Pontifícia Universidade Católica
do Rio de Janeiro

Antônio Márcio Tavares Thomé

Sales and Operations Planning Impact on Manufacturing Operational Performance

Tese de Doutorado

Thesis presented to the Programa de Pós-Graduação em Engenharia de Produção of the Departamento de Engenharia Industrial, PUC-Rio as partial fulfillment of the requirements for the degree of Doutor em Engenharia de Produção

Advisor: Prof. Luiz Felipe Roris Rodriguez Scavarda do Carmo

Co-Advisor: Prof. Rui Soucasaux Sousa

Rio de Janeiro

August 2013

PONTIFÍCIA UNIVERSIDADE CATÓLICA
DO RIO DE JANEIRO

Antônio Márcio Tavares Thomé

Sales and Operations Planning Impact on Manufacturing Operational Performance

Thesis presented to the Programa de Pós-Graduação em Engenharia de Produção of the Departamento de Engenharia Industrial do Centro Técnico Científico da PUC-Rio, as partial fulfillment of the requirements for the degree of Doutor.

Prof. Luiz Felipe R.R. Scavarda do Carmo
Advisor
Departamento de Engenharia Industrial - PUC-Rio

Prof. Rui Soucasaux Sousa
Co-Advisor
Universidade Católica Porto - Portugal

Prof. Katja Klingebiel
Fraunhofer institut Für Materialfluss und Logistik

Prof. Paulo Augusto Cauchick Miguel
Departamento de Engenharia de Produção e Sistemas - UFSC

Prof. Silvio Hamacher
Departamento de Engenharia Industrial - PUC-Rio

Prof. Eugenio Kahn Epprecht
Departamento de Engenharia Industrial - PUC-Rio

Prof. José Eugenio Leal
Coordinator of the Centro Técnico Científico da PUC-Rio

Rio de Janeiro, August 28th, 2013

Antônio Márcio Tavares Thomé

Antônio Márcio Tavares Thomé graduated in Political Sciences at the Institut d'Études Politiques de Bordeaux and holds an M.Sc. degree in Demography from Paris University I and an MSc degree in Logistics from the Pontifical Catholic University of Rio. He has published in peer reviewed Journals as "Population Studies", "Studies in Family Planning", "International Journal of Production Economics" and "International Journal of Productivity and Production Management". He held executive managerial positions in BEMFAM, Westinghouse Electric Corporation, The Population Council and Cambridge Consulting Corporation. In performing his duties he lived and traveled abroad extensively in Latin and Central America, Africa and South-East Asia. Actually, he is the Executive Director of CONAPES - Associate Consultants and Research and the Director of the Evaluation and Statistics Department at Bemfam - Family Wellfare Association in Brazil.

Bibliographic data

Thomé, Antônio Márcio Tavares

Sales and operations planning impact on manufacturing operational performance / Antônio Márcio Tavares Thomé; advisor: Luiz Felipe Roris Rodriguez Scavarda do Carmo; co-advisor: Rui Soucasaux Sousa. – 2013.

142f. il.; 30 cm

Tese (Doutorado em Engenharia de Produção) – Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Engenharia Industrial, 2013.

Inclui bibliografia

1. Engenharia Industrial – Teses. 2. S&OP. 3. Desempenho operacional da manufatura. 4. Revisão da literatura. 5. Integração interfuncional. 6. Cadeia de suprimentos. 7. Teoria da contingência. 8. Modelos de equações estruturais. 9. Regressão múltipla passo a passo. I. Carmo, Luiz Felipe Roris Rodriguez Scavarda do. II. Sousa, Rui Soucasaux. III. Pontifícia Universidade Católica do Rio de Janeiro. Departamento de Engenharia Industrial. IV. Título.

CDD: 658.5

Acknowledgements

To my wife, sons and daughters for understanding and graciously coping with the long hours kept away from their company and for not being as available as I would have wished. Their support and sharing of my hopes and anxieties were invaluable.

I would also like to thanks my advisor, Prof. Dr. Luiz Felipe Roris Scavarda do Carmo, and co advisor Prof. Dr. Rui Soucasaux Sousa, for their support, patience and numerous advices. All remaining errors despite their dedication are evidently of my own.

To Jorge and Sylvia, beloved parents (in memoriam)

Abstract

Thomé, Antônio Márcio Tavares; Carmo, Luiz Felipe Roris Rodrigues Scavarda do (Advisor), Sousa, Rui Soucasaux (Co-Advisor). **Sales and Operations Planning Impact on Manufacturing Operational Performance.** Rio de Janeiro, 2013. 142p. D.Sc. Thesis – Departamento de Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro.

Sales and Operations Planning (S&OP) is a new and growing research field in Operations Management. The thesis intends to: (i) provide a comprehensive research synthesis of the extant literature on S&OP; and (ii) explore S&OP impact on manufacturing operational performance dimensions of quality, delivery and flexibility, informed by structural contingency theory. A synthesis framework was proposed. Due to disparate concepts and measurements, the field is not yet ripe for meta analysis. There is also a paucity of rigorous empirical research in the impact of S&OP on manufacturing operational performance, anchored in Operations Management theories. Data from 725 metal products and machinery manufacturers (ISIC 3.1, code 28-35) in 34 countries from the fifth round of the International Manufacturing Strategy Survey was used for hypotheses tests. Scales were validated with confirmatory factor analysis and analyzed with stepwise multiple regression. S&OP effect size on quality, delivery and flexibility was on the 0.26 - 0.36 range, after controlling for economic development, market dynamics and firm size. Supply Chain integration with suppliers and manufacturing process technology moderate S&OP impact on all three performance dimensions. Product technology moderates quality but not delivery or flexibility. Misfit of process technology, cross functional team work and product technology adversely affect performance. Practitioners should simultaneously pursue S&OP implementations, integration with suppliers and use of adequate technology to boost performance. Further research should focus on theory validation, case studies and survey research on S&OP.

Keywords

S&OP; manufacturing operational performance; literature review; cross functional integration; supply chain; contingency theory; structural equation modeling; step-wise multiple regression.

Resumo

Thomé, Antônio Márcio Tavares; Carmo, Luiz Felipe Roris Rodrigues Scavarda do (Orientador); Sousa, Rui Soucasaux (Co-Orientador). **Impacto do Planejamento de Vendas e Operações no Desempenho Operacional da Manufatura**; Rio de Janeiro, 2013. 142p. Tese de Doutorado – Departamento de Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro.

Esta tese aborda o tema de Planejamento de Vendas e Operações, designado pelo acrônimo inglês de S&OP (“Sales and Operations Planning”). Trata-se de um campo recente em Gerência de Operações. S&OP é definido como um processo interfuncional e integrado de planejamento tático e como um conjunto coeso de práticas gerenciais que unificam diferentes planos de negócios (vendas, marketing, desenvolvimento de novos produtos, manufatura, compras e finanças) em um conjunto de planos integrados internamente e na cadeia de suprimentos, com a finalidade de criar valor e impacto no desempenho das empresas. Objetiva equilibrar oferta e demanda em nível de produtos e famílias de produtos, com um horizonte de planejamento que coincide com o ciclo de planejamento estratégico dos negócios. A eficiência do processo é medida e avaliada para melhoria continua. Compreende um conjunto coeso de práticas gerenciais, direcionado a incentivar o alinhamento horizontal (entre funções) e vertical (do plano de negócios a operações), na empresa e na cadeia de suprimentos. O objetivo da tese é duplo: proceder a uma revisão sistemática e abrangente da literatura em S&OP; avaliar o impacto dos processos e das práticas de S&OP no desempenho operacional da manufatura. A revisão bibliográfica sobre S&OP foi feita a partir das bases de dados eletrônicas EBSCO, Emerald e SCIENDIRECT. Ao todo 271 resumos e 55 textos completos foram revistos e classificados em um quadro conceitual de referência, que relaciona variáveis contextuais, de entrada (inputs), objetivos, estruturas e processos, resultados intermediários e resultados finais do S&OP. Foi constatada a ausência de sínteses anteriores da literatura sobre o tema e uma grande disparidade de conceitos e modelos de maturidade do S&OP, que impossibilitaram a análise estatística dos resultados publicados (meta-análise). Uma síntese sistematizada da literatura foi apresentada. Notou-se igualmente que existem poucos artigos científicos rigorosos que demonstrem o impacto das práticas de S&OP no desempenho das empresas. Ainda mais raros são os estudos empíricos baseados em teorias de gerência de operações. A verificação empírica do impacto das práticas de S&OP interno e de integração na cadeia de suprimentos com fornecedores e com clientes foi realizada com modelos de equações estruturais e de regressão múltipla passo a passo. A base de dados da Pesquisa Internacional de Estratégia da Manufatura (IMSS-V), reagrupando 725 empresas de 34 países foi utilizada na análise. A formulação dos modelos baseou-se na teoria de contingência estrutural. O efeito do S&OP (medido pelo coeficiente de regressão) no desempenho operacional da manufatura foi positivo e consistente para as dimensões da qualidade, flexibilidade e entregas, situando-se no intervalo entre 0,26 e 0,36. Contatou-se igualmente que a integração com fornecedores e as tecnologias de processo na manufatura são moderadoras do impacto no desempenho em todas as dimensões de desempenho e que a tecnologia de produtos modera o desempenho em termos de qualidade. Conclui-se que há uma necessidade de aprofundar a agenda de pesquisas com estudos empíricos baseados em teorias de gerência de operações na manufatura em diferentes contextos e indústrias, de estender e aprofundar a análise do S&OP na cadeia de suprimento, assim como de conduzir estudos de casos. A principal implicação prática do estudo resulta dos fatores contingenciais do impacto do S&OP no desempenho. A indústria ganharia a conduzir processos e práticas de S&OP de forma concomitante com a integração com fornecedores na cadeia de suprimento e a adoção de tecnologias de processo e de produtos que sejam adequadas ao ambiente no qual atua.

Palavras-chave

S&OP; desempenho operacional da manufatura; revisão da literatura; integração interfuncional; cadeia de suprimentos; teoria da contingência; modelos de equações estruturais; regressão múltipla passo a passo.

Summary

List of Tables

List of Figures

1
Introduction

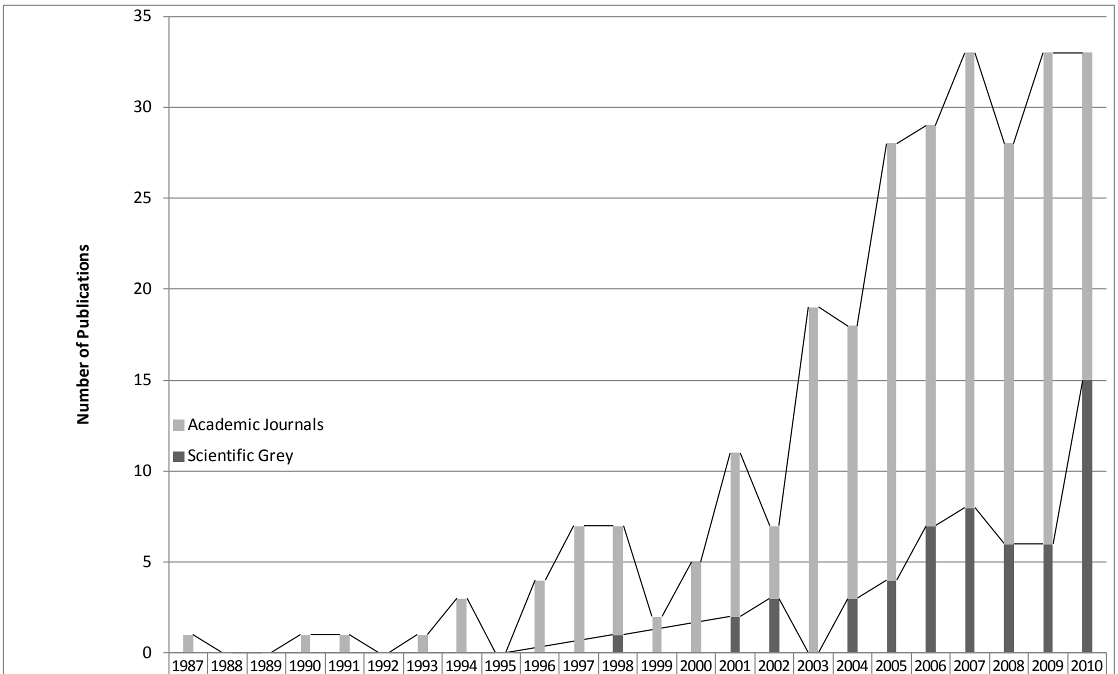
Sales and Operations Planning (S&OP) appears as a new focus in the area of operations planning and control in manufacturing firms. As such, it was absent from most text books and historical reviews of the evolution of industrial engineering and operations management (OM) until recently. Companies are facing fierce competition and are competing simultaneously in quality, cost-efficiency, flexibility and consistent delivery of more complex products, with shorter life-cycles and fluctuating demand. Consequently, requests for planning and control systems in manufacturing firms are increasingly more complex. Historically, it evolved from shop floor control and reorder point systems to material requirements planning (MRP) systems, manufacturing resource planning (MRP II) systems, enterprise resource planning (ERP) systems, S&OP and supply chain management (SCM) systems (Olhager, 2013).

S&OP is situated at the level of long-term planning of production, within the framework of manufacturing planning and control systems (MPC). From this stance, aggregate production planning (APP) is part of the S&OP process, which is viewed as being "the long term planning of production and sales relative the forecasted demand and the supply of capacity of sales". Still, from a manufacturing strategy standpoint, S&OP is part of the infrastructure decision-making process, playing a pivotal role between strategy and operations (Olhager et al., 2001).

Interest in the subject is growing, as evidenced by the number of papers recently published on different aspects of S&OP, as depicted in Figure 1.1.

There is an upward trend in the number of publications in this area, with few publications during the nineties and a growing number of papers in the first decade of this century, accelerating after 2003. The large number of publications appearing in non peer-reviewed academic Journals (scientific grey literature) is consistent with the fact that some authors trace the regain of interest in S&OP to practitioners working at firms such as Procter & Gamble or Gessy Lever or as an offspring of the early MRP-II implementation projects (Basu, 2001; Wallace &

Stahl, 2006; Dougherty & Gray, 2006). Figure 1.1 also shows that practitioners (who mainly access non academic - peer reviewed / grey literature) and academics alike, are increasingly interested in the subject.



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Academic Journals	1	0	0	1	1	0	1	3	0	4	7	6	2	5	9	4	19	15	24	22	25	22	27	18
Scientific Grey		0	0			0			0			1			2	3	0	3	4	7	8	6	6	15

Figure 1.1: Number of publications on S&OP by type and year *

* Studies retrieved from Elsevier, Emerald and EBSCO electronic databases (see Section 3.1)

The pioneering work of Holt, Modigliani, Muth and Simon (HMMS) on APP in the early fifties of the last century is at the origin of the new paradigm of what later became known as S&OP. They described their seminal work in APP as a “study of decision making under uncertainty” in the context of inadequate forecasts, fluctuating demand for multiple products, and imbalances between aggregate and product-level production plans. It resulted in substantive gains for the companies involved, but mainly it was a shift in APP paradigms, introducing the need to incorporate cross-functional teams, demand-supply balance and explicit bridging of business plans to operations into the planning process. Charles Holt, an electrical engineer and economist lead the team. He is mostly known by the Holt-Winter model of exponential forecasting. Herbert Simon later won the Nobel Prize in economics for his research on the “decision-making process within economic organizations”, in 1978. Franco Modigliani was a Nobel Prize laureate in economics in 1985. Jonh F. Muth was an industrial engineer and he is at the origin of the economic theory of “rational expectations”, which led to the Nobel Prize in economics to Robert Lucas in 1995 (Singhal & Singhal, 2007).

Despite its solidly grounded origin and growing body of literature on S&OP, efforts to synthesize the state of the art of research in this area are limited. Furthermore, the regain of interest in the subject from practitioners was not followed by rigorous, large scale, theoretically-grounded empirical work relating S&OP practices to manufacturing operational performance (Thomé et al., 2012a; 2012b).

This Thesis intends to contribute to fill this gap. The goal of the Thesis is two-fold:

(i) to integrate the findings of existing studies about S&OP;

(ii) to identify and measure the S&OP impact on manufacturing operational performance.

The systematic review of the extant literature on S&OP was meant as an effort to unite the highly dispersed literature on the subject (see Chapter 3), as well as to integrate the findings of existing studies aiming at identifying and measuring the effects of S&OP on firm performance.

The empirical study aims at measuring the impact of S&OP practices on manufacturing operational performance. It is grounded on what Sousa & Voss (2008) termed operations management practice contingency research (OM-PCR), or the application of a contingency approach to the study of OM best practices. It is based on a dataset of 725 companies from 34 countries, gathered in 2009-2010 as part of the fifth round of the International Manufacturing Strategy Survey (IMSS-V). The study investigates the direct relationships between the use of S&OP practices within the firm and in the Supply Chain (SC) and the different dimensions of manufacturing (operational) performance of quality, flexibility and delivery. The moderating effect of supply chain integration (SCI) and the fit of product and process technology are also put to empirical test, with the backdrop of contingency theory research.

Several important contributions are made by the Thesis. First, it seems to be the first study to measure S&OP as a bundle of practices and as a multi dimensional, second-order construct with a large international database. Second, it examines the individual impact of different types of S&OP practices (internal S&OP, integration with suppliers and customers measured separately) on manufacturing operational performance. Third, the impact of S&OP practices on different dimensions of operational performance is empirically tested, rather than using a unique dimension of manufacturing performance or a general measure of business performance. Fourth, it is the first attempt to explicitly apply OM-PCR to S&OP. Fifth, different forms of fit are measured and related to different dimensions of operational performance. It allows for data triangulation and rigorous control of the contingency effects of task complexity and technology on S&OP impact on performance. Sixth, it contributes to mid-range theories (as defined further in Chapter 2) for the generalization of the concept of S&OP and of its impact on manufacturing performance under different contexts.

For practitioners the study intends to shed light on the S&OP practices that contribute the most to manufacturing performance. As a whole, S&OP practices impacts directly upon manufacturing operational performance. Practitioners will also benefit from insights related to the intermediate role of specific S&OP practices in mediating the effects of internal management practices on manufacturing operational performance. There is at least partial evidence that cross-functional planning processes can mitigate the negative effect of misaligned organizational structures and contradictory incentives schemes on firm performance. Formal and informal communications between functions, networking and internal integrating roles can boost performance. Furthermore, internal alignment seems to facilitate supply chain integration (SCI) with both suppliers and customers, particularly when inter-organizational information systems favor SCI. Inversely, it appears that SCI with suppliers is a powerful lever that amplifies S&OP impact on performance.

The structure of the Thesis is as follows. After this introduction, the theoretical foundations of the empirical research and basic concepts are defined in Chapter two. The synthesis framework, methodology and results of the systematic literature review on S&OP and its impact on performance are laid and discussed in Chapter three. The empirical investigation of S&OP impact on manufacturing operational performance is described in Chapter four, where the methodology, theoretical models and results are presented and discussed. Empirical validation of theories about the impact of S&OP on manufacturing operational performance and the moderator role and fit of technology are analyzed; research findings and implications for practitioners are further discussed in this chapter. Finally, conclusions are summarized in Chapter five.

2
Theoretical foundations: definitions and basic concepts

This chapter covers the definitions and basic concepts of S&OP and of OM-PCR. First, the definitions of S&OP as a process and as a bundle of management practices are reviewed. A definitional synthesis that relates S&OP to both a managerial planning process and to a set of management practices deemed necessary for the planning process to succeed is proposed. Second, the key concepts of OM-PCR are introduced. The basic concepts are introduced in order to situate the research as a contribution to mid-range theories of OM. The term "middle-range" or mid-range theory is a classic distinction in social sciences research (Merton, 1957) and is an approach to theory building based on two postulates: (i) it is possible and desirable to consolidate otherwise disperse hypotheses and partial empirical evidences of a phenomenon, therefore building cumulative knowledge; and (ii) it is not possible to summarize all the knowledge about a given phenomenon in an overarching and all-inclusive theory."

2.1
Definitions of S&OP

S&OP can be conceptualized as being a planning process and a cohesive set of management practices of coordination and integration within the firm and in the SC.

2.1.1
S&OP as a process

S&OP as a process is defined differently by different authors in different contexts. The main definitions and characteristics emanated from the systematic literature review are summarized in Appendix 1.

S&OP is a tool that unites different business plans into one integrated set of plans. Its main purpose is twofold: (1) to balance supply and demand and (2) to build bridges between the business or strategic plan and the operational plans of the firm. S&OP addresses the key issue of alignment— a central theme in the field of strategic management— from the perspective of both vertical and horizontal alignment. Vertical alignment “refers to the configuration of strategies, objectives, actions plans, and decisions throughout the various levels of the organization”, while horizontal alignment “can be defined in terms of cross-functional and intra-functional integration” (Kathuria et al., 2007: pp. 505).

Cox & Blackstone (2002) provide a comprehensive definition of S&OP, as

> “… a process that integrates customer-focused marketing plans for new and existing products with the operational management of supply chains. The process brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, and financial) into one integrated set of plans. The process must reconcile all supply, demand and new-product plans at both the detailed and aggregate level, and tie to the business plan. It is the definitive statement of the company’s plans covering a horizon sufficient to plan for resources and to support annual business planning process. Executed properly, SOP links the strategic plans for business with its execution and reviews performance measures for continuous improvement”.

According to this definition, the main features of S&OP are as follows: (i) it is a cross-functional and integrated tactical planning process, situated between strategic business plans and operations; (ii) it integrates customer-focused marketing plans with OM in the supply chain; (iii) it unites all of the plans of the business; (iv) it has a planning horizon that matches annual strategic business planning; and (v) it creates value and the S&OP process should be measured for continuous improvement.

S&OP can be viewed as a supply chain management (SCM) practice (Kahn & Mentzer, 1996; Gimenez & Ventura, 2003; Saeed et al., 2005; van Hoek et al., 2008; Nakano, 2009; Jüttner et al., 2010). The Global Supply Chain Forum defines SCM as the integration of key business processes from the end user to the original supplier, who provides products, services, and information, that add value for customers and other stakeholders (Lambert & Cooper, 2000). SCM is also defined as the coordination of material, informational, and financial flows within a firm and across legally separated entities (Christopher, 1998). Cross-functional alignment and integration within a firm and in the supply chain are essential ingredients for businesses' survival and expansion in a global economy that is characterized by fierce competition, short product life cycles, and technological complexity (Bowersox et al., 1999; Lambert, 2006; McKinsey, 2008).

2.1.1.1
Learning to evolve

Conceptually, S&OP evolved from aggregate production planning (APP) in the early 1950s (Singhal & Singhal, 2007) to manufacturing resources planning (MRP II) in the mid-1980s. Most case studies and reports on MRP II trace the origins of S&OP back to practitioners' work (Wallace & Stahl, 2006; Dougherty & Gray, 2006). S&OP evolved into a business process that aligns production and sales within the firm and in the supply chain (Lapide, 2004a; Lapide, 2005; Grimson & Pyke, 2007; Feng *et al*., 2008; Ivert & Jonsson, 2010).

The pioneering work in APP by Holt, Modigliani, Muth, and Simon (HMMS) in the early 1950s provided a foundation for shifts in OM paradigms and initiated what became known as S&OP (Singhal & Singhal, 2007). Their work resulted in substantial economic gains for participating companies. However, the most important result was that seemingly unrelated managerial functions emerged as part of a new, integrated production planning environment aimed at aligning the supply and demand sides of a business (Holt, 2002).

The early definitions of S&OP referred to the process as being part of aggregated production planning (APP - Singhal & Singhal, 2007). Lee & Ng (1997) seem to be among the first authors to point to the emerging trends in Supply Chain Management (SCM) of coordination of information flows among companies and the required internal integration of different "disciplines and functions, such as manufacturing, distribution, marketing, accounting, information, and engineering". Gianesi (1998) emphasizes that APP works with families of products, allowing top management to have a broader view of manufacturing operations. Horizontally, it is a communication channel to bridge manufacturing and other functional areas of the firm. It integrates vertically the business planning with production planning and MRP-II. Olhager et al. (2001)

situate S&OP at the level of long-term planning of production, within the framework of manufacturing planning and control systems (MPC). From a manufacturing strategy perspective, S&OP is viewed as belonging to a manufacturing infrastructure decision category. For the authors, APP is part of the S&OP process, which is defined as being the long term planning of production and sales relative the forecasted demand and the supply of capacity of sales. In this sense, S&OP is part strategic and part tactical. This view consubstantiate early APP models like the HMMS framework:

> "The issues of aggregate production planning and disaggregation that Holt et al. addressed represent the primary links between strategic and tactical decisions in a firm. Aggregate production planning links operations with strategy. It plays a key role in enterprise resource planning and organizational integration by linking operations with accounting, distribution, finance, human resource management, and marketing. It also drives interorganizational coordination by linking operations with both upstream and downstream supply chains" (Singhal & Singhal, 2007; page 304).

In the systematic literature review described in Chapter 3, only Godsell et al. (2010) define S&OP as belonging to operational and line management processes.

Paralleling progresses in production planning and operations management, frameworks for conflict-solving and integration in the supply chain emanated from organizational theories. They also contributed to disseminate S&OP as a multi-functional and integrated process. Most case studies and reports in this area trace the origins of S&OP to practitioners working at firms such as Procter & Gamble or Gessy Lever or as an established company-wide business planning process in the Oliver Wright consultancy firm's MRP-II methodology (Basu, 2001; Wallace & Stahl, 2006; Dougherty & Gray, 2006). Theoretical approaches to operations, information systems, marketing, and supply chain disciplines emphasize the need for close, cross-functional coordination within a firm to enable better network integration among firms in the supply chain (Kahn & Mentzer, 1996; Gimenez & Ventura, 2003; Saeed et al., 2005; van Hoek et al., 2008; Nakano, 2009; Jüttner et al., 2010). An early distinction introduced by Kahn & Mentzer (1996) suggests that integration requires interaction and collaboration that operates beyond the coordination of plans. The coordination of workflows requires adapting inter-organizational plans across organizational units in the supply chain (Stadler, 2009). Integration requires collaborative assessments, planning, and decision making (Oliva & Watson, 2011). Viewed as a business process, S&OP is at the center of the strategic alignment of the firm.

The issue of aligning functions within the firm is not new in the OM literature. More than 45 years ago, Lawrence & Lorsch (1967a, 1967b) launched key concepts to define inter-functional integrations and their effects. Ten years later, Shapiro (1977) asked the question, “Can marketing and manufacturing co-exist?” Later, Malhotra & Sharma (2002) posed a new question: “can marketing and manufacturing afford not to co-exist?” Conflicts between these functions arise naturally because the goal of marketing is to increase product diversity, while the aim of manufacturing is to reduce this diversity through longer and more stable production runs of a narrower product line (Shapiro, 1977). The relevance of cross-alignment may be reflected by several special issues pertaining to the topic. One of these was a special issue published by the Journal of Operations Management (JOM) in 1991, titled “Linking strategy formulation in marketing and operations: empirical research.” The International Journal of Production Economics (IJPE) published a special issue on marketing-sales coordination in 1994 (Whybark & Wijngaard, 1994). Later, JOM published another issue in 2002, titled “Managing the interface between marketing and operations” (Malhotra & Sharma, 2002). Despite its focus on marketing and operations, this integration is analyzed more broadly and includes the need for alignment between the many different functions of an organization.

In addition to OM and organizational perspectives, practitioners and academics concerned with marketing plans and accurate demand forecast have defined S&OP mainly through the lenses of Marketing and Sales. It is approached from the perspective of demand management and is at the cornerstone of *establishing a single set of numbers with common business objectives* (Basu, 2001); or still establishing the *best practice of single number forecasting* (Lapide, 2002). S&OP process includes formal mechanisms with regular meetings, empowerment of S&OP teams, participation of top management in the process (Lapide, 2002, 2006; Dougherty & Gray, 2006; Harwell, 2006; Grimson & Pyke, 2007; Boyer, 2009; Maloni & Franza, 2009). The managerial process of an orchestrated cross-functional planning matching supply and demand is emphasized (Lapide, 2002, 2006, 2007; Croxton et al., 2001; Malhotra & Sharma, 2002; Bower, 2005; Whisenant, 2006; Grimson & Pyke, 2007; Maloni & Franza, 2009; Cacere et al., 2009; Feng et al., 2008). In this perspective, the S&OP process is underpinned by progressive business planning meetings covering demand planning supply review and pre executive S&OP meetings (Basu, 2001). It comprises a series of steps. The number of steps and its contents varies from author to author. Wallace & Stahl (2006) describe a basic five steps planning process: (i) sales elaborate forecasts; (ii) operations review information on inventory and productive capacity; (iii) sales and operations forecasts and plans are reconciled; (iv) plans are distributed and implemented; and (v) the S&OP executive meeting measure results and efficiency, redirect the process and eventually take decisions reaching beyond functional boundaries. Meetings are convened at least monthly and can involve participants from several departments inside the firm, as well as customers and suppliers. A sixth step might be added for Global S&OP and will consist of the consolidation of local plans (Wallace & Stahl, 2006). The Global S&OP is an extension of the Local one for a multi-national global enterprise (Basu, 2001).

Other authors will emphasize specific aspects of S&OP such as communication and information flows (Mentzer & Moon, 2004; Dougherty & Gray, 2006; Slone et al., 2007); and technology and APS (Muzundar & Fontanella, 2006; Slone et al., 2007; Affonso et al., 2008; Chen-Ritzo et al., 2010a). Others still extend the frontiers of S&OP – primarily a manufacturing process – beyond the factory walls and into the SC (Basu, 2001; Cox & Blackstone, 2002; Bower, 2005; Muzumdar & Fontanella, 2006; Singhal & Singhal, 2007; Slone et al., 2007; Affonso et al., 2008; Nakano, 2009); and to such a diversified array of fields as a retail environment (Harwell, 2006), blood banks (Keal & Hebert, 2010), city water management (Maloni & Franza, 2009), tobacco companies (Godsell et al., 2010).

2.1.1.2 S&OP and maturity models

Attempts to systematize studies that define S&OP as a business process encompass the adoption of maturity models inspired by the Capability Maturity Model (CMM), which was proposed by the Software Engineering Institute at Carnegie Mellon University (Paulk et al., 1993).

S&OP maturity models were summarized by Grimson & Pyke (2007) and were further extended by Viswanathan (2009) and Cacere et al. (2009). From the least to the most advanced stage, maturity models consist of multiple evolutionary and successive stages in the advancement of business processes (Lapide, 2005). S&OP maturity models vary in the number of stages that they contain as well as in their description of inputs, process components, and outputs. Table 2.1 provides an overview of the different S&OP maturity models offering their respective number of steps with a brief description of each one.

Table 2.1: Brief description of S&OP maturity models

Reference	Number of stages	Brief description of the stages
Wing & Perry (2001)	Three	The stages are: (i) integrated planning solution; (ii) collaboration with trade partners and; (iii) network hub solutions. These stages are essentially based on information technology (IT).
Lapide (2005)	Four	The stages are: (i) marginal; (ii) rudimentary; (iii) classic and; (iv) ideal. Enterprises starts with sporadic meetings decoupled planning not aligned with demand and a “multitude” of spreadsheets. It gradually moves to an ideal stage characterized by event-driven meetings; integrated planning aligned with customers and suppliers; use of advanced S&OP software that are integrated with internal IT systems.
Ventana Research (2006)	Four	The stages are: (i) tactical; (ii) advanced; (iii) strategic and; (iv) innovative. In the first stage, planning focuses on balancing supply and demand. At the advanced stage, formal planning and review meetings are instituted. S&OP advances to the strategic stage when the company uses S&OP to align operational planning with corporate strategic objectives. It finally reaches full maturity at the innovative stage, when performance management and incentives are aligned with the S&OP process.
Grimson & Pyke (2007)	Five	The five stages are: (i) no S&OP process; (ii) reactive; (iii) standard; (iv) advanced; and (v) proactive. These stages range from a non-existent, silo culture to a paradigmatic proactive stage, in which meetings are event-driven; plans and software are fully integrated within the firm and with customers and suppliers. At this stage, the process aims to optimize profitability and performance is measured and rewarded accordingly. Intermediate stages are reactive, standard and advanced. A formal S&OP structure is empowered; formal meetings and integrated software are instituted throughout those intermediate stages. The financial function, new product introduction and constrained plans are gradually integrated into the S&OP stages.
Feng et al. (2008)	Three	The stages are: (i) decoupled plans; (ii) partially integrated plans; (iii) integrated plans throughout the supply chain. In the first stage sales, production, distribution and procurement plans are decoupled. At the second stage sales and production plans are integrated, but distribution and procurement plans are decoupled. In the third stage S&OP process is integrated throughout the supply chain.
Viswanathan (2009)	Three	The Aberdeen maturity model stages are: (i) best in class (top 20%); (ii) average (mid 50%), and; (iii) laggards (bottom 30%). The three metrics used to range industries are customer service level, average cash conversion cycle and average forecast accuracy at the product family level.
Caceres et al. (2009)	Four	The AMR Research model stages are: (i) reactive; (ii) anticipative; (iii) collaborative; and (iv) orchestrate. At the reactive stage, plans are operational; factory capabilities prevail over sales; S&OP is measured by fill rates, asset utilization and inventory levels. At the second stage the goal is to match supply and demand. Operations still prevails over sales, but marketing function and the planning of factory capability are integrated into S&OP. The third stage is the collaborating stage, during which sales and operations are balanced into integrated and proactive “go-to-market” plans, comprised of demand-driven, make and deliver processes. At the final stage, operations and sales carry equal weights in what is described as an optimized demand shaping plan. Its metrics are demand risk, customer services, cash flow, market share and profit.

Early maturity models in S&OP referred to specific aspects of the process, such as information technology (Wing & Perry, 2001) and demand planning

(Mentzer & Moon, 2004). Maturity models with a broader view were proposed more recently. Lapide (2005) considered three dimensions: people, processes, and technology. Ventana Research (2006) proposed a maturity model in which the classification was made according to the firm position along the dimensions of people, process, technology, and performance management. Aberdeen Group proposed a model with a somehow similar classification: process, organization, knowledge, technology and performance (Viswanathan, 2009). Grimson & Pike's (2007) S&OP maturity model was built on the ones proposed by the Aberdeen Group and Lapide (2005). Their classification was made according to the firm position in five dimensions: meetings and collaboration (which evaluates the effectiveness of the human component in S&OP), organization (which focuses on the corporate S&OP structure), measurements (which applies to both company performance as well as the effectiveness of the S&OP process), information technology (which focuses on an information process rather than a business process), and S&OP plan integration (which measures how effectively a company builds an integrated plan and how well the plan interfaces with the other four dimensions). Feng et al. (2008) position their S&OP maturity stages in three levels according to the integration of procurement, production and distribution plans, ranging from decoupled to fully integrated set of plans. The AMR Research maturity model classifies organizations in four dimensions: balancing sales and operations, goals of the process, plan ownership, and metrics (Cacere et al., 2009).

2.1.2
S&OP as management practices

Consistent with Voss et al. (1998), practices are defined as being the processes adopted to improve management. In this sense, S&OP is a bundle of management practices of horizontal and vertical alignment within the firm and in the supply chain (SC). Consistent with a contingency theory approach to Operations Management research (to be further defined in Section 2.3), it is posited that S&OP practices are directed at improving firm performance. Thus, the review of S&OP practices focuses on studies showing empirical evidences of the relationships of sets of practices and firm performance. Furthermore, it is also posited that most analysis of supply chain integration (SCI) implicitly address the horizontal and vertical alignment dimensions of S&OP process, and SCI should be viewed as an important part of the S&OP concept domain.

The major S&OP practices are: (i) integration of plans within the firm; (ii) use of standard norms, procedures, regular meetings and empowerment of S&OP teams; (iii) use of information technology to boost integration; (iv) regular monitoring and evaluation of results; (v) SC participation (customers and suppliers) (Lapide, 2005; Wallace & Stahl, 2006; Grimson & Pyke, 2007).

Internal S&OP as a bundle of management practices is a second order construct comprising four internal S&OP practices, based on Grimson & Pyke's (2007) concept domain: Meetings and Organization (MO - organizational integration across functions and the use of cross-functional teams); Measurement (M - process control and information-sharing); Technological Integration (TI - techniques and methods used to enhance technological integration across functions); and Integration of Plans (IP - cross-functional integration of plans and action programs within the firm).

The S&OP practices can be summarized in three main sets: (i) internal S&OP, (ii) integration with customers and (iii) integration with suppliers.

Research on the impact of each of the three sets of S&OP practices on performance is summarized in Appendix 2. Each study is characterized in Appendix 2 in terms of the employed sample, S&OP practices, performance dimensions and results. A classification of bibliographical references by set of S&OP practices is subsumed in Table 2.2.

Table 2.2: Set of S&OP practices by references

Practices	References
Internal S&OP	Stank et al. (1999); Ellinger et al. (2000); Stank et al. (2001); O'Leary Kelly & Flores (2002); Parente et al. (2002); Rozensweig et al. (2003); Droge et al. (2004); McKormack and Lockamy (2005); Koufteros et al. (2005); Giménez & Ventura (2005); Olhager & Selldin (2007); Das et al. (2006); Swink et al. (2007); Daugherty et al. (2009); Flynn et al. (2010); Nakano (2009); Boon-itt & Wong (2011); Rexhausen et al. (2012)
External Integration with customers	Zhao et al. (2001); Rozensweig et al. (2003)
External Integration with Suppliers	Droge et al. (2004); Cousins & Menguc (2006); Das et al. (2006); Hadaya & Cassivi (2007)
External Integration with Customers and Suppliers	Frohlich & Westbrook (2001); Stank et al. (2001); Rozensweig et al. (2003); McKormack & Lockamy (2005); Koufteros et al. (2005); Giménez & Ventura (2005); Simatupang & Sridharan (2005); Swink et al. (2007); Quesada et al. (2008); Flynn et al. (2010); Nakano (2009); Lau et al. (2010); Boon-itt & Wong (2011); Prajogo & Olhager (2012)

2.1.2.1
Internal S&OP practices

Several studies found empirical evidence of a direct impact of internal cross-functional integration on performance (Stank et al., 1999, 2001; Ellinger et al., 2000; Parente et al., 2002; Rozensweig et al., 2003; Das et al., 2006; Swink et al., 2007; Daugherty et al., 2009; Flynn et al., 2010; Nakano, 2009; Boon-itt & Wong, 2011), although some did not find such a relationship (Giménez & Ventura, 2005; Koufteros et al., 2005). Other studies found that the effect of internal S&OP practices on performance was contingent upon a number of factors such as business strategy and demand uncertainty (O'Leary & Flores, 2002); order-type as engineering-to-order (Parente et al., 2002); competitive capabilities – quality, reliability, flexibility and costs (Rosenzweig et al., 2003); time-based variables such as 'time-to-market', 'time-to-product', and customer responsiveness (Dröge et al., 2004); product innovation, quality and 'equivocality'/uncertainty (Koufteros et al., 2005); technological and demand uncertainties (Boon-itt & Wong, 2011).

Only a few studies formally included broader definitions of internal S&OP as a determinant of firm performance. McKormack & Lockamy (2005) found that the ‘horizontal’ mechanisms of integrating roles, formal organization, informal collaboration and networks within the firm were positively related to the performance of the SC processes of plan, source, make and deliver. Olhager & Selldin (2007) found that Manufacturing Planning and Control systems (MPC - including S&OP and Master Scheduling) played a mediator role between market uncertainty and manufacturing performance. Rexhausen et al. (2012) included three aspects of internal S&OP (existence of a formal process, participation of top management, adherence to the process) as a latent variable into a broader measure of demand management. The authors concluded that both demand and distribution management impacted upon the performance of the firm, but S&OP and warehouse management processes contributed little to the impact.

Despite the large diversity of integration mechanisms and paths of influence that have been examined, the hypothesis that more internal integration is conducive to better performance is prevalent in the literature (Fabbe-Costes & Jahre, 2008). Appendix 2 shows empirical support for this hypothesis from a diversified set of samples, from different countries, type of businesses and economic sectors.

2.1.2.2
Integration with Suppliers and Customers

It is long recognized that SCI has a positive impact on performance (e.g., Heskett, 1977; Birou et al., 1998). The papers summarized in Appendix 2 can be classified in six broad categories regarding the impact of SCI on performance. There are studies that found: (i) a direct impact of the integration with customers and suppliers, analyzed jointly in the study (Frohlich & Westbrook, 2001; Rozensweig et al., 2003; Quesada et al., 2008); (ii) a direct impact of the integration with customers and suppliers, analyzed separately in the study (Koufteros et al., 2005; Lau et al., 2010; Huo, 2012); (iii) a direct impact of the integration with suppliers only (Dröge et al., 2004; Simatupang & Sridharan, 2005; Das et al., 2006; Hadaya & Cassivi, 2007; Swink et al., 2007; Boon-itt & Wong, 2011; Prajogo & Olhager, 2012); (iv) a direct impact of the integration with customers only (Zhao et al., 2001; Giménez & Ventura, 2005; Flynn et al., 2010); (v) an impact of the integration with either customers or suppliers mediated by other variables (Dröge et al., 2004; Boon-itt & Wong, 2011); (vi) no impact of integration with customers (Devaraj et al., 2007), with suppliers (Cousins & Menguc, 2006), with neither customers nor suppliers (Stank et al., 2001; Vereecke & Muylle, 2006; Nakano, 2009).

Overall, we observe some inconsistencies in the findings from different studies. Such inconsistencies have been attributed to the use of different definitions of SCI, different aspects of integration (with both suppliers and customers, with suppliers only or with customers only) and different definitions of performance (Fabbe-Costes & Jahre, 2008; Flynn et al., 2010; Huo, 2012). In accordance with the contingency approach to OM research (described next, Section 2.3), it is posited that differences in the impact of external integration with customers and with suppliers might also be due to differences in contingent variables such as national context and culture, company size, manufacturing strategy, industry type, technology, product-production process mix, plant's age (Sousa & Voss, 2008). Since there seem to be differences found in the impact of supplier and customer integration on performance, some authors analyzed separate hypotheses for these two aspects of SCI, while others choose to investigate the simultaneous effect of integration with both customers and suppliers.

2.2
Defining S&OP: a synthesis

Based on prior definitions of S&OP as a management process and as management practices, S&OP can be synthesized as follows:

> "Sales and Operations planning is a cross functional and integrated tactical planning process and a cohesive bundle of management practices that unites different business plans (sales, marketing, new product development, manufacturing, sourcing, and financial) into an integrated set of plans internally and in the supply chain, with the ultimate goal of creating value and impact upon firm's performance. It aims to balance supply and demand at family and individual product levels, with a planning horizon that matches the strategic business planning cycle. The efficiency of the process is measured and evaluated for continuous improvement. It comprises a set of cohesive management practices

directed to boost alignment horizontally (across functions) and vertically (from business plan to operations), within the firm and in the supply chain".

2.3
Contingency theory from an OM perspective

This brief review of contingency theory and its application to the field of OM will be restricted to the basic concepts needed to situate the empirical research formulated and discussed in Chapter 4.

2.3.1
Structural contingency

Sousa & Voss (2008) were the first to call for a systematic investigation of contingent effects on performance in the field of OM. They named this approach operations management practice contingency research (OM – PCR).

Viewed with the lenses of contingency theory, S&OP practices should fit manufacturing structure and the environment in order to positively impact upon performance. An organization is effective when it matches its organizational characteristics to contingencies. ‘‘Contingency’’ is defined as ‘‘any variable that moderates the effect of an organizational characteristic on organizational performance’’ (Donaldson, 2001). The four basic postulates at the core of the paradigm of structural contingency theory are that: (i) contingency impact the organizational structure and the organizational structure impacts upon performance; (ii) there ought to be some level of fit between the structural variable and each level of the contingency, whereby high levels of fit causes effectiveness and low fit (misfit) causes ineffectiveness; (iii) there is no universal type of the most efficient organization; and (iv) the impact of organizational structure on performance is empirically analyzable (Donaldson, 2001).

The first mention to contingency theory appears in the seminal work of Lawrence & Lorsch about the role of differentiation and integration in complex organizations (Lawrence & Lorsch, 1967a, 1967b; Donaldson, 2001).

Differentiation designates the partition of the organization into task specialized subunits. Integration is the process of achieving unit among diverse organizational subunits. From an OM – PCR perspective, S&OP practices can be conceptualized as "integrative devices", in Lawrence & Lorsch's terminology (e.g., organizational and technological integration, organization and meetings; cross functional teams, task forces, integrative roles). Lawrence & Lorsch (1967a; 1967b) work is at the origin of the "structural contingency" theory. But there are other contingency theories of organizations that focus on management, human resources, and strategy. Lawrence & Lorsch's own theory was put to empirical test in six chemical processing industries under rapid technological change, product modification and innovation – new and improved products. Their conclusion was that in a context of high task complexity and environmental uncertainty, manufacturers will perform better if the diversification of their manufacturing processes sub-units and their use of "integrative devices" (e.g., cross-functional teams, concurrent engineering, co-location) fits the environment (Lawrence & Lorsch, 1967b). Simply put, the diversification and integration framework of Lawrence & Lorsch (1967b) states that highly technological and complex organizations have a diverse set of subunits, and the more diversified the organizations are the higher the need to develop "integrative devices" that fits the environment and industrial structure. Organizations who adapt (fit) to its technic-economic, market and scientific sub environments will survive and flourish (Lawrence & Lorsch, 1967b). Two dimensions of the framework will be tested in Chapter 4 as they relate to technology and to the construct of Internal S&OP practice: product/task complexity of the core manufacturing activity and the degree of advance in process technology of the dominant manufacturing activity. According to the framework, misfit between the technology applied to the dominant activity of the factory and its sub environments will negatively affect performance.

Structural contingency theory can be subdivided in three main areas: (i) harmonization of organizational structures and the environment (uncertainty, diversity, complexity); (ii) analysis of the effect of applied technology on performance; and (iii) analysis of the relationships between company size and structure (Donaldson, 2001). The chosen contingency approach to S&OP in this research privileges the use of Advanced Manufacturing Technology (AMT), because of its relevance to contingency theory and for the performance of the companies analyzed in Chapter 4 (they all belong to ISIC 3.1, codes 28-35: manufacturers of metal products, machinery, semiconductor, transportation, advanced instruments and audio/video. See Chapter 4, Section 4.1).

2.3.2
The contingent effect of Technology

Advanced manufacturing technology (AMT), broadly defined:

> "is a total socio-technical system where the adopted methodology defines the incorporated level of technology. AMT employs a family of technologies that includes computer-aided design (CAD), computer-aided manufacturing (CAM), flexible manufacturing systems (FMS), manufacturing resource planning (MRP II), automated material handling systems, robotics, computer-numerically controlled (CNC) machines, computer-integrated manufacturing (CIM) systems, optimized production technology (OPT), and just-in-time (JIT)". (Zamuto & O'Connor, 1992; pp. 701; Zairi, 1993, pp. 123; Svobodobá, 2011).

Swamidass (1996) makes a further distinction between soft technology, which encompasses methods and techniques (e.g., kanban, JIT, ERP) and hard technologies, which includes hard and software (e.g., robots, CAD, CAM) (Svobodobá, 2011). The term is used in this Thesis in its broad definition including both processes/methods and equipment.

Technology has a dual role, as informed by the duality of structure concept in the theory of structuration (Giddens, 1984), which sees the structure or institutional properties of social systems as created by human action, which subsequently serves to shape future human action. Applied to technology this view sees technology as resulting from management decisions, but also as a more "static" contingency variable that moderates the impact of management practices on performance (Morton & Hu, 2008). At the same time that choice and investments in technology can emanate from management decisions, technology is viewed as a more static contextual variable that moderates the impact of management practices on performance; in other terms – it is also viewed as a contingency.

Under a contingency theory approach, technologies will impact upon performance if they are adequate, if they fit the environment, structure and processes of the firm. The adequacy (or fit) of technology to the environment, processes and structure of the firm is vital to boost performance. This is consistent with early findings from Boyer et al. (1996, 1997), who states that investments in AMT alone is not a causal factor in manufacturing performance. Das & Jayaran (2003) identified that work organizational arrangements and lean manufacturing are the principal contingency variables moderating the impact of AMT on performance. Internal S&OP, co-location of design and manufacturing teams and job rotation among design and manufacturing are types of contingent work arrangements analyzed in this study. Swink & Nair (2007) demonstrate the moderator role of design-manufacturing integration (DMI) in the relationships between technology and performance. To the best of our knowledge, this Thesis is the first one to treat AMT as a contingent variable and not as the primary agent impacting directly on performance (Matyusz, 2012).

Technology also deserves further attention as it is a disputed issue in the S&OP literature. While some authors advocate the use of Advanced Planning and Scheduling (APS) systems in S&OP (Wing & Perry, 2001; Lapide, 2004b; Ivert & Jonsson, 2010), others would caution that adequate and simple information systems technology such as spreadsheets and dashboards would fit better than APS at least at the earlier stages of S&OP maturity models (Wallace & Stahl, 2006; Grimson & Pyke, 2007). But conversely, and of the uttermost importance for this study, from a contingency theory point of view, it is expected that S&OP will impact manufacturing performance differently in different technological contexts.

Technology can be viewed as a process (or manufacturing technology) or as a product technology (techniques and definitions taken to make a unique and reproducible product). The classic definition of technology in structural contingency theory states that technology consists of the techniques that are used in workflow activities, providing goods and services directly (Pugh et al., 1963). One of the most influential work relating both dimensions is the Hayes & Wheelwright (1979) product-process matrix. Technology as a process can be further subdivided into design technology, process technology and administrative/planning technology (Swink & Nair, 2007). A non-exhaustive taxonomy of AMT is provided in Table 2.3, expanded from Boyer et al. (1996, 1997) and Swink & Nair (2007). The dimensions of technology used in Chapter 4 of this study are also portrayed in the table.

Table 2.3: Taxonomy of Advanced Manufacturing technologies (AMT) and constructs used in the empirical study

Type of Technology	Constructs used in the study
DESIGN	
Computer-aided design (CAD)	S&OP: Integrated Planning
Computer-aided engineering (CAE)	S&OP: Integrated Planning
Computer-aided process planning (CAPP)	S&OP: Integrated Planning
MANUFACTURING	
Computer numerical control (CNC)	
Computer-aided manufacturing (CAM)	S&OP: Integrated Planning
Flexible manufacturing systems (FMS)	Process Technology
Automated material handling systems	Process Technology
Programmable controllers	
Cellular manufacturing	Process Technology
Computer-aided quality control	S&OP: Technological Integration
Failure mode and effect analysis (FMEA) *	S&OP: Technological Integration
Quality function deployment (QFD) *	S&OP: Technological Integration
Bar coding/automatic identification systems	S&OP: Measurement
Environmental control systems	
Real time process control systems	S&OP: Measurement
Group technology (GT)	
Robotics	
ADMINISTRATIVE / PLANNING	
Material requirements planning (MRP)	
Just in time	
Shop floor control	
Manufacturing resource planning (MRP II)	S&OP: Measurement
Activity-based accounting	
Enterprise resource planning (ERP)	S&OP: Measurement
Electronic mail	
Office automation	
Knowledge-based systems	
Decision support systems	
Advanced planning systems (APS) *	

Based on Boyer et al. (1996, 1997); Swink & Nair (2007)

(*) Added to previous taxonomies

In order to avoid confound and as depicted in Table 2.3, the construct of technology introduced in Chapter 4, Section 4.3 “Moderator role of Technology” was restricted to specific technologies not previously included in the construct of internal S&OP presented in Section 4.2. “S&OP and manufacturing operational performance”, which includes different measures of design (e,g, CAD, product life cycle management), manufacturing (CAM, computer-aided quality control) and planning technology (e.g. integrated information systems).

Furthermore, when analyzing technological fit as a system in Sub-section 4.3.2.2., “Measure of fit”, integration will be measured as a construct formed by job rotation and co-location between design and manufacturing engineering, which reflects design and manufacturing integration (DMI; see Swink & Nair, 2007), in order to avoid confound with the technological dimensions of integration embedded in the construct of internal S&OP.

Among the classical research on contingency theory, Woodward (1965) measured technology by workflow integration and labor costs. Pugh et al. (1969a; 1969b) measured product complexity and diversity, as well as the production mode (process versus discrete production). Dalton & Lawrence (1970) approached product complexity as the number of assembly stages. Funk (1995) proposed to measure logistical product complexity by the number of manufacturing steps or by the number of parts.

In the field of OM, few authors measured technology as product complexity and found mixed results. For example, Koh & Simpson (2005) found an impact on late deliveries while Zhang et al. (2006) found no evidence of impact of type of products on flexibility.

According to the review of Sousa & Voss (2008), most of the OM-PCR that analyses technology as a contingency uses production process-related variables. Several authors measured technology as a process and in most cases, its impact on performance was positive (e.g. Mc-Kone & Schroeder, 2002; Das & Narisimnhan, 2001; Koh & Simpson, 2005; Swink & Nair, 2007).

2.3.3 Defining Fit

In its simpler expression, the contingency theory states that organizations adapt their structures and processes to their environment, in order to attain high performance (Donaldson, 2001; Sousa & Voss, 2008). The concept of fit is central to contingency theory. As stated by Drazin & Van de Ven (1985; page 515), "central to a structural contingency theory is the proposition that the structure and process of an organization must fit its context (…), if it is to survive or be effective". The concept of fit is not straightforward (da Silveira & Sousa, 2010). There are several definitions and correspondent measurement of fit (Drazin & Van de Ven, 1985; Venkatraman, 1989; Sousa & Voss, 2008). In light of OM-PCR, there would not be universal S&OP practices as it is always grounded in specific contexts. Furthermore, as there are several possible definitions and measurements of fit, the assessment of fit should take this diversity into account and triangulate measurements for hypotheses testing (Drazin & Van de Ven, 1985; Venkatraman, 1989).

Drazin & Van de Ven (1985) distinguishes between three forms of fit in structural contingency theory: selection, interaction and systems. Venkatraman (1989) proposed an expanded typology with six types of fit: moderation, mediation, matching, gestalt, profile deviation and covariation. As summarized by Sousa & Voss (2008), the two typologies are not antagonistic. Their definition, measurement techniques and equivalences are summarized in Table 2.4, based on the more parsimonious taxonomy of Drazin & Van de Ven (1985).

Under the perspective of natural or managerial selection, fit is the congruence between structure and processes. Only the best performers survive and the understanding of the match between the environment, structure and processes is the focus of the analysis. No explicit reference is made to performance as it is granted that congruence assures performance.

Fit as interaction is conceptualized as the study of the impact on performance of different interactions between structure and processes, analyzed as a dyad involving a management practice and a contextual variable, taken one by one. Fit as interaction is usually measured with mediating or moderating variables in multiple regression equations; or by comparison between sub-samples of the same population (e.g., median split samples).

Table 2.4: The concept of fit in strategy and operations management practice contingency research (OM PCR)

Characteristics	**Drazin and Van de Ven (1985) typology of Fit**		
	Selection	**Interaction**	**Systems**
Equivalence with Venkatraman (1989) [a]	Matching	Moderation, Mediation	Gestalt, Profile deviation, Co-variation
Definition of Fit [b]	Assumed congruence between context and structure	Bivariate interaction of organizational context - structure factors affecting performance	Internal consistence of multivariate contingencies and structural factors affecting performance
Research proposition [c]	The match between practices and structure impacts performance	The interaction between practices and structure is mediated or moderated by fit	(i) internal congruence of fit variables differs from "high" and "low" performers; (ii) the degree of adherence to a specific profile or the internal consistency of fit variables affects performance
Number of variables [c]	Two	Two (Moderation) Two to Multiple (Mediation)	Multiple
Analytical scheme [b,c]	ANOVA, Deviation scores, Residual analysis, bi-variate regression	Analysis of variance, mediated or moderated regression, subgroup analysis, path analysis	Cluster and factor analysis, deviation as a n-dimensional euclidian distance, Structural equation modeling
Measurement of fit [c]	Interval-level	Statistical deviation	Ordinal/Interval level
Test Methods [b]	Variables subjected to universal switching should be highly correlated with context, while particularistic variables need not to be	The coefficients of context-structure regressions on performance should be statistically significant	Relationship between context-structure and performance constructs should be significant while manifest-directly observed variables might not be

Adapted from: [a] Sousa & Voss (2008); [b] Drazin & Van de Ven (1985); [c] Venkatraman (1989)

Contextual variables of fit are shown to moderate the impact of different OM best practices in the areas of general manufacturing, quality management, human resources, productive maintenance, lean, just-in-time, and new product development (Sousa & Voss, 2008). A large set of contextual variables are shown to moderate the impact of the S&OP integrative practices on performance. As shown in Sub-section 2.1.2.1, the effects of internal integration on performance was shown to be moderated by the perceived effectiveness of interdepartmental relations, distribution services performance (Ellinger et al., 2000); business strategy and demand uncertainty (O'Leary Kely & Flores, 2002); product type (engineered-to-order) (Parente et al., 2002); manufacturing-based competitive capabilities of quality, reliability, flexibility and costs (Rozensweig et al., 2003); technological and demand uncertainties (Boon-It & Wong, 2011). Concurrent engineering effect on performance was shown to be moderated by the contingency effects of "equivocality" (Koufteros et al., 2005). Product co-development with suppliers improves performance moderated by innovation (Lau et al., 2010) (see Appendix 2).

In the systems approach, fit is a holistic concept asserting that context-structure-performance relationships are multi-faceted and can only be analyzed simultaneously, taking several contingencies into account at the same time. Embracing the concept of equifinality, fit is viewed as a system of "feasible sets of equally effective alternative designs" affecting performance (Drazin & Van de Ven, 1985). Most common measures of fit as a system are multivariate regressions, structural equation modeling and profile-deviation.

While advocating for applying the contingency theory to the field of OM, Sousa & Voss (2008) also pointed to its limitations in explaining the current patterns of adoption of OM practices. Alternative explanatory theories are the institutional theory (Di Maggio & Powell, 1981), the strategic choice theory (Child, 1972), the resource-based view of the firm (Barney, 1991) and the "structuration" theory (Giddens, 1984). Rival theories are mentioned based on the summary provided by Sousa & Voss (2008), due to its relevance to understand the empirical results and the discussions in Chapter 5. Giddens' (1984) structuration theory is added due to its relevance in understanding the dual role exerted by technology.

OM - PCR states that performance is the resultant of the adequacy (or fit) between the introduction of management best practices (which includes S&OP) and the organizational context (structure-processes-environment); and that best practices are adopted because of their technical efficiency. But there is evidence of low performance of management practices even when there is fit between organizational context-structure and the adoption of the management best practice. Inversely, best practices might be adopted in a context of fit but not result in improved performance; or even still, be adopted in a context of misfit. Those situations cannot be explained by OM-PCR alone.

Possible argument that helps in understanding fit or deviating paths from fit comes from competing theories. OM best practices can also be adopted due to:

- non efficiency (institutional) factors, such as established norms and procedures, outside pressures emanating from government, trade unions or professional associations;
- management choices and decisions (strategic choice theory);
- inadequate use of resources that are useful, valuable and difficult to obtain or trade (resource-based view of the firm);
- dual role of social actions / technology that shape and are shaped by the structure ("structuration" theory).

This chapter introduced the basic concepts of S&OP and contingency research that will be applied in Chapters 3 and 4.

3
A synthesis framework for S&OP and its impact on Performance

This Chapter presents the research methods and main findings of the systematic literature review. First, the research synthesis methods are presented. The synthesis framework and study descriptors, covering the fifty five retrieved papers are described next. The review of the very few survey-based empirical evidence of the impact of S&OP as a process on performance based on four papers follows. Finally the last section offers a research synthesis and the implications for research and practice.

3.1
Methods

Systematic literature review or research syntheses “focus on empirical studies and seek to summarize past research by drawing overall conclusions from many separate investigations that address related or identical hypotheses” while meta-analysis refers to the “quantitative procedures used to statistically combine the result of studies” (Cooper, 2010, pp. 4). This distinction is relevant to the discussions introduced in Section 3.4 “Outlook”.

The author of this Thesis led a team of four researchers, in accordance with the rigorous methods of objective and verifiable research synthesis (Cooper, 1984; Lipsey & Wilson, 2001; Cooper, 2010).

The current systematic literature review of S&OP covers papers published until 2010. The literature review on Supply Chain Integration (SCI), as it relates to the S&OP construct and the searches on the theoretical approach to Operations Management (OM) were obtained by manual search on references appearing in papers selected during the systematic literature review on S&OP.

A six-step process was adopted to select and retrieve papers: (i) computerized database selection, (ii) identification of keywords for search, (iii) criteria for exclusion of studies, (iv) manual review of selected abstracts by at least three researchers; (v) full-text review of selected papers; and (vi) a manual search on the bibliographical references of papers selected.

Two data-entry screens were prepared with the US Bureau of Census' survey software, CS-Pro: one for the study identification and one for the study descriptors. They were populated during the retrieval process.

Three databases were selected for the search; these three databases consist of papers published in the large majority of scientific journals of interest to operations, organizational management, and social sciences research: EMERALD, EBSCO (including Academic Search Complete, Business Source Premier, CINAHL with Full Text, Information Science & Technology Abstracts [ISTA], Library, Information Science & Technology Abstracts with Full Text, Regional Business News, SocINDEX with Full Text and Academic Search Premier), and SCIENCEDIRECT.

In accordance with recommendations for initial research synthesis (Cooper, 2010), the keywords selected were sufficiently broad to avoid artificially limiting results and still provided limitations to avoid undesirable results. In pseudo code, the following phrase was adapted to the search engines in each database: "Sales and Operations Planning" OR "S&OP" NOT "S OP". The last term was added to preclude articles in the field of chemistry from appearing in the results of the search.

Grey literature review was included in the search databases, and manual searches as reflected in the choice of bibliographic databases. This literature was included for two reasons: first, to limit the "file drawer" problem or dissemination bias that may arise because results that are statistically non-significant tend to be less accessible to computer searches; and second, to include more recent research that may currently be in the process of being published (Rothstein & Hopewell, 2009). Gray, grey or fugitive literature is synonymous (Rothstein & Hopewell, 2009; pp. 104). It was defined on the Third International Conference on Grey Literature in Luxembourg in 1997 as "that which is produced in all levels of government, academics, business and industry, in electronic and print formats not controlled by commercial publishers (Auger, 1998). An alternate definition was proposed by McKimmie & Szurmak (2002) as including all material not identifiable through traditional index or bibliographic database and that are, therefore, hard to retrieve. Following Rothstein & Hopewell (2009), we adopt the more general definition by Weintraub (2000): “scientific grey literature comprises newsletters, reports, working papers, theses, government documents, bulletins, fact sheets, conference proceedings and other publications distributed freely, available by subscription or for sale” (Rothstein & Hopewell, 2009; pp. 105). This definition allows the inclusion of bibliographic sources that goes beyond peer-reviewed academic journals, and that are likely to do not be selected otherwise. The inclusion of working paper series from major Universities and Research Centers allow early citation of academic work that will only be published months or years later.

Several classification schemes were proposed in the literature to judge the quality of primary research included in research synthesis. Threats to validity of research synthesis reported range from eleven (Cooper, 1984) to 21 (Matt & Cook, 1994) to 29 (Shadish et al., 2002); and yet to a list of 28 (Matt & Cook, 2009). Following Cooper (2010), we regrouped threats to validity in broad categories and used the categories as criteria for the exclusion of papers. But papers were first selected for inclusion. Studies were included based in two criteria. First, only papers dealing with the S&OP concept as an integrated business process were included. This first criterion excluded papers dealing with S&OP elements treated in isolation (e.g., information systems integration, business forecasts). Second, the selection process for empirically-based validations of the S&OP construct was restricted as a decision from the author to include only papers that were based on survey data, due to the known paucity of rigorous scientific case study research in this area. In addition, it was decided by the author that in order to be eligible for the analysis of effect sizes, survey-based papers had to present as a minimum a description of data sources, pre-test of the instruments, content validity, reliability and regression coefficients. This criterion excludes papers regardless of the nature of the relationship of S&OP elements and firm performance, or of its lack thereof (for an extensive discussion about quality in secondary data research, see Valentine, 2009).

Applying the search words and the criteria for inclusion, the search returned 271 papers, and all abstracts were read by at least three researchers. The full bibliography list is available upon request.

Five criteria were adopted to exclude papers from the initial list of 271 abstracts. Papers were excluded based on:

(i) lack of relevance of the construct of S&OP or poorly defined constructs of S&OP;

(ii) poorly defined methodology, resulting in different strength of the evidence of S&OP effects. In judging primary study methodological quality, a classification scheme ranking papers by the strength of empirical evidence described was adapted from Lipsey & Wilson (2001) in seven subgroups: (1) author's opinion only; (2) direction of effects; (3) percent change; (4) percent change and sample size (N); (5) means, standard deviation, and N; (6) regressions/correlations; (7) do not apply (see Valentine, 2009 for a full discussion about primary research quality in research synthesis). Papers based on author’s opinion only were excluded from further analysis;

(iii) agreement among reviewers, - an interactive process was adopted to ensure high levels of inter-coders reliability;

(iv) causal relationship was only accepted based on clearly defined empirical evidences based on explicit mathematical modeling or case studies;

(v) no cumulative results were extrapolated to a whole industry or set of countries, in order to avoid undue generalization of firm-based findings.

After reading the abstracts, duplicate papers and those not corresponding to the above criteria were excluded, resulting in 89 papers selected for full-text review. After a full-text reading, an additional 34 papers were excluded. Thus, 55 papers were included in the study identification and study descriptors. Those papers were reviewed and cross-examined by at least two researchers. The validation of S&OP impact was based on survey data as a preferred inferential method for impact evaluation (Gertler et al., 2011). After applying the criteria to select survey-based validations of the impact of S&OP construct on performance, only four papers were included.

The review process was interactive and resulted in high levels of agreement. First, three researchers independently searched databases with different keywords. In a second round, a unified pseudo code for systematic search was agreed-upon. In the third round, criteria for exclusion was debated and summarized in the basic five-item list described above. In the fourth round, the full list of 271 abstracts were distributed to three researchers and debated in four consecutive meetings. A high level of agreement among the researchers was obtained from this screening process. It was measured with Cohen's kappa inter-ratters reliability coefficient, which varies from 0 (no agreement) to 1 (total agreement). Inter-ratters reliability after the third consecutive meeting, as measured by Cohen's kappa for three judges on abstract reviews was 0.47 with a standard deviation of 0.12, which was significantly different from agreement by chance alone (Fleiss, 1971). The main reason for disagreement was the inclusion in the abstract's review of many articles from industry magazines that provided few explanation of the strength of the evidence upon which conclusions were based. Cohen's kappa nearly doubled (0.83) during the fourth review meeting, after consensus was reached about the exclusion of articles from industry magazines and trade journals.

3.2
Synthesis framework and study descriptors

The results are presented in three broad categories: study identification, research synthesis framework and descriptors.

3.2.1
Study Identification

Figure 3.1 presents the number of papers retrieved for the systematic review analysis, totaling 55 papers, as described in Section 3.1 and depicted in Table 3.1. Interest in the subject is growing, as evidenced by the number of papers recently published on different aspects of S&OP.

The 55 articles included in the summary of results are listed in Table 3.1. Google Scholar (GS) was used for the citation quotes. GS was chosen for four main reasons: (i) it is freely available on the Internet; (ii) it is reputedly fast; (iii) it includes scientific grey literature; and (iv) it compares favorably with fee-based citation databases such as Thomson ISI Web of Knowledge and Scopus. GS is used in scientific reviews in several disciplines (Harzing & van der Wal, 2008; Bornmann *et al*., 2009).

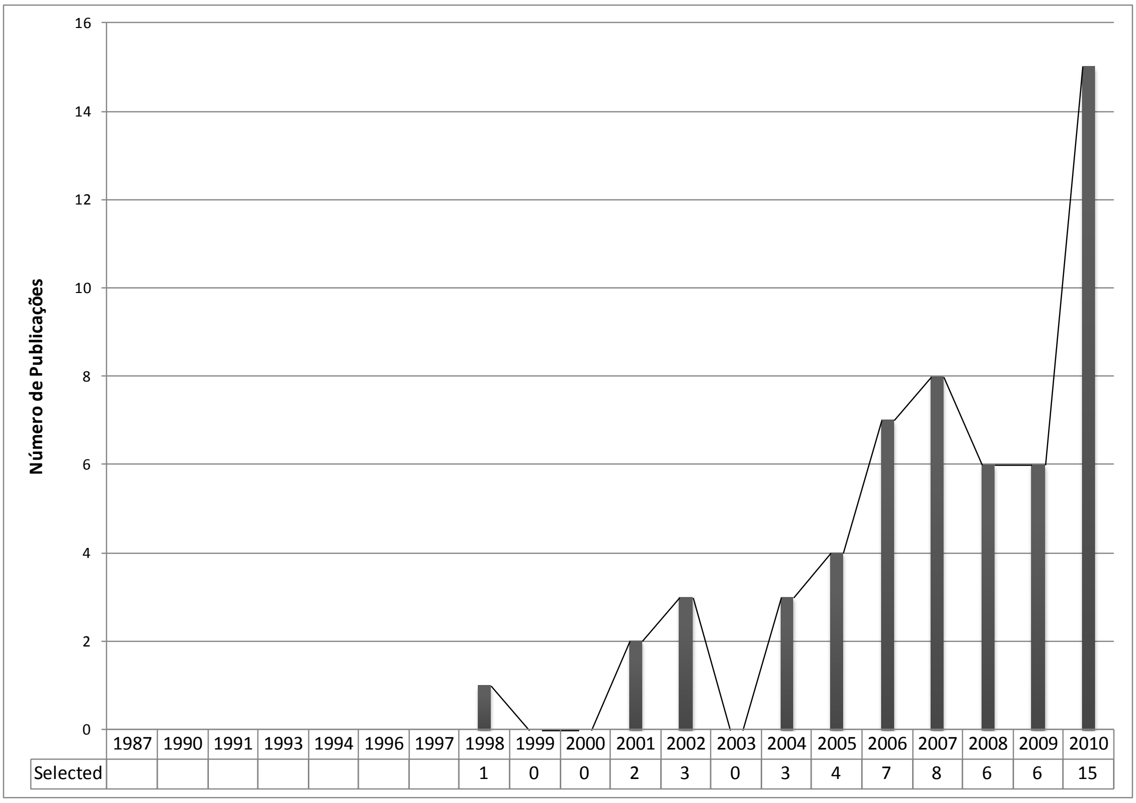


Figure 3.1: Number of selected publications on S&OP per year

The required cleaning was performed in GS to avoid duplicate entries (Rosenstreich & Wooliscroft, 2009).

Table 3.1: Papers selected by year, number of citation and source

Author	Year	Number of citations (GS) *	Source
Gianesi	1998	16	IJOPM
Olhager *et al*.	2001	63	IJPE
Basu	2001	45	MBE
Lapide	2002	57	JBF
Malhotra & Sharma	2002	22	JOM
Olhager & Rudberg	2002	19	IJPR
Menzter & Moon	2004	19	SCMR
Lapide	2004a	9	JBF
Lapide	2004b	5	JBF
Lapide	2005	4	JBF
Bower	2005	3	JBF
Reyman	2005	1	JBF
McCormack & Locakmy	2005	1	GBCE
Collin & Lorenzin	2006	17	IJPDLM
Whisenant	2006	4	JBF
Sehgal et al.	2006	3	IJPPM
Muzumdar & Fontanella	2006	3	SCMR
Harwell	2006	1	JBF
Lapide	2006	6	JBF
Wallace	2006	2	JBF
Olhager & Selldin	2007	105	IJPR
Singhal & Singhal	2007	15	JOM
Slone *et al*.	2007	12	HBR
Hadaya & Cassivi	2007	12	IMDS
Grimson & Pyke	2007	10	IJLM
Lapide	2007	2	BF
Burrows	2007	0	JBF
Chou *et al*.	2007	14	IJPE
Feng *et al*.	2008	9	IJPE
Affonso *et al*.	2008	6	PPC
Milliken	2008	0	JBF
Piechule	2008	0	JBF
Tohamy	2008	0	SCMR
Wallace & Stahl	2008	0	JBF
Lapide	2009a	0	SCMR
Lapide	2009b	0	SCMR
Chae	2009	4	SCMIJ
Nakano	2009	2	IJPDLM

Table 3.1: Papers selected by year, number of citation and source (cont.)

Author	Year	Number of citations (GS) *	Source
Boyer	2009	0	JBF
Muzumdar & Viswanathan	2009	0	SCMR
Ivert & Jonsson	2010	1	IMDS
Godsell *et al*.	2010	0	SCMIJ
Chen Ritzo *et al*.	2010a	0	EJOR
Chen-Ritzo *et al*.	2010b	0	EJOR
Mellen *et al*.	2010	0	SCMR
Nielsen *et al*.	2010	0	CI
Oliva & Watson	2010	2	JOM
Goodwin *et al.*	2010	1	EJOR
Paiva	2010	1	IJPE
Olhager	2010	1	CI
Singh	2010	0	SCMR
Smith *et al*.	2010	0	JBF
Baumann	2010	0	JBF
Keal & Hebert	2010	0	Tr
Baumann & Andraski	2010	0	IE

EJOR - European Journal of Operations Research; GBCE - Global Conference on Business and Economics; HBR - Harvard Business review; IJLM - International Journal of Logistics Management; IJOPM - International Journal of Operations and Production Management; CI - Computer in Industry; IJPDLM - International Journal of Physical Distribution and Logistics Management; IJPE - International Journal of Production Economics; TR - Transfusion; IE - Industry Engineer; IJPPM - International Journal of Productivity and Performance Management; IJPR - International Journal of Production Research; IMDS - Industrial Management & Data Systems; JBF - The Journal of Business Forecasting; JOM - Journal of Operations Management; MBE - Measuring Business Excellence; PPC - Production Planning and Control; SCMIJ - Supply Chain Management - An International Journal; SCMR - Supply Chain Management Review.
* Calculated in June of 2011

The number of citations was concentrated in a few lead authors coming from both peer-reviewed journals and scientific grey literature (trade and industry magazines). In particular, Olhager & Lapide represented together 271 of the total of 497 citations. These authors had also published the largest number of papers on the subject.

3.2.2
Research synthesis framework

To assist in summarizing the empirical results, a research synthesis framework is proposed in Figure 3.2 as a structuring tool to assemble S&OP

descriptors from the extant literature. Study descriptors are summaries of moderator or intervening effects occurring between S&OP and its results; they include the study of artifacts and the completeness of reporting on procedures, measures, treatments, or results (Lipsey, 2009).

The research synthesis framework was first based on the initial review of S&OP maturity models depicted in Table 2.1 and further refined during the article's full text review.

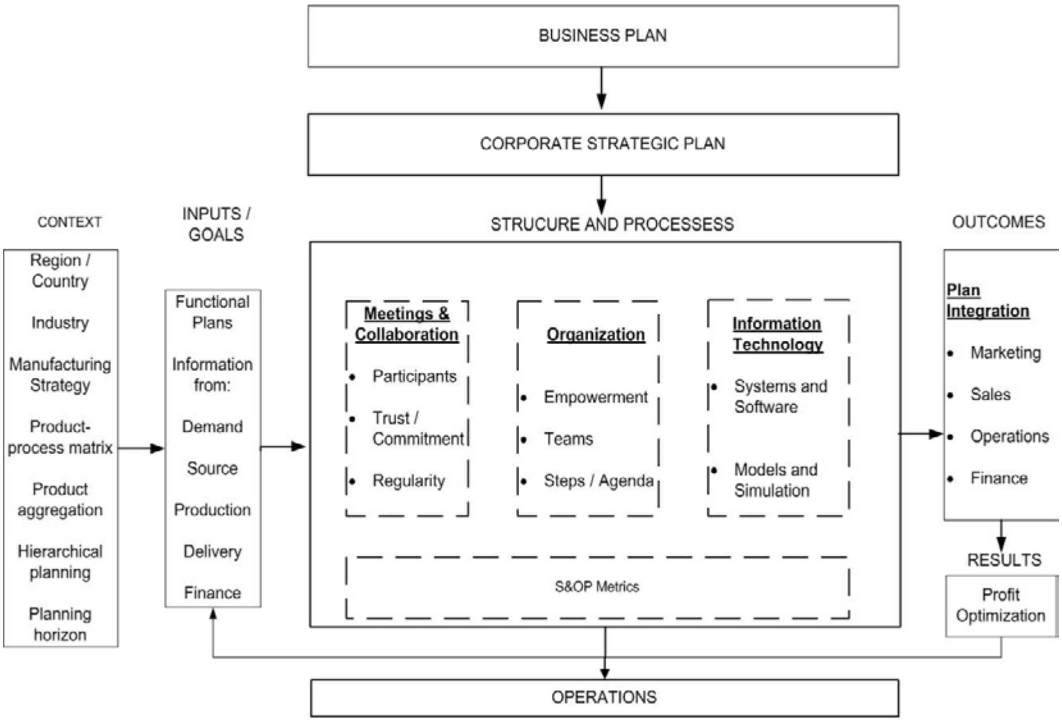


Figure 3.2: Literature search synthesis framework

The framework depicts contextual information that defines the characteristics of the environment where the S&OP is developed. Contextual information includes region/country, industry, manufacturing strategy, product-process matrix (Hayes & Wheelwright, 1979), level of product aggregation (product family and/or SKUs), hierarchical planning (strategic versus tactical), and planning horizon (short, medium or long term). Inputs to the S&OP process regroup functional plans and information from demand, source, delivery and finance.

Structure and processes are described through the four basic dimensions of Grimson & Pyke (2007). Meeting and collaboration regroup participants and promote trust, commitment, and meeting regularity. Organizational aspects include empowerment and the degree of formalization in the S&OP process (teams, number of steps, and agenda).

Information technology is subdivided into systems, software, models, and simulations. Measurements are regrouped under S&OP metrics. From the perspective of vertical alignment, structures and processes are situated below business plans and corporate strategic planning but above operations. Outcomes regroup the fifth dimension of Grimson & Pyke's framework (2007) and consist of plan integration between operations, marketing, sales, and finances. The result of the system is summarized as profit optimization.

The study descriptors of this synthesis framework are used to guide the analysis of the literature findings on S&OP offered in the next sub-section.

3.2.3
Study Descriptors

In the sub-sections that follow, a review of research and key findings in the framework categories of context, inputs/goals, structure and processes, and outcomes is presented.

Categories used for analysis were derived from the basic definition of S&OP as an integrated set of plans from section 2.1 and from the research synthesis framework. The approach of summarizing findings according to the definition of S&OP was corroborated with specific findings from the framework and from the literature review. The resulting analytic categories are described in tables 3.2 to 3.4. Context data was analyzed in-light of the research synthesis framework. Inputs to the S&OP process were analyzed in the broad areas of demand, source, production, delivery and finance, cross-classified by the analytical categories of plans, constraints and others. Structure and processes and outcomes were scrutinized through the analysis of S&OP drivers (objectives of the process) and metrics.

3.2.3.1
Context

Most of the papers retrieved from step (v) of the literature search were descriptive and normative, i.e., they explain how things should be with a focus on improving performance (Olhager & Rudberg, 2002; Lapide, 2002). As such, they contribute to the concepts and conceptual frameworks in the field of operations management and related areas. However, few case studies and surveys with clear descriptors of methodology, datasets, analysis, and results exist in the S&OP field. This result is consistent with observations that the bulk of recent S&OP development has taken place in industry (Wallace & Stahl, 2006; Dougherty & Gray, 2006; Grimsom & Pyke, 2007). Moreover, many of the maturity models applied to S&OP have no common framework (Lapide, 2004a; Lapide 2004b; Mentzer & Moon, 2004; Lapide 2005; Grimson & Pyke, 2007).

There is a large array of contextual data from different countries, industries, company sizes, manufacturing strategies, product process-matrix, product aggregation level, planning hierarchy, and horizons (McCormack & Lockamy, 2005; Grimson & Pyke, 2007; Olhager & Seldin, 2007; Hadaya & Cassivi, 2007; Nakano, 2009; Collin & Lorenzin, 2006; Godsell *et al.*, 2010).

Analyzing a dataset of 15 U.S.-based firms representing different sizes and combinations of processes and products, Grimson & Pyke (2007) did not find evidence to support the use of the product-process matrix of Hayes & Wheelwright (1979) as an S&OP descriptor. In contrast, several papers reported differences in S&OP approaches for make-to-order (MTO) and make-to-stock (MTS) contexts (Olhager *et al.*, 2001; Olhager & Rudberg, 2002; Olhager & Selldin, 2003; Reyman, 2005; Collin & Lorenzin, 2006; Burrows, 2007; Grimson & Pyke, 2007; Piechule, 2008; Wallace & Stahl, 2008; Godsell *et al.*, 2010; Chen Ritzo, 2010a).

While most S&OP planning is done at the product family level, there are examples of SKU-based S&OP (Sehgal *et al.*, 2006; Collin & Lorenzin, 2006) and S&OP processes that combine both product family and SKU for selected products (Bower, 2005; Singh, 2010). The literature positions S&OP on different hierarchy planning levels, being it either at the strategic level, at the tactical level or trying to cover both. Olhager *et al*. (2001), Olhager & Rudberg (2002), and Olhager & Selldin (2007), for instance, situated S&OP as being part at the strategic and part at the tactical levels of the manufacturing planning and control (MPC) system. These authors recognized not only that balancing supply and demand at aggregate or product levels is a tactical issue but also that this balancing might at times require the expansion of productive capacity, for example, which is clearly a strategic issue. Therefore, they classified S&OP as partly tactical and partly strategic. However, the dominant perception of the role of S&OP is at the tactical level. Most papers covering the planning function situated S&OP at the tactical level of the planning hierarchy, bridging the corporate strategic plan to operations. Planning horizons, usually situated between 6 and 18 months, can vary from 3 to 6 months (Gianesi, 1998) to a longer time span of over 18 months (Basu, 2001; Wallace, 2006; Godsell *et al*., 2010; Baumann, 2010; Smith *et al*., 2010).

3.2.3.2
Inputs and Goals

Study descriptors of inputs are presented in Table 3.2. The classification emerged from the papers reviewed. The typology of inputs was organized by cross-tabulating the retrieved papers for this review (see Table 3.1) in the categories of demand, source, production, delivery, and finance with the input levels of plans, constraints, and others. Although planning processes are usually constrained plans, Table 3.2 reports them separately, reflecting their positioning in the original papers. The large majority of papers described inputs as plans for demand, sales, and production. Plans related to procurement, supply, distribution and finance are also considered in the input category of descriptors, but to a lesser extent. Production capacity is one of the most relevant operations restrictions to the S&OP process. Finance constraints are introduced mainly as budgetary restrictions and as financial goals (product margins and profitability).

Table 3.2: Classification of Inputs to the S&OP process

Type of Inputs	**Input Levels**		
	Plans	**Constraints**	**Other**
Demand			
Demand and functional plans (marketing and sales)	Ivert & Jonsson (2010), Gianesi (1998), Nakano (2009), Godsell et al. (2010), Collin & Lorenzin (2006), Hadaya & Cassivi (2007), Sehgal et al. (2006), Affonso et al. (2008), Bower (2005), Boyer (2009), Burrows (2007), Chen Ritzo et al. (2010a), Feng et al. (2008), Grimson & Pyke (2007), Harwell (2006), Lapide (2002, 2004a, 2004b, 2005, 2006), Menzter & Moon (2004), Milliken (2008), Olhager & Rudberg (2002), Olhager et al.(2001), Olhager & Selldin (2007), Piechule (2008), Reyman (2005), Singhal & Singhal (2007), Slone et al. (2007), Wallace (2006), Wallace & Stahl (2008), Whisenant (2006), Malhotra & Sharma (2002), Nielsen et al. (2010), Oliva & Watson (2011), Chou et al. (2007), Paiva (2010), Olhager (2010), Singh (2010), Smith et al.(2010), Baumann(2010), Baumann & Andraski (2010)		
Sales / demand forecasts	Feng *et al*. (2008), Mellen et al. (2010), Menzter & Moon (2004), Lapide (2009a), Muzumdar & Fontanella (2006), Muzumdar & Viswanathan (2009), Tohamy (2008), Chen Ritzo et al. (2010b), Oliva & Watson (2011), Goodwin et al. (2010), Paiva (2010), Singh (2010), Smith et al.(2010), Baumann(2010), Baumann & Andraski (2010)		
Demand impacts (e.g., competitors' actions)			Grimson & Pyke (2007), Lapide (2002)

Table 3.2: Classification of Inputs to the S&OP process (cont.)

Type of Inputs	**Input Levels**		
	Plans	**Constraints**	**Other**
Marketing and sales actions			Chen Ritzo *et al*. (2010a), Grimson & Pyke (2007), Lapide (2004a), Lapide (2009b), Menzter & Moon (2004), Keal & Hebert (2010)
Information on customers			Hadaya & Cassivi (2007), Burrows (2007), Lapide (2004a), Grimson & Pyke (2007), Lapide (2004b)
Information on sales	Oliva & Watson (2011)		Burrows (2007), Menzter & Moon (2004), Piechule (2008)
Source			
Procurement / supply plan	Ivert & Jonsson (2010), Affonso et al. (2008), Chen Ritzo et al. (2010a), Lapide (2002), Lapide (2006), Whisenant (2006), Smith *et al*. (2010)		
Lead time		Affonso *et al*. (2008), Chen Ritzo et al. (2010b), Olhager (2010)	
Supply capacity		Lapide (2004a), Olhager (2010)	
Supplier constraints		Chen Ritzo *et al*. (2010a), Olhager (2010)	
Purchasing data	Olhager (2010)		Nakano (2009)
Information on supplier			Hadaya & Cassivi (2007), Burrows (2007), Grimson & Pyke (2007), Lapide (2004a)

Table 3.2: Classification of Inputs to the S&OP process (cont.)

Type of Inputs	Input Levels		
	Plans	**Constraints**	**Other**
Raw material forecast			Piechule (2008)
Production			
Production / capacity plan	Ivert & Jonsson (2010), Sehgal et al. (2006), Affonso et al. (2008), Bower (2005), Chen Ritzo et al. (2010a), Feng et al. (2008), Harwell (2006), Lapide (2004b), Lapide (2006), Menzter & Moon (2004), Milliken (2008), Muzumdar & Viswanathan (2009), Olhager et al.(2001), Slone et al. (2007), Whisenant (2006), Nielsen et al. (2010), Oliva & Watson (2011), Chou et al. (2007), Singh (2010), Baumann (2010), Keal & Hebert (2010)		
Inventory	Ivert & Jonsson (2010), Gianesi (1998), Nakano (2009), Godsell et al. (2010), Collin & Lorenzin (2006), Hadaya & Cassivi (2007), Sehgal et al. (2006), Affonso et al. (2008), Bower (2005), Boyer (2009), Burrows (2007), Feng et al. (2008), Grimson & Pyke (2007), Lapide (2002), Lapide (2004a), Lapide (2004b), Lapide (2006), Lapide (2009a), Mellen et al. (2010), Menzter & Moon (2004), Milliken (2008), Muzumdar & Fontanella (2006), Muzumdar & Viswanathan (2009), Olhager & Rudberg (2002), Olhager et al.(2001), Olhager & Selldin (2007), Piechule (2008), Reyman (2005), Singhal & Singhal (2007), Slone et al. (2007), Tohamy (2008), Wallace (2006), Wallace & Stahl (2008), Whisenant (2006), Malhotra & Sharma (2002), Goodwin et al. (2010), Smith et al.(2010), Baumann(2010), Baumann & Andraski (2010)		

Table 3.2: Classification of Inputs to the S&OP process (cont.)

Type of Inputs	**Input Levels**		
	Plans	**Constraints**	**Other**
Production capacity		Ivert & Jonsson (2010), Gianesi (1998), Nakano (2009), Godsell et al. (2010), Collin & Lorenzin (2006), Hadaya & Cassivi (2007), Sehgal et al. (2006), Affonso et al. (2008), Boyer (2009), Burrows (2007), Feng et al. (2008), Grimson & Pyke (2007), Lapide (2002), Lapide (2004a), Lapide (2004b), Lapide (2006), Mellen et al. (2010), Menzter & Moon (2004), Milliken (2008), Muzumdar & Fontanella (2006), Muzumdar & Viswanathan (2009), Olhager & Rudberg (2002), Olhager et al.(2001), Piechule (2008), Reyman (2005), Singhal & Singhal (2007), Slone et al. (2007), Tohamy (2008), Wallace (2006), Wallace & Stahl (2008), Whisenant (2006), Malhotra & Sharma (2002), Nielsen et al. (2010), Chou *et al*. (2007)	
Work-force level		Feng *et al*. (2008), Olhager et al.(2001), Singhal & Singhal (2007)	
Operational resources		Nakano (2009), Nielsen et al. (2010), Keal & Hebert (2010)	
Other operational constraints		Nakano (2009), Milliken (2008), Oliva & Watson (2011)	
Lead time		Affonso *et al*. (2008)	
Production time		Ivert & Jonsson (2010)	
Flexibility		Affonso *et al*. (2008)	
Contingencies (e.g. strikes)			Lapide (2002)

Table 3.2: Classification of Inputs to the S&OP process (cont.)

Type of Inputs	**Input Levels**		
	Plans	**Constraints**	**Other**
Delivery			
Distribution plan	Milliken (2008), Whisenant (2006), Olhager (2010), Baumann (2010)		
Delivery capacity		Hadaya & Cassivi (2007), Lapide (2004b)	
Lead time		Ivert & Jonsson (2010), Affonso et al. (2008), Mellen et al. (2010), Chou et al. (2007), Baumann (2010)	
Other constraints		Harwell (2006)	
Transportation status		Slone *et al*. (2007)	
Service capacity		Collin & Lorenzin (2006)	
Service level targets		Mellen *et al*. (2010), Smith et al.(2010), Baumann (2010)	
Finance			
Financial plans	Harwell (2006), Whisenant (2006), Oliva & Watson (2010), Chou et al. (2007), Singh (2011), Smith *et al*. (2010)		
Budgets		Gianesi (1998), Bower (2005), Grimson & Pyke (2007), Harwell (2006), Lapide (2002), Lapide (2004a), Lapide (2006), Menzter & Moon (2004), Tohamy (2008), Wallace (2006), Wallace & Stahl (2008), Whisenant (2006), Baumann (2010)	
Financial goals		Menzter & Moon (2004), Tohamy (2008), Singh (2010), Smith et al.(2010), Baumann (2010)	

The goals of the S&OP process emerged from the literature review and were grouped by similarity in the categories of:

(i) Alignment and integration (vertical alignment and integration, align/balance demand and supply, align different firm functions, align/integrate plans, refines/adjusts/improves functional plans, horizontal alignment within the supply chain);

(ii) Operational improvement (improve forecast, improve operational performance, reduce/manage inventory and stock-outs, manage/balance/align volume and mix, manage/balance/align capacity resources, manage constraints, manage uncertainly and risk, allocate critical resources, optimize supply capability, aid new product introduction, measure value creation, measure/review business performance);

(iii) Results Focused on a Single Perspective (improve business/supply chain performance, improve revenue, improve customer service, minimize business/supply chain costs, minimize demand distortion, conduct yield management/pricing);

(iv) Results Based on Trade-offs (increase/optimize enterprise profits, optimize customer service vs. inventory, meet demand with reduced inventory, meet customer needs with minimum cost);

(v) End-results (gross profit return on space, return on net assets, gross profit return on inventory, company/product profitability, contribution margins).

Table 3.3 shows descriptors of S&OP goals. Balance of supply and demand, vertical and cross-functional alignment, integration of plans, their refinement and improvement, and horizontal alignment within the supply chain with customers and suppliers are important drivers to the S&OP process. Several studies focused on operational improvements in specific areas, such as forecast, inventory, management and balance of the mix and the volume of products, and capacity resources. They also focused on the operational aspects of managing risks and constraints, allocating resources, assisting in new product development, and improving measurement of value creation and business performance. End-result focused goals appeared as improvements of the performance of the business and of the supply chain, increased revenues, enhanced customer services, and minimization of demand distortion. Descriptors were also presented as trade-offs, maximizing profits or customer level at minimum inventory and supply chain costs. The integration of marketing practices of yield management and dynamic pricing appeared in few studies, reflecting the noted absence or low levels of integration of financial goals and financial plans into S&OP practice (Grimson & Pyke, 2007; Muzumdar & Viswanathan, 2009).

Table 3.3: References to S&OP goals

Goals	References
Alignment and integration	
Vertical alignment and integration	Ivert & Jonsson (2010), Gianesi (1998), Affonso et al. (2008), Bower (2005), Nielsen et al. (2010), Oliva & Watson (2011), Singh (2010), Smith et al.(2010), Baumann(2010), Keal & Hebert (2010)
Align / balance demand and supply	Chae (2009), Collin & Lorenzin (2006), Bower (2005), Boyer (2009), Chen Ritzo et al. (2010a), Feng et al. (2008), Grimson & Pyke (2007), Lapide (2002), Lapide (2004a), Lapide (2005), Muzumdar & Fontanella (2006), Muzumdar & Viswanathan (2009), Olhager et al.(2001), Wallace (2006), Malhotra & Sharma (2002), Chou et al. (2007), Goodwin et al. (2010), Singh (2010), Smith et al.(2010), Baumann(2010), Keal & Hebert (2010)
Align different firm functions	Ivert & Jonsson (2010), Gianesi (1998), Nakano (2009), Hadaya & Cassivi (2007), Affonso et al. (2008), Chen Ritzo et al. (2010a), Menzter & Moon (2004), Malhotra & Sharma (2002), 255, Oliva & Watson (2011), Chou et al. (2007), Paiva (2010), Singh (2010), Smith et al.(2010), Baumann & Andraski (2010)
Align / integrate plans	Ivert & Jonsson (2010), Bower (2005), Chen Ritzo et al. (2010a), Feng et al. (2008), Harwell (2006), Lapide (2009b), Mellen et al. (2010), Menzter & Moon (2004), Tohamy (2008), Nielsen et al. (2010), Oliva & Watson (2011), Singh (2010), Smith et al.(2010), Baumann (2010), Keal & Hebert (2010)
Refines / adjusts / improves functional plans	Basu (2001), Collin & Lorenzin (2006), Bower (2005), Chen Ritzo et al. (2010a), Harwell (2006), Lapide (2002), Lapide (2005), Lapide (2006), Lapide (2009b), Muzumdar & Fontanella (2006), Tohamy (2008), Wallace (2006), Oliva & Watson (2011), Smith et al.(2010), Baumann(2010), Keal & Hebert (2010)
Horizontal alignment within the supply chain	Gianesi (1998), Godsell et al. (2010), Hadaya & Cassivi (2007), Sehgal et al. (2006), Affonso et al. (2008), Lapide (2005), Menzter & Moon (2004), Nielsen et al. (2010), Baumann (2010)
Operational improvement	
Improve forecast	Bower (2005), Lapide (2002), Menzter & Moon (2004), Wallace & Stahl (2008), Nielsen et al. (2010), Baumann(2010), Keal & Hebert (2010)
Improve operational performance	Milliken (2008), Olhager & Selldin (2007), Nielsen et al. (2010), Goodwin et al. (2010), Olhager (2010)
Reduce / manage inventory and stock-outs	Collin & Lorenzin (2006), Muzumdar & Fontanella (2006), Piechule (2008), Reyman (2005), Paiva (2010), Baumann (2010)
Manage / balance / align volume and mix	Wallace (2006), Chen Ritzo et al. (2010b), Olhager (2010)
Manage / balance / align capacity resources	Collin & Lorenzin (2006), Burrows (2007), Olhager & Rudberg (2002)

Table 3.3: References to S&OP goals (cont.)

Goals	References
Manage constraints	Harwell (2006), Tohamy (2008)
Manage uncertainly and risk	Lapide (2009a), Lapide (2009b), Muzumdar & Fontanella (2006), Smith et al.(2010), Keal & Hebert (2010), Baumann & Andraski (2010)
Allocate critical resources	Milliken (2008)
Optimize supply capability	Collin & Lorenzin (2006)
Aid new product introduction	Godsell *et al*. (2010)
Measure value creation	Burrows (2007)
Measure / review business performance	Basu (2001), Bower (2005)
Results Focused on a Single Perspective	
Improve business /supply chain performance	Bower (2005), Slone et al. (2007), Malhotra & Sharma (2002), Oliva & Watson (2011), Paiva (2010)
Improve revenue	Collin & Lorenzin (2006), Chen-Ritzo *et al*. (2010b)
Improve customer service	Nakano (2009), Boyer (2009), Burrows (2007), Piechule (2008), Reyman (2005), Chou et al. (2007), Keal & Hebert (2010)
Minimize business / supply chain costs	Affonso *et al*. (2008), Boyer (2009), Lapide (2004a), Lapide (2004b), Lapide (2005), Olhager et al.(2001), Singhal & Singhal (2007)
Minimize demand distortion	Hadaya & Cassivi (2007)
Conduct yield management / pricing	Collin & Lorenzin (2006), Singhal & Singhal (2007), Paiva (2010)
Results Based on Trade-offs	
Increase / optimize enterprise profits	Godsell *et al*. (2010), Grimson & Pyke (2007), Menzter & Moon (2004), Muzumdar & Fontanella (2006), Muzumdar & Viswanathan (2009), Tohamy (2008), Whisenant (2006), Chou et al. (2007), Singh (2010), Baumann(2010), Baumann & Andraski (2010)
Optimize customer service vs. inventory	Lapide (2004b)
Meet demand with reduced inventory	Lapide (2004a), Lapide (2004b), Lapide (2005), Mellen *et al*. (2010)
Meet customer needs with minimum cost	Sehgal et al. (2006), Milliken (2008), Slone et al. (2007), Paiva (2010)

3.2.3.3
Structure and processes

Regarding the descriptors of S&OP structure and processes, the issue of who should participate in S&OP meetings was discussed mainly in the context of the firm: cross-functionality was sought through joint participation in meetings and communication channels by marketing, sales, production, logistics, sourcing, and to a lesser extent, finance. Some authors expanded participation to the supply chain, including both suppliers and customers (Gianesi, 1998; Basu, 2001; Collin & Lorenzin, 2006; Wallace, 2006; Hadaya & Cassivi, 2007; Singhal & Singhal, 2007; Slone *et al*., 2007; Grimson & Pyke, 2007; Nakano, 2009; Ivert & Jonsson, 2010), while others called this extension ‘collaborative planning, forecasting and replenishment’ (CPFR) (Smith *et al*., 2010; Baumann & Andraski, 2010). Most papers describing the S&OP process emphasized the need for regular meetings and for mechanisms to foster trust and confidence among the team. Meeting regularity varied from monthly to weekly; some authors suggested that frequent meetings are disruptive while others advocated an evolution from regular to event-driven, *ad hoc* meetings (Grimson & Pyke, 2007). Wallace & Stahl (2008) described a five-step monthly S&OP process used at most companies. The agenda for the first meeting is to gather and review data on actual supply and demand, inventory, backlog, and statistical forecasts. During the second meeting, the demand plan is reviewed, followed by a revision of supply plans in the third meeting. The fourth meeting is preparatory to the executive S&OP meeting. Decisions, recommendations, scenarios, and the agenda for the executive meeting are reviewed. The executive S&OP meeting closes the monthly process.

The existence of a formal S&OP structure and the empowerment of the S&OP team and of the individuals participating in the team are described as essential ingredients to the process (Lapide, 2002; Lapide, 2004a; 2005, 2006; Whisenant, 2006; Piechule, 2008; Singh, 2010). As a process descriptor, information systems are perceived as enabling technologies (Lapide, 2005), although some authors cautioned that at the initial stages, simple spread sheets can be used as S&OP scoreboards with the bulk of effort focused on strengthening the S&OP process and on empowering a formal team rather than heavily investing in complex and sophisticated information systems (Grimson & Pyke, 2007; Wallace & Stahl, 2008). The use of simulation techniques and mathematical models to optimize the integration of the supply and demand side of business as well as the role of advanced planning and scheduling systems (APS) in S&OP were discussed by Feng *et al*. (2008), Affonso *et al*. (2008), Ivert & Jonsson (2010), and Chen Ritzo *et al*. (2010a), among others.

3.2.3.4 Metrics

Metrics described in the S&OP literature are classified in Table 3.4. The five meta-processes of the SCOR framework (Supply Chain Council, 2001) were adapted for the S&OP classification in Table 3.4, complemented by frameworks proposed by Gunasekaran *et al*. (2001), Gunasekaran *et al*. (2004), and Chae (2009). At the plan level, most measures related to production, inventory levels, demand and order forecast, cash to cash, and product development cycle time. Lead time, quality, and information are the essential metrics for sourcing. Capacity and resource utilization, human resources productivity and production lead time, quality, costs, flexibility, variability, and shortages were regrouped under production. Delivery comprised timeliness, lead times, reliability, variability, speed, flexibility, costs, backlogs, and user satisfaction.

S&OP dashboards are instrumental in facilitating regular meetings and keeping up with a set agenda. Dashboards review functional plans and ensure adherence to the plans as measured by the comparison between planned and effected demand, production and inventory, a follow-up of forecast accuracy, and comparison of quantities shipped versus quantities ordered. End results are measured by profit rates and product margins. Although metrics were highlighted in many papers as being very important, none of the papers worked directly with metrics aimed at measuring the S&OP process itself.

Table 3.4: Classification of Metrics by references

Type of Metrics	Reference Numbers
Plan	
Inventory turnover	Chae (2009), Paiva (2010)
Inventory level (e.g. days of inventory & stock value)	Chae (2009), Nakano (2009), Boyer (2009), Milliken (2008), Reyman (2005), Whisenant (2006), Singh (2010), Baumann & Andraski (2010)
Track variations in inventory level	Hadaya & Cassivi (2007)
Rate of obsolete inventory	Chae (2009), Boyer (2009), Reyman (2005), Paiva (2010)
Cash-to-cash cycle time	Chae (2009), Whisenant (2006), Paiva (2010)
Planning cycle time	Chae (2009)
Forecast volatility	Chae (2009)
Track variations in customer demand	Hadaya & Cassivi (2007)
Order fill rate	Boyer (2009), Singh (2010), Keal & Hebert (2010)
Product development cycle time	Grimson & Pyke (2007)
Level of customer perceived value of product	Burrows (2007)
Total production	Milliken (2008)
Source	
Lead time	Chae (2009)
Materials quality	Chae (2009)
Supplier fill rate	Singh (2010)
Track variations of deliveries with suppliers	Hadaya & Cassivi (2007)
Production	
Capacity utilization	Chae (2009), Grimson & Pyke (2007), Lapide (2004b), Milliken (2008), Piechule (2008)
Production lead time	Chae (2009), Chou *et al*. (2007)
Production quality	Chae (2009)
Track variations in production	Hadaya & Cassivi (2007), Chou *et al*. (2007)
Flexibility (product, volume, mix)	Gianesi (1998), Chou *et al*. (2007)
Production costs	Gianesi (1998), Nakano (2009), Chou *et al*. (2007)
Human resource productivity index	Chae (2009)
Production capacity shortages	Lapide (2004b)
Delivery	
On-time delivery of goods	Godsell *et al*. (2010), Chae (2009), Boyer (2009), Milliken (2008), Reyman (2005)
Lead time	Nakano (2009), Chou *et al*. (2007)
Delivery reliability performance	Gianesi (1998)
Track variations in delivery capability	Hadaya & Cassivi (2007)
Delivery speed	Gianesi (1998), Nakano (2009), Olhager (2010)
Delivery flexibility	Gianesi (1998), Olhager (2010)
Distribution costs	Godsell *et al*. (2010), Milliken (2008), Singh (2010)
Customer satisfaction/retention	Sehgal et al. (2006), Lapide (2004b), Baumann(2010), Keal & Hebert (2010)

Table 3.4: Classification of Metrics by references (cont.)

Type of Metrics	Reference Numbers
S&OP Dashboard	
Accuracy of forecast techniques	Chae (2009), Bower (2005), Boyer (2009), Grimson & Pyke (2007), Lapide (2004a), Lapide (2004b), Milliken (2008), Reyman (2005), Whisenant (2006)
Adherence to sales, marketing and operations plan	Lapide (2004a), Lapide (2004b), Paiva (2010)
Forecast versus order	Chae (2009)
Total sales as a proportion of demand	Milliken (2008), Paiva (2010)
Variance regarding baseline forecasts and budgets	Lapide (2004a), Lapide (2004b)
Measurement of major strategic initiatives	Bower (2005)
Actual versus planned demand	Milliken (2008)
Actual versus planned production	Milliken (2008)
Actual versus planned inventory	Milliken (2008)
Actual quantities shipped versus quantities ordered	Milliken (2008)
End-Results	
Gross profit return on space (GPROS)	Harwell (2006)
Return on net assets (RONA)	Keal & Hebert (2010)
Gross profit return on inventory (GPROI)	Harwell (2006)
Company/product profitability	Grimson & Pyke (2007), Singh (2010), Keal & Hebert (2010)
Contribution margin ($/lbs)	Milliken (2008)

3.2.3.5
Outcomes

The main outcome posited in the search synthesis framework was the integration of plans. It appears as an input in Table 3.2 in 44 papers (as integrated demand and functional plans), fifteen papers quote integrated sales and demand forecasts, eight quotes procurement and supply planning, 21 refers to integrated production/capacity plan, and yet forty-one papers include plans for inventory as inputs to the S&OP process. Those papers reported partial or comprehensive integration among marketing, sales, and operations. The inclusion of finance plans in this integration was considered by a smaller number of papers, with only six papers clearly quoting finance planning as a key input into the S&OP process.

3.3 Evidences of S&OP impact on performance

Among the 55 papers reviewed, just six papers analyzed the impact of S&OP on the performance of the firm. Two used mathematical modeling (Feng et al., 2008) or case studies (Oliva & Watson, 2011). Four used survey data to empirically validate theory (McCormack & Lockamy, 2005; Hadaya & Cassivi, 2007; Ollager & Selldin, 2007; Nakano, 2009). In all cases, the performance of the firm was measured differently, making comparisons and cumulative meta-analysis difficult.

Feng et al. (2008) applied a mixed integer-based programming model to empirical data obtained from a make-to-order manufacturing environment in Canada. Three models were compared: a multi-site, integrated and centralized cross-functional planning model of sales, production, distribution, and procurement; a model with centrally integrated sales and production but with local purchasing and distribution decisions; and a traditional decoupled plan with centralized sales functions and decentralized/separated functions of production, distribution, and procurement planning. They concluded that the fully integrated model results in higher financial returns than the partially integrated S&OP and that the partially integrated model outperformed the decoupled planning model.

Oliva & Watson (2011) described a case study of sales and operations planning in a global consumer electronics company in which the structural determinants of performance, such as work groups, incentives and rewards, are separately set for the different functions of the firm (sales, marketing, operations and finance). The functional misalignments identified were the traditional Shapiro's cross-functional conflicts (Shapiro, 1977); this finding reinforced the generalizability of the study's results. In conducting the case study, the authors employed semi-structured interviews, direct observation of planning and forecast meetings, and the review of documents. The planning process was defined as a "sequence and interdependency of activities designed to achieve a goal". The general goal was the integration of demand planning (forecasts, market analysis, promotions, and new product launches) and supply planning (master schedule, material requirement, production, and distribution) and the organization of the flow of information among them. It is hypothesized that S&OP has an intermediate role between the structural determinants of cross-functional alignment and firm performance through the mediating effects of information quality, procedural quality and alignment quality. Furthermore, it is posited that alignment quality is more important in determining performance than the constructs of information quality and procedural quality. It is argued that the attributes of the S&OP process affect firm performance even when the functional structure and incentives are contradictory and defined in isolation from each other.

Ollager & Selldin (2007) found that S&OP and master planning play a mediating role between market uncertainty and the firm's results. Nakano (2009) found a positive relationship between internal and external alignments and their effects on performance. Hadaya & Cassivi (2007) found positive effects of collaboration and information systems on performance. McCormack & Lockamy (2005) found significant positive correlations between informal organization, formal groups, integrating roles, and network building and performance.

The remaining of this section focus on the studies that used survey data to validate S&OP theories-based studies as described in Section 3.1. Survey-based S&OP research that focuses on firm performance is depicted in Table 3.5, and the main results of these papers are summarized in Table 3.6. Table 3.5 presents the basic measures of scale questionnaire development, internal construct reliability, convergent and discriminant validity (Hensley, 1999; Brahma, 2009), and overall structural equation model fit (Shah & Goldstein, 2006).

Construct validity indicates the degree to which the scale measures the abstract concept (construct) that it is intended to measure. Internal construct reliability refers to the internal homogeneity of the items composing a construct when compared with other constructs. Reliability is usually measured by Cronbach's alpha coefficient. Cut-off values are often set at 0.7 for confirmatory and 0.6 for exploratory data analysis (Hensley, 1999; Hadaya & Cassivi, 2007; Brahma, 2009).

Convergent validity measures the correlation among different measures of the same construct. Discriminant validity verifies whether the scales measuring different constructs have low correlation (Hensley, 1999); it indicates the uniqueness of the item measures in defining a construct (Hadaya & Cassivi, 2007).

In the four papers reviewed in Table 3.5, survey questionnaires were sorted for construct validity through literature reviews, interviews, and pretest. McCormack & Lockamy (2005) did not report on pretests. Ollager & Selldin (2007) did not report on confirmatory interviews and pretests. All papers met with low response rates, but all researchers except McCormack & Lockamy (2005) reported tests for answers from early and late respondents and did not find any significant differences; this result indicates a low probability of non-response sampling bias. All four papers reported partial coefficients and a test of statistical significance. None of the papers reported on statistical power.

Different aspects of the S&OP process are evaluated. McCormack & Lockamy (2005) identify the specific horizontal mechanisms deployed within the S&OP process and statistically examine their relationship with supply chain performance. Olhager & Selldin (2007) investigated the mediating role of planning and control approaches (S&OP and master planning) between market uncertainty and firm performance. Hadaya & Cassivi (2007) aim "to measure the influence of joint collaboration planning actions, inter organizational information systems (IOISs) use and firm flexibility". Finally, Nakano (2009) focused on the effect of internal and external alignment (collaborative forecasting and planning – CFP) on logistics and production performance.

Firm performance was measured differently in each study. The four papers reviewed in Table 3.5 reported measurements of performance with the use of five-point Likert scales for all constructs, but Hadaya & Cassivi (2007) used a seven-point scale.McKormack & Lockamy (2005) applied a Likert scale of self-assessed performance ratings of supply chain management in the following four areas: plan, source, make and deliver. Olhager & Selldin (2007) measured performance with Likert scales comparing competitors in terms of delivery speed, delivery reliability, volume flexibility and product-mix flexibility.

Table 3.5: Survey research regarding the effect of S&OP on firm performance

Author	Ollager & Selldin (2007)	Nakano (2009)	Hadaya & Cassivi (2007)	McCormack & Lockamy (2005)
Empirical Setting	2001 Mail questionnaire in Sweden	2001 Mail questionnaire in Japan	e-mail survey in US and Canada	Mail survey in the U.S.
Response Rate	25%	25%	40.8%	10.5%
Non-response Rate Bias Reported	Yes: late respondents versus early respondents	Yes: late respondents versus early respondents	Yes: late respondents versus early respondents	No
Response Bias	No (p = 0.05)	No (p < 0.05)	Non-significant t-test	Not reported
Usable Sample	n = 128	n = 65	n = 53	n = 55
Sorting of Items - Content Validity	Literature review	Literature review. 22 in-depth interviews.	Literature review. Interviews with SCM managers and buyers supplemented with on-site observation and secondary documentation	Literature review. Interviews with SCM experts and practitioners
Questionnaire Pretest	Not reported	With four SCM or logistics managers and one consultant	With OEM's supply management, eSourcing groups, first-tier suppliers	Not reported
Scale Measurement	Five-point Likert scale and floating scales	Five-point Likert scale	Seven-point Likert scale	Five-point Likert scale
Constructs	Marketing uncertainty (alpha = 0.74)	Internal CFP - alpha = 0.829	Joint collaboration planning actions - AVE = 0.74	Integrating role - alpha = 0.746
	MPC approaches (alpha = 0.66)	CFP with suppliers - alpha = 0.910	Strength of relationships - AVE = 0.92	Formal group - alpha = 0.7691
	Performance (alpha = 0.70)	CFP with costumers - alpha = 0.904	Firm flexibility (AVE = 0.55)	Informal Organization - alpha = 0.46
		Performance - alpha = 0.780		Network building - alpha = 0.8195
Number of Items in Scales	9	18	10	32

Table 3.5: Survey research regarding the effect of S&OP on firm performance (cont.)

Author	**Ollager & Selldin (2007)**	**Nakano (2009)**	**Hadaya & Cassivi (2007)**	**McCormack & Lockamy (2005)**
Model Fit Indices	Chi-square, RMSEA, CFA standard loadings and Cronbach's alpha	$\chi 2$, df, $\chi 2$/df, p, GFI, RMR, CFI, IFI, NNFI	$\chi 2$, Normed $\chi 2$, df, p-value, RMSEA, SRMR, CFI, TLI	Not reported
Reliability	Cronbach's alpha (a)	Cronbach's alpha (b)	AVE and Jöreskog coefficient	Cronbach's alpha (b)
Convergent Validity	CFA standard loadings	CFA, standardized coefficients, t-values	CFA load, p coefficient and AVE	Not reported
Discriminant Validity	Not reported	CI test	Square root of AVE and correlations among constructs	Not reported
Coefficients Reported	Partial regression coefficients	Partial regression coefficients	Partial least square coefficients	Bivariate regression coefficients
Ci for Coefficients	No	No	No	No
t- test for Coefficients	No	Yes	No	No
p Value Reported	Yes	Yes	Yes	Yes

Hadaya & Cassivi (2007) applied Likert scales to constructs of firm flexibility: product volume and mix, new product introduction, and delivery flexibility. Nakano (2009) applied Likert scales to measure logistics costs, manufacturing costs, final product inventory levels, order fill rate, delivery speed, and delivery times. The diversity of definitions and measurements of firm performance renders comparisons and cumulative meta-analysis difficult.

The main results are summarized in Table 3.6, in which the theoretical statements (propositions), hypotheses and correlation coefficients among the study descriptors are reviewed. The expected sign of correlation coefficients are shown between parentheses on the hypothesis column.

The results obtained by McKormack & Lockamy (2005) strongly suggest that organizations can enhance their S&OP processes by deploying horizontal mechanisms that are designed to facilitate intra- and inter-organizational collaboration and integration. The horizontal mechanisms that were significant and not surprising in this study were the positive relationships between the existence of integrating roles and firm performance and between formal S&OP organization and firm performance. However, the strong regression coefficient for the informal organization mechanism was surprising; this coefficient essentially reflects a high level of cross-functional collaboration. This result indicates that the “soft” aspects of implementing an S&OP process can be very important. Network-building practices were also shown to improve performance. The authors measured S&OP results with a five point Lickert scale on self-assessed performance of the firm.

Olhager & Selldin (2007) measured market uncertainty asking respondents to rank from 1 to 5 the following market requirements: product design, product variety, individual volume per product, and delivery speed. Low market uncertainty will correspond to manufacturing environments with high volume, standardized products with few variants, short delivery and production lead times. Market uncertainty was related to the choice of material planning and control methods: S&OP, master scheduling, material planning, and production activity control. Only S&OP and master scheduling were kept for final regression

Table 3.6: Study results on the effects of S&OP on firm performance

Study	Propositions	Hypothesis	Partial coefficients
Ollager & Selldin (2007)	Market uncertainty directly affects the choice of Manufacturing Planning and Control (MPC) approaches	H1: Marketing uncertainty and MPC approaches (+)	0.553 (p<0.001)
	The choice of MPC approaches directly affects performance	H2: Choice of MPC approaches and performance (+)	0.258 (p=0.117)
	Market uncertainties negatively affects performance	H3: Marketing uncertainty and performance (-)	-0.383 (p=0.013)
	The effect of MPC approaches mediates the effect of market uncertainties on operational performance	H1 x H3 (= 0.553 x 0.258)	0.143
Nakano (2009)	High degrees of internal CFP directly affects CFP with suppliers	H1a: internal CFP and CFP with suppliers (+)	0.835 (p<0.01)
	High degrees of internal CFP directly affects CFP with retailers	H1b: internal CFP and CFP with wholesalers/retailers (+)	0.612 (p<0.01)
	High degrees of CFP with suppliers directly affects CFP with retailers	H2: CFP with suppliers and CFP with wholesalers/retailer (+)	0.58 (p< 0.01)
	Internal CFP impacts upon relative performance	H3: Internal CFP and performance (+)	0.746 (p<0.05)
	CFP with suppliers directly affects performance	H4a: CFP with suppliers and performance (+)	-0.174 (n.s.)
	CFP with retailers directly affects performance	H4b: CFP with wholesalers/retailers and performance (+)	-0.009 (n.s.)

Table 3.6: Study results on the effects of S&OP on firm performance (cont.)

Study	Propositions	Hypothesis	Partial coefficients
Hadaya & Cassivi (2007)	Joint collaboration planning actions among partners in the supply chain influence the strength of relationships	H1: Joint collaboration planning and strength of relationships (+)	0.731 (p<0.01)
	Joint collaboration planning actions will influence the use of interorganizational information systems (IOISs)	H2: Joint collaboration planning and IOISs use (+)	0.451 (p<0.01)
	The strength of relationships directly influences the use of IOISs	H3: Strength of relationships and IOISs use (+)	0.493 (p<0.01)
	Joint collaboration planning actions will influence firm flexibility	H4: Joint collaboration planning and firm flexibility (+)	- 0.299 (n.s.)
	The strength of relationships will influence firm flexibility	H5: Strength of relationships and firm flexibility (+)	0.09 (n.s.)
	The use of IOISs will influence firm flexibility	H6: IOISs use and firm flexibility (+)	0.659 (p<0.001)
McCormack & Lockamy (2005)	Defined integrating roles affects performance	Integrating role and firm performance (+)	0.3285 (p=0.05)
	The existence of formal groups affects performance	Formal groups and firm performance (+)	0.4402 (p=0.05)
	The practice of informal exchanges affects performance	Informal organization and firm performance (+)	0.5054 (p=0.05)
	The practice of network building affects performance	Network building and firm performance (+)	0.2442 (p=0.05)

analysis. The authors found that market uncertainty has a negative effect on performance (-0.383). The negative effect can be partially mitigated by the optimal choice of MPC (S&OP and master scheduling). The indirect effect of market uncertainty through MPC approaches is 0.143 (0.5 x 0.258).

Olhager & Selldin (2007) conclude that "Sales and Operations Planning (...) have a significant and positive mediating role for improving operational performance in manufacturing environments that are characterized by market uncertainty". However, the magnitude of the indirect regression coefficient between market uncertainty and S&OP does not offset the direct negative effect of uncertainty on performance. S&OP appear to be a condition necessary but not sufficient to mediate the effects of market uncertainty on performance.

According to Hadaya & Cassivi (2007), without joint collaborative planning such as S&OP, strong relationships among partners and interorganizational information systems (IOISs), it would be impossible to implement the core process improvement that characterizes a demand-driven supply network. The performance measure in the supply chain adopted was flexibility (volume, launch of new products, access/distribution networks, product customization, and responsiveness to key markets). Interorganizational collaboration requires planning. The authors aim to provide exploratory evidences of the relationship of joint collaboration planning actions on the strength of the relationship among partners, IOISs and firm flexibility.

Hadaya & Cassivi (2007) surprisingly did not find a positive effect of joint collaborative actions on flexibility. However, they found direct, positive effects between joint collaborative planning actions and the strength of relationships and between joint collaborative planning and the use of inter-organizational information systems (IOISs). These researchers also found that the strength of relationships positively influences the use of IOISs. Regarding indirect effects, IOISs was found to be an important mediator of the effect of the following: (i) joint collaboration planning actions on firm flexibility, with an indirect effect of 0.57 (0.812 x 0.619) as opposed to a direct effect of -0.257 and (ii) the strength of relationships on firm flexibility, with an indirect effect of 0.44 (0.828 x 0.535) as opposed to a direct effect of -0.028. It is interesting to note that flexible manufacturing is expected to respond better under joint planning and that stronger relationships are expected to favor flexibility. Yet, the authors found negative direct effects of joint planning and of the strength of relationships on flexibility. They hypothesize that joint planning and collaboration might well focus on other goals than flexibility, resulting in low or negative statistical effects among variables. The positive effects of a demand driven S&OP only happens through the adoption of IOISs.

Nakano (2009) quantifies the effect of collaborative forecasting and planning (CFP) in the supply chain (S&OP) on operational measures of performance, namely logistics and production. Operational results were measured by logistics costs, manufacturing costs, inventory, order fill rate, delivery speed and times. Collaborative forecasting and planning were subdivided into the following dimensions: information sharing (standardized and customized), coordination by plan and by feedback, collaborative process redesign and continuous process improvement. These dimensions were separately analyzed internally, with main suppliers and with main costumers.

A positive relationship between internal collaborative forecasting and planning and firm performance was found. A positive relation was also found between internal collaborative forecasting and planning and collaborative forecasting and planning with main suppliers and with main wholesalers/retailers. This result is consistent with previous findings from Gimenez & Ventura (2003, 2005) and from Stank et al. (2001). However, the correlation observed with upstream firms was stronger than the correlation observed with downstream firms. There was no evidence of effect of external CFM on operational performance in the Japanese firms surveyed.

The main elements of S&OP analyses and its effect on the performance of the firm are summarized in Table 3.7.

Table 3.7: Study results on the effects of S&OP on firm performance

Authors	S&OP elements analyzed	Effects on Performance
McCormack &Lockamy (2005)	• Integrators role - assigning Supply Chain (SC) responsibilities to functional managers • Informal groups – information sharing • Creation of a formal S&OP team • Network building practices with regular meetings and integration within a firm and in the SC	All elements are positively related to manager's self-assessment of firm performance in the supply chain. The strong regression coefficient found for informal groups stresses the relevance of "soft" aspects of information sharing and cross-functional alignment.
Olhager & Selldin (2007)	• Choice of S&OP for "chase demand" or S&OP for level demand (production at a steady pace)	Market uncertainty is positively related to the choice of S&OP strategy (chase or level). S&OP is positively related to results. The appropriate choice of S&OP strategy have a mediating role between market uncertainty and performance measured by quality, delivery speed, delivery reliability, volume flexibility and mix flexibility. S&OP mitigate but do not offset the negative impact of uncertainty on performance.
Hadaya & Cassivi (2007)	• Joint collaborative planning such as demand driven S&OP among SC partners	S&OP with SC partners does not directly influence performance measured as flexibility (volume, launch, access/distribution, product-mix, responsiveness to markets). A firm would gain on flexibility only if it uses interorganizational information systems (IOISs) to burst collaborative planning and strength relationships. S&OP as a collaborative planning tool will positively influence the strength of relationships and IOISs use.
Nakano (2009)	• Internal collaborative forecasting and planning • External collaborative forecasting and planning	S&OP enhance collaboration with suppliers and with costumers, although the effect of S&OP is higher with partners upstream in the SC than with those that are downstream. S&OP is also positively correlated with operational results in logistics and production. There was no evidence that external collaboration with partners upstream and downstream in the SC would enhance performance. Results were drawn from specific industries in Japan.

3.4
Outlook

The systematic review of the extant literature on S&OP was meant as an effort to unite the disperse literature on the subject, as well as to identify and measure the effects of S&OP on firm performance. This section covers a synthesis of research findings and implications for research and practice.

3.4.1
Synthesis of research findings

Despite the growing interest in S&OP as evidenced by the number of papers recently published, efforts to synthesize the state-of-the-art in S&OP have so far been rather limited. This systematic review of the extant literature should fill this gap. The review was based on a research synthesis framework gathering S&OP descriptors in the broad areas of context information, inputs, structure and processes, outcomes, and results.

The theme of S&OP is treated predominantly in a prescriptive manner in the operations and organizational management literature. S&OP originated in industry, and several publications are still found in trade and industry magazines. Academic research in S&OP has been developed in past years, with a holistic approach to S&OP as a business process.

S&OP processes vary according to industrial contexts and manufacturing strategies. Most papers focused on the aggregate level of a family of products, and process cycles ranged from 3 to 18 months. The dominating perception of the role of S&OP is that it is predominantly a tactical planning tool, deployed once business and strategic plans are set, bridging these plans to operations. Although S&OP has mainly focused on an intra-company perspective, it has been gradually extended to the supply chain. The latter is often referred in the literature as CPFR.

Inputs to the S&OP process were plans from different functional areas and constraints mainly related to finance (budgets) and operations (production capacity). There are also a large variety of S&OP drivers or goals, such as reducing inventories, improving forecasts, balancing supply and demand, integrating plans intra and inter-firms, and improving results by optimizing revenues and profits.

Discussions on organizational aspects of S&OP emphasize who should participate in meetings and regularity of these meetings. There is no single rule, but authors agree on the need to define formal S&OP teams; to empower participants; and to ensure the participation of top management, key customers, and suppliers from the beginning of the process. Trust and confidence among team members are also emphasized. Information systems are viewed as essential to align strategies and operations. However, it seems that there is no agreement on the level of investment in information systems, particularly at the initial stages of the process. While some authors recommended simple spread sheets, others demonstrated the positive effects of advanced planning systems in S&OP.

The diversity of the maturity models underlying the empirical research and differences in operational definitions of the performance of the firm precluded a statistical analysis of S&OP results based on the literature search. Some aspects of the S&OP as a set of management practices correspond to more traditional areas of research in operations management and might be further explored through research synthesis and meta-analyses; in particular, the sub-processes of vertical and horizontal alignment (including cross functional integration) and their effects on new product development, the performance of the firm, and the supply chain.

Facing such a diversified array of S&OP process descriptors, it is difficult to quantify findings within the boundaries of a well-established and accepted framework. There are several papers dealing with discrete elements of S&OP (the so called S&OP management practices) and its effects on performance, but most are descriptive and prescriptive, e.g. the papers describe how the process should be and how it will impact performance. They also prescribe how practitioners could benefit from implementation. Yet, few papers are based on mathematical modeling, carefully designed case studies or survey data. The assumptions upon which constructs are based, the methodology and data sets are seldom presented. This makes scientific verification and validation difficult. Studies that are carefully designed, implemented and presented are still very few. Even among carefully conducted research papers, different measures of the performance of the firm in the supply chain are used, as depicted in column 4 of Appendix 2. This fact makes rigorous analysis of the effects of S&OP on firm performance difficult. The framework proposed in this literature review, which was based on S&OP maturity models, was valuable to summarize findings, but it did not lead to quantitative comparisons and measurements. Clearly, descriptors were identified and reviewed in accordance with the first purpose of the review, but this process did not lead to a statistical analysis of effect sizes. It seems that the literature in S&OP research is not yet ripe for meta-analysis.

Overall, there is a positive effect of S&OP in performance, although performance is measured in different ways by different authors. However, as quoted by Nakano (2009) most results depend on the sample of industries and countries included in the analysis. Also, some samples are small and the research is necessarily formative and exploratory (e.g., Hadaya & Cassivi, 2007). Despite those limitations, there is evidence of a positive impact of some elements of S&OP on the performance of the firm in the supply chain.

Ollager & Selldin (2007) estimate that S&OP processes attenuate the negative effect of market uncertainty on firm performance. Nakano (2009) suggests a positive correlation between the internal and external collaborations inherent in the S&OP process and firm performance. The correlation is more acute with suppliers than with distributors and wholesalers. Hadaya & Cassivi (2007) found that the effect of the organizational aspect of S&OP related to collaboration (formal groups and informal communication) on firm performance is mediated by the use of inter-organizational information systems. IOISs are important mediators of the effect of joint collaboration planning actions and the strength of the relationship (measured by scales of trust, commitment, and loyalty) on firm performance. McCormack & Lockamy (2005) found significant positive correlations between informal organization, formal groups, integrating roles, and network building with firm performance. The S&OP effect on firm performance is mediated by different descriptors, such as planning and control mechanisms, collaborative forecasting and planning, inter organizational information systems, and horizontal collaboration within a firm. Mathematical modeling by Feng et al. (2008) also shows that integrated planning yields a superior performance compared with traditional decoupled planning. Oliva & Watson (2011) hypothesize that the S&OP process affects performance even when functional incentives and rewards are contradictory and not prone to consensus and cross-functional alignment.

3.4.2
Implications for research and practice: future directions

Researchers may contribute further to the research on S&OP as a business process and as a cohesive set of management practices. There is a need for a better understanding of its effects on firm performance. There is still a lack of well documented case studies describing S&OP processes in different cultures and industries. Demonstrating how the findings obtained for specific industries and cultures can be generalized has yet to be achieved. Empirical data obtainable through surveys and in-depth interviews with managers and stakeholders in the supply chain are still lacking. Additional case studies and survey research are necessary to corroborate findings and to reveal new venues for research questions and hypothesis tests regarding the role of sales and operation planning in the supply chain.

Few survey papers on the effect of S&OP presented study descriptors in a detailed manner leading to a clear understanding of the strengths and limitations of the evidence presented. The S&OP effect on the results of the firm is mediated by different descriptors such as planning and control mechanisms, collaborative forecasting and planning, interorganizational information systems, and horizontal collaboration within the firm. It seems that there is at least partial evidence that the process in itself might make a difference for the performance of the firm, even when incentives and contracts are contradictory and do not encourage collaboration (Oliva & Watson, 2011). The partial evidence identified so far leaves room for additional empirical investigation, through case studies and survey research work, of the S&OP process and its determinants and consequences for the performance of the firm and of the supply chain.

Few papers presented descriptors that include financial plans, goals, and participants from financial departments. The need to further integrate the financial function and its owners into the S&OP process was highlighted by some authors and warrants further research.

As for the description of the process, measurement issues were highly dispersed and metrics varied widely among authors. Future research on this topic is also suggested.

Researchers may contribute further to the research on S&OP as a business process and as a set of management practices; and on its effects on firm performance. This research identifies the following five main venues of future research as it emerges from the literature review:

- First, the analysis of S&OP impact on firm performance should be expanded to different contexts (e.g., industries, countries or regions, manufacturing strategies, products, processes, planning horizons), in order to generalize its findings to different countries and industries.
- Second, additional case studies, survey data and modeling of the relationship between S&OP elements and performance are necessary before any definitive conclusions about S&OP effects could be generalized.
- Third, S&OP as a bundle of management practices is still to be analyzed and the impact of these practices on the performance of the firm ought to be evaluated. Good candidates are the prevalent practices of cross-functional coordination, internal and external alignment.
- Fourth, the factors that mediate S&OP impact on performance should be explored further.
- Fifth, a more homogeneous and agreed-upon framework to measure the performance of supply chains, such as the one described by Beamon (1999) should be applied to the measure of S&OP performance.

All the research gaps quoted above but the last are partly covered in Chapter 4.

Practitioners will be able to review a synthesis of different aspects of the S&OP process and have a better understanding of its role as a mediator of firm performance. There is at least partial evidence that cross-functional planning processes can mitigate the negative effect of misaligned organizational structures and contradictory incentives schemes on firm performance. Also, integrated planning was shown to be more effective in impacting upon firm performance than disaggregated planning. Practices of formal and informal communications between functions, networking and internal integrating roles can boost performance. Furthermore, the S&OP practice of internal alignment seems to facilitate supply chain integration with both suppliers and customers, particularly when inter-organizational information systems favor supply chain integration.

Based on the literature reviewed in this chapter, the research agenda was set for the empirical validations of S&OP impact on manufacturing operational performance. The empirical research is further described in Chapter 4.

4
Empirical investigation on the impact of S&OP on performance

This Chapter applies quantitative techniques to the analysis of S&OP impact on manufacturing performance, using the database of the fifth round of the International Manufacturing Strategy Survey (IMSS-V), further described in Section 4.1. Both the direct effect of S&OP on manufacturing performance and the contingent effect of technology as moderator of the effect of S&OP on performance will be analyzed. IMSS scales will be validated with confirmatory factor analysis in structural equation models. Three different models will be tested. The three models examine the following relationships: (i) the direct impact of internal S&OP practices, external integration with suppliers and customers, measured separately, on manufacturing operational performance; (ii) the moderator effect of product and process technology on the relationships between internal S&OP and manufacturing operational performance; (iii) the Lawrence & Lorsch (1967b) framework of fit between diversity and integration through technology in complex organizations, as it relates to a contingency theory view of S&OP as an "integrative device". The first two will be put to test with hierarchical stepwise multiple regressions. The third model will be measured with profile-deviation analysis and tested with simple linear regression. Regression model two and the profile-deviation analysis will be looking at validating fit as interaction and fit as system, respectively, consistent with definitions and theoretical background described in Chapter 3.

4.1
Research Methodology

This section is a brief presentation of the techniques used for data analysis and the survey dataset.

Data is analyzed using confirmatory factor analysis and structural equation modeling with maximum likelihood estimates in AMOS 19.0 (Arbuckle, 2010) and hypotheses were tested with the statistical significance of standardized regression coefficients and F-change statistics computed with hierarchical stepwise multiple regression in SPSS 19.0. The analysis of technology as profile deviation was based on calculations of the standard deviation of the Euclidean distance between the observed and average scores of the variables. A simple linear regression estimate was calculated in SPSS 19.0 and hypotheses tested with the statistical significance of the standardized regression coefficients. The procedures are further detailed in this chapter under measurement model sections for each mathematical model.

Survey data were drawn from the fifth round of the International Manufacturing Strategy Survey (IMSS-V). This global project periodically collects data on medium and large manufacturing firms (over 50 employees). The sample is a balanced representation of different sectors of manufacturing and assembly, with a larger proportion of manufacturer of metal products (ISIC 28) and machinery (ISIC 29). Semiconductor (ISIC 30), transportation (ISIC 35), advanced instruments (ISIC 33), and audio/video (ISIC 32) industries are least represented. About 50% of the sample was batch manufacturers, 26% was one-off producers, and 23% was mass producers (for more details on the sample, see Laugen & Boer, 2011 or the IMSS site: http://www.manufacturingstrategy.net). Questions were asked about the description, strategy and performance of the business unit; description, strategy and performance of manufacturing for the dominant activity of the plant; and about current manufacturing and supply chain practices, past and planned action programs. It was filled in by the companies' Director of Operations or equivalent from 34 countries, in 2009-2010. The survey was centrally coordinated to maximize consistency in data collection procedures across countries. Country offices translated the questionnaire into the local language when needed and were responsible for local data collection and verification. Companies and their contact information were initially identified by search in public or private databases in each country. Questionnaires were sent out to the target companies, followed by additional reminders and contacts for the completion of missing data. Altogether, 4,457 questionnaires were sent, resulting in 725 valid answers (16.3% response rate). Analysis of non-respondent biases on key demographics such as company size and ISIC codes were not significant, after testing for statistically significant differences between early and late respondents. The sample is spread over a large range of GDP per capita and firm sizes (number of employees) as depicted in Table 4.1.

Table 4.1: Distribution of firm sizes and GDP per capita by country – IMSS-V

Country	Respondents	Size (No. of employees)	2009 GDP Percapita in US$ (*)
Belgium	36	294	43799
Brazil	37	687	8251
Canada	19	205	39656
China	59	1198	3749
Denmark	18	110	56330
Estonia	27	134	14375
Germany	38	754	40275
Hungary	71	314	12635
Ireland	6	206	50034
Italy	56	253	35237
Japan	28	4447	39456
Korea	41	52	17110
Mexico	17	639	7876
Netherlands	51	192	47998
Portugal	10	251	22016
Romania	31	231	7500
Spain	40	270	31891
Switzerland	31	370	63568
Taiwan	31	2042	32300
UK	30	136	35129
USA	48	629	45793
Total	**725**	**623**	**29379**

Note (*) World Bank (2012)

4.2
S&OP and manufacturing operational performance

The development of the measurement model involved the selection of items to measure each construct, followed by validation using confirmatory factor analysis, in order to check for unidimensionality, validity and reliability. The two-step approach to structural equation models recommended by Anderson & Gerbing (1988) was adopted. Prior to the analysis, data were visually checked for errors and outliers, and assessed for skewness and kurtosis. Neither major outliers nor departures from the assumptions of normality and homocedasticity were detected.

4.2.1
Theoretical model and hypothesis

Hypotheses were based on the theoretical foundations of Chapter 2 (in particular Sub-section 2.1.2 “S&OP as management practices”) and will be tested based on the statistical significance of standardized regression coefficients and F-value. The model is depicted in Figure 4.1.

Hypotheses:

H1: Internal S&OP practices impact positively on manufacturing performance.

H2: Integration with suppliers impacts positively on manufacturing performance.

H3: Integration with customers impacts positively on manufacturing performance.

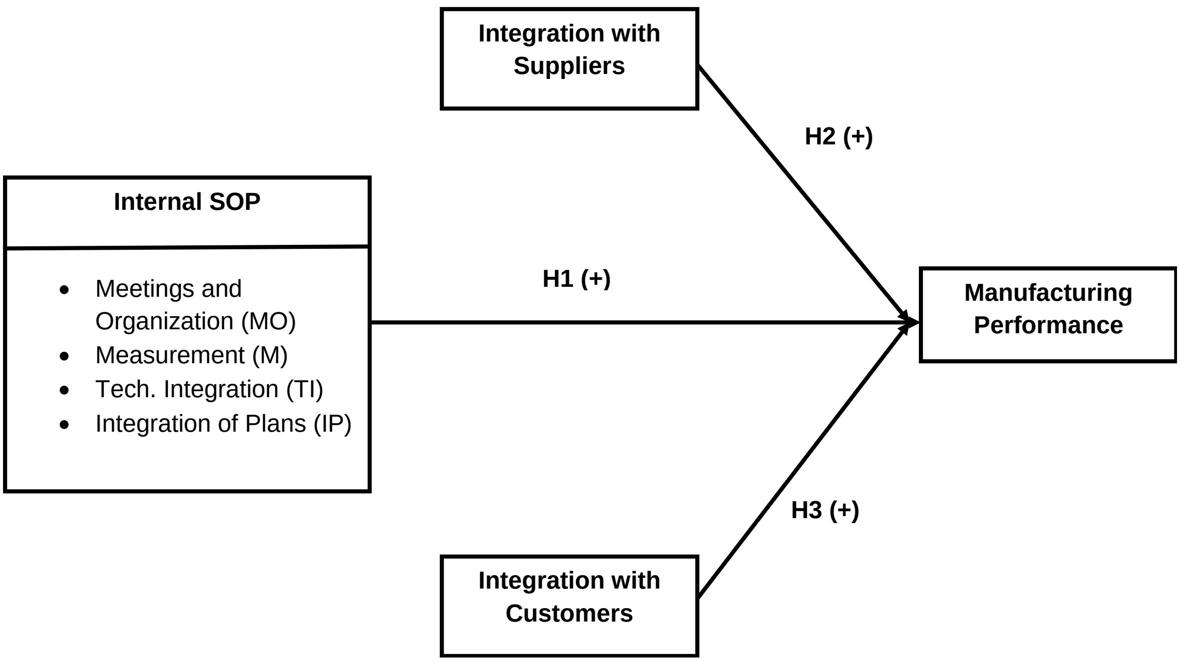


Figure 4.1: Theoretical model and hypotheses: Internal S&OP and integration with customers and suppliers.

4.2.2
Measures

The initial choice of items was based on theory; subsequently, a few items were dropped due to statistical reasons. The selection of the survey items to measure each construct was based on the following criteria: (i) content validity, e.g. the conceptual fit of the item with existing definitions for similar constructs in the literature (Ping, 2004); (ii) individual factor loadings being close to or higher than 0.6 (Chin, 1998); (iii) the extent to which the inclusion of the item contributed to the increase in overall model fit and; (iv) the need for the item to load in one factor only in confirmatory factor analysis, ensuring unidimensional constructs (Anderson & Gerbing, 1988). Consistent with our earlier conceptualization of S&OP, Internal S&OP is a second-order latent variable (e.g. formed by other latent variables), while the other S&OP constructs are first-order latent variables (e.g., directly formed by manifest or observed variables). Internal S&OP comprises the latent variables of integration of plans (IP), meetings and organization (MO), measurement (M) and technological integration (TI) (Figure 4.1). Integration with customers and integration with suppliers are framed around planning decisions and the flow of goods. The corresponding measurement items and descriptive statistics are given in Tables 4.2 and 4.3. The items in these tables cover the conceptual domain of the associated S&OP practices, as discussed in Chapter 3.

Manufacturing performance was assessed through the dimensions of cost, quality, delivery and flexibility (Hill, 1994; Gunasekaran et al., 2004; Gunasekaran & Kobu, 2007; Akyuz & Erkan, 2010). These dimensions have been widely used in previous research (Schmenner & Swink, 1998; Ward et al., 1998; Schroeder et al., 2002) and were applied to the IMSS-IV dataset by da Silveira & Cagliano (2006), Vereecke & Muylle (2006) and da Silveira & Sousa (2010), among others. The measurement items for manufacturing performance correspond closely to those used by da Silveira & Sousa (2010). The items and descriptive statistics are shown in Table 4.4.

Table 4.2: Measurement items for the dimensions of internal S&OP

		Descriptive Statistics		
Dimensions of Internal S&OP	**IMSS-V questions**	**N**	**μ**	**σ**
Technological Integration (TI)	**How do you technologically coordinate design and manufacturing:**			
	Failure Mode and Effect Analysis (FMEA)	688	2.82	1.31
	Quality Function Deployment (QFD)	681	2.58	1.25
Meetings and Organization (MO)	**How do you organizationally coordinate design and manufacturing:**			
	Concurrent engineering (i.e. overlapping product and process design)	681	3.09	1.16
	Cross functional teams	695	3.41	1.08
Measurement (M)	**Indicate the effort put into implementing the following action programs in the last three years:**			
	Engaging in product/part tracking and tracing programs (bar codes, RFID)	701	2.75	1.30
	Implementing ICT supporting information sharing and process control in production	693	2.85	1.22
	How advanced is the core process technology of your dominant activity:			
	The overall process is monitored and controlled in real- time by a dedicated information system.	706	3.13	1.18
Integration of Plans (IP)	**Indicate the effort put into implementing the following action programs in the last three years:**			
	Increasing design integration between product development and manufacturing through e.g. platform design, standardization and modularization, design for manufacturing, design for assembly	686	3.02	1.20
	Increasing the organizational integration between product development and manufacturing through e.g. teamwork, job rotation and co-location	687	2.95	1.15
	Increasing the technological integration between product development and manufacturing through e.g. CAD-CAM, CAPP, CAE, Product Lifecycle Management	681	3.00	1.17

Note: All items measured on a five-point scale, with degree of adoption end points 1=None and 5=High

Table 4.3: Measurement items for external S&OP practices (supply chain integration)

		Descriptive Statistics		
Constructs	**IMSS-V questions**	**N**	**μ**	**σ**
Integration with Suppliers (IS)	**How do you coordinate planning decisions and flow of goods with your key/strategic suppliers?**			
	Share inventory level information	667	2.96	1.25
	Vendor managed inventory or consignment stock	653	2.65	1.19
	Plan, forecast and replenish collaboratively	655	2.92	1.20
	Just-in-time replenishment (e.g. kanban)	653	2.66	1.27
Integration with Customers (IC)	**How do you coordinate planning decisions and flow of goods with your key/strategic customers?**			
	Share inventory level information	665	2.97	1.36
	Share production planning and demand forecast information	665	3.09	1.26
	Agreements on delivery frequency	667	3.61	1.24
	Plan, forecast and replenish collaboratively	656	2.83	1.25

Note: All items assessed on a five-point scale with degree of adoption end points 1=None and 5=High

Table 4.4: Measurement items for manufacturing performance.

Performance Measure	IMSS-V Question	Descriptive Statistics		
		N	μ	σ
How does your current performance compare with your main competitor(s)?				
Cost (*)	Unit manufacturing cost	561	3.13	0.82
	Procurement costs	557	3.14	0.73
	Labor productivity	550	3.34	0.76
	Inventory turnover	536	3.24	0.83
	Capacity utilization	542	3.29	0.81
	Manufacturing overhead costs	541	3.11	0.83
Delivery	Delivery speed	584	3.44	0.79
	Delivery reliability	586	3.49	0.81
	Manufacturing lead time	563	3.36	0.72
	Procurement lead time	556	3.16	0.71
Flexibility	Product customization ability (*)	581	3.56	0.84
	Volume flexibility	579	3.58	0.81
	Mix flexibility	582	3.51	0.79
	Time to market (*)	569	3.31	0.86
Quality	Manufacturing conformance	596	3.49	0.72
	Product quality and reliability	601	3.63	0.79
	Customer service and support (*)	571	3.47	0.81

(*) Excluded in subsequent validation stage.
Note: All items measured in a five-point scale with degree of adoption end points 1=Much worse and 5=Much better

4.2.3
Measurement model assessment

In assessing the measurement model, three basic measures of goodness of fit generally used in the literature were adopted: (i) the Chi-Square ($\chi2$), with the number of degrees of freedom and *p* value; (ii) the root mean square error of approximation - RMSEA; and (iii) the comparative fit index – CFI. For a model to be accepted, the p value associated with the $\chi2$ value should be larger than 0.05, RMSEA should be close to or lower than 0.05 (Browne & Cudeck, 1993; Hu & Bentler, 1999; Schermelleh-Engel et al., 2003) and CFI should be close to or higher than 0.95 (Hu & Bentler, 1999; Schermelleh-Engel et al., 2003). Jöreskog & Sörbom (1993) suggested the use of normed-$\chi2$ as a better measure of model fit, calculated as the chi-square divided by the number of degrees of freedom in the model ($\chi2$ /DF). Normed-$\chi2$ should be close to or higher than 1 and close to or lower than 3 for a good or acceptable model fit to data.

The assessment of the measurement model was performed in two parts. First, the second order construct of internal S&OP was validated. The results are shown in Table 4.5. The measurement model for Internal S&OP had good fit estimates ($\chi2$/DF = 3.2; NFI = 0.959; TLI = 0.948; CFI = 0.971; RMSEA = 0.056; CI = 0.044 – 0.068; PCLOSE = 0.212). In addition, the construct met all three criteria for convergent validity: (i) factor loads close to or above 0.6 (Chin, 1998); ii) composite reliabilities (CR) close to or above 0.6 and; iii) average variance extracted (AVE) close to or above 0.5 (Fornell & Larcker, 1981; Anderson & Gerbing, 1988). Also, AVE's square roots were higher than inter-variable correlations, except for Meetings and Organization and Integration of Plans. For these two variables the AVE square roots were slightly lower than one inter-variable correlation. They were kept in the model due to their theoretical relevance for the S&OP concept domain.

Second, the full model with all constructs was assessed. An initial model with internal S&OP, integration with customers, integration with suppliers and performance constructs resulted in some of the scales not passing the test for convergent validity, with AVEs below 0.5 (Fornell & Larcker, 1981): AVE for COST was 0.47 and 0.48 for FLEXIBILITY. Also, pairwise correlations among some manufacturing performance constructs were higher than the square root of their AVEs, showing a lack of discriminant validity (Fornell & Larcker, 1981): the square root of the AVE for COST was 0.68, while correlation between COST and FLEXIBILITY was 0.87 and between COST and QUALITY, 0.72.

Table 4.5: Internal S&OP construct measurement model

Latent Variables	Factor Loads	C.R.	AVE	1	2	3	4
1. MEASUREMENT (M)		0.61	0.54	*(0.73)*			
Tracking and tracing	0.731						
Information sharing	0.861						
Real time dedicated information system	0.584						
2. MEETINGS AND ORGANIZATION (MO)		0.56	0.46	0.66	*(0.68)*		
Cross-functional teams	0.607						
Concurrent engineering	0.742						
3. TECHNOLOGICAL INTEGRATION (TI)		0.67	0.61	0.52	0.69	*(0.78)*	
Failure Mode and Effect Analysis	0.767						
Quality Function Deployment	0.801						
4. INTEGRATION OF PLANS (IP)		0.61	0.54	0.59	0.78	0.62	*(0.73)*
Design integration	0.767						
Organizational integration	0.721						
Technological integration	0.715						

C.R.: composite reliability; AVE: square roots in the main diagonal, in italics and parentheses.
Factor loads and correlations obtained with Amos 19.

Based on these initial results, the model was refined by dropping the scale on COST and by dropping two items from FLEXIBILITY and one item from QUALITY. Items dropped from subsequent analysis are marked with an asterisk in Table 4.4. The relevant statistics for the refined model are presented in Table 4.6. Overall, the model displays a good fit to data. As expected, the Chi-Square ($\chi 2$) was not significant. Normed chi-square was 2.465, below the cut-off value of 3. The CFI value of 0.93 was close to the cut-off point of 0.95 and RMSEA was 0.045, below the cut-off point of 0.05, falling in an interval of 0.041-0.049, at 90% probability.

Table 4.6: Measurement Model Statistics

Latent Variables	Factor Loads	C.R.	AVE	1	2	3	4	5	6
1. DELIVERY		0.83	0.54	*(0.74)*					
Delivery speed	0.733								
Delivery reliability	0.731								
Manufacturing lead time	0.785								
Procurement lead time	0.696								
2. FLEXIBILITY		0.78	0.64	0.70	*(0.80)*				
Volume flexibility	0.792								
Mix flexibility	0.811								
3. QUALITY		0.75	0.60	0.67	0.57	*(0.77)*			
Manufacturing conformance	0.787								
Product quality and reliability	0.759								
4. Internal SOP		0.88	0.66	0.34	0.34	0.46	*(0.81)*		
Integration of Plans	0.818								
Organizational Management	0.900								
Measurement	0.744								
Technological Coordination	0.768								
5. COORDINATION WITH SUPPLIERS		0.80	0.50	0.27	0.25	0.34	0.61	*(0.71)*	
Share inventory level information	0.675								
Vendor managed inventory or consignment stock	0.704								
Plan. forecast and replenish collaboratively	0.662								
Just-in-time replenishment (e.g. kanban)	0.789								
6. COORDINATION WITH CUSTOMERS		0.83	0.54	0.23	0.27	0.23	0.51	0.58	*(0.74)*
Share inventory level information	0.731								
Share production planning and demand forecast information	0.801								
Agreements on delivery frequency	0.670								
Plan. forecast and replenish collaboratively	0.740								

C.R.: composite reliability; AVE: square roots in the main diagonal, in italics and parentheses. Factor loads and correlations obtained with Amos 19.

The PCLOSE index was 0.984. All three conditions for convergent validity of the constructs were met for the revised model: (i) factor loadings are above the threshold of 0.6 recommended by Chin (1998) and are significant at $p < 0.001$ with critical ratios above 2.0, suggesting convergent validity (Anderson & Gerbing, 1988); (ii) composite reliabilities are all above the threshold of 0.6; and (iii) AVEs for all constructs are equal or above the level of 0.5. In addition, the square roots of the AVEs are consistently above pairwise correlations among latent variables, confirming convergent and discriminant validity.

Common Method Bias

In surveys with information collected from a single respondent, biases may arise from “courtesy” or false correlations. To minimize such biases, the survey guaranteed anonymity and confidentiality, and questions/items were described clearly and concisely (Podsakoff et al., 2003). We tested for the existence of common method bias by conducting Harman’s single-component test (Podsakoff et al., 2003). In this test, we allowed all 28 manifest variables to load in one single latent variable. The resulting model fit was poor ($\chi 2/DF = 10.549$; CFI = 0.531; NFI = 0.51; TLI = 0.456; RMSEA = 0.115; PCLOSE = 0.000), suggesting the absence of common method bias.

4.2.4
Control Variables

A number of variables shown in previous studies to be correlated with firm performance were controlled for. Specifically, the controls used by da Silveira & Sousa (2010) who investigated manufacturing performance using IMSS-IV data, namely, firm size, country development and market dynamics were employed. Firm size was measured by the number of employees in the business unit (SIZE, μ= 1,949.61; σ = 8,811.82; N = 715) and was LN-transformed to improve normality (Elango, 2006; da Silveira & Sousa, 2010). Country development was measured by gross domestic product per capita, obtained from the World Bank (2012) Development Indicators (GDP, μ= 29,379.34; σ = 17,169.67; N = 725). Market dynamics was measured by the survey respondents’ perceptions on a Likert scale ranging from 1 – market declining rapidly to 5 – market growing rapidly (MKT, μ= 2.92; σ = 0.91; N = 714).

4.2.5
Results

The hypotheses were tested using stepwise multiple linear regressions with control variables, in SPSS 19.0. The variables included in the regression were obtained by averaging the scores of their respective manifest or latent variables. The analysis was performed with listwise deletion of missing values, after verifying that the 12 variables used in the regressions were missing completely at random (MCAR). Little's (1988) MCAR test was non-significant, with $p>0.10$ (Chi-Square = 454.534, DF = 428).

Control and independent variables were regressed on all three performance variables. In order to avoid multicollinearity, control and independent variables were entered in two different steps (da Silveira & Sousa, 2010) and all predictors were mean centered (Jaccard et al., 1990). Resulting variance inflation factors (VIF) were well below 10 and condition indexes (CI) below 30, suggesting the absence of multicollinearity (Kennedy, 2003). Histograms and plots of residuals suggested that they were normally distributed. The hypotheses tests were based on the significance of standardized regression coefficients and F-change. The results are presented in Table 4.7.

Table 4.7: Regression coefficients on manufacturing performance

Variables	QUALITY		FLEXIBILITY		DELIVERY	
			Hypotheses Tests			
GDP	-0.119	*	-0.083		-0.171	*
LNSIZE	0.083		0.087		-0.063	
MKTDYN	0.096	*	0.016		0.061	
F-change	5.172	*	2.212		5.330	*
R^2	0.035		0.016		0.038	
Adjusted R^2	0.028		0.009		0.031	
GDP	-0.096	*	-0.052		-0.145	**
LNSIZE	-0.052		-0.032		-0.194	**
MKTDYN	0.034		-0.028		0.009	
Internal SOP	0.323	**	0.255	**	0.288	**
IS	0.098		0.032		0.073	
IC	0.008		0.084		0.068	
F-change	20.773	**	12.561	**	17.206	**
R^2	0.159		0.097		0.147	
Adjusted R^2	0.147		0.084		0.135	
			Moderation Tests			
GDP	-0.077		-0.036		-0,120	*
LNSIZE	-0.052		-0.032		-0.197	**
MKTDYN	0.041		-0.021		0.024	
Internal SOP	0.317	*	0.248	**	0.278	**
IS	0.069		0.007		0.043	
IC	0.007		0.081		0.060	
Internal SOPxIS	0.144	*	0.139	*	0.234	**
Internal SOPxIC	0.059		0.009		-0.044	
F-change	8.068	*	4.531	*	10.918	**
R^2	0.190		0. 117		0.192	
Adjusted R^2	0.175		0.100		0.175	

Note: significance levels *$p < 0.05$, ** $p < 0.01$.*
Coefficients are unadjusted standardized coefficients

Hypothesis H1 (internal S&OP practices impact positively on manufacturing performance) was fully supported for all three performance dimensions of quality, flexibility and delivery, after controlling for the potentially confounding effects of firm's size, country's economic development and market dynamics. Moreover, the effects size were moderate to strong, with standardized regression coefficients on the 0.25 – 0.32 range. Hypotheses H2 and H3 (integration with suppliers/customers impacts positively on manufacturing performance) were not confirmed. Results are discussed in Sub-section 4.4.1.

Moderation Tests

Given the somewhat surprising result of the absence of direct effects of integration with suppliers (IS) and integration with customers (IC) on performance, the hypothesis that IS and IC have a positive moderation effect on the relationship between Internal S&OP and performance was tested. This follows a number of studies that have emphasized the synergies between Internal S&OP and SC integration practices, such as CPFR, VMI, JIT, etc. (Stank et al., 2001; Giménez & Ventura, 2003, 2005; Nakano, 2009; VICS, 2010).

Following Cohen & Cohen (1983) and Aiken & West (1991), stepwise hierarchical regression models entering control variables in step 1, predictors in step 2 and the interaction terms of Internal SOP x IS and Internal SOP x IC in step 3 were built. The full regression equation was:

$$Y = \alpha + \beta_1 GDP + \beta_2 LN(SIZE) + \beta_3 MKTDYN + \beta_4 Internal\ SOP + \beta_5 IS + \beta_6 IC + \beta_7 (Internal\ SOP \times IS) + \beta_8 (Internal\ SOPxIC) + \varepsilon \quad [1]$$

where Y is the dependent variable (QUALITY, FLEXIBILITY, DELIVERY).

The moderation result in Table 4.7 show that IS plays a positive moderator role, amplifying the effects of Internal SOP on all three measures of performance. We found no significant moderation effect of IC on the relationship between Internal SOP and performance.

4.3
Moderator role of technology

The construct of Internal S&OP and the measures of manufacturing operational performance presented in Section 4.2 will also be used to measure the impact of S&OP and technology on manufacturing operational performance. The reader is referred to Section 4.2, Tables 4.2 and 4.5, for descriptive statistics on Internal S&OP and to Table 4.4, also in Section 4.2, for manufacturing operational performance.

4.3.1 Theoretical model and hypothesis

Two different models are proposed in this section to test the moderator role of technology: technology as interaction (Figure 4.2) and technology as equifinality (Figure 4.3). They are briefly justified next.

It is posited that the complexity of the manufacturing process and task complexity positively moderates the impact of internal S&OP on manufacturing operational performance. The hypotheses relating to the moderator role of technology were based on the theoretical foundations of Chapter 2 (in particular Sub-section 2.3.2 “The contingent effect of Technology”; and Sub-section 2.3.3. “Defining fit”) and will be tested based on the statistical significance of standardized regression coefficients and F-value. The model for the moderator effect of technological complexity is depicted in Figure 4.2.

It is also emphasized that technological process and task complexity should fit the environment, structure and manufacturing processes, in order to positively impact on manufacturing operational performance. Inversely, a misfit, or deviation from the ideal profile of fit, will negatively impact upon manufacturing operational performance. This corresponds to the definition of fit as a system under equifinality: different possible arrangements of technology complexity and structure are equally effective in producing results if they are adequate, if they fit the environment. Under Lawrence & Lorsch (1967b) framework of integration and differentiation in complex organizations, the more complex the tasks are, the more diversified are the sub-units of the organization and the more integration among sub-units are necessary in order to boost performance.

Following Drazin & Van den Ven (1985), Venkatraman (1989) and Sousa & Voss (2008), different measures of fit should be applied to the same dataset to "triangulate" results and reinforce the robustness of empirical results regarding fit. This is particularly true for new and relatively unexplored subjects. Therefore, in addition to test the interaction terms of technology complexity and integration, the hypotheses of technological moderation were submitted to a further test under equifinality.

4.3.1.1
Hypotheses about technology moderation (fit as interaction)

Hypotheses were based on the theoretical foundations of Chapter 2, Section 2.3 "Contingency theory from an OM perspective". Hypothesis 4 refers to the direct effect of S&OP on manufacturing operational performance and is similar to H1, under Model 1. Hypotheses 2 and 3 refer to the positive moderator role of complexity in the relationships between S&OP practices and performance.

H4: Internal S&OP practices impact positively on manufacturing operational performance.

H5: The complexity of the process technology positively moderates the effect of Internal S&OP on manufacturing operational performance.

H6: The complexity of the manufacturing task positively moderates the effect of Internal S&OP on manufacturing operational performance.

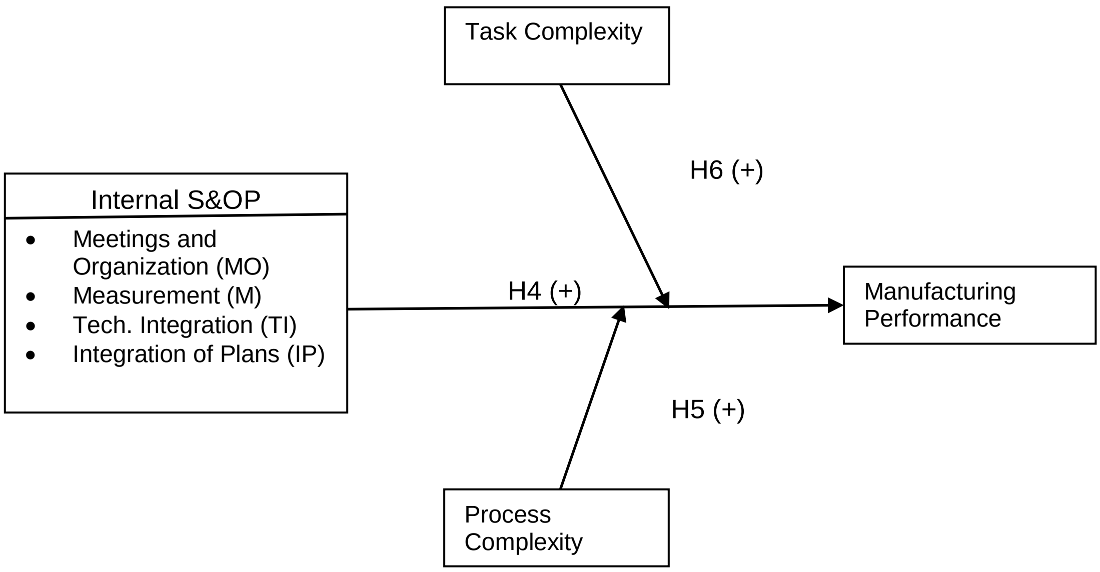


Figure 4.2: Theoretical model and hypotheses: Internal S&OP and Technology.

4.3.1.2
Hypothesis of technological fit under equifinality

A seventh hypothesis relates to the measurement of fit of technology complexity as a system, measured by profile deviation (defined further on Sub-section 4.2.2) and depicted in Figure 4.3. As discussed earlier, S&OP is perceived as an “integrative device”, in Lawrence & Lorsch’s (1967b) terminology. In this model, the construct of “integrative devices” of Internal S&OP is replaced by a construct formed by co-location and job rotation in design-manufacturing integration (DMI) for two reasons. First, it corresponds closely to the concept of DMI in the Lawrence & Lorsch (1967b) framework, in particular their “Hypothesis 7: when the environment requires both a high degree of sub-system differentiation and a high degree of integration, integrative devices will tend to emerge” (e.g., cross functional teams, task forces, integrative roles). Second, it avoids confound with technology variables of integration that are embedded into the construct of internal S&OP. The following hypothesis is put forward:

H7: A misfit to an ideal profile of integration in a context of process and task complexity will negatively affect manufacturing operational performance.

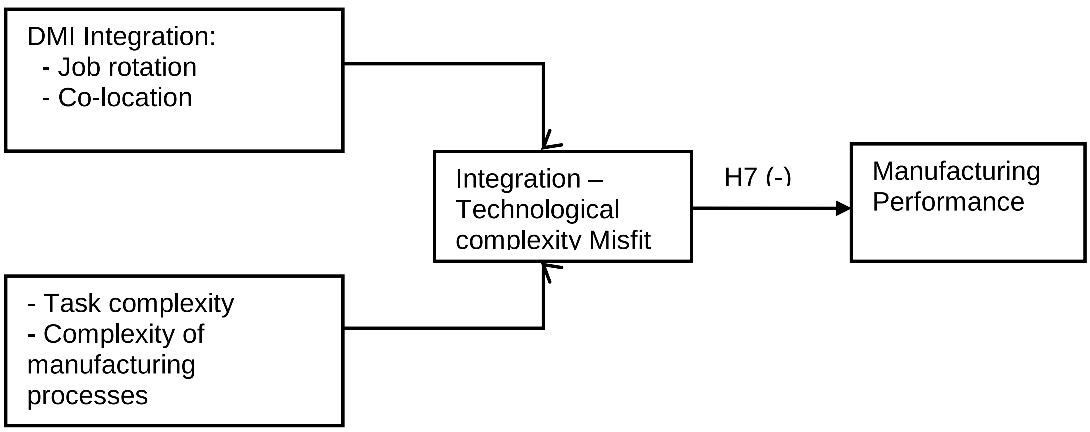


Figure 4.3: Framework for organizational-technological fit and manufacturing performance

4.3.2
Measures

Measures are presented first for latent constructs and second for the systemic measure of fit under equifinality.

4.3.2.1
Measure of latent variables

Consistent with our definition of S&OP practices outlined in Chapter 3 and measured as described in section 4.2.2, Internal S&OP is a second order construct that closely corresponds to Grimson & Pyke (2007) S&OP maturity model.

The first order constructs of task complexity (PROD) and process complexity (TECH) and their descriptive statistics are depicted in Table 4.8.

4.3.2.2
Measure of fit

The concept of fit was measured both as equifinality corresponding to the systemic definition of fit and as moderators in multiple regressions corresponding to the concept of fit as interaction. The latter is straightforward and will be presented in the moderation tests of the section on results. For the systemic measure of fit, the average of the manifest variables depicted in Table 4.8 for a given organization is used as the ideal profile against which each individual variable is compared (da Silveira, 2005).

Table 4.8: Measures and ideal profiles of fit (mean values)

Construct/manifest variables	Variable	Definition	Aspects in Lawrence & Lorsch (1967)	μ	σ
Task Complexity	**prod**	**How would you describe the complexity of the dominant activity?**	**Structural "complexity of tasks"**	**3.76**	**1.03**
	B2b	Single manufactured components - Finished assembled products		3.72	1.42
	B2c	Very few parts/materials, one-line bill of material Many parts/materials, complex bill of material		3.72	1.31
	B2d	Very few steps/operations required - Many steps/operations required		3.84	1.09
Integration of teams	**int**	**How do you organizationally coordinate design and manufacturing?**	**"Requisite integration" and Integrative Devices (e.g., cross functional teams, task forces, integrative roles)**	**2.37**	**1.04**
	PD2g	Job rotation between design and manufacturing		2.16	1.09
	PD2h	Co-location of design engineers and manufacturing managers		2.57	1.28
Process Complexity	**tech**	**How advanced is the core process technology of your dominant activity?**	**Technic-economic sub environment**	**2.68**	**0.95**
	T1a	Mostly manual operations - Highly automated machine tools		3.0	1.1
	T1b	Mostly standalone machines - Fully integrated systems		2.8	1.2
	T2a	Engaged in process automation programs in the past 3 years		2.5	1.2
	T2b	Engaged in flexible manufacturing/assembly systems - cell programs in the past 3 years		2.7	1.3

Note: extremes of Likert scales are Low (1) and High (5)

The choice of an ideal profile as the average of fit variables is due to the assumption made in the Lawrence & Lorsch's (1967b) framework that each manufacturing organization attains its ideal profile by matching its own structure with managerial processes and with the environment. This measure of ideal profile is consistent with Hill's (2000) definition of the ideal profile of manufacturing organizations in the orders winners' framework and contrast with definitions of ideal profiles based on a sample of top performers (e.g., Venkatraman & Prescott, 1990) or by comparison with best systems defined in the literature (e.g., Ahmad & Schroeder, 2003).

Equation [2] is proposed by da Silveira (2005). It gives the standard deviation of the Euclidean distance of the variable X_{ij} from the ideal profile of organization $_i$ (average):

$$MISFIT_i = \sqrt{\frac{\sum_{j=1}^{9}(X_{ij} - (\sum_{j=1}^{9}\frac{X_{ij}}{9}))^2}{8}} \quad [2]$$

where $_i$ denote the organization and $_j$ denotes the fit variables.

Being a measure of the distance of the observed profile to the ideal profile, equation [2] is best described as misfit. The standard deviation of X_{ij} was used instead of the Euclidean distance because it produces scores that are close to a normal distribution, which is an assumption for regression analysis (da Silveira, 2005). As all variables included in the equation were measured using the same scale there was no need to normalize the indexes. Also, as there is no reason to suppose a priori that one fit variable is more important than others, they all received equal weights.

4.3.3
Measurement model assessment

In describing the measurement model for model 2 (structural equation model for assessing the moderator role of technology) some repetitions from the analysis of the measurement model 1 (structural equation model for assessing the direct impact of S&OP within the firm and in the SC) will be unavoidable, for two reasons. First, they are two different models with a common component (the construct of Internal S&OP), but they differ in the related constructs (supply chain integration in one case and technology in the other). Therefore, their measurement statistics might differ and should be commented in separate. Second, the techniques of structural equation model are similar (model to data fit indices, convergent and discriminant validity tests, common method bias, missing completely at random tests, etc.) and should be presented for a full understanding of the modeling. Repetitions will be avoided however, whenever possible and the reader will be cross-referenced to the appropriate section of the text.

As in model 1, the measurement model was assessed with confirmatory factor analysis for unidimensionality, validity and reliability. The two-step approach to structural equation models recommended by Anderson & Gerbing (1988) was adopted. The model was run in Amos 19.0, with maximum likelihood estimates (Arbuckle, 2010). Data was visually checked for outliers, skewness and kurtosis, with no major departures from the assumptions of normality and homoscedasticity detected. Data items were selected based on theory, with few items subsequently dropped due to statistical reasons.

The assessment of the measurement model was validated in two steps. The second order construct of S&OP was validated first; and second the full measurement model with all latent constructs was validated. Results for the first step, the internal S&OP measurement model, were described in Section 4.2 and will not be repeated here.

As in the previous model, described in Section 4.2, an initial full structural equation model with all constructs failed to pass the test of convergent validity, with average variances extracted (AVE) below 0.5 (Fornell & Larcker, 1981) for the scales of COSTS (0.47) and FLEXIBILITY (0.48). There was also a lack of discriminant validity, with pairwise correlations among some manufacturing performance items being higher than the square root of their AVE (Fornell & Larcker, 1981). Consistent with the previous model (Section 4.2), this model was also refined by dropping the scale on COST, two items from FLEXIBILITY and one item from QUALITY. Items dropped are marked with an asterisk in Table 4.4. Results from the refined model are depicted in Table 4.9.

The measurement model overall fit to data was good ($\chi2$/DF = 2.853; CFI = 0.929; RMSEA = 0.051; CI = 0.046 – 0.055; PCLOSE = 0.407). All three conditions for convergent validity were met: (i) factor loadings above 0.6 (Chin, 1998) and significant at $p < 0.001$ with critical ratios above 2.0; (ii) composite reliabilities are all above the threshold of 0.6; and (iii) AVEs for all constructs are equal or above the level of 0.5. The square roots of the AVEs are consistently above pairwise correlations among latent variables, confirming convergent and discriminant validity.

Table 4.9: Measurement model statistics

Latent Variables	**Factor Loads**	**C.R.**	**AVE**	**1**	**2**	**3**	**4**	**5**	**6**
1. DELIVERY		0.83	0.54	(0.74)					
Delivery speed	0.733								
Delivery reliability	0.731								
Manufacturing lead time	0.785								
Procurement lead time	0.696								
2. FLEXIBILITY		0.78	0.64	0.70	(0.80)				
Volume flexibility	0.792								
Mix flexibility	0.811								
3. QUALITY		0.75	0.60	0.67	0.57	(0.77)			
Manufacturing conformance	0.787								
Product quality and reliability	0.759								
4. Internal SOP		0.88	0.66	0.34	0.34	0.46	(0.81)		
Integration of Plans	0.818								
Organizational Management	0.900								
Measurement	0.744								
Technological Coordination	0.768								
5. PROCESS COMPLEXITY		0.77	0.53	0.32	0.31	0.35	0.75	(0.72)	
Highly automated machines	0.719								
Fully integrated systems	0.743								
Effort in cell programs	0.712								
6. TASK COMPLEXITY		0.78	0.64	0.13	0.06	0.13	0.29	0.07	(0.79)
Many parts	0.909								
Many steps	0.672								

C.R.: composite reliability; AVE: square roots in the main diagonal, in italics and parentheses.
Factor loads and correlations obtained with Amos 19.

In order to minimize biases that could arise from information collected from a single respondent, the survey guaranteed anonymity and confidentiality; questions were described clearly and concisely (Podsakoff et al., 2003). Data was scrutinized for common method bias with the Harman's single-component test (Podsakoff et al., 2003). All 17 manifest variables were allowed to load on a single factor, resulting in poor model fit, which suggests the absence of common method bias ($\chi 2$/DF = 11.033; CFI = O.544; NFI = 0.524; TLI = 0.465; RMSEA = 0.118; CI = 0.114 - 0.121; PCLOSE = 0.000).

4.3.4
Control variables

Control variables of firm size, country development and market dynamics which were shown in previous studies to be correlated with performance (da Silveira & Sousa, 2010; Elango, 2006) were used. They were measured with the same variables used in Model 1 and will not be repeated here.

4.3.5
Results

Hypotheses were tested using stepwise multiple regression with control variables to ascertain the direct effect of S&OP practices and to test the moderator effect of complexity and technology. Simple linear regression of misfit on performance to test fit as equifinality was used. Both tests were run with SPSS 19.0.

4.3.5.1
Direct effect of S&OP practices

The variables included in the regression were obtained by averaging the values of their manifest or latent variables. As the analysis was performed with listwise deletion of missing cases, Little's missing completely at random (MCAR) test was applied to all variables in the multiple regression equation and was non-significant ($p>0.1$).

To minimize multicollinearity, all independent variables were mean centered (Jacquard et al., 1990); and control and independent variables were entered in two different steps (da Silveira & Sousa, 2010). Variance inflation factors (VIF) were well below 10 and condition indexes (CI) were below 30, suggesting the absence of multicollinearity (Kenedy, 2003). Visual inspection of plots of residual suggested that they were normally distributed. Hypotheses tests were based on the significance of standardized regression coefficients and F-change. Results are depicted in Table 4.10.

Hypothesis H1 (S&OP practices impact positively on manufacturing operational performance) is confirmed for all three measures of performance, with standardized regression coefficients in the 0.262 – 0.361 range and $p<0.01$ in all cases.

4.3.5.2
Contingent effect of fit as interaction

The hypotheses of fit as interaction are confirmed if individual fit latent variable moderates the relationships between S&OP practices and manufacturing operational performance. The test is performed for the multiplicative effect of the dyad S&OP practice and contextual/contingent variable, taken one at a time. Following Cohen & Cohen (1983) and Aiken & West (1991), stepwise hierarchical regression models were built entering control variables in step 1, predictors in step 2 and the interaction terms of S&OP practices and the moderator in step 3.

The full equation is:

$$Y = \alpha + \beta_1 GDP + \beta_2 LN(SIZE) + \beta_3 MKTDYN + \beta_4 Internal\ SOP + \beta_5 MOD + \beta_6 (Internal\ SOP \times MOD) + \varepsilon \qquad [3]$$

where Y is the dependent variable (QUALITY, FLEXIBILITY, and DELIVERY) and MOD is the moderator (PROD – TASK COMPLEXITY or TECH – MANUFACTURING PROCESS COMPLEXITY).

The equation was estimated in two separate runs: one with PROD as moderator and other with TECH as moderator. In this way, the interaction term of

Internal S&OP and the contingency variable was analyzed separately, as a dyad (see table 2.4).

Based on Table 4.10, Hypothesis 4, the direct and significant effect of Internal S&OP practices on manufacturing performance, is confirmed for all three manufacturing operational performance variables of quality, delivery and flexibility.

The moderation results in Table 4.10 confirm Hypothesis 5 (the degree of complexity of advance of the core process technology of the dominant activity of the manufacturing firm moderates the impact of S&OP practices on manufacturing operational performance) is confirmed for quality, delivery and flexibility, with $p<0.05$ for quality, $p<0.01$ for delivery and with $p<0.1$ for flexibility.

Hypothesis 6 (task complexity moderate the impact of S&OP practices on manufacturing operational performance) is confirmed only for quality with $p<0.05$, in Table 4.10. The hypothesis is not confirmed for delivery nor flexibility.

4.3.5.3
Contingent effect of fit as system

The hypothesis H7 states that misfit will negatively affect performance. Following da Silveira (2005) this hypothesis was tested by simple linear regression of misfit on manufacturing operational performance, given by:

$$Y = \alpha + \beta_1 \text{ MISFIT}_i + \xi_{,I} \qquad [4]$$

where Y is the performance measures of QUALITY, FLEXIBILITY and DELIVERY, calculated in three separate equations. Results are depicted in Table 4.11

As seen in Table 4.11, all regression standardized coefficients are negative and statistically significant. Hypothesis H7 is confirmed with $p < 0.1$ for quality and delivery and with $p < 0.05$ for flexibility.

Table 4.10: Regression coefficients on manufacturing operational performance

VARIABLES	QUALITY				DELIVERY				FLEXIBILITY			
	PROD		TECH		PROD		TECH		PROD		TECH	
					Hypotheses Tests							
GDP	-0.146	***	-0.160	***	-0.161	***	-0.170	***	-0.072		-0.071	
LNSIZE	0.025		0.024		0.114	**	0.115	**	0.105	**	0.111	**
MKTDYN	0.028		0.026		-0.014		-0.013		-0.020		-0.023	
F-change	4.296	***	5.061	***	7.344	***	8.037	**	3.120	**	3.363	**
R^2	0.025		0.029		0.045		0.049		0.019		0.020	
Adjusted R^2	0.019		0.024		0.039		0.043		0.013		0.014	
					Direct Effects							
GDP	-0.117	**	-0.122	***	-0.142	***	-0.146	***	-0.051		-0.042	
LNSIZE	0.013		0.001		0.105	**	0.103	**	0.095	**	0.093	**
MKTDYN	0.024		0.020		-0.018		-0.017		-0.017		-0.023	
Internal SOP	0.361	**	0.359	***	0.265	***	0.270	***	0.262	***	0.263	***
MODERATOR	-0.015		0.048		0.005		0.019		-0.026		0.031	
F-change	37.960	**	39.676	***	18.491	***	19.800	***	18;078	***	19.048	***
R^2	0.153		0.162		0.114		0.123		0.086		0.091	
Adjusted R^2	0.145		0.154		0.105		0.113		0.077		0.082	
					Moderation Tests							
GDP	-0.108	**	-0.110	***	-0.142		-0.131	***	-0.047		-0.033	
LNSIZE	0.010		0.005		0.105	**	0.108	**	0.093	**	0.096	**
KTDYN	0.029		0.025		-0.018		-0.009		-0.015		-0.019	
ernal SOP	0.364	***	0.361	***	0.265	***	0.272	***	0.263	***	0.263	***
ODERATOR	-0.017		0.041		0.005		0.014		-0.027		0.024	
ernal SOP x ODERATOR	0.093	**	0.087	*	-0.003		0.112	***	0.038		0.074	*
-change	5.116	**	4.433	**	0.006		6.686	***	0.751		2.891	*
R^2	0.162		0.169		0.114		0.135		0.088		0.096	
Adjusted R^2	0.152		0.159		0.103		0.124		0.076		0.085	

ote: significance levels * p<0.1, ** *p < 0.05*, *** *p < 0.01.*
oefficients are unadjusted standardized coefficients
ROD: Complexity of product tasks; TECH: Complexity of manufacturing process technology

Table 4.11: Regression analysis of misfit on performance

Variables	Quality	Flexibility	Delivery
Constant	**3,708 (0,000)**	**3,721 (0,000)**	**3,514 (0,000)**
MISFIT	**-0,075**	**-0,09**	**-0,084**
R^2	0,006	0,008	0,007
F	**3,036**	**4,254**	**3,506**
d.f.	(1,539)	(1,521)	(1,495)
p-value	0,082	0,04	0,062

p-values for unstandardized parameter estimate are in parenthesis.
Significant estimates and F are set in bold (p<0.1)

4.4
Outlook

The main research findings will be discussed first, followed by the analysis of the implications of results for research and practice.

4.4.1
Discussion of research findings

The results of the three models are discussed. First, the direct effect of S&OP on manufacturing performance and the moderator effect of SCI with suppliers are debated. Second, the relationships between S&OP and technology is analyzed, with the back-drop of contingency theory. Third, technology fit measured as a system is discussed.

4.4.1.1
The effect of S&OP on manufacturing operational performance

The results provide evidence of a consistent and positive impact of internal S&OP practices on manufacturing performance, impacting all three dimensions of performance. Furthermore, this relationship holds even after controlling for firm size, level of country development and market dynamics. This emphasizes the key role of the internal S&OP practices of integration of plans, meetings and organization, measurement and technological integration in generating manufacturing performance.

The lack of a direct positive impact of integration with suppliers and customers on manufacturing performance was somewhat surprising, but consistent with partial evidence from previous research of a lack of direct impact of SC integration on performance (see Appendix 2 and hypotheses H2 and H3 in Subsection 4.2.1). This result led to the analysis of whether integration with customers and suppliers had instead a moderation effect on the relationship between internal S&OP and performance. It was found that this is the case for the integration with suppliers, but not with customers. The finding concerning suppliers is consistent with studies that have established that integration with suppliers contributes to providing a stable internal environment. For example, research in JIT/Lean suggests that just-in-time deliveries from suppliers are a requirement for internal JIT (Narasimhan et al., 2006; Shah & Ward, 2003; Shah & Ward, 2007; Vonderembse et al., 2006). Thus, integration with suppliers amplifies the benefits of internal integration. The finding concerning integration with customers was rather surprising, especially given the significant moderation effect of integration with suppliers. A possible explanation for this result may be the existence of asymmetric relative power relationships in the SC between the focal firm and its customers and suppliers. While a focal firm has significant leverage to influence supplier practices, so that they may enhance the benefits of internal S&OP, this may be more difficult to accomplish with customers. Interestingly, in a recent study Boon-itt & Wong (2011) found that supplier integration, but not customer integration, was positively related to delivery performance. This result might also be related to the nature of the industries included in the sample (described in Section 4.1. "Methodology"): one may expect that integration with customers play a less predominant role in mass and batch production industries (73% of the sample) than in one of a kind production (26% of total sample).

Regarding the results concerning the control variables (direct effect model), the impact of GDP per capita was negative and significant for quality and delivery, but not significant for flexibility. The impact of size on performance was negative and significant for delivery but not significant for quality and flexibility. Market dynamics showed no statistically significant impact on performance. Overall, these results are partly consistent with results found elsewhere in the literature. Da Silveira & Sousa (2010) found similar results for the negative impact of GDP per capita on quality and delivery, as well as for the weak effect of firm size on performance. However, the lack of significant co-variation of market dynamics and performance goes somewhat against expectation, as companies operating in fast growing markets would be expected to show greater performance improvements (Landsom, 2000).

The results show that the internal S&OP practices of integration of plans, organization and meetings, measurement and technological integration have a moderate to strong impact on manufacturing performance in terms of quality, flexibility and delivery. This finding is consistent with previous research on the impact of internal integration on firm and manufacturing performance (e.g., Stank et al., 2001; McKormack & Lockamy, 2005; Hadaya & Cassivi, 2007; Olhager & Selldin, 2007; Nakano, 2009) and is less in line with few studies which have found only a weak effect of internal S&OP on manufacturing performance (e.g., Rexhausen et al., 2012). Although it was not found a significant direct performance impact of integration with customers and suppliers, it was found that integration with suppliers enhanced the impact of internal S&OP on quality, flexibility and delivery.

4.4.1.2
The moderator role of technology

Most studies either analyzed the direct effect of technology on performance (e.g., Lawler, 1988; Sitkin et al., 1994; Gonzalez-Benito, 2002) or included technology as a control variable in multiple regression analysis (e.g., Zhang et al., 2006; Swink & Nair, 2007). The analysis of the moderator role of technology between S&OP practices and manufacturing operational performance in the context of S&OP and integration practices is an original contribution of this Thesis, but it also makes comparisons of the moderator role of technology with early studies in S&OP at least difficult.

The first outstanding result from model 2 is the consistent direct effect of S&OP practices on all three dimensions of operational manufacturing performance (quality, delivery, flexibility). This result was amply commented in relation to model one and will not be repeated here.

Product task complexity (few/many steps; few/many parts) was measured in accordance to early measures suggested by Dalton & Lawrence (1970) and Funk (1995). According to the results of model 2, product task complexity is not directly related to any dimension of performance, although it moderates the impact of S&OP on quality ($p<0.05$). But the moderator effect was not significant for delivery and flexibility.

The complexity of process technology was measured in model 2 as being the simultaneous pursuit of process automation and flexible and cellular manufacturing programs in the context of highly automated machine tools and fully integrated systems in assembly. The positive moderator role of process technology shows that in technologically complex manufacturing processes the S&OP effect on operational performance is amplified. This result consistently holds for all three performance dimensions of quality, delivery and flexibility (all with $p<0.01$). Viewed as an "integrative device" in Lawrence & Lorsch (1967b) framework, internal S&OP will play a stronger role in more diversified context of complex organizations. It is consistent with the framework of integration and differentiation in complex organizations (Lawrence & Lorsch, 1967a; 1967b), in a context of a large international sample of metal and machinery manufacturers (ISIC 3.1, code 28-35).

4.4.1.3
Technology fit as a system

The positive results of technology fit measured as profile deviation upon all three dimensions of manufacturing operational performance make two important contributions. First, they apply successfully the Venkatraman's (1989) Euclidean distance approach and da Silveira (2005) measurement technique of profile-deviation using simple linear regressions to the analysis of technology fit in technologically complex manufacturing processes. It thus contributes to the generalization of a simple method to access fit as a simultaneous and complex set of contingency factors. Second, it is consistent with Lawrence & Lorsch (1967a, 1967b) framework of diversification and integration in complex organizations, reinforcing the validity of the framework more than 45 years after its enunciation. By repeating empirical tests in different contexts with different measurements of the same construct, it contributes to consolidate mid-range theories about the structural contingent effect of technology in manufacturing performance.

4.4.2
Implication for research and practice: future directions

The study makes a number of important contributions to research and practice. For research, the study provides strong empirical evidence of the impact of S&OP on manufacturing performance. To the best of our knowledge, this is one of the first studies to look at the impact of S&OP specifically on multiple dimensions of manufacturing performance (quality, delivery, flexibility), rather than on business performance in general. By drawing on a large international sample, the study provides a rigorous empirical examination of the performance impacts of S&OP that has been lacking in past research. Furthermore, we examine the individual impacts of different types of S&OP practices (internal S&OP, integration with suppliers and integration with customers), as well as their interactions. We found that while internal S&OP practices have a direct positive effect on performance, integration with suppliers plays a moderation role on the relationship between internal S&OP and performance, and integration with customers does not have either a direct or a moderation role on performance in this sample. The study also emphasizes the moderator effect of structural contingency variables related to task and process technological complexity. By demonstrating the negative effect of misfit between product task complexity (finished assembled products, many parts/complex bill of materials, many steps/operations required), the complexity of manufacturing technology (highly automated machines, fully integrated manufacturing systems, process automation programs, flexible manufacturing/cell programs) and integrative devices (design-manufacturing integration through co-location and job rotation), the study makes an important contribution to validate theoretical postulates of early OM-PCR studies. It thus contributes to mid-range theories about the adoption of S&OP as best management practice in different contexts.

For practitioners, the study brings to the fore a core set of internal S&OP practices that can boost manufacturing performance: (i) integration of plans and action programs across organizational functions; ii) organizational integration across functions and the use of cross-functional teams; iii) measurement, process control and information-sharing; iv) usage of techniques and methods to enhance technological integration across functions; v) integration with suppliers in the SC; vi) adoption of adequate process technologies of the core production of the plant. Moreover, since it was controlled for firm size, country development and market dynamics, the results suggest that the effect of internal S&OP practices on performance could hold for a wide range of companies, countries and markets. Finally, because it was found that integration with suppliers and adequate advanced manufacturing technology had an amplifying effect on the impact of internal S&OP, firms should pursue integration with suppliers and the adoption of advanced manufacturing technologies simultaneously with the deployment of internal S&OP practices.

In demonstrating the negative impact of a misfit between the adoption of a bundle of process and product complex practices and work organization practices such as co-location and job rotation between manufacturing and design engineers, the study emphasizes to practitioners the need to take technological complexity into account while adopting integration practices aiming at boosting manufacturing performance.

However, the study has some limitations which open up opportunities for future research.

First, scales for measuring S&OP as a process (i.e., as an integrated planning and management tool) are still to be developed and tested. As a consequence, the extant research was followed and S&OP was measured as a set of practices. Future research should develop scales for measuring S&OP as a comprehensive process, and examine the impact of S&OP as a process on performance.

Second, our sample was drawn from companies from ISIC 3.1, codes 28-35, limiting generalization to other industries. Future research should examine S&OP impacts on other industry sectors.

Third, the findings on the effects of SC integration should be further explored by future studies. A possible explanation for the lack of direct impact of SC integration on manufacturing performance could be that empirically, our scales of SC integration focused on planning and the flow of goods (CPFR, VMI, JIT, production planning, forecasts and inventories). Other dimensions of integration could lead to different results. The findings on the non-symmetrical impacts of integration with customers and suppliers in enhancing internal S&OP impacts, namely the fact that customer integration was not found to enhance internal S&OP impacts, also deserve future attention. In addition, although it was found that integration with suppliers enhances the performance benefits of internal S&OP practices, there is no indication about the mechanisms through which it might actually operate. Two suggestions are offered for future research in this area. One is the use of different methodological approaches, such as case-based research describing actual S&OP implementations, in order to bridge gaps in our understanding of the causal impacts of S&OP on performance. Another is to investigate whether the impacts of SC integration may be contingent upon covariates of a host of contingency variables such as economic context, SC configurations, and SC power relationships, country of origin and culture, company size, type of industry, production processes and products. Future studies should explore further how relationships in the SC affect Internal S&OP practices.

Fourth, the fact that it was not found a moderator role of task complexity on performance, but for quality opens venues for future research on task complexity measures and its moderator role in manufacturing operational performance.

The research demonstrated the direct impact of S&OP on manufacturing operational performance, going beyond anecdotal evidences or isolated “success histories”. It contributed to answer the basic research question of this Thesis. It also demonstrated the moderator role of integration with suppliers and of task and process complexity, which amplifies the positive impact of S&OP on performance. Thus, it seems that firms seeking to strengthen their S&OP impact on performance should simultaneously seek to integrate with suppliers and are more likely to succeed in more complex manufacturing environments. Furthermore, the need for the adequacy or fit between S&OP as an “integrative device” with tasks and process complexity of the core dominant activity of the factory was demonstrated. The results are consistent with the contingency theory and show that there is not such a thing as “one rule fit all”, or universal S&OP practice. They are always context-dependent and result from fit between structures, processes and the environment.

5
Conclusion

This Thesis provided the first extensive and systematic literature review of S&OP as it relates to manufacturing operational performance. Operations management practices contingency research (OM-PCR) was applied to a relatively new field in industrial engineering also for the first time. An empirical examination of S&OP as a management practice and its impact in manufacturing operational performance was accomplished using rigorous data analysis techniques of structural equation modeling, confirmatory factor analysis and hierarchical stepwise multiple regression. Hypothesis were tested and verified.

A first conclusion from the literature review is that the S&OP field is not yet ripe for meta-analysis. To perform a meta-analysis was the original intent. But the diversity of definitions of S&OP maturity models and the diverse set of performance measures encountered in the literature precluded a cumulative statistical analysis of results. A rigorous research synthesis and a synthesis framework were proposed instead as unifying tools in search of mid-range theory building in this field. Facing the diversity of performance measurement in this field, the study focused on operational measures (quality, flexibility and delivery), in order to avoid the confounding influences not directly attributable to manufacturing practices, such as pricing, promotional activities, advertisement, R&D, etc.

In reviewing the disperse literature, it was also found that S&OP embraces a set of management practices and is not only a structured business process, a planning exercise with formal mechanisms and periodicity. Three main practices were identified as being prevalent in the literature: S&OP practices internal to the firm; the extension of S&OP with key suppliers; and S&OP practices with customers. The practices go beyond the factory walls and into the SC. Taking this diversity into account, a synthetic definition of S&OP as a process and as a cohesive bundle of management practices was proposed.

The impact of S&OP on manufacturing operational performance was put to test with survey data from the fifth round of the International Manufacturing Strategy Survey (IMSS-V). Data was collected in 2009-2010, from 725 manufacturers in 34 countries in complex industries of metal products, machinery, semiconductor, transportation, advanced instruments and audio/video. Internal S&OP impacted consistently and significantly upon manufacturing operational dimensions of quality (manufacturing conformance, product quality and reliability), delivery (delivery speed, delivery reliability, manufacturing lead time, procurement lead time) and flexibility (volume and mix flexibility). S&OP effect size measured by the standardized regression coefficient ranged from 0.26 to 0.36, a moderate to large impact upon performance. The fact that results hold after controlling for company size, country economic development and market dynamics/volatility allow for the generalization of results to a large set of industries, albeit restricted to the industrial sector comprised by ISIC 3.1 codes 28-35. By implementing S&OP practices described in this study, manufacturers could enhance their operational results, depending on the operational performance dimension being targeted.

Besides a direct impact on performance, S&OP effect can be amplified by the moderating effect of integration with suppliers and of task and process complexities.. Consistent with previous studies, it was found that work organizational arrangements such as S&OP can be enhanced when undertaken simultaneously with proven supply chain integration and novel technologies. More specifically, for this group of industries there was not much gain to integrate with customers as it had with suppliers. Also, taking in isolation as a dyad, S&OP effect on quality was enhanced when coupled with complex product technologies (finished assembled products, complex bill of materials and with many steps/operations required). S&OP effect size on quality, flexibility and delivery is also amplified in contexts of complex manufacturing technology (highly automated machines, fully integrated manufacturing systems, process automation programs, flexible manufacturing/cell programs).

Results were also consistent with the Lawrence & Lorsch (1967b) framework of integration and diversification in complex organizations: a misfit between the complexity of products and processes with integrative devices of job co-location and job rotation between new product design and manufacturing affected negatively all three dimensions of manufacturing operational performance. This finding adds to the cumulative development of mid-range theories in the OM field.

Despite the relevance of the obtained results, the Thesis opens venues for future studies. There is an ample and fertile field of research in applying contingency theories to S&OP. Far from being a universal prescription for success, S&OP practices are reputedly lengthily, can be costly and is context-dependent. Understanding the host of factors that can make it successful should be further explored in the areas of different organizational arrangements, market/product environments and concurrent management practices such as lean, JIT, agile networks, six-sigma and theory of constraints. Approaching AMT as a contingent variable was a novel contribution from this thesis and its analysis should be pursued further. Finally, a research agenda comprised of four topics can be derived from the present work: to conduct field data collection under the form of case study and survey research on S&OP and performance, enlarging the set of S&OP practices being analyzed and the performance measures adopted; to investigate the possibility of conducting meta-analysis in secondary data on more developed S&OP practices, such as cross-functional integration and supply chain integration; to systematically apply OM-PCR to the S&OP field, analyzing contradictory results in-light of rival theories such as institutional theory, resource-based view of the firm, strategic choice and structuration; to apply similar analysis with different data bases from different industries; to conduct longitudinal analysis with data from regular and periodic survey programs such as IMSS.

It is the expectation at the end of this research that both academics and practitioners could take advantage of the findings and perhaps mainly of the limitations of this Thesis, in order to advance further in the theory and practice of operations management.

References

AFFONSO, R.; MARCOTTE, F. and GRABOT, B. (2008). Sales and operations planning: the supply chain pillar. **Production Planning & Control**, 19(2), 132-141.

AIKEN, L.S. and WEST, S.G. (1991). Multiple Regression: Testing and Interpreting Interactions, Sage, Thousand Oaks, CA.

AKYUZ, G.A. and ERKAN, T.E. (2010). Supply chain performance measurement: a literature review. **International Journal of Production Research**, 48(17), 5137-5155.

AHMAD, S. and SCHROEDER, R.G. (2003). The impact of human resource management practices on operational performance: recognizing country and industry differences. **Journal of Operations Management**, 21(1), 19-43.

ANDERSON, J.C. and GERBING, D.W. (1988). Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach. **Psychological Bulletin**, 103(3), 411-423.

ARBUCKLE, J.L. (2010). IBM SPSS® Amos™ 19 User's Guide.

AUGER, C.P. (1998). Information Sources in Grey Literature. Guide to Information Sources, 4th. ed., London: Bowker Saur.

BARNEY, J. (1991). Firm resources and sustained competitive advantage. **Journal of Management**, 17 (1), 99-120.

BASU, R. (2001). New criteria of performance management: A transition from enterprise to collaborative supply chain. **Measuring Business Excellence**, 5(4), 7-12.

BAUMANN, F. (2010). The Shelf-Connected Supply Chain: Strategically Linking CPFR with S&OP at the Executive Level. **Journal of Business Forecasting**, 29(4), 21-27.

BAUMANN, F. and ANDRASKI, J. (2010). Collaborate, externally and internally. **Industrial Engineer: IE**, 42(6), 37-40.

BEAMON, B.M. Measuring Supply Chain Performance. **International Journal of Operations & Production Management**, 19(3), 275-292.

BEAUMONT, N.B. and SCHROEDER, R.M. (1997). Technology, manufacturing performance and business performance amongst Australian manufacturers. **Technovation**, 17, 297-307.

BEEDE, D.N. and YOUNG, K.H. (1998). Patterns of advanced technology adoption and manufacturing performance. **Business Economics**, 33, 43-48.

BIROU, L.M.; FAUCET, S.E. and MAGNAN, G.M. (1998). The product life cycle: a tool for functional strategic alignment. **International Journal of Purchasing and Materials Management**, 34(2), 37-51.

BOON-ITT, S. and WONG, C.Y. (2011). The moderating effects of technological and demand uncertainties on the relationship between supply chain integration and customer delivery performance. **International Journal of Physical Distribution & Logistics Management**, 41(3), 253-276.

BORNMANN, L.; MARX, W.; SCHIER, H.; RAHM, E.; THOR, A. and DANIEL, H. (2009). Convergent validity of bibliometric Google Scholar data in the field of chemistry – Citation counts for papers that were accepted by Angewandte Chemie International Edition or rejected but published elsewhere, using Google Scholar, Science Citation Index, Scopus, and Chemical Abstracts. **Journal of Informetrics**, 3(1), 27-35.

BOWERSOX, D.J.; CLOSS, D.J. and STANK, T.P. (1999). 21st century logistics: making supply chain integration a reality. **Council of Logistics Management**, Oak Brook, IL.

BOWER, P. (2005). 12 most common threats to sales and operations planning process. **Journal of Business Forecasting**, 24(3), 4-14.

BOYER, K.K.; WARD, P.T. and 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. and KRAJEWSKI, L.J. (1997). Unlocking the potential of advanced manufacturing technologies. **Journal of Operations Management**, 15 (4), 331-347.

BOYER Jr, J.E. (2009). 10 proven steps to successful S&OP, **Journal of Business Forecasting**, 28(1), 4-10.

BRAHMA, S. (2009). "Assessment of construct validity in management research", **Journal of Management Research**, Vol. 9 No. 2, 59-71.

BURROWS III, R.P. (2007). Demand driven S&OP: a sharp departure from the traditional ERP approach. **Journal of Business Forecasting**, 26(3), 4-13.

BROWNE, M.W. and CUDECK, R. (1993). Alternative ways of assessing model fit. In K.A. Bollen, J.S. Long (Eds.), **Testing structural equation models**. Newbury Park, CA: Sage.

CACERE, L.; BARRET, J. and MOORAJ, H. (2009). Sales and Operations Planning: Transformation From Tradition. Industry Value Chain Strategies. **AMR Research**, Boston, MA.

CAGLIANO, R. and SPINA, G. (2000). Advanced manufacturing technologies and strategically flexible production. **Journal of Operations Management**, 18, 169-190.

CHAE, B. (2009). Developing key performance indicators for supply chain: an industry perspective. **Supply Chain Management: An International Journal**, 14(6), 422-428.

CHEN-RITZO, C.-H.; ERVOLINA, T.; HARRISON, T.P. and GUPTA, B. (2010a). Sales and operations planning in systems with order configuration uncertainty. **European Journal of Operational Research**, 205(3), 604-614.

CHEN-RITZO, C.-H.; ERVOLINA, T.; HARRISON, T.P. and GUPTA, B. (2010b). Component rationing for available-to-promise scheduling in configure-to-order systems. **European Journal of Operational Research**, Available at http://www.sciencedirect.com/science?_ob.../sdarticle.pdf (accessed 20 December 2010).

CHILD, J. (1972). Organizational structure, environment, and performance: the role of strategic choice. **Sociology** 6, 1-22.

CHIN, W.W. (1998). The partial least squares approach to structural equation modeling, in Marcoulides, G.A. (Ed.), **Modern Methods for Business Research**, Lawrence Erlbaum Associates, Mahwah, NJ, 295-336.

CHOU, Y.-C.; CHENG, C.-T.; YANG, F.-C. and LIANG, Y.Y. (2007). Evaluating alternative capacity strategies in semiconductor manufacturing under uncertain demand and price scenarios. **International Journal of Production Economics**, 105(2), 591-606.

CHRISTOPHER, M. (1998). Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service. 2nd edition, **Financial Times, Prentice Hall**, Great Britain.

COHEN, J. and COHEN, P. (1983). Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences, 2nd ed., Erlbaum, Hillsdale-NJ.

COLLIN, J. and LORENZIN, D. (2006). Plan for supply chain agility at Nokia: Lessons from the mobile infrastructure industry. **International Journal of Physical Distribution & Logistics Management**, 36(6), 418-430.

COOPER, H. (1984). The integrative research review: A systematic approach. **Sage Publications**. Newbury Park, CA.

COOPER, H. (2010). Research synthesis and meta-analysis: a step-by-step approach. Applied Social Research Methods Series, 2, 4th. Edition, **Sage Publications**, Thousand Oaks, California.

COUSINS, P.D. and MENGUC, B. (2006). The implications of socialization and integration in supply chain management. **Journal of Operations Management**, 24(5), 604-620.

COX, J.F. and BLACKSTONE, J.H. (2002). APICS Dictionary, 10th ed. **APICS**. Alexandria, VA.

CROXTON, K.L.; GARCIA-DASTUGUE, J.; LAMBERT, D.M. and ROGERS, D.S. (2001). The Supply Chain Management Processes. **International Journal of Logistics Management**, 12(2), 13-36.

DA SILVEIRA, G.J.C. (2005). Market priorities, manufacturing configuration, and business performance: an empirical analysis of the order-winners framework. **Journal of Operations Management**, 23, 662-675.

DA SILVEIRA, G.J.C. and CAGLIANO, R. (2006). The relationship between interorganizational information systems and operations performance. **International Journal of Operations & Production Management**, 26(3), 232-253.

DA SILVEIRA, G.J.C. and SOUSA, R. (2010). Paradigms of choice in manufacturing strategy: Exploring performance relationships of fit, best practices, and capability-based approaches. **International Journal of Operations & Production Management**, 30(12), 1219-1245.

DALTON, G.W. and LAWRENCE, P.R. (ed.) (1970). Organizational Structure and Design. Richard D. Irwin, Inc.

DAUGHERTY, P.J.; CHEN, H.; MATTIODA, D.D. and GRAWE, S.J. (2009). Marketing/logistics relationships: influence on capabilities and performance. **Journal of Business Logistics**, 30(1), 1-18.

DAS, A. and NARASIMHAN, R. (2001). Process-technology fit and its implications for manufacturing performance. **Journal of Operations Management**, 19(5), 521-540.

DAS, A. and JARAYAN, J. (2003). Relative importance of contingency variables for advanced manufacturing technology. **International Journal of Production Research**, 41(18), 4429-4452.

DAS, A.; NARASIMHAN, R. and TALLURI, S. (2006). Supplier integration – finding an optimal configuration. **Journal of Operations Management**, 24(5), 563-582.

DEAN, J.W. Jr. (1987). Deciding to Innovate: How Firms Justify Advanced Technology. Cambridge, MA: Ballinger.

DEVARAJ, S.; KRAJEWSKI, L. and 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, 1199-1216.

DIMAGGIO, P. and POWELL, W. (1991). Introduction. In: Powell, W., DiMaggio, P. (Eds.), **The New Institutionalism in Organizational Analysis**, University of Chicago Press, Chicago.

DONALDSON, L. (2001). The Contingency Theory of Organizations. USA: Sage Publications.

DOUGHERTY J. and GRAY, C. (2006). Sales & Operations Planning – Best Practices. **Partners for Excellence**, Trafford Publishing. Belmont, NH.

DRAZIN, R. and VAN DE VEN, A. (1985). Alternative Forms of Fit in Contingency Theory. **Administrative Science Quarterly**, Vol. 30, No. 4, 514-539.

DRÖGE, C.; JAYARAM, J. and VICKERY, S.K. (2004). The effect of internal versus external integration practices on time-based performance and overall firm performance. **Journal of Operations Management**, 22, 557-573.

ELANGO, B. (2006). An empirical analysis of the internationalization-performance relationship across emerging market firms. **Multinational Business Review**, 14(1), 21-44.

ELLINGER, A.E.; DAUGHERTY, P.J. and KELLER, S.B. (2000). The relationship between Marketing/logistics interdepartmental integration and performance in U.S. Manufacturing firms: an empirical study. **Journal of Business Logistics**, 21(1), 1-22.

ETTLIE, J.E. (1988). Taking Charge of Manufacturing. San Francisco: Jossey-Bass.

FABBE-COSTES, N. and JAHRE, M. (2008). Supply chain integration and performance: a review of the evidence. **The International Journal of Logistics Management**, 19(2), 130-154.

FAWCETT, S.E. and MYERS, M.B. (2001). Product and employee development in advanced manufacturing implementation and impact. **International Journal of Production Research**, 39, 65-79.

FENG, Y.; SOPHIE D'AMOURS, S. and BEAUREGARD, R. (2008). The value of sales and operations planning in oriented strand board industry with make-to-order manufacturing system: Cross functional integration under deterministic demand and spot market recourse. **International Journal of Production Economics**, 115(1), 189-209.

FLEISS, J.L. (1971). Measuring nominal scale agreement among many raters. **Psychological Bulletin**, 76(5), 378-382.

FLYNN, B.B.; HUO, B. and ZHAO, X. (2010). The impact of supply chain integration on performance: A contingency and configuration approach. **Journal of Operations Management**, 28, 58-71.

FORNELL, C. and LARCKER, D.F. (1981). Evaluating structural equation models with unobservable variables and measurement error. **Journal of Marketing Research**, 18(1), 39-50.

FROHLICH, M.T. and WESTBROOK, R. (2001). Arcs of integration: an international study of supply chain strategies. **Journal of Operations Management**, 19, 185-200.

FUNK, J.L. (1995). Just-in-time manufacturing and logistical complexity: a contingency model. **International Journal of Operations and Production Management**, 15(5), 60-71.

GERTLER, P.J.; MARTINEZ, S.; PREMAND, P.; RAWLINGS, L.B. and VERMEERSCH, C.M.J. Impact Evaluation in Practice. Washington: The International Bank for Reconstruction and Development / The World Bank.

GIANESI, I.G.N. (1998). Implementing manufacturing strategy through strategic production planning, **International Journal of Operations & Production Management**, 18(3), 286-299.

GIDDENS, A. (1984). The constitution of society: Outline of the theory of structuration. Berkeley, CA: University of California Press.

GIMÉNEZ, C. and VENTURA, E. (2003). Supply chain management as a competitive advantage in the Spanish grocery sector. **The International Journal of Logistics Management**, 14(1), 77-88.

GIMÉNEZ, C. and VENTURA, E. (2005). Logistics-production, logistics-Marketing and external integration: Their impact on performance. **International Journal of Operations & Production Management**, 25(1), 20-38.

GODSELL, J.; BIRTWISTLE, A. and VAN HOEK, R. (2010). Building the supply chain to enable business alignment: lessons from British American Tobacco (BAT). **Supply Chain Management: An International Journal**, 15(1), 10-15.

GOODWIN, P.; ÖNKAL, D. and THOMSON, M. (2010). Do forecasts expressed as prediction intervals improve production planning decisions?. **European Journal of Operational Research**, 205(1), 195-201.

GONZÁLEZ-BENITO, J. (2002). Effect of the characteristics of the purchased products in JIT purchasing implementation. **International Journal of Operations and Production Management**, Vol. 22, No. 8, 868-886.

GRIMSON, J.A. and PYKE, D.F. (2007). Sales and operations planning: an exploratory study and framework. **International Journal of Logistics Management**, 18(3), 322-346.

GUNASEKARAN, A.; PATEL, C. and TIRTIROGLU, E. (2001). Performance measures and metrics in a supply chain environment, **International Journal of Operations and Production Management**, 21(1-2), 71-87.

GUNASEKARAN, A.; PATEL, C. and MCGAUGHEY, R.E. (2004). A framework for supply chain performance measurement. **International Journal of Production Economics**, 87(3), 333-347.

GUNASEKARAN, A. and KOBU, B. Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications. **International Journal of Production Research**, 45(12), 2819-2840.

GYAN-BAFFOUR, G. (1994). Advanced manufacturing technology, employee participation and economic performance: an empirical analysis. **Journal of Managerial Issues**, 6, 491-505.

HADAYA, P. and CASSIVI, L. (2007). The role of joint collaboration planning actions in a demand-driven supply chain. **Industrial Management & Data Systems**, 107(7), 954-978.

HARWELL, J. (2006). Sales & operations planning in the retail industry. **Journal of Business Forecasting**, 25(3), 4-10.

HAYES, R.H. and WHEELWRIGHT, S.C. (1979). Link manufacturing process and product life cycles. **Harvard Business Review**, January-February, 133-140.

HARZING, A.W.K. and VAN DER WAL, R. (2008). Google Scholar as a new source for citation analysis. **Ethics in Science and Environmental Politics**, 8(1), 61-73.

HAYES, R.H. and WHEELWRIGHT, S.C. (1979). Link manufacturing process and product life cycles. **Harvard Business Review**, 57(1), 133-140.

HENSLEY, R. (1999). A review of operations management studies using scale development techniques, **Journal of Operations Management**, Vol. 17, No. 3, 343-358.

HESKETT, J.L. (1977). Logistics - essential to strategy. **Harvard Business Review**, 55(6), 85-96.

HILL, T. (1994). Manufacturing Strategy - Text and Cases, Richard D. Irwin, Homewood, IL.

HILL, T. (2000). Manufacturing Strategy: Text and Cases, second ed. Palgrave, Basingstoke.

HOLT, C. (2002). Learining how to plan production inventories and work force, **Operations Research**, Vol. 50 No. 1, 96-99.

HU, L. and BENTLER, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. **Structural Equation Modeling**, 6, 1-55.

HUO, B. (2012). The impact of supply chain integration on company performance: an organizational capability perspective. **Supply Chain Management: An International Journal**, 17(6), 596-610.

IVERT, L.K. and JONSSON, P. (2010). The potential benefits of APS systems in sales-and-operations planning, **Industrial Management & Data Systems**, 110(5), 659-681.

JACCARD, J.; WAN, C.K. and TURRISI, R. (1990). The detection and interpretation of interaction effects between continuous variables in multiple regression. **Multivariate Behavioral Research**, 25(4), 467-78.

JÖRESKOG, K.G. and SÖRBOM, D. (1993). Structural equation modeling with the SIMPLIS command language. Chicago: Scientific Software.

JÜTTNER, U.; CRISTOPHER, M. and GODSELL, J. (2010). A strategic framework for integrating marketing and supply chain strategies. **The International Journal of Logistics Management**, Vol. 21, No. 1, 104-126.

KAHN, K.B. and MENTZER, J.T. (1996). Logistics and Interdepartment Integration. **International Journal of Physical Distribution and Logistics Management**, Vol. 26, No. 8, 6-14.

KATHURIA, R.; JOSHI, M.P. and PORTH S.J. (2007). Organizational alignment and performance: past, present and future. **Management Decision**, 45(3), 503-517.

KEAL, D.A. and HEBERT, P. (2010). Benefits to blood banks of a sales and operations planning process. **Transfusion**, 50(12), 2785-2787.

KENNEDY, P. (2003). A Guide to Econometrics. **The MIT Press**, Cambridge-MA.

KOH, S.C.L. and SIMPSON, M. (2005). Change and uncertainty in SME manufacturing environments using ERP. **Journal of Manufacturing Technology Management**, 16(6), 629-653.

KOUFTEROS, X.; VONDEREMBSE, M. and JAYARAM, J. (2005). Internal and external integration for product development: the contingency effect of uncertainty, equivocality and platform strategy. **Decision Sciences**, 36(1), 97-113.

LANDSOM, C.D. (2000). The missing link. **Production & Inventory Management Journal**, 41(1), 66-71.

LAMBERT, D.M. and COOPER, M. (2000). Issues in Supply chain management, **Industrial Marketing Management**, Vol. 29, No. 2, 65-83.

LAMBERT, D.M. (2006). Supply Chain Management – Processes, **Partnerships**, **Performance**. Second Editon. SCMI.

LAPIDE, L. (2002). New developments in business forecasting. **Journal of Business Forecasting**, 21(2), 12-14.

LAPIDE, L. (2004a). Sales & operations planning part I: the process. **Journal of Business Forecasting**, 23(3), 17-19.

LAPIDE, L. (2004b). Sales & operations planning part II: enabling technology. **Journal of Business Forecasting**, 23(4), 18-20.

LAPIDE, L. (2005). Sales & operations planning part III: a diagnostic model. **Journal of Business Forecasting**, 24(1), 13-16.

LAPIDE, L. (2006). Top-down & bottom-up forecasting in S&OP. **Journal of Business Forecasting**, 25(2), 14-16.

LAPIDE, L. (2007). Sales & operations planning (S&OP) mindsets. **Journal of Business Forecasting**, 26(1), 21-31.

LAPIDE, L. (2009a). Risk and the Planning Process. **Supply Chain Management Review**, 13(7), 4-5.

LAPIDE, L. (2009b). The S&OP Rudder. **Supply Chain Management Review**, 13(2), 4-6.

LAU, A.; TANG, E. and YAM, R.C.M. (2010). Effects of supplier and customer integration on product innovation and performance: empirical evidence in Hong Kong manufacturers. **The Journal of Product Innovation Management**, 27(5), 761-777.

LAUGEN, B.T. and BOER, H. (2011). The International Manufacturing Strategy Survey 2009: A global report, Continuous Innovation Network (CINet). **Research in Continuous Innovation**, series: 7.

LAWLER, E.E. III. (1987). Choosing an Involvement Strategy. **The Academy of Management Executive**, 2(3), 197-204.

LAWRENCE, P.R. and LORSCH, J.W. (1967a). Organization and Environment: Managing Differentiation and Integration. Division of Research. **Graduate School of Business Administration**, Harvard: Harvard Press.

LAWRENCE, P.R. and LORSCH, J.W. (1967b). Differentiation and Integration in Complex Organizations. **Administrative Science Quarterly**, 12(1), 1-47.

LEE, H.L. and NG, S.M. (1997). Introduction to the Special Issue on Global Supply Chain Management. **Production and Operations Management**, 6(3), 191-192.

LIPSEY, M.W. and WILSON D.B. (2001). Practical Meta-Analysis. **Applied Social Research Methods**, Series. Vol. 49. Edition, Sage Publications, Thousand Oaks, California.

LIPSEY, W.L. (2009). Identifying Interesting Variables and Analysis Opportunities, in Cooper, H.C., Hedges, L.V., Valentine, J.C. (Eds), **The Handbook of Research Synthesis and Meta-Analysis**, 2nd. Edition, Russel Sage Foundation, New York, NY.

LITTLE, R.J.A. (1988). A test of missing completely at random for multivariate data with missing values. **Journal of the American Statistical Association**, 83(404), 1198-202.

MALHOTRA, M.K. and SHARMA, S. (2002). Spanning the continuum between marketing and operations. **Journal of Operations Management**, 20(3), 209-219.

MALONI, M.J. and FRANZA, R.M. (2009). Applying Sales and Operations Planning to the Metro-Atlanta Water Crisis. **Decision Sciences Journal of Innovative Education**, 7(2), 505-510.

MATT, G.E. and COOK, T.D. (1994). Threats to the validity of research syntheses. In Cooper, H. and Hedges, L.V. (eds.), **The handbook of research synthesis**. Russel Sage Foundation. New York.

MATT, G.E. and COOK, T.D. (2009). Threats to the validity of generalized inferences from research synthesis, in Cooper, H., Hedges, L.V., Valentine, J.C. (eds), **The Handbook of Research Synthesis and Meta-Analysis**, Russel Sage Foundation, Ney York, NY.

MATYUSZ, Z.S. (2012). The effect of contingency factors on the use of manufacturing practices and operations performance. Ph.D. Thesis. Corvinus University of Budapest.

McCORMACK, K. and LOCKAMY, A. (2005). The impact of horizontal mechanisms within sales and operations planning processes on supply chain integration and performance: a statistical study. **Proceedings of the 4th Global Conference on Business & Economics**, Oxford, UK. Available at http://www.drkresearch.org/Contact_Us/McCormackandLockamy4thGlobalConferncePaper_FinalVersion.pdf (accessed 4 August 2010).

McKINSEY. (2008). Managing Global Supply Chains. **McKynsey Quarterly**, Boston, MA.

MCKIMMIE, T. and SZURMAK, S. (2002). Beyond Grey Literature: How Grey Questions Can Drive Research. **Journal of Agricultural and Food Information**, 4(2), 71-79.

MCKONE, K.E. and SCHROEDER, R.G. (2002). A plant’s technology emphasis and approach. A contextual view. **International Journal of Operations and Production Management**, 22(7), 772-792.

MELLEN, C.; ALLEN, B. and PROKOPETS, L. (2010). Putting S&OP on the fast track. **Supply Chain Management Review**, 14(1), 40-45.

MENTZER, J.T. and MOON, M.A. (2004). Understanding demand. **Supply Chain Management Review**, 8(4), 38-45.

MERTON, R.K. (1957). Social Theory and Social Structure, revised and enlarged edition. **Glencoe**, IL: Free Press.

MILLIKEN, A.L. (2008). Sales & operations planning: building the foundation. **Journal of Business Forecasting**, 27(3), 4-12.

MORTON, N.A. and HU, Q. (2008). Implications of the fit between organizational structure and ERP: A structural contingency theory perspective. **International Journal of Information Management**, 28(2008), 391-402.

MUZUMDAR, M. and FONTANELLA, J. (2006). The Secrets to S&OP Success. **Supply Chain Management Review**, 10(3), 34-41.

MUZUMDAR, M. and VISWANATHAN, N. (2009). Integrated Business Planning: kicking S&OP up a notch. **Supply Chain Management Review**, 13(7), 34-41.

NAKANO, M. (2009). Collaborative forecasting and planning in supply chains: The impact on performance in Japanese manufacturers. **International Journal of Physical Distribution & Logistics Management**, 39(2), 84-105.

NARASIMHAN, R.; SWINK, M.L. and KIM, S.W. (2006). Disentangling leanness and agility: an empirical investigation. **Journal of Operations Management**, 24(5), 440-457.

NIELSEN, P.; NIELSEN, I. and STEGER-JENSEN, K. (2010). Analyzing and evaluating product demand interdependencies. **Computers in Industry**, 61(9), 869-876.

O'LEARY-KELLY, S.W. and FLORES, B.E. (2002). The integration of manufacturing and marketing/sales decisions: Impact on organizational performance. **Journal of Operations Management**, 20, 221-240.

OLHAGER, J. and RUDBERG, M. (2002). Linking manufacturing strategy decisions on process choice with manufacturing planning and control systems. **International Journal of Production Research**, 40(10), 2335-2351.

OLHAGER, J.; RUDBERG, M. and WIKNER, J. (2001). Long-term capacity management: Linking the perspectives from manufacturing strategy and sales and operations planning. **International Journal of Production Economics**, 69(2), 215-225.

OLHAGER, J. and SELLDIN, E. (2007). Manufacturing planning and control approaches: market alignment and performance. **International Journal of Production Research**, 45(6), 1469-1484.

OLHAGER, J. (2010). The role of the customer order decoupling point in production and supply chain management. **Computers in Industry**, 61(9), 863-868.

OLHAGER, J. (2013). Evolution of operations planning and control: from production to supply chains. **International Journal of Production Research**, DOI:10.1080/00207543.2012.761363, Available at http://www.tandfonline.com/doi/abs/10.1080/00207543.2012.761363?journalCode=tprs20#preview (accessed: March 15th 2013).

OLIVA, R. and WATSON, N. (2011). Cross-Functional Alignment in Supply Chain Planning: A Case Study of Sales and Operations Planning. **Journal of Operations Management**, 29(5), 434-448.

PAGELL, M. and KRAUSE, D.R. (1999). A multiple-method study of environmental uncertainty and manufacturing flexibility. **Journal of Operations Management**, 17, 307-325.

PAIVA E.L. (2010). Manufacturing and marketing integration from a cumulative capabilities perspective. **International Journal of Production Economics**, 126(2), 379-386.

PARENTE, D.H.; PEGELS, C.C. and SURESH, N. (2002). An exploratory study of the sales-production relationship and customer satisfaction. **International Journal of Operations & Production Management**, 22(9), 997-1013.

PARTHASARTHY, R. and SETHI, S.P. (1992). The impact of flexible manufacturing automation on business strategy and organizational structure. **Academy of Management Review**, 17, 86-105.

PAULK, M.C.; WEBER, C.V. and CHRISSIS, M.B. (1993). The Capability Maturity Model for Software, Version 1.1. ed. [S.l.]: **Software**. Engineering Institute, Carnegie Mellon University, Pittsburgh, PA.

PIECHULE, J. (2008). Implementing a sales and operations planning process at sartomer company: a grass-roots approach. **Journal of Business Forecasting**, 27(3), 13-18.

PING Jr., R.A. (2004). On assuring valid measures for theoretical models using survey data. **Journal of Business Research**, 57, 125-141.

PODSAKOFF, P.M.; MACKENZIE, S.B.; LEE, J.Y. and PODSAKOFF, N.P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. **Journal of Applied Psychology**, 88(5), 879-903.

PRAJOGO, D. and OLHAGER, J. (2012). Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. **International Journal of Production Economics**, 135, 514-522.

PUGH, D.S.; HICKSON, D.J.; HININGS, C.R.; MACDONALD, K.M.; TURNER, C. and LUPTON, T. (1963). A Conceptual Scheme for Organizational Analysis. **Administrative Science Quarterly**, 8(3), 289-315.

QUESADA, G.; RACHAMADUGU, R.; GONZALEZ, M. and MARTINEZ, J.L. (2008). Linking order winning and external supply chain integration strategies. **Supply Chain Management: An International Journal**, 13(4), 296-303.

REXHAUSEN, D.; PIBERNIK, R. and KAISERD, G. (2012). Customer facing supply chain practices: The impact of demand and distribution management on supply chain success. **Journal of Operations Management**, 30, 269-281.

REYMAN, G. (2005). How Johnsondiversey implemented S&OP in Europe. **Journal of Business Forecasting**, 24(3), 20-28.

ROTHSTEIN, H.R. and HOPEWELL, S. (2009). Grey Literature in Cooper, H., Hedges, L.V. and Valentine, J.C., 2009, **The Handbook of Research Synthesis and Meta-Analysis**, 2nd. ed., New York: Russel Sage Foundation, 103-125.

ROSENSTREICH, D. and WOOLISCROFT, B. (2009). Measuring the impact of accounting journals using Google Scholar and the g-index. **The British Accounting Review**, 41(4), 227-239.

ROSENZWEIG, E.D.; ROTH, A.V. and DEAN JR., J.W. (2003). The influence of an integration strategy on competitive capabilities and business performance: an exploratory study of consumer products manufacturers. **Journal of Operations Management**, 21, 437-456.

SAEED, K.; MALHOTRA, M.K. and GROOVER, V. (2005). Examining the impact of inter-organizational systems on process efficiency and sourcing leverage in buyer-supplier dyads. **Decision Sciences**, Vol. 36, No. 3, 365-96.

SCHERMELLEH-ENGEL, K.; MOOSBRUGGER, H. and MÜLLER, H. (2003). Evaluating the fit of structural equation models: tests of significance and descriptive goodness-of-fit measures. **Methods of Psychological Research Online**, 8(2), 23-74.

SCHMENNER, R.W. and SWINK, M.L. (1998). On theory in operations management. **Journal of Operations Management**, 17(1), 97-113.

SCHROEDER, R.G.; BATES, K.A. and JUNTTILA, M.A. (2002). A resource-based view of manufacturing strategy and the relationship to manufacturing performance. **Strategic Management Journal**, 23(2), 105-17.

SEHGAL, S.; SAHAY, B.S. and GOYAL, S.K. (2006). Reengineering the supply chain in a paint company. **International Journal of Productivity and Performance Management**, 55(8), 655-670.

SHAH, R. and WARD, P.T. (2003). Lean manufacturing: context, practice bundles, and performance. **Journal of Operations Management**, 21(2), 129-149.

SHAH, R. and GOLDSTEIN, S.M. (2006). Use of structural equation modeling in operations management research: Looking back and forward. **Journal of Operations Management**, Vol. 24, No. 2, 148-169.

SHAH, R. and WARD, P.T. (2007). Defining and developing measures of lean production. **Journal of Operations Management**, 25(4), 785-805.

SHADISH, W.R.; COOK, T.D. and CAMPBELL, D.T. (2002). Experimental and quasi-experimental designs for generalized causal inference. **Houghton Mifflin**, Boston.

SHAPIRO, B.P. (1977). Can marketing and manufacturing coexist?, **Harvard Business Review**, September-October, 104-113.

SIMATUPANG, T.M. and SRIDHARAN, R. (2005). The collaboration index: a measure for supply chain collaboration. **International Journal of Physical Distribution & Logistics Management**, 35(1), 44-62.

SINGH, M.K. (2010). What Makes a Winning S&OP Program. **Supply Chain Management Review**, 14(3), 22-27.

SINGHAL, J. and SINGHAL, K. (2007). Holt, Modigliani, Muth and Simon’s work and its role in the renaissance and evolution of operations management. **Journal of Operations Management**, 25(2), 300-309.

SITKIN, S.B.; SUTCLIFFE, K.M. and SCHROEDER, R.G. (1994). Distinguishing control from learning in total quality management: a contingency perspective. **Academy of Management Review**, Vol. 19, No. 3, 537-564.

SLONE, R.E.; MENTZER, J.T. and PAUL DITTMANN, J. (2007). Are You the Weakest Link in Your Company's Supply Chain?. **Harvard Business Review**, 85(9), 116-127.

SMITH, L.; ANDRASKI, J.C. and FAWCETT, S.E. (2010). Integrated Business Planning: A Roadmap to Linking S&OP and CPFR. **Journal of Business Forecasting**, 29(4), 4-9.

SOUSA, R. (2003). Linking quality management to manufacturing strategy: an empirical investigation of customer focus practices. **Journal of Operations Management**, 21, 1-18.

SOUSA, R.S. and VOSS, C.A. (2008). Contingency research in operations management practices. **Journal of Operations Management**, 26(2008), 697-713.

STADLER, H. (2009), A framework for collaborative planning and state-of-the-art. **OR Spectrum**, Vol. 31, 5-30.

STANK, T.; DAUGHERTY, P.J. and ELLINGER, A.E. (1999). Marketing/Logistics integration and firm performance. **The International Journal of Logistics Management**, 10(1), 11-24.

STANK, T.P.; KELLER, S.B. and DAUGHERTY, P.J. (2001). Supply chain collaboration and logistics service performance. **Journal of Business Logistics**, 22(1), 29-48.

Supply-Chain Council. (2001). Supply-Chain Operations Reference-model Overview of SCOR Version 5.0, Supply-Chain Council, Pittsburg.

SVOBODOVÁ, L. (2011). Advanced manufacturing technology utilization and realized benefits, in Proceedings of the 15th WSEAS International Conference on Systems (Part of the 15th WSEAS CSCC Multiconference), Corfu Island, Greece, July 14-16, 137-142.

SWAMIDASS, P.M. (1996). Benchmarking manufacturing technology use in the United States. Gaynor, G.H. **Handbook of Technology Management**, 1st ed., New York: McGraw-Hill.

SWAMIDASS, P.M. and KOTHA, S. (1998). Explaining manufacturing technology use, firm size and performance using a multidimensional view of technology. **Journal of Operations Management**, 17, 23-37.

SWINK, M.; NARASIMHAN, R. and WANG, C. (2007). Managing beyond the factory walls: effects of four types of strategic integration on manufacturing plant performance. **Journal of Operations Management**, 25, 148-64.

SWINK, M. and NAIR, A. (2007). Capturing the competitive advantages of AMT: Design–manufacturing integration as a complementary asset. **Journal of Operations Management**, 25(2007), 736-754.

TOHAMY, N. (2008). The Evolution of S&OP. **Supply Chain Management Review**, 12(5), 10-11.

THOMÉ, A.M.T.; SCAVARDA, L.F.; FERNANDEZ, N.S. and SCAVARDA, A.J. (2012a). Sales and operations planning: A research synthesis. **International Journal of Production Economics**, 138, 1-13.

THOMÉ, A.M.T.; SCAVARDA, L.F.; FERNANDEZ, N.S. and SCAVARDA, A.J. (2012b). Sales and Operations Planning and the firm performance. **International Journal of Productivity and Performance Management**, 61(4), 359-381.

VALENTINE, J.C. (2009). Judging the quality of primary research, in Cooper, H., Hedges, L. V., Valentine, J. C. (eds), **The Handbook of Research Synthesis and Meta-Analysis**, Russel Sage Foundation, Ney York, NY.

VAN HOEK, R.; ELLINGER, A.E. and JOHNSON, M. (2008). Great divides: internal alignment between logistics and peer functions. **The International Journal of Logistics Management**, Vol. 19, No. 2, 110-129.

VENKATRAMAN, N. (1989). The concept of fit in strategy research: toward verbal and statistical correspondence. **Academy of Management Review**, 14(3), 423-444.

VENKATRAMAN, N. and PRESCOTT, J.E. (1990). Environment-strategy coalignment: an empirical test of its performance implications. **Strategic Management Journal**, 11(1), 1-23.

Ventana Research. (2006). Sales and operations planning: measuring maturity and opportunity for operational performance management, **Ventana Research**, San Mateo, CA.

VEREECKE, A. and MUYLLE, S. (2006). Performance improvement through supply chain collaboration in Europe. **International Journal of Operations & Production Management**, 26(11), 1176-1198.

VICS. (2010). Linking CPFR and S&OP: A Roadmap to Integrated Business Planning, Voluntary Interindustry Commerce Solutions.

VISWANATHAN, N. (2009). Sales and operations planning: integrate with finance and improve revenue. **Aberdeen Group**, Boston, MA.

VONDEREMBSE, M.; UPPAL, M.; HUANG, S.H. and DISMUKES, J.P. (2006). Designing supply chains: towards theory development. **International Journal of Production Economics**, 100(2), 223-238.

VOSS, C.; BLACKMON, K.L.; CAGLIANO, R.; HANSON, F. and WILSON, F. (1998). Made in Europe: Small Companies. **Business Strategy Review**, 9(4), 1-19.

WALLACE, T. (2006). Forecasting and sales & operations planning: synergy in action. **Journal of Business Forecasting**, 25(1), 16-36.

WALLACE, T.F. and STAHL, R.A. (2006). Sales & Operations Planning. **The Executive Guide**, T.F. Wallace & Company.

WALLACE, T.F. and STAHL, R.A. (2008). The demand planning process in executive planning S&OP. **Journal of Business Forecasting**, 27, 19-24.

WARD, P.T.; MCCREERY, J.K.; RITZMAN, L.P. and SHARMA, D. (1998). Competitive priorities in operations management. **Decision Sciences**, 29(4), 1035-1046.

WEINTRAUB, I. (2000). The impact of alternative presses on scientific communication. **The International Journal on Grey Literature**, 1(2), 54-59.

WHISENANT, C. (2006). The politics of forecasting in sales and operations planning. **Journal of Business Forecasting**, 25(2), 17-19.

WHYBARK, D.C. and WIJNGAARD, J. (1994), Editorial: Manufacturing-sales coordination. **International Journal of Production Economics**, Vol. 37, No. 1, 1-4.

WING, L. and PERRY, G. (2001). Toward Twenty-First-Century Pharmaceutical Sales and Operations Planning. **Pharmaceutical Technology**, 20-26.

World Bank (2012). World Development Indicators (WDI), available at: http://data.worldbank.org/data-catalog/world-development-indicators. (accessed July 20th 2012).

ZAMMUTO, R.F. and O'CONNOR, E.J. 1992. Gaining Advanced Manufacturing Technologies' Benefits: The Roles of Organizational Design and Culture. **Academy of Management Review**, 17 (4), 701-28.

ZHAO, M.; DRÖGE, C. and STANK, T.P. (2001). The effects of logistics capability on firm performance: customer-focused versus information-focused capabilities. **Journal of Business Logistics**, 22(2), 91-107.

ZHANG, Q.; VONDEREMBSE, M.A. and CAO, M. (2006). Achieving flexible manufacturing competence. The roles of advanced manufacturing technology and operations improvement practices. **International Journal of Operations and Production Management**, 26(6), 580-598.

ZAIRI, M. (1993). Competitive Manufacturing: Combining Total Quality with Advanced Technology. Long Range Planning, 26(3),123-132.

Appendix 1. Definitions and characteristics of S&OP

Authors	Definition and Characteristics
Lee & Ng (1997)	''It seems that the distinction between the so-called supply chain management today and traditional operations management lies in two dimensions of integration and coordination: organizational integration and flow coordination. (. . .) Companies are also overcoming the functional boundaries, so that the different disciplines and functions, such as manufacturing, distribution, marketing, accounting, information, and engineering, are better integrated''.
Gianesi (1998)	It is aggregate, i.e. it deals with production, sales and inventory levels of product families, considering monthly or quarterly periods. It thus allows top management to have a broader view of manufacturing operations, establishing global goals to be sought by the more detailed planning levels. It is also the linking element between manufacturing and other functional areas of the organization, as far as the plan, stated in terms of units to produce, is translated into the proper language of each functional area (e.g. units to the sales function, pounds to the marketing and finance functions, required resources to manufacturing and engineering functions). It therefore establishes the channel for vertical (business planning – PP – MRP II) and horizontal (between functions) communication, and constitutes a regular and systematic process in which the general manager meets the functional area managers in order to update plans, focusing on what is to be produced in the next 12 months or so. As a result, the process builds a teamwork culture among functional managers, thus allowing the mutual understanding of the capabilities, competencies and constraints of each other's area, ensuring in the end, realistic and coherent functional plans.
Basu (2001)	Sales and operation planning has been an established company-wide business planning process in the Oliver Wright MRPII methodology. The prime purpose of S&OP, in which all key executives participate, is to review the company performance and operating plans for a two year planning horizon. The Global S&OP is an extension of the Local one for a multi-national global enterprise. The SOP process is underpinned by progressive business planning meeting covering Demand planning, Supply review and Pre S&OP meetings. This process ensure participation at all levels, although not all staff in every meeting, and establishes a single set of numbers with common business objectives. The representatives from selected customers and suppliers in relevant meetings enhance the two-way communication.
Olhager et al. (2001)	Sales and operations planning (S&OP) is the long-term planning of production levels relative to sales within the framework of a manufacturing planning and control system. Within the S&OP, resource planning is used for determining the appropriate capacity levels in order to support the production plan. Manufacturing strategy and sales and operations planning provide two perspectives on long-term capacity management, raising and treating different issues. Thus, S&OP belongs to a manufacturing infrastructure decision category from a manufacturing strategy perspective. However, we want to distinguish S&OP from the others, where we see aggregate production planning (APP) as a part of the S&OP process, which is the long-term planning of production and sales relative the forecasted demand and the supply of capacity. The S&OP process is the forum where different functional strategies meet for establishing a production plan that economically serves the needs of the market, while supporting both the strategic and financial plans of the firm. One of the most interesting features of S&OP is its part strategic and part tactical nature.

Authors	Definition and Characteristics
Cox & Blackstone (2002)	A process that integrates customer-focused marketing plans for new and existing products with the operational management of supply chains. The process brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, and financial) into one integrated set of plans. The process must reconcile all supply, demand and new-product plans at both the detailed and aggregate level, and tie to the business plan. It is the definitive statement of the company's plans covering a horizon sufficient to plan for resources and to support annual business planning process. Executed properly, SOP links the strategic plans for business with its execution and reviews performance measures for continuous improvement.
Croxton et al., 2002	S&OP is a synchronization mechanism that matches the demand forecast with supply chain capabilities through coordination of marketing, manufacturing, purchasing, logistics and financing decisions and activities.
Lapide (2002)	Conceptually, the [S&OP] process is the mechanism by which a company matches it supply and demand plans to insure that everyone's plans are based on achieving the same set of goals and objectives. [It is] the best practice of single number forecasting. The major element of a SOP process is a periodic meeting that takes place with a cross-functional team empowered to develop demand and supply plans. The meeting's purpose is to develop a consensus-based set of forecasts and plans based on reviewing and adjusting a set of preliminary ones.
Malhotra & Sharma (2002)	MSOP (...) is an integrated planning and control process that seeks alignment between different functions of the organization. Decisions made here balance customer demand and supply resources.
Menzter & Moon (2004)	SOP [is] a "junction box", where information can flow between the demand side and the supply side of an enterprise. The SOP process matches future demand – expressed in the sales forecast with future supply projections evident in the capacity plan.
Bower (2005)	S&OP is an orchestrated effort to influence future business, based on cooperative, ongoing analysis of available intelligence and key metrics with the following end goals: to continuously measure business performance, to align operations with goals, to create precise demand and supply plans, to strike a balance of supply and demand that improves overall supply chain efficiency and cost effectiveness of the organization.
Whisenant (2006)	The goal of S&OP is to continuously balance demand, supply, distribution, and financial plans to achieve corporate objectives. (...) It is designed to keep operational execution aligned with corporate goals.
Dougherty and Gray (2006)	[S&OP] indicates the multi-functional scope of the planning process, which is essentially one of communication. It involves a monthly review and recalibration of plans setting the overall level of manufacturing output, sales and the resultant inventories, backlogs and competitive lead times for major product families. The process involves converting the business plan in dollars, to an equivalent planning unit, such as each, dozens, etc. (...) The impact of future changes should also be considered in these monthly meetings. These include sales promotion, price changes, new product introductions, product changes, etc. In the end, the company has one totally integrated set of plans to be used by marketing, manufacturing, finance, engineering, etc., which have been reconciled and committed to by the executives of the company.
Harwell (2006)	Sales and Operations Planning – primarily a manufacturing process – can be applied in a retail environment to successfully manage the constraints of limited inventory budget, display space in the store and marketing funds. S&OP is an ideal structure to facilitate decisions to optimize profits from promotional activities. In the S&OP structure, participants working at the execution level manage both item plans (SKUs and quantities) and financial plans (sales, gross profits, and inventory dollars aggregated at various levels of product hierarchy). Teams are formed to align with product categories or subcategories, enabling everyone to focus on the same strategies and results. S&OP is a highly cross-functional activity.

Authors	Definition and Characteristics
Lapide (2006)	This is a cross-functional process that brings together teams of individuals on a routine basis to plan for where businesses are going on a tactical basis. Each team member brings to the process a specific perspective during the development of supply and demand plans/forecasts. a process that is predicated on developing consensus-based demand and supply plans. Cross-function teams comprised of members from the supply chain, operations, marketing, sales, and finance organizations meet to discuss their plans for generating and satisfying customer demand. The process is driven by a baseline demand forecast that reflects the demand expected from the marketing and sales plans, which in turn drives the supply plans reflecting the future activities of the operations, manufacturing, logistics, and procurement organizations. The S&OP process also involves refining the supply and demand plans, as well as the baseline-demand forecast.
Muzumdar & Fontanella (2006)	S&OP is the set of business processes and technologies that enable an enterprise to respond effectively to demand and supply variability.
Grimsom & Pyke (2007)	S&OP is a business process that links the corporate strategic plan to daily operations plans and enables companies to balance demand and supply for their products. Many view S&OP as a process to build a consensus-based operations plan to meet the forecast demand, while others suggest that it be used as a real-time technique to adjust quickly to changing market and operating situations.
Lapide (2007)	S&OP process aims to optimally match supply and demand from a planning perspective. [It is] a cross functional process (...) which requires a team of Sales, Marketing, Supply Chain, Operations, Logistics, and Finance managers to engage in joint planning. (...) [It] bridges a team of customer facing managers from Sales, Marketing, and Customer Services with supply facing managers from Manufacturing, Operations, Logistics, Supply Chain, and Procurement.
Singhal & Singhal (2007)	The issues of aggregate production planning and disaggregation that Holt et al. addressed represent the primary links between strategic and tactical decisions in a firm. Aggregate production planning links operations with strategy. It plays a key role in enterprise resource planning and organizational integration by linking operations with accounting, distribution, finance, human resource management, and marketing. It also drives interorganizational coordination by linking operations with both upstream and downstream supply chains.
Slone et al. (2007)	S&OP software [is viewed] as a communications hub for everyone in the business and for selected supply chain partners. The system allows for real-time access to demand plans, inventory levels, and the transportation status of various different deliveries – information that in turn can be coordinated with demands from supply chain customers and inbound materials from supply chain providers.[It] sits atop the supply chain processes developed jointly by the company and its supply chain partners, is fully exploited as a competitive tool to deliver product faster and cheaper than rivals' supply chains do. (...) For the company to excel in the technology area, should also demonstrate a thorough understanding of how the firm is applying these technologies.
Affonso et al. (2008)	The S&OP process supports vertical integration, in relating strategic and financial plans to operational plans. It also supports integration between companies department with the customer purchase service, and the company's purchasing department with the commercial department of the suppliers.
Feng et al. (2008)	S&OP is a monthly-based tactical planning process. Led by senior management, it is performed to balance demand and all the supply capabilities of production, distribution, procurement, and finance to ensure the plans and performances of all business functions are aligned to support the business strategic plan. It is an integrated planning process that gathers all the plans from different functional units, evaluates, revises, and brings to consensus any conflict in order to generate a unique set of plans to orchestrate and control performance.

Authors	Definition and Characteristics
Milliken (2008)	[S&OP] is the process by which we bring together all the plans for the business (Customers, Sales, Marketing, Development, Manufacturing, Sourcing, and Financial) into one integrated set of tactical plans. The S&OP process provides management the ability to direct its business to achieve a sustainable competitive advantage. The overall objective of S&OP is to arrive at a business "Game Plan" to help manage and allocate critical resources to meet the needs of a customer at the least cost. S&OP is a top-down process. The overall goal of S&OP is to improve bottom-line performance.
Boyer (2009)	It is a top management's handle on business, which requires balancing demand and supply on a regular and formal basis. Here, top management means the company president, the people who report directly to the president (direct reports), and a few other selected people like the demand manager.(...) By "regular" I mean at set intervals, such as monthly, and by "formal" I mean that there are very specific data formats, meeting agendas, and a meeting calendar.
Cacere et al. (2009)	S&OP translates business strategy into an operational plan that serves as the foundation for translating channel demand into supply while balancing constraints
Maloni & Franza (2009)	Sales and operations planning (S&OP) is a critical intrafirm, cross-functional planning process that helps a business match supply with demand. Operations, sales and marketing, and finance collaborate, generally during a monthly meeting, to first validate a consensus demand plan (forecast). They then build a supply plan, including production and inventory planning, to meet that demand plan. As such, S&OP helps management tactically control the business while improving customer service and lowering inventory.
Nakano (2009)	The forecasting and planning process in supply chain is often called sales and operations planning (S&OP). In the S&OP process, sharing resources is to share standardized information (e.g., forecast, shipment, inventory, production, and purchasing data) and customized information (e.g., factors of demand fluctuation, and operational resources and constraints). (...) Collaborative process operation is to connect forecast and plan based on a schedule established in advance and to reexamine activities to adjust deviations from forecast and plan when contingencies arise. (...) we can call the former coordination by plan and the latter coordination by feedback. The purpose of these activities is to execute forecasting and planning in the S&OP process periodically. Through these activities, firms can integrate the S&OP operational process monthly, weekly, and daily.
Chen-Ritzo et al. (2010a)	S&OP is a process that enables alignment between front-end sales and marketing plans with back-end operational plans. It is apparent that S&OP integrates the financial, marketing and supply chain decisions at a company.
Godsell et al. (2010)	The S&OP process is part of the operational and line management processes. It is through this process that the operational alignment to strategy can be managed and implemented. The S&OP process normally manages the 1 to 2 year forward horizon.
Keal & Hebert (2010)	A formal sales and operations planning (S&OP) process is a decision making and communication process that balances supply and demand while integrating all business operational components with customer-focused business plans that links high level strategic plans to day-to-day operations.

Appendix 2. Empirical studies addressing the impact of S&OP practices on firm performance

Studies	Sample	S&OP practices / Dimensions	Performance Dimensions	Results
Stank et al. (1999)	309 U.S. based manufacturers	Internal integration (Marketing / Logistics)	Effectiveness of marketing/logistics integration and firm performance	More integration results in better logistics operational results.
Ellinger et al. (2000)	309 U.S. based manufacturers	Internal collaboration, consultation, information-exchange	Distribution service and firm performance (sales growth, overall customer satisfaction, profitability)	Integration impacts on the effectiveness of interdepartmental relations, which is positively associated with distribution services performance. Distribution services impacts on firm performance.
Frohlich & Westbrook (2001)	322 international manufacturers	External: Intensity ("arcs") of integration in Supply Chain (SC) with suppliers and with customers	Nineteen diverse measures of marketplace, productivity and non-productivity success	The largest the "arc of integration", simultaneously with suppliers and customers the larger the increase in performance.
Stank et al. (2001)	306 firms from the US, , Canada and Mexico	Internal integration among departments and External collaboration with suppliers and customers	Firm performance (delivery speed, dependability, responsiveness, flexibility and customer satisfaction)	Internal collaboration improves performance. External collaboration does not lead directly to improved performance. Collaboration in SC influences increased internal collaboration, which in turn improves logistical services.
Zhao et al. (2001)	195 North American-based firms	External integration with customers	Return on assets, logistics costs, customer satisfaction	Customer-focused capabilities were significantly related to firm performance. There was no direct link between information-focused capabilities and performance.
O'Leary Kelly & Flores (2002)	121 U.S.-based manufacturers	Internal integration of Manufacturing and Marketing/Sales	Profitability	The impact of integration of marketing/sales decisions on performance is dependent on the business strategy and demand uncertainty faced by the firm.
Parente et al. (2002)	79 customers, 10 sales-persons, 15 production managers, 128 sales-product-customer triads and 30 sales-product dyads from 3 manufacturers	Internal sales-production relationship (conflict, connectedness, coordination)	Customer satisfaction: product availability, on-time delivery, price, technical support, breath of line, technical quality, reliability, design.	Sales-production relationship and interdepartmental connectedness are positively associated with customer satisfaction. Interdepartmental conflict is negatively associated with customer satisfaction. There is no association between coordination/information sharing and performance. Product type (engineer-to-order) moderates internal integration impact on performance.
Rozensweig et al. (2003)	238 manufactures from North & Latin America, Europe and Asia-Pacific	Internal integration and external integration with suppliers, retailers and end-customers	Return on assets, sales growth, customer satisfaction, % revenue from new products	SCI Intensity leads directly to improved business performance. Manufacturing-based competitive capabilities (quality, reliability, flexibility and costs) mediate the relationship between integration and performance.

Studies	**Sample**	**S&OP practices / Dimensions**	**Performance Dimensions**	**Results**
Droge et al. (2004)	57 US-based manufacturers	Internal and external integration with suppliers	Time-based (Time to market, time to product, responsiveness), Market (market share, growth in market share), financial (return on assets, return on investments, return on sales).	Internal and external integration are related to 'time-to-market', 'time-to-product', and customer responsiveness. External integration has a direct positive impact on market share. The interaction of internal and external integration was significantly related to both market share and financial performance.
McKormack & Lockamy (2005)	55firms from the Supply Chain Council membership list	Internal and external S&OP roles of informal communication, integrator roles, formal communication mechanisms and networks	Firm performance (processes of plan, source, make and deliver)	S&OP practices were shown to improve plan, source, make and deliver processes.
Koufteros et al. (2005)	244 US-based manufacturers	Internal (concurrent engineering) and external integration with suppliers and customers	Quality, innovation, profitability	Internal and external integration positively influence performance. Contingency effects: equivocality moderates the relationships between integration and performance.
Giménez & Ventura (2005)	64 Spanish manufacturers	Internal integration: Marketing-Logistics, Production-Logistics, External integration through informal channels, joint undertakings, Continuous replenishment	Cost to serve, transport, process an order; reductions of stock-out and lead time	External integration has a positive and direct effect on performance. Internal integration does not. Internal integration (Logistics-Production) is correlated with external integration. Logistics-production integration and external integration in the SC reduces costs, stock-outs and lead time.
Olhager & Selldin (2007)	128 Swedish manufacturers	Internal S&OP process	Delivery speed, reliability, volume flexibility, mix flexibility	Market uncertainty is negatively related to performance. Market uncertainty is positively related to Manufacturing Planning and Control systems (MPC - including S&OP and Master Scheduling). S&OP plays a mediator role between uncertainty and performance.
Simatupang & Sridharan (2005)	76 companies of New Zealand	External collaboration in SC (information sharing, decision synchronization, incentive alignment) with suppliers and retailers.	Order fulfillment, inventory and responsiveness	Collaboration significantly impact on fulfillment and inventory performance. Information sharing had only a moderate influence on responsiveness.

Studies	Sample	S&OP practices / Dimensions	Performance Dimensions	Results
Cousins & Menguc (2006)	142 manufacturers and services companies in the UK	External integration with suppliers	Operational: Total cost reductions, delivery to schedule, quality improvements, conformance to specifications, lead times, time to market, process improvements. Communication: effectiveness, information exchange, feedback from supplier.	There is a strong direct relationship between the level of the supplier's socialization and contractual conformance; between operational and communication performance on contractual conformance. Integration with suppliers did not affected operational performance. Socialization mechanisms impact upon supplier's communication and operational performance.
Das et al. (2006)	322 U.S. manufactures	Internal integration and external integration with suppliers	Manufacturing cycle time, customization, cost, quality, speed (delivery), new product introduction time, and flexibility	Internal and external integration correlates with performance but "excess" integration with suppliers impacts negatively on performance.
Hadaya & Cassivi (2007)	53 suppliers in the U.S., Canada, others (non specified)	External joint planning actions with suppliers	Firm flexibility: product volume and mix; new product introduction, delivery flexibility	Joint planning actions, the strength of relationships and the use of interorganizational information systems positively influence performance.
Swink et al. (2007)	224 North American manufacturers	Internal and external integration with suppliers and customers	Market performance, Customer satisfaction	Corporate strategy and product–process integration have greater impacts on manufacturing competitive capabilities at the plant level than strategic supplier and customer integration. Strategic supplier integration is significantly linked to market performance, but not to customer satisfaction. Strategic customer integration is positively associated with customer satisfaction, but it is negatively associated with market performance.
Quesada et al. (2008)	646 manufacturers from 23 countries	External integration with suppliers and customers	Manufacturing performance (quality, price, delivery, flexibility, customer service)	Integration with both suppliers and customers in areas related to quality, delivery, service and flexibility improved performance, while integration in areas related to cost alone did not.
Daugherty et al. (2009)	125 logistics/supply chain executive members of the Council of Supply Chain Management Professionals	Internal integration between Marketing and Logistics	Logistics performance: ability to reduce lead time; to meet delivery dates and quantities; to change order, size and volume.	Information capability and firm-wide integration positively impacts logistic performance.

Studies	Sample	S&OP practices / Dimensions	Performance Dimensions	Results
Flynn et al. (2010)	617 Chinese firms	Internal and external integration with suppliers and customers	Operational (flexibility, on-time delivery, order fulfillment, customer services) and financial (growth and return in sales, market share, ROI, growth on ROI)	Internal integration was directly related to business and operational performance. Customer integration was directly related to operational performance. Supplier integration was not directly related to either type of performance. The interaction of supplier and customer integration was related to operational performance.
Nakano (2009)	65 Japanese manufacturers	Internal and external collaborative forecasting and planning with suppliers and customers	Logistics costs, manufacturing costs, inventory level, order fill rate, delivery speed, delivery times	Internal collaborative forecasting and planning has a positive effect on relative logistics and production performance. External collaborative forecasting and planning does not have a significant effect on relative logistics and production performance.
Lau et al. (2010)	251 manufacturers in Hong Kong	External integration with suppliers and customers	Product performance: sales and profitability	There is a direct, positive relationship between supplier and customer integration and product performance. Product co-development with suppliers improves performance, mediated by innovation.
Boon-itt & Wong (2011)	151 manufacturers in Thailand	Internal integration and external integration with suppliers and customers	On-time delivery, right quantity, lead time, reliability.	Internal and supplier integration, but not customer integration, were positively associated with performance. Technological and demand uncertainties were found to moderate the relationships between integration and performance.
Prajogo & Olhager (2012)	232 Australian manufacturers	External integration with suppliers	Quality, delivery, flexibility, costs	Logistics integration positively impacts on performance. Information technology and information sharing have effects on logistics integration. Long-term supplier relationships have both direct and indirect (via information integration and logistics integration) effects on performance.
Rexhausen et al. (2012)	116 multinational companies based in Europe	Internal S&OP practices (fully integrated S&OP process; organization follows S&OP process; participation of decision-makers)	Supply chain performance on costs, service level and flexibility.	Demand management (Dem) and Distribution management (Dim) practices positively impact the performance of a firm’s supply chain. Adherence to DeM and DiM processes and demand segmentation emerged as the major performance levers. The effects of other practices such as warehouse management or S&OP turned out to be "moderate at best".