Supply Chain Planning and Execution
Tool Efficiency: the Impact of
Upstream and Downstream Collaboration
on Performance

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Résumé

Cet article porte sur l’efficience relative des différents outils de collaboration électronique et leur impact sur la performance des firmes au sein d’une même chaîne d’approvisionnement dans le domaine des équipements de télécommunication. Basée sur deux phases d’analyse (étude de cas détaillée et questionnaire électronique), cette étude s’attarde tant à la collaboration électronique en amont qu’à la collaboration électronique en aval de cette chaîne d’approvisionnement. Dans un premier temps, l’article identifie les outils de collaboration électronique utilisés en ce qui a trait à la planification et à l’exécution d’une chaîne d’approvisionnement et mesure l’efficience relative de ces outils. Dans un second temps, différentes configurations de collaboration électronique sont comparées en fonction de leur potentiel de performance respectif.

Abstract

This paper focuses on the relative efficiency of different e-collaboration tools and their impact on the performance of individual firms positioned along the supply chain. This study, in which we analyze the supply chain of one large telecommunications OEM, was carried out in two consecutive phases, a detailed case study and an electronic survey, and allows for an examination of the entire supply chain from both upstream and downstream perspectives. It also identifies supply chain execution and supply chain planning e-collaboration tools and assesses their relative efficiency. This paper also attempts to map out the tools’ potential to enhance the performance of individual firms, in particular the link between e-collaboration configuration and key performance dimensions.

Mot-clés :
HA 07 Inter-organizational systems
HA 12 Common systems / Collaborative work systems
EI 0202 Efficiency
Introduction

In the so-called “networked economy,” collaboration between partners along supply chains plays an essential role. In order to gain a sustainable competitive edge, companies rely increasingly on collaboration tools to optimize the performance of supply chains. According to several authors, competition in the future will be between supply chains, not between companies [1, 2, 3]. As companies place more emphasis on creating an effective demand-driven (or customer-driven) supply chain, the development and implementation of collaborative initiatives focus on providing the required tools and processes to manage the large amounts of information being shared between supply chain partners. Efficient management of a supply chain implies the integration and coordination of information obtained from upstream and downstream supply chain partners. Some studies highlight the importance of collaborating across the entire supply chain [4, 5], but very few have tried to assess the impact of collaboration tools on the performance of a supply chain from both supplier and customer perspectives.

This paper focuses on the relative efficiency of different supply chain execution and planning e-collaboration tools and their impacts on the performance of individual firms positioned along the supply chain. Since the management of critical information and the flow of materials are being progressively extended beyond the borders of the firm to involve upstream and downstream activities, our study gathers empirical evidence on the use of e-collaboration tools from the two perspectives: dealing with suppliers (upstream perspective), and dealing with customers (downstream perspective). Qualitative and quantitative data were gathered from firms located at different layers of the supply chain of one major telecommunications equipment manufacturer.

The specific objectives pursued in this paper are as follows:

(i) to assess and compare the relative efficiency of different supply chain execution and planning e-collaboration tools used, from both upstream and downstream perspectives (first set of variables);
(ii) to investigate the relative importance of some key performance dimensions for individual firms (second set of variables);
(iii) to examine the strength of the relationship between the first and second sets of variables, and to test whether the strength of this relationship varies according to firm size and position along the supply chain.

The paper begins with a brief discussion of supply chain management issues relating to a demand-driven manufacturing environment, followed by the methodology of the empirical study and the main results. It concludes with a discussion of both theoretical and practical implications of this research.

Managing the Supply Chain in a Demand-driven Environment

Efficient supply chain management in a demand-driven manufacturing environment requires high levels of collaboration among supply chain members, which are often achieved due to the use of different types of collaboration tools. This section first defines supply chain management (SCM) and demonstrates the importance of managing both upstream and downstream activities in the supply chain. It also looks into demand-driven SCM strategies and two main types of
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The efficient management of demand-driven supply chains calls for advanced e-collaboration tools. Many software companies now offer packages targeting the supply chain software market, which is now estimated at more than $7 billion worldwide [16]. Some vendors provide very focused supply chain packages, and others, mainly ERP vendors, have expanded their existing

Collaboration tools: supply chain planning (SCP) and supply chain execution (SCE). Finally, supply chain performance measurement issues, which raise some conceptual and operational difficulties, are presented.

Upstream and Downstream Perspectives on Supply Chain Management

The Global Supply Chain Forum provides a broad definition of SCM: “Supply Chain Management is the key integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customers and other stakeholders” [6]. APICS [7] offers a similar general definition: “A supply chain is defined as the processes linking supplier and user companies, from the initial raw materials to the ultimate consumption of the finished product.” One of the most comprehensive definitions is proposed by Schorr [2]: “It integrates planning and balances supply and demand across the entire supply chain—it ties suppliers and customers together in one concurrent business process that focuses on the ultimate customer.” SCM is thus viewed as the process of developing strong ties with suppliers and customers and managing the flow of information, goods and services within and between organizations [8]. The literature often cites the importance of looking after both upstream (supplier side) and downstream (customer side) activities when cultivating supply chain relationships, but very few studies have been able to analyze and compare these two perspectives. Fawcett and Magnan’s [9] study describes some differences between the two perspectives and justifies the need for further empirical studies on the subject.

Supply Chain Management Strategies in a Demand-driven Environment

To stay competitive in a fast-paced, build-to-order manufacturing industry, firms need to adopt supply chain strategies that are flexible and customer-oriented [10]. Such strategies are usually described as demand-driven [11, 12]. Demand-driven strategies rely on fast turnover cycles, low inventories, and quick response of the supply network, as well as real visibility across the supply chain. The adoption of demand-driven supply chain strategies is often driven by high price erosion and rapid technological improvements [13]. The level of outsourcing can also trigger the use of demand-driven strategies. As more business partners get involved in the manufacturing process, increased collaboration is required to carry out forecasting, demand and planning-related activities. Nokia and Dell are well-known examples of firms that have successfully implemented such demand-driven strategies [14].

One of the main concerns of demand-driven supply chain strategies is the reduction of the bullwhip effect [15], that is, the fluctuation of inventories at all levels of the supply chain. Accurate planning and forecasting analysis play an important role in controlling fluctuations, different methodologies and tools are used by prime contractors to generate forecasts that will allow suppliers and customers to access accurate real-time manufacturing information. This increased visibility throughout the chain requires efficient communications between the planning and manufacturing systems of all supply chain partners.

The Use of E-collaboration Tools for Supply Chain Management

The efficient management of demand-driven supply chains calls for advanced e-collaboration tools. Many software companies now offer packages targeting the supply chain software market, which is now estimated at more than $7 billion worldwide [16]. Some vendors provide very focused supply chain packages, and others, mainly ERP vendors, have expanded their existing

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enterprise-wide applications to include interorganizational supply chain applications. With the advent of Web-based supply chain applications, SCM is now becoming accessible to smaller firms dealing with larger business partners.

There are two different types of SCM tools: supply chain planning (SCP) and supply chain execution (SCE) [17]. The two target very different, but complementary SCM tasks. SCP focuses mainly on end-customer demand forecasting and production capacity alignment, and usually offers functionalities such as demand management, sales and operations planning, manufacturing planning, master production scheduling, and distribution requirements planning [18]. As for SCE tools, they focus on the operational aspects of supply chain management. They smooth the progress of material flows within the supply chain and adjust production planning activities accordingly. SCE tools usually involve the management of inventory, transportation, warehousing and supply chain events [16].

**Measuring the Performance of Firms along a Supply Chain**

Measuring the operational performance of a supply chain is considered a very challenging task due to the number of stakeholders involved in the completion of the product or service. Initiatives such as SCOR (www.supply-chain.org) guide supply chain managers in the definition of operational activities. SCOR and its partners have developed a framework that identifies key actions in several activities (plan, source, make, deliver). One of its objectives is to develop a list of supply chain metrics that can be used in different industries. SCOR and other supply chain initiatives allow engineers to redesign important business processes, especially those directly linked to their partners.

In order to identify performance measures for a supply chain, a good understanding of the most important research initiatives in logistics, manufacturing and operations activities is mandatory. The cross-boundary management required for an efficient supply chain means that a company’s management team must work across traditional internal functional areas and manage external interactions with both suppliers and customers. Hence, in order to monitor progress and adjust the development of a supply chain, performance indicators should generally be based on process performance, and not strictly on financial performance [19].

Several fields of research have focused on quantifying the performance of individual firms, of specific departments of a company, of entire industries, and of key suppliers. The competitive environments of many industries now call for the evaluation of the performance of complete supply chains (from the suppliers’ suppliers to the customers’ customers). Authors such as Van Hoek [20], and Lambert and Pohlen [21] have pointed out the difficulty of measuring and improving performance in a supply chain. To evaluate the performance of SCM systems, researchers have developed a number of conceptual frameworks.

Some research initiatives divide the performance of a supply chain into different categories. In their study of power influences in the supply chain, Maloni and Benton split performance measures into three categories: supplier performance, manufacturer performance, and supply chain performance [21]. Shin et al. also identify supplier and buyer performance measures [23]. The supplier performance construct is composed of the following variables: lead times, on-time delivery, product quality, delivery reliability (fill rate) and product cost. Using a larger number of performance measures, Shin’s framework allows for an even more complete assessment of buyer performance along the following dimensions: process flexibility and volume flexibility,
production cost and production lead times, speed of delivery, delivery reliability and delivery lead times, and product quality [23]. Finally, Spekman et al. investigate the role and characteristics of partnerships in supply chains [24]. In this latter research initiative, two separate performance measures are identified to assess the performance of partnerships in a supply chain: cost reduction and customer satisfaction.

Numerous other research initiatives have combined different measures to assess the performance of various elements of a supply chain, such as customer responsiveness and costs [25]. Lead times, stock-out probabilities and fill rates shape customer responsiveness whereas costs relate to inventory and operation expenses. Arntzen et al., in their study of a large computer company, concentrate on the amount of time consumed in executing supply chain activities [26].

After scrutinizing the most important studies of performance measures, we found the most complete set of performance measures in Beamon’s study, which incorporates all the critical performance measures identified by earlier authors [27]. This initial set of measures (resource, output and flexibility measures) is retained in our study and enhanced with other measures suggested in the literature.

**Research Propositions**

According to several authors, the operational and financial benefits of efficiently managing the supply chain are numerous [28, 29, 30 and 31]. These benefits are the results of both SCP and SCE activities. For example, SCP facilitates collaborative scheduling actions within the network of firms [17] and SCE is often linked to faster response time.

The performance of SCM is often closely associated with the level of electronic integration within the supply chain [32, 33, 34]. However, few empirical studies have looked into the impact of fostering supply chain management by means of electronic commerce tools. Yao et al. found a positive relationship between supply chain performance and the implementation of electronic commerce initiatives [35]. Rutner et al. found that firms that have successfully executed SCM are likely to have implemented some electronic commerce initiative, thus supporting the view that integrated logistics systems go hand in hand with e-commerce [36]. It should also be noted that, even though little specific empirical evidence exists on this topic, the interorganizational information systems literature provides ample evidence of the benefits of electronic integration, notably inventory reductions, shortened lead times, cost reductions, and improved buyer-seller relationships [37, 38, 39, 40].

The significant levels of outsourcing in some industrial sectors amplify the collaboration opportunities for all product life cycle activities (from R&D to recycling). For instance, a manufacturer may decide to design a product and ask its suppliers to provide insights into different characteristics of the product such as manufacturing capabilities and material quality. The original equipment manufacturer (OEM) will also ask its customers to state clearly their requirements. Hence, the efficiency and speed of product completion depend not only on the activities of each tier of the supply chain but also on the information flows along the supply chain. This example clearly illustrates the close relationship there can be between the performance of the supply chain and the use of electronic collaboration tools.

These supply chain collaboration issues lead us to make the following proposition:
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**P1:** The efficiency of supply chain execution and planning e-collaboration tools has a positive influence on the performance of firms positioned along a supply chain.

As noted by Håkansson and Snehota, firms are far from being secluded islands; rather, they are embedded in networks of relationships [41]. In manufacturing environments, networks are often linear in nature, with material flowing towards end-customers, whereas financial and information flows move upstream towards the supplier base.

Of course, all firms in such a manufacturing network need to engage and maintain relationships with both upstream and downstream partners. Yet, when it comes to electronic integration of supply chains, firms tend to be more inclined to integrate upstream activities. Fawcett and Magnan [9] provide empirical evidence of this trend, as their results indicate that SCM initiatives are significantly more focused on the integration of key suppliers.

There may be different rationales underlying this tendency. Some authors have argued that firms have a greater influence on the integration process when dealing with suppliers than when dealing with customers [42]. With a more dominant position downstream, the firm may adjust the supply chain tools to its requirements, which may lead to better collaboration tool efficiency. In the same way, Fawcett et al. [9] reveal that firms are less inclined to integrate customers because they believe that the gains obtained from the collaboration tools might be seized opportunistically by the downstream partners.

On these grounds, we suggest the following proposition:

**P2:** The strength of the relationship between the efficiency of supply chain execution and planning e-collaboration, and the performance of the supply chain is significantly greater upstream than downstream on the supply chain.

**Methodology**

**The Telecommunications Equipment Industry Supply Chain**

The telecommunications equipment industry includes all companies involved in the manufacturing of equipment and in the software used for information processing and communication, including transmission and display. The data gathered from the multiple-case study gave us some insight into the four layers of the telecommunications equipment industry supply chain (figure 1). Each layer, beginning with the sub-assemblers (i.e., the manufacturers of parts and components) and ending with the network operators (i.e., the final users of the optical products), includes several key players that either manufacture, assemble, integrate or operate some type of telecommunications device (or equipment).
Network operators possess and operate different types of communication networks (transport networks, metropolitan area networks and access networks). Several interesting opportunities have opened up for network operators with the development of new services such as the Internet and the deregulation of the telecommunications industry in some regions.

In the telecommunications equipment industry, system integrators play the role of OEMs. The major OEMs in the industry tend to be large multinational firms such as Alcatel, Ciena, Cisco, Fujitsu, Lucent, NEC, Nortel Networks, Sycamore and Tellabs. System integrators are constantly investing in R&D to develop new products, tightly managing customer and supplier relationships, and integrating components to offer a solution that meets the customers’ requirements. Hence, value for OEMs is largely derived from knowledge-based activities.

In the assembler layer of the telecommunications industry, assembly activities are gradually being outsourced by OEMs to electronic manufacturing specialists (EMSs, also referred to as contract manufacturers). The EMSs’ ability to produce more flexibly and at a much lower cost than most traditional system integrators is the critical factor behind this outsourcing trend. The decision to outsource to EMSs is also based on their ability to efficiently respond to highly fluctuating demands.

Sub-assemblers consist of second-, third- and fourth-tier suppliers of assemblers or system integrators. The size and status of sub-assemblers vary but their functions and tasks are basically the same. Some sub-assemblers are subsidiaries of large multinationals with global contracts; others are small- and medium-sized enterprises (SMEs) that rely on orders from one or two major customers. The main activities carried out by sub-assemblers are component manufacturing and subsystem assembly.

This study, which focuses on the supply chain of one large telecommunications OEM, was carried out in two consecutive phases.

**Phase 1 – A Detailed Case Study**

The case study method appears rather appropriate for exploring the complex issues related to the research propositions. Seven firms (including the OEM) acting at different layers of the chosen supply chain were selected. Three main sources of evidence were examined and analyzed to
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allow triangulation [43, 44]: (i) publicly available information on the industrial context, the firms and their specific products, (ii) internal documents, and (iii) on-site interviews with 23 senior managers. The semi-structured interviews, carried out by three interviewers, followed a strict protocol: a minimum of four respondents per firm had to be interviewed, the interview guide included prepared questions based on the literature review, as well as open-ended questions. All interviews were transcribed in field notes. Within- and cross-case analyses of interview data were performed.

Seven firms were selected for the case study. They span the entire supply chain:

(i) one very large network operator at the farther downstream end of the supply chain that primarily acts as a provider of international voice, wireless and data/IP services to a large base of international customers;

(ii) the OEM, a very large company that offers customized and complex transmission solutions;

(iii) two large assemblers that are considered as preferred strategic suppliers;

(iv) two sub-assemblers, a medium-sized enterprise that manufactures cable and electromechanical components, and a large multi-layer PCB card sub-assembler—they are first-tier suppliers of the assembler and, in some cases, of the OEM;

(v) one medium-sized enterprise, which operates as a second-tier supplier in the metal sheet transformation sector. This company is located at the upstream end of the supply chain.

The main objectives of this case study were twofold: first, to gain a deeper understanding of the chosen supply chain, its members, their strategies and their relationships; second, to identify e-collaboration tools and to assess their use.

Phase 2 – An Electronic Survey

Based on the results of the case study, a questionnaire was developed to facilitate the input of information by both the managers involved in the upstream activities of the supply chain (i.e., individuals responsible for supplier-related functions such as procurement and design), and the executives involved in the downstream activities (i.e., individuals involved in customer-related functions, for instance, sales and marketing). Several of the OEM’s strategic suppliers, along with the OEM’s supply management group and supplier collaboration group, tested the questionnaire. Some adjustments were made based on their feedback.

The electronic survey appeared to be most appropriate in a supply chain whose members are located all around the world, and that is regarded by most observers as being at the leading edge of electronic collaboration. Furthermore, electronic surveys present several advantages over mail surveys, such as more flexible and individualized presentation: (i) questions tailored to individual responses to earlier questions [45]; (ii) colorful, attractive and interactive presentation [46, 47]; and (iii) more cost-effective and less error-prone data collection [48, 49]. However, a drawback arises from the dual nature of the questionnaire, which requires the input of at least two pre-qualified respondents for each participating firm—i.e., one senior manager for the upstream side (familiar with supplier issues) and one for the downstream side (dealing with customers). According to follow-up discussions with some respondents, in some cases they answered the questions as a group while others passed along the questionnaire from one person
to the next to confirm and complement the answers provided by their peers. However, with at least two respondents per company, it is assumed that the data are more reliable than they would have been with a single informant [50].

A total of 53 companies participated in the Web survey, for a 40.8% response rate. Each responding firm completed both the supplier-related questions and the customer-related queries. The upstream and downstream perspectives can be therefore assessed for each participating firm, resulting in a paired sample. All 53 responding firms are internationalized, carrying out both sales and procurement activities in external markets. Assemblers and sub-assemblers that act respectively as strategic and first-tier suppliers represent 71% of respondents while 25% are second-tier suppliers and 4% are third- and fourth-tier suppliers. Responding firms are deeply involved in collaboration with different levels of suppliers: 40% deal with three or more levels of suppliers whereas another 40% deal with two levels of suppliers.

The combination of the two data collection methods greatly enhances this study. The multiple-case study gives some valuable insights into the e-collaboration strategies of the chosen supply chain and the actual use of e-collaboration tools. The electronic survey allows the assessment of the relative efficiency of e-collaboration tools and the strength of the relationships between e-collaboration tools and key dimensions of the performance of supply chain members.

Results and Discussion

The general results of the multiple-case study are presented first in this section. The results of the electronic survey (statistical analyses) follow.

Results of the Case Study

E-collaboration Strategies

In pursuit of a demand-driven SCM strategy, the OEM and several of its most important assemblers have been the key sponsors for the diffusion of e-collaboration tools among the members of the supply chain. Based on 23 interviews with executives from the seven different participating firms, we identified the most important aspects of this collaborative strategy:

(i) increased visibility among supply chain partners—the collaboration tools produced real-time Web-based access to the OEM’s and the assemblers’ sales forecast, production planning and inventory levels;

(ii) increased supply chain velocity and flexibility—the collaboration tools enabled a 24- to 48-hour replenishment window to improve component turnover and, therefore, reduce inventory buffers on the shop floor;

(iii) reduced human interventions in the procurement process—collaborative initiatives in the supply chain aimed at redeploying resources previously allocated to supply chain execution to the supply chain’s collaborative planning activities;

(iv) improved data integrity and traceability—the integration of e-collaboration tools into internal informational systems contributed to the efficiency of information exchanges among the business partners.
E-collaboration Tools

In the chosen supply chain, different collaboration tools are used. On-site interviews revealed the existence of eight, which are briefly described in figure 2.

**The business strategy tool** collects and shares the actions that need to be taken to support the objectives and mission of the supply chain. General supply chain objectives are drawn from each organization’s goals and specific actions to achieve these common goals and then determined by the group.

**The direct procurement tool** is used, in most cases Web-based, to forward purchase orders (POs) to pre-qualified suppliers. Direct procurement, which replaces fax systems, is usually an alternative to electronic data interchange (EDI) and is often linked to an ERP system. An acknowledgment of receipt is usually posted on the direct procurement tool by the supplier.

**The replenishment tool** drives an ordering system from the shop floor. When material is needed on a production line, an order is placed through the replenishment system. The supplier usually has a specific amount of time to deliver ordered material either to the production line or to a stockroom.

**The projected shortages tool** scans the buyer’s production plan to project expected material shortages. Suppliers access the tool frequently and provide the delivery schedules of items with potential shortages. The tool also provides real-time information to manufacturing and supply management units.

**The capacity planning tool** determines the capacity required to produce. It establishes, measures and adjusts the levels of capacity in terms of labor and machine resources, and material necessary to accomplish the operational tasks.

**The forecasting tool** frequently exchanges the forecast information provided by both the buyer and supplier. The forecast information, which is a prediction of sales and use of products in order to purchase the appropriate quantities in advance, is usually obtained from ERP or APS systems.

**The design tool** enables the use of interactive engineering drawing and storage of CAD designs by all the key stakeholders of the supply chain involved in the product design activity. The collaborative design tool may be used to ensure that the final design meets all of the stakeholders’ requirements.

**The delivery and tracking tool** generates a payment and a delivery request automatically when a product goes from a supplier to its customer. It is also designed to collect shipping information from the third-party logistic providers. It is tightly linked to the direct procurement tool to automatically close purchase orders.

Figure 2 – Description of the e-collaboration tools

These tools are used on the Web to exchange critical information between supply chain partners but their use appears to be concentrated in the upstream end of the supply chain. Except for one pilot project, no e-collaboration tools are used between the network operator and the OEM. According to senior managers in both firms, the complex customized solutions delivered by the system integrator would make the use of these tools almost impossible.

However, the use of e-collaboration tools could be traced to all the different upstream layers of the supply chain, involving even third- and fourth-tier suppliers.

**Results of the Electronic Survey**

**The Relative Efficiency of E-collaboration Tools: the Upstream vs. Downstream Perspectives**
Data collected during the case study reveals that supply chain members feel that it is important for telecommunications equipment supply chain partners to exploit the eight collaborative tools displayed in figure 2 with both their own suppliers (upstream perspective) and customers (downstream perspective). However, are these tools efficient? Empirical data from the electronic survey provide us with some answers (table 1).

Table 1 – The relative efficiency of different e-collaboration tools

<table>
<thead>
<tr>
<th>E-collaboration tools</th>
<th>Upstream when dealing with suppliers</th>
<th>Downstream when dealing with clients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average score¹</td>
<td>Rank</td>
</tr>
<tr>
<td>Direct procurement</td>
<td>5.27</td>
<td>4</td>
</tr>
<tr>
<td>Replenishment</td>
<td>5.28</td>
<td>3</td>
</tr>
<tr>
<td>Shortages</td>
<td>5.12</td>
<td>5</td>
</tr>
<tr>
<td>Delivery and tracking</td>
<td>5.32</td>
<td>2</td>
</tr>
<tr>
<td>Design (CAD)</td>
<td>5.61</td>
<td>1</td>
</tr>
<tr>
<td>All collaboration tools for supply chain execution (SCE)</td>
<td>5.28</td>
<td>-</td>
</tr>
<tr>
<td>Forecasting</td>
<td>5.10</td>
<td>6</td>
</tr>
<tr>
<td>Capacity planning</td>
<td>4.91</td>
<td>7</td>
</tr>
<tr>
<td>Business strategy</td>
<td>4.54</td>
<td>8</td>
</tr>
<tr>
<td>All collaboration tools for supply chain planning (SCP)</td>
<td>4.84</td>
<td>-</td>
</tr>
<tr>
<td>All collaboration tools (SCE and SCP)</td>
<td>5.10</td>
<td>-</td>
</tr>
</tbody>
</table>

¹ average scores using list-wise procedures; based on a scale of 1 to 7
² level of significance for the two-tailed t-test (paired sample) - * (p < 0.1)

Some interesting observations can be derived from the data obtained from the 53 responding firms and shown in table 1:

(i) When comparing average scores, the efficiency of e-collaboration tools is systematically higher for the upstream perspective than it is for the downstream perspective, the one exception being delivery and tracking. This result is partly explained by the fact that the information coming from suppliers through the collaboration tools is usually configured to the manufacturer’s desired data format, thus facilitating the integration with the manufacturer’s internal systems (e.g., ERP system). The efficiency of the collaboration tools when used by a manufacturer and its customer (downstream perspective) is not as high due to the data conversion that might be required by the customer.

However, the only significant difference between the two perspectives (p < .10) relates to the direct procurement tool, where numerous PO formats are frequently created by the buyer (manufacturer). Hence, a manufacturer selects its formats for supplier relationships (thus enhancing relative efficiency) but is often forced to use other PO formats that jeopardize relative efficiency when dealing with customers.

(ii) The second and fourth columns in table 1 show two relatively similar rankings for the efficiency of the eight collaboration tools. In fact, there is almost total agreement between the upstream and downstream perspectives (p = .0644 for Kendall’s test of concordance in which p = 0 indicates complete agreement, and p = 1 complete disagreement).
(iii) The collaborative design tool appears to be important for both perspectives considering the importance of design activities in this high-tech industry. The short product life cycles and the high costs of components justify the importance of the activities related to design.

(iv) The last row of table 1 presents the combined score of efficiency for all eight collaboration tools. As could be expected from the above discussion, the score is higher (but not significantly) for the upstream perspective than for the downstream perspective.

(v) When examining the ranking, we find that collaboration tools focusing on SCE activities such as direct procurement, replenishment, shortages, and delivery and tracking receive high ranks compared to planning-oriented collaboration tools such as business strategy (ranked 8th for both perspectives), capacity planning (ranked 7th for both perspectives), and forecasting (ranked 5th for the upstream perspective and 6th for the downstream perspective). This result is aligned with the fact that companies are willing to share very precise information on short-term activities but are reluctant to give out information related to long-term strategic activities. This also explains the higher efficiency scores for SCE tools than for SCP tools (5.28 vs. 4.84 for the upstream perspective and 5.02 vs. 4.55 for the downstream perspective).

The Relative Importance of Key Performance Dimensions

The data collected from the electronic survey also allow us to assess the performance of the 53 responding firms according to three dimensions, namely resource, output and flexibility. Examination of table 2 enables us to observe some interesting points. First, the average scores of the five resource performance measures, which are usually those focused on by a company when evaluating its performance, are lower than the output and flexibility measures. The four flexibility performance measures, which are sometimes difficult to measure due to the intangible benefits they produce, are relatively high. The eight output measures are also characterized by the same trend, where the more intangible performance measures such as product quality and customer satisfaction have higher scores, and lower performance scores are assigned to tangible performance measures, namely sales volume and product variety.
Table 2 – Performance dimension average scores

<table>
<thead>
<tr>
<th>Performance dimensions</th>
<th>Average score</th>
<th>Cronbach alphas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory levels</td>
<td>3.84</td>
<td></td>
</tr>
<tr>
<td>Equipment utilization, energy use and cost</td>
<td>3.88</td>
<td></td>
</tr>
<tr>
<td>Operational costs *</td>
<td>3.96</td>
<td></td>
</tr>
<tr>
<td>Inventory costs *</td>
<td>3.98</td>
<td></td>
</tr>
<tr>
<td>Personnel requirements</td>
<td>4.02</td>
<td></td>
</tr>
<tr>
<td><strong>Resource measures - Overall (RM)</strong></td>
<td><strong>3.95</strong></td>
<td><strong>.89</strong></td>
</tr>
<tr>
<td>Time utilized to offer a product or service</td>
<td>4.02</td>
<td></td>
</tr>
<tr>
<td>Number of items produced</td>
<td>4.30</td>
<td></td>
</tr>
<tr>
<td>Time required to produce a product</td>
<td>4.42</td>
<td></td>
</tr>
<tr>
<td>Lead times *</td>
<td>4.49</td>
<td></td>
</tr>
<tr>
<td>Fill rates *</td>
<td>4.61</td>
<td></td>
</tr>
<tr>
<td>Stock-outs</td>
<td>4.84</td>
<td></td>
</tr>
<tr>
<td>Product quality</td>
<td>5.19</td>
<td></td>
</tr>
<tr>
<td>Number of on-time deliveries</td>
<td>5.27</td>
<td></td>
</tr>
<tr>
<td>Improvement in customer satisfaction</td>
<td>5.40</td>
<td></td>
</tr>
<tr>
<td><strong>Output measures – Overall (OM)</strong></td>
<td><strong>4.74</strong></td>
<td><strong>.69</strong></td>
</tr>
<tr>
<td>Sales volume</td>
<td>4.84</td>
<td></td>
</tr>
<tr>
<td>Product variety (mix)</td>
<td>4.86</td>
<td></td>
</tr>
<tr>
<td>New product introductions *</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Flexibility to deliver the product</td>
<td>5.07</td>
<td></td>
</tr>
<tr>
<td><strong>Flexibility measures - Overall (FM)</strong></td>
<td><strong>4.94</strong></td>
<td><strong>.79</strong></td>
</tr>
</tbody>
</table>

* added to Beamon’s measures [27]

In order to obtain a more manageable number of performance measures, we combined the performance measures into three performance dimensions (bottom row of each part of table 2). Construct reliability for the three performance dimensions is quite satisfactory, with Cronbach alphas ranging from 0.69 to 0.89 (last column of table 2). Furthermore, the overall performance for each of the three dimensions clearly demonstrates that the firms retained in our sample perform best in terms of flexibility (average score 4.94).

The Strength of the Relationships between SCE and SCP E-collaboration Tools and Key Performance Dimensions

For both upstream and downstream perspectives, table 3 illustrates the relationships between the level of efficiency of the SCP and SCE e-collaboration tools and the key dimensions of performance. Overall, the efficiency of e-collaboration tools (SCE and SCP) contributes more to the three key dimensions of the performance of the individual firms acting along the supply chain when they are used with suppliers than when dealing with customers—bottom line and first column of each of performance measure of table 3 (r₁₁ = 0.31**, r₁₂ = 0.43 ***, r₁₃ = 0.43*** vs. r₂₁ = 0.08, r₂₂ = 0.14, r₂₃ = 0.40***). This partially implies a top-down approach to the use of e-collaboration tools where the flow of decisions originates with the customers’ customer and moves up to the suppliers’ supplier. Further, collaboration tools are related to a greater extent to the flexibility dimension and, as a result, seem to support the concept of flexible integrated supply chains.

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### Table 3 – Pearson correlation coefficients between the level of efficiency of collaboration tools and performance when controlling for size and position held in the chain

<table>
<thead>
<tr>
<th>Collaboration tools</th>
<th>(↔ Upstream)</th>
<th>Resource measures</th>
<th></th>
<th></th>
<th>Output measures</th>
<th></th>
<th></th>
<th>Flexibility measures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No control variable</td>
<td>Size as a control variable</td>
<td>Position as a control variable</td>
<td>No control variable</td>
<td>Size as a control variable</td>
<td>Position as a control variable</td>
<td>No control variable</td>
<td>Size as a control variable</td>
</tr>
<tr>
<td>Collaboration tools for supply chain execution (SCE)</td>
<td></td>
<td>0.24 *</td>
<td>0.24 *</td>
<td>0.22 *</td>
<td>0.44 ***</td>
<td>0.44 ***</td>
<td>0.42 ***</td>
<td>0.46 ***</td>
<td>0.47 ***</td>
</tr>
<tr>
<td>Collaboration tools for supply chain planning (SCP)</td>
<td></td>
<td>0.36 **</td>
<td>0.38 **</td>
<td>0.34 **</td>
<td>0.37 ***</td>
<td>0.36 **</td>
<td>0.35 **</td>
<td>0.38 ***</td>
<td>0.39 ***</td>
</tr>
<tr>
<td>All collaboration tools (SCE and SCP)</td>
<td></td>
<td>0.31 **</td>
<td>0.32 **</td>
<td>0.29 **</td>
<td>0.43 ***</td>
<td>0.43 ***</td>
<td>0.41 ***</td>
<td>0.43 ***</td>
<td>0.44 ***</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collaboration tools</th>
<th>(Downstream ➔)</th>
<th>Resource measures</th>
<th></th>
<th></th>
<th>Output measures</th>
<th></th>
<th></th>
<th>Flexibility measures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No control variable</td>
<td>Size as a control variable</td>
<td>Position as a control variable</td>
<td>No control variable</td>
<td>Size as a control variable</td>
<td>Position as a control variable</td>
<td>No control variable</td>
<td>Size as a control variable</td>
</tr>
<tr>
<td>Collaboration tools for supply chain execution (SCE)</td>
<td></td>
<td>0.05</td>
<td>-0.05</td>
<td>0.12</td>
<td>0.12</td>
<td>0.23 *</td>
<td>0.14</td>
<td>0.34 **</td>
<td>0.35 ***</td>
</tr>
<tr>
<td>Collaboration tools for supply chain planning (SCP)</td>
<td></td>
<td>0.09</td>
<td>0.01</td>
<td>0.06</td>
<td>0.15</td>
<td>0.20</td>
<td>0.14</td>
<td>0.40 ***</td>
<td>0.42 ***</td>
</tr>
<tr>
<td>All collaboration tools (SCE and SCP)</td>
<td></td>
<td>0.08</td>
<td>-0.02</td>
<td>0.10</td>
<td>0.14</td>
<td>0.22 *</td>
<td>0.15</td>
<td>0.40 ***</td>
<td>0.42 ***</td>
</tr>
</tbody>
</table>

p = level of significance of the Pearson correlation coefficient (unilateral test)
* p < 0.1 ** p < 0.05 *** p < 0.01 **** p < 0.001

Some distinctions are made between the relationships involving SCE and SCP tools. On the upstream side, the relationships between the tool efficiency and output and flexibility measures are stronger for SCE tools whereas the relationship with resource measures is stronger for SCP tools. These results confirm the role of each type of tool: SCE tools to handle day-to-day activities to maximize productivity (output and flexibility), and SCP to plan the optimal (minimal) use of inputs (human and monetary resources) into the production process. On the downstream side, no distinction is measurable as the coefficients are similar. Only the relationships with flexibility measures are significant, which indicates that both types of tools, when used efficiently, are able to improve supply chain flexibility when dealing with customers.

Going one step further, we investigate the influence of two variables that could be considered as proxies for the power of individual firms [51], namely their position in the supply chain and their size. Neither control variable appears to have any significant impact on the relationships between the efficiency of e-collaboration tools and key performance dimensions; correlation coefficients
are remarkably stable, with or without the control variables (table 3). The only slight differences in the strength of these relationships are observed for the influence of firms’ size on the relationship between the efficiency of SCE and SCP e-collaboration tools when dealing with customers (downstream perspective) and the output performance measures. Performance measures, which are exchanged between partners of a demand-driven supply chain, are mainly output measures; the other two types of measures are usually used internally. The information relating to output measures is more likely to be taken into consideration by a customer if it originates from a large company. Therefore, when compared to a smaller company, the perception of a larger company on the efficiency of e-collaboration tools is greater. The company size provides more bargaining power in a demand-driven context and enables the company to exchange information more frequently with its customers, particularly data relating to output measures.

E-collaboration Configurations

The lack of influence of the position held by supply chain members and of their size prompted us to explore the presence of e-collaboration configurations. Would different types of e-collaboration, independent of the position held in the supply chain and of the firm’s size, be more closely associated with different key performance dimensions? In order to discover e-collaboration configurations, cluster analysis was done on the 53 firms to classify groups along four variables: the SCE and SCP e-collaboration tools for both downstream and upstream perspectives.

The results presented in table 4 demonstrate the presence of three significantly different groups of firms (level of significance p = .009 or less):

(i) The **first and smallest group** \( n_1 = 9 \) trails behind the others with respect to the efficiency scores for SCE and SCP e-collaboration tools, either when dealing with suppliers or when dealing with customers and could be called “laggers.”

(ii) The **second and largest group** \( n_2 = 25 \) appears to be midway between the first and the third groups. The highest scores for the efficiency of the e-collaboration tools are observed on the supplier side (5.28 and 4.95 upstream vs. 4.87 and 3.76 downstream). The firms in this second cluster seem to collaborate efficiently in a traditional way, with an emphasis on supply chain execution—they could be termed as “traditionalists.”

(iii) The **third group** \( n_3 = 19 \) displays the highest scores; these firms are engaged in full two-way e-collaboration using both SCE and SCP tools efficiently—they act as “leaders.”
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Table 4 – E-collaboration configurations: Results from the cluster analysis

| E-collaboration tools | Group 1 Laggers \( n_1=9 \) | Group 2 Traditionalists \( n_2=25 \) | Group 3 Leaders \( n_3=19 \) | \( p \)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>When dealing with suppliers (( \leftarrow ) Upstream)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCE</td>
<td>4.08</td>
<td>5.28</td>
<td>5.85</td>
<td>***</td>
</tr>
<tr>
<td>SCP</td>
<td>2.29</td>
<td>4.95</td>
<td>5.92</td>
<td>****</td>
</tr>
<tr>
<td>When dealing with customers (( \rightarrow ))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCE</td>
<td>2.77</td>
<td>4.87</td>
<td>6.28</td>
<td>****</td>
</tr>
<tr>
<td>SCP</td>
<td>3.17</td>
<td>3.76</td>
<td>6.25</td>
<td>****</td>
</tr>
</tbody>
</table>

SCE = Supply chain executions, SCP = Supply chain planning  
\(^1\) Level of significance of the Kruskall Wallis test (non-parametric ANOVA)  
* \( p < 0.1 \) ** \( p < 0.05 \) *** \( p < 0.01 \) **** \( p < 0.001 \)

For SCE tools, the laggards (group 1) are significantly different from the other two groups, traditionalists being closer to the leaders. The opposite occurs for SCP tools, as the leaders differentiate themselves from the other two groups. The level of maturity of the e-collaboration tools may explain these results. Activities of procurement, replenishment, shortage, delivery, and tracking, and design (SCE) are not as complex as SCP activities and have been carried out electronically for some time now. The electronic versions of the more complex SCP tools (forecasting, planning, and business strategy), which were developed later on, are taking some time to mature. They seem to be used adequately by the leaders, especially during downstream activities.

Table 5 – E-collaboration configurations and performance

| Key performance dimensions | Group 1 Laggers \( n_1=9 \) | Group 2 Traditionalists \( n_2=25 \) | Group 3 Leaders \( n_3=19 \) | \( p \)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources measures (RM)</td>
<td>3.09</td>
<td>3.94</td>
<td>4.37</td>
<td>*</td>
</tr>
<tr>
<td>Output measures (OM)</td>
<td>2.62</td>
<td>3.19</td>
<td>5.00</td>
<td>***</td>
</tr>
<tr>
<td>Flexibility measures (FM)</td>
<td>4.05</td>
<td>4.80</td>
<td>5.54</td>
<td>***</td>
</tr>
</tbody>
</table>

\(^1\) Level of significance of the Kruskall Wallis test (non-parametric ANOVA)  
* \( p < 0.1 \) ** \( p < 0.05 \) *** \( p < 0.01 \) **** \( p < 0.001 \)

As a final step in the statistical analysis, the link between e-collaboration configurations and key performance dimensions is explored (table 5). As might be expected, leaders (group 3) score highest on all key performance dimensions, which strengthens the position of firms that use SCP tools to conduct business with both upstream and downstream supply chain partners. The largest statistical differences between the three groups are found for the flexibility measures and for the output measures. This result indicates that efficient SCP and SCE tools meet some of the main concerns of a demand-driven supply chain:

(i) Obtain information visibility to quickly transform key design, manufacturing, and logistic activities. In particular, the efficiency of SCP tools, when used with customers, seems to be strongly associated to the flexibility measures (5.54, highest value in table 5).

(ii) Adequately manage the large amounts of information available to ensure the delivery of on-time quality products to customers. Efficient supply chain planning tools such as
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forecasting clearly improve the output measures (2nd row of table 5: 5.00 value for the leaders vs. 2.62 and 3.19 for the laggers and traditionalists respectively).

Conclusion

This study contributes to a better understanding of an important but under-investigated area of research, namely supply chain management and the role of e-collaboration tools.

The main results are as follows:

(i) The OEM and a few of its preferred strategic suppliers initiated the use of e-collaboration tools. These tools were implemented to support collaboration initiatives in a demand-driven environment with the purpose of reducing inventories, production lead times and operational costs. The e-collaboration tools are more directed towards SCE activities than SCP activities. Their deployment seems positively biased towards the upstream part of the chain.

(ii) The relative efficiency of e-collaboration tools appears to be higher when dealing with suppliers (upstream perspective) than when used with customers (downstream perspective).

(iii) The level of efficiency of SCE and SCP e-collaboration tools is positively related to the three key performance dimensions. These relationships are stronger for the flexibility dimension and for the upstream perspective, and are not influenced by either the position held in the supply chain or firm size.

(iv) E-collaboration configurations (i.e., the combination of e-collaboration tools for the downstream and upstream perspectives) point out three distinct groups of firms. Leaders find both SCE and SCP tools efficient and score best in all three performance dimensions, especially in terms of flexibility and to a lesser extent in terms of output measures. Traditionalists focus mainly on execution tools while the group with the worst performance record (laggers) does not seem to find any e-collaboration tools efficient.

However, the results presented in this paper should be interpreted in the light of a few limitations. First, the focus on one supply chain represents both a limit and a major strength. Obviously, the sample size (seven firms for the case study and 53 firms for the electronic survey) is rather small, but we were able to gather detailed empirical evidence from both the upstream and downstream perspectives in a paired sample design. Furthermore, the combination of the data collection strategies seems particularly relevant. It allows us to gain a better understanding of e-collaboration strategies and tools by analyzing the rich qualitative data obtained from the multiple-case study; this initial understanding proved to be valuable in designing the questionnaire and interpreting the quantitative data obtained from the larger number of firms in the electronic survey.

Second, the measurement of supply chain performance is plagued with difficulties. This paper examines the performance of individual firms acting along the different nodes of the supply chain, which is obviously an important first step before measuring the overall performance of one supply chain.

Third, we have selected one demand-driven supply chain, which is considered by most observers to be proactive in terms of e-collaboration [4]. The generalization of results to other supply chains may be questionable, and concerns about external validity may be raised. The dilemma of
external versus internal validity is omnipresent with most research initiatives, and ours is no exception.

The paper also makes some interesting contributions. The research design allows for an examination of the entire supply chain from both upstream and downstream perspectives. Until now, research relating to supply chains has tended to be limited to studies involving only two levels of the chain [52, 53]. Some studies deal with a single-supplier, single-retailer relationship [54, 55]; others focus on single-supplier, multiple-retailer relationships [56, 57]. This research design covers both upstream and downstream perspectives, which departs from previous studies (the only exception, to our knowledge, being Fawcett and Magnan [9].

Another important contribution of this paper is the identification of e-collaboration tools, the assessment of their relative efficiency throughout the entire chain and the analysis of both upstream and downstream perspectives. The most important contribution may reside in an attempt to map out the tools’ potential to enhance the performance of individual firms, in particular the link between e-collaboration configurations and key performance dimensions. Because the chosen supply chain is rather proactive in terms of e-collaboration, the results may be of interest to top executives and operations/production managers as they attempt to capitalize on supply chain initiatives and e-collaboration tools. The improvement of supply chain measures is a research topic that demands a large amount of data. The use of efficient e-collaboration tools, when applied according to the supply chain strategy, becomes valuable to all partners as it supports the core of the supply chain: information visibility from one end of the chain to the other.
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