, F., Crippa, L., Pero, M., Sianesi, A., & Spina, G. (2015). Internationalisation and outsourcing of operations and product development in the fashion industry. *Production Planning and Control, 26*(9), 706–722.

Loppacher, J. S., Cagliano, R., & Spina, G. (2010). Key factors in a global supply headquarters-subsidiary control systems. *Journal of Manufacturing Technology Management, 21*(7), 794–817.

Loppacher, J. S., Cagliano, R., & Spina, G. (2011a). Key dimensions of global supply strategy: A model of interrelated decisions. *International Journal of Procurement Management, 4*(5), 455–482.

Loppacher, J. S., Cagliano, R., & Spina, G. (2011b). Key drivers of buyer-supplier relationships in global sourcing strategies. *International Journal of Procurement Management, 4*(2), 156–180.

Loppacher, J. S., Luchi, R., Cagliano, R., & Spina, G. (2006). Global sourcing and procurement strategy: A model of interrelated decisions. *Supply Chain Forum: An International Journal, 7*(1), 34–46.

Luzzini, D., Brandon-Jones, E., Brandon-Jones, A., & Spina, G. (2015). From sustainability commitment to performance: The role of intra- and inter-firm collaborative capabilities in the upstream supply chain. *International Journal of Production Economics, 165*, 51–63.

Luzzini, D., Caniato, F., Ronchi, S., & Spina, G. (2012). A transaction cost approach to purchasing portfolio management. *International Journal of Operations and Production Management, 32*(9), 1015–1042.

Luzzini, D., Caniato, F., & Spina, G. (2014). Designing vendor evaluation systems: An empirical analysis. *Journal of Purchasing and Supply Management, 20*(2), 113–129.

Luzzini, D., Ronchi, S., & Spina, G. (2008). Supply chain coordination: The problem of risk and benefit sharing. *Supply Chain Forum, 8*(2), 54–65.

Spina, G. (1998). Manufacturing paradigms versus strategic approaches: A misleading contrast. *International Journal of Operations & Production Management, 18*(8), 684–709.

Spina, G., Bartezzaghi, E., Cagliano, R., Bert, A., Draaijer, D., & Boer, H. (1996). Strategically flexible production: The multi-focused manufacturing paradigm. *International Journal of Operations & Production Management., 16*(11), 20–41.

Spina, G., Campanella, N., & Codeluppi, G. (2000). Make vs buy vs partnership in distributing commodities: A case study and a methodology. *Integrated Manufacturing Systems, 11*(2), 112–120.

Spina, G., Caniato, F., Luzzini, D., & Ronchi, S. (2013). Past, present and future trends of purchasing and supply management: An extensive literature review. *Industrial Marketing Management, 42*(8), 1202–1212.

Spina, G., Caniato, F., Luzzini, D., & Ronchi, S. (2015). Assessing the use of external grand theories in purchasing and supply management research. *Journal of Purchasing and Supply Management, 22*(1), 18–30.

Spina, G., Verganti, R., & Zotteri, G. (2002). A model of codesign relationships: Definitions and contingencies. *International Journal of Technology Management, 23*(4), 304–321.
Spina, G., Verganti, R., & Zotteri, G. (2002). Factors influencing co-design adoption: Drivers and internal consistency. *International Journal of Operations & Production Management, 22*(12), 1354–1366.
Spina, G., & Zotteri, G. (2000). The implementation process of customer-supplier partnership: Lessons from a clinical perspective. *International Journal of Operations & Production Management, 20*(10), 1164–1182.
Spina, G., & Zotteri, G. (2001). The strategic context of customer-supplier partnerships: Evidence from a global survey. *Integrated Manufacturing Systems, 12*(7), 483–492.

International Book Edition and Chapters

Bartezzaghi, E., Filippini, R., Spina, G., & Vinelli, A. (Eds.). (1999). *Managing operations networks*. Padova: SGE.
Bartezzaghi, E., & Spina, G. (1998). Italian assembly industry facing globalisation and innovation. In C. A. Voss, K. Blackmoon, & P. Lindberg (Eds.), *International manufacturing strategies: Context content and change—A worldwide study of competitive priorities and decision areas*. Berlin: Kluwer.
Perona, M., Spina, G., & Turco, F. (1991). Success measure of just-in-time: Shifting manufacturing trade-offs. A field research in Italy. In Satir A. (Ed.), *Just-in-time manufacturing systems* (pp. 333–349), Amsterdam: Elsevier.
Bartezzaghi, E., Spina, G., & Verganti, R. (1993). Modelling the lead-time of operations processes. In R. Johnston & N. D. C. Slack (Eds.), *Service operations—The design and delivery of effective service operations* (pp. 117–124). UK: Operations Management Association.
Spina, G., Bartezzaghi, E., Cagliano, R., Bert, A., Draaijer, D., & Boer, H. (1998). The multifocused manufacturing paradigm: Adoption and performance improvements within the assembly industry. In C. A. Voss, K. Blackmoon, & P. Lindberg (Eds.), *International manufacturing strategies: Context content and change—A worldwide study of competitive priorities and decision areas*. Berlin: Kluwer.
Spina, G., & Verganti, R. (1992). Process specialization versus integration: Why the trade-off is shifting. In R. H. Hollier, R. J. Boaden, & S. J. New (Eds.), *International operations: Crossing borders in manufacturing and service* (pp. 311–316). Amsterdam: Elsevier.
Spina, G., & Verganti, R. (1993). Designing and implementing CIM to support the lean production paradigm. In C. Kooji, P. A. Mac Connaill, & J. Bastos (Eds.), *Realising CIM's industrial potential* (Vol. 2, pp. 268–278), Amsterdam: IOS Press.

Books in Italian Language

Bartezzaghi, E., Mariotti, S., & Spina, G. (1997). *La diffusione del paradigma dell'impresa flessibile—Politiche e strumenti l'innovazione e la competitività dell'industria italiana*, Quaderno MIP, n. 5.
Bartezzaghi, E., Spina, G., & Verganti, R. (1994). *Nuovi modelli d'impresa e tecnologie d'integrazione*. Milano: Franco Angeli.
Bartezzaghi, E., Spina, G., & Verganti, R. (1999). *Organizzare le Piccole e Medie Imprese per la crescita—Come sviluppare i più avanzati modelli organizzativi per competere: Gestione dei processi, lavoro per progetti, sviluppo delle competenze.* Milano: IlSole24Ore.

Cagliano, R., & Spina, G. (2001). *Pratiche gestionali e successo competitivo nella piccola impresa e nell'artigianato*. Franco Angeli: Una ricerca nelle imprese manifatturiere e nei distretti dell'Emilia Romagna.

Spina, G. (2013). *La gestione dell'impresa: Organizzazione, processi decisionali, marketing, acquisti e supply chain. Terza edizione*. Milano: ETAS.

Spina, G., Crippa, L., & Golini, R. (2009). *Casi di gestione aziendale: Applicazioni pratiche, temi svolti*. Milano: ETAS.