The development and empirical validation of an e-based supply chain strategy optimization model

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Abstract
Examines the formulation of supply chain strategies in complex environments. Argues that current state-of-the-art e-business and supply chain management, combined into the concept of e-SCM, as well as the use of transaction cost theory, network theory and resource-based theory, altogether can be used to form a model for analyzing supply chains with the purpose of reducing the uncertainty of formulating supply chain strategies. Presents e-supply chain strategy optimization model (e-SOM) as a way to analyze supply chains in a structured manner as regards strategic preferences for supply chain design, relations and resources in the chains with the ultimate purpose of enabling the formulation of optimal, executable strategies for specific supply chains. Uses research results for a specific supply chain to validate the usefulness of the model.

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Introduction

Current models for supply chain management (SCM) agree that the sharing of business information is a crucial element, which binds supply chains together from end-to-end (e.g. Cooper *et al.*, 1997; Schary and Skjøtt-Larsen, 2001). However, there is no consensus as to which of the many SCM-business processes should be coordinated on a tactical or operative level across the chains in such a manner. Recent SCM theory concentrates on strategic collaborative planning and execution.

The sharing of business information seems to be an acceptable assumption in dyadic business relationships, in which two companies agree on aligning processes and share the information necessary to conduct SCM and achieve efficiencies in the operations (Zhenxin *et al.*, 2001). However, most supply chains involve far more than just two companies, which may not have the same interests, understanding of SCM, resource levels, willingness to invest in necessary IT infrastructure and consequently might also have a different strategic focus. Conflicts of interests are unavoidable:

> Putting together strategy, information technology and the supply chain to achieve success is not easy (Nickles *et al.*, 2001).

Research question and methodology

How can a SCM executive reduce uncertainty within supply chains, which involve more than two companies in order to develop and execute supply chain strategies? The problem might be easy to solve in such chains, where a focal company has a dominating role, such as the initiatives carried out by channel captains like Wal-Mart and Procter & Gamble (see Kotzab, 1997) and/or General Motors (Deloitte Research, 2001).

Both have implemented integrated IT systems, which binds together the focal company and its vast pool of supply chain partners; projects that demand large resources and the pre-existence or creation of relations between the focal company and its supply chain partners.

In order to answer the question raised, we introduce a model that integrates the current academic view on SCM as a management tool, new research on the subject of state-of-the-art e-business, which can be viewed as somewhat close to the practitioners' implementation of conceptual SCM, and three managerial economics theories (transaction cost theory, network theory, and resource-based theory). The model, which we call e-supply chain strategy optimization model, can be used to analyze supply chains systematically and to provide a holistic view of the possibilities when formulating e-strategies for entire supply chains in complex environments. Essential elements are the analysis of supply chain resources, relations and strategic preferences for supply chain design, which in turn form the basis for the formulation of optimal, executable supply chain strategies.

The complexity of developing and executing a valid supply chain stragegy

The supply chain management definition "problem"

There is no "right or wrong" definition of SCM. Many researchers within the field have

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published their view on SCM (see Lummus and Vokurka, 1999). Houlihan (1986) defines SCM as "a complete process for providing goods and services to final users", which is in line with the holistic view and focus on end-user value as presented by Cooper *et al.* (1997). Hines (1993) defines SCM as "the supply chain begins with the customer and shape the organization of the supply chain". This too represents a customer focus, but also indicates that SCM must consider organizational issues as well, not only marketing, logistics and distribution of products or services (e.g. Lummus *et al.*, 2001). SCM consists, according to Cooper *et al.* (1997), of three key elements: business processes, supply chain structure, and management components. In that sense, defines Houlihan (1986), relevant processes such as those that bring value to the market or customers. This very broad definition indicates that each supply chain is likely to have its own unique set of value-creating processes. Examples of relevant processes could be the seven processes as described by Hewitt (1994):

1 customer service;
2 order fulfillment;
3 demand management;
4 production flow management;
5 procurement, product development;
6 marketing and commercialization of new products; and
7 customer relationship management (CRM).

These processes can also be found in the widely accepted SCM model presented by Cooper *et al.* (1997). However, it must be emphasized that there is no consensus on which business processes the coordination should be built up.

The supply chain management components and the supply chain structure

The management components and supply chain structure is another area which involves a great deal of discussions between researchers (e.g. Chandra and Kumar, 2000). Table I shows an example of the difference that can be found on the subject.

Schary and Skjøtt-Larsen (2001) have a strategic view on the management of SCM compared to the more pragmatic view as presented by Cooper *et al.* (1997). Schary and Skjøtt-Larsen (2001) emphasizes the need to formulate an overall strategy for the supply chain, and then develop relevant organizational structures and information systems, which fit the strategy. Another important perspective is the need to develop inter-organizational relations as well as securing adequate resources through combinations of in-house competence development or outsourcing via contractual relations in order to execute the overall strategy. The management of supply chains therefore involves cooperation across supply chains at strategic as well as tactical levels. This indicates that top level management must be involved in formulating SCM strategies and those should be aligned with the overall strategy for the company as well as the entire supply chain.

Supply chain structure is strongly dependent on the managements' ability to create the necessary inter-organizational relations. This also means that the supply chain actors must agree on which business processes to coordinate and consequently, which information categories should be shared between the actors. These are huge issues, which can be extremely difficult to overcome in real world supply chain integration with many supply chain participants. The complexity of supply chains can be enormous, since each company has its own strategy and participate in many supply chains that may be nearly impossible to integrate based on the same business processes and information. The formulation of a supply chain strategy and the creation of necessary information systems, thus formal information sharing, as described by Schary and Skjøtt-Larsen (2001), are as such very relevant. However, it may prove to be extremely difficult to realize in complex supply chains, which we define as supply chains consisting of more than two supply chain partners and consequently of more than a selection of dyadic business processes. Each business process can then also prove to be very complex by itself.

Research performed by Vinum and Skjoldager (2001) showed that a product container tracking process in the US agricultural chemical industry included as many as 274 steps in the process across the chain, which indicated movements of the container and information exchange between supply chain actors and their IT systems. This is just one process, which needs to be standardized in order to coordinate across the entire chain. It is clear that the complexity increases for each additional process, and also when more companies are included in the supply chain integration. This is a huge issue when assembling representatives from an entire supply chain and agreeing on a standard for business processes, which may involve business

Table I
SCM management components

Cooper *et al.* (1997)	Schary and Skjøtt-Larsen (2001)
Planning and control	Establishment of overall strategy
Work structures	Organizational structure
Organizational structure	Development of common information systems
Flow of goods and facility structure	Establishment of inter-organizational relations for integration of operations
Information flow and IT structure	Secure adequate resources through ownership and outsourced contractual relations
Product structure	Secure continuous improvements and innovation
Management methods and management style	Monitoring of the supply chain
Power and management structure	
Risk and award structure	
Culture and attitude	

Source: Vinum and Skjoldager, 2001

process reengineering and change management of the adaptation of standardized processes in each participating company, which will require both financial and human resources.

State-of-the-art e-business: three integration levels in e-business

Defining the concept of state-of-the-art e-business

There is also no consensus between academia and business practice of what e-business is. E-business can be viewed as the term for trading activities with goods and services and exchange of information over IT and communication networks (e.g. Grieger, 2001; Wigand, 1997; Timmers, 1999). Here, we do not consider the initiation of trading activities via homepages as e-business, which is more viewed as a subset (e-commerce) to the supporting activities that are necessary to conduct real transactions via electronic media (e-business, see Vinum and Skjoldager, 2001).

The recent developments in electronic business tend to lean towards more integrated business models such as c-business (collaborative business) and/or SRM (supplier relationship management) (see e.g. Murillo, 2001), which represent state-of-the-art e-business. Practitioners often define c-business as means to leverage new technology in order to enable a set of complex cross-enterprise business processes allowing entire value chains to share decision making, workflow, capabilities, and information with others (Vinum and Skjoldager, 2001).

There is no doubt among decision makers that c-business and SCM is on the mind of the executives. In a survey among 356 executives across different industries, a total of 60 per cent of the respondents said that "collaborative-commerce" now and in the near future would be of critical importance for their business (Deloitte Research, 2001).

Regardless of the terminology used, state-of-the-art e-business is about collaboration and building tighter integrated supply chains, which indicates that the advanced electronic business models and today's state-of-the-art e-business solutions are becoming more closely related to the theoretical frameworks known from SCM and incorporates more than just technology and arms-length relations.

However, the aspect of collaboration cannot be limited to one single organizational stage.

The three levels of supply chain integration

Collaboration in supply chains can take place on three levels (in accordance to Kalakota and Robinson, 2001; Grieger, 2001; Cooper *et al.*, 1997; Zhenxin *et al.*, 2001):

1. Technical integration is the technical standard for data integration.
2. Application integration is how companies actually do the physical integration of software and hardware technology.
3. Business integration, on the other hand, is the actual value driver for collaboration among corporations and institutions, a necessary value driver behind the physical integration.

The basis of such collaboration is seen in automated integration by exchanging information from application to application between companies. From an organizational theory point of view the current evolution within business integration is heading towards developing trust between business partners, so that greater value can be gained through pervasive, real-time collaboration (Skjøtt-Larsen, 1999). Business partners share information such as demand plans, manufacturing schedules, inventory levels,

and order status, as well as work together to design product, ship it, account for it, and serve customers more efficiently. At this level, intelligence is linked to transactions. Businesses do not just share data and information. They co-manage activities through automated processes that span their organizations.

This means that placing an order can trigger a range of events from checking parts availability at a supplier to updating the production schedule with a contract manufacturer to identifying trends in a customer's buying patterns to changing forecasts shared with partners.

With pervasive collaboration, a supply chain realizes the greatest value because efficiencies and innovations flow through multiple businesses. It is not simply optimizing a single enterprise, it is co-creating efficient, effective value chains. Therefore, technical integration and technology are merely the prerequisites for the creation of actual value through business integration.

The e-based supply chain strategy optimization model (e-SOM)

General introduction

Vinum and Skjoldager (2001) define e-SCM as a management discipline, which concerns electronic supply chain integration on a technical, application and business management level. E-SCM also includes optimization of business processes and resources across supply chains, from customers to suppliers of products, services or information. The purpose of e-SCM is to achieve quick response to fluctuations in customer demand and at the same time reduce transaction costs for the entire supply chain and thereby creating maximal value for the end-user. A requirement for achieving the value-creating business collaboration and integration in a supply chain is the managements' ability to formulate and agree on a unified strategy for the supply chain. Furthermore, the creation of trust between the supply chain partners will make it possible to create the necessary e-relations, such as willingness to share essential e-SCM process information.

Theoretical perspectives of e-SOM

Our proposed model for developing and executing SCM strategies in complex environments, the e-supply chain strategy optimization model (e-SOM), thus focuses on enabling an analysis of supply chains from "end-to-end" with regard to identifying and considering strategic preferences, relations and resources in the supply chain. The basis of the model is formed as a combination of the SCM concept as well as on the current state-of-the-art e-business.

The theoretical foundation of the model is built upon three advanced managerial economics theories, which are used to define the boundaries of e-SCM:

- transaction cost theory;
- network theory; and
- resource-based theory.

Transaction cost theory: contractual governance of supply chain structures and relations

Transaction cost analysis (TCA) is used to give guidelines to the structuring and governance of supply chains. Individuals are assumed to behave opportunistically and to keep information to themselves (asymmetric information). Opportunistic behavior is regarded as the key driver behind transaction costs (Williamson, 1993; Hobbs, 1996).

There are three different kinds of transaction costs:

1 information gathering;
2 negotiation (attorneys and internal human resources); and
3 surveillance/monitoring costs.

In perspective of e-SCM, transaction costs are regarded as financial inefficiencies. TCA is therefore used as a method to identify when and where transaction costs may arise as well as to minimize these costs. Transaction cost theory thus explains why pervasive supply chain collaboration will create economic efficiencies as opposed to arms-length relationships.

E-SCM emphasizes the importance of long-term cooperation throughout the supply chain. Williamson (1993) argues that trust, on several levels, is one of the long-term drivers behind the minimization of transaction costs. Top level management should therefore focus on creating trust between the supply chain partners in order to reduce the risk of transaction costs. Further reduction of the risk of transaction costs can be achieved through contractual means. The recommendable regulation depends on the transaction frequency, asset specificity and degree of uncertainty in the relationship.

On one end of the scale are spot markets, such as the stock markets, which require very little contractual regulations because of high transaction frequency, low asset

specificity and low uncertainty. On the other end of the scale is full integration. This type of contractual relationship is caused by very high potential transaction costs due to high transaction frequency, high asset specificity and high uncertainty: the cost of outright buying another company is lower than the transaction costs that could occur. Between spot markets and full integration are hybrids, such as strategic alliances and joint ventures. These two are characterized by various degrees of asset specificity, transaction frequency and uncertainty. Instead of fully integrating the companies, contracts are used to govern the relations and keep them intact over a long period of time (Lippert-Rasmussen and Mols, 1994).

These types of relations are typical for e-SCM. Generally, relations with strategically important supply chain partners, such as raw materials suppliers, which own proprietary rights to their products (high asset specificity), should be regulated more extensively than non-strategic suppliers, such as companies that supply generic or commodity-like materials (low/medium asset specificity).

The structuring of supply chains and governance of relations thus involves reduction of the risk of transaction costs via different types of contractual means, which makes it possible to govern effectively the uncertainty of integrating business processes across supply chains, and especially in complex supply chains with many actors.

Network theory: the creation of trust in inter-organizational relations

Network theory focuses on the creation of inter-organizational relations and argues that real trust between individuals will safeguard sufficiently against transaction costs and keep the relationship intact over time (e.g. Håkansson and Johanson, 1993; Ring and Van De Ven, 1994). It describes very well the importance of long-term relationships between individuals in organizations. Transaction cost theory recognizes the need for trust between individuals, but fails to describe how the trust can be established (Skjøtt-Larsen, 1999). However, it is naive to think that trust alone is sufficient to govern the relations. The authors are convinced that the combination of management focus on establishing personal relations in conjunction with the transaction cost theories' method to choose the "correct" contractual governance of a relation altogether forms a very powerful management tool. The principle behind the network theory is that individuals, who seek to build trust with each other, enter into informal psychological contracts (Ring and Van De Ven, 1994).

This means that the individuals make a verbal agreement, which states that they seek to enter into a long-term business relationship with defined goals. Over time the individuals will gradually gain trust in each other as their business relations evolve and as the individuals see that they can trust the other person, and therefore also gradually get greater access to competencies outside of their own company – in the network of personal relations (Håkansson and Johanson, 1993).

E-SCM requires that supply chain partners share information with each other. A great portion of this information is usually regarded as private or sensitive information, which is traditionally not shared with anyone outside the company. It is clear that creation of inter-organizational trust is necessary in order to actually share the information with other companies, which is necessary to facilitate the integration of business processes and thus realize the full potential of SCM. The creation of relations based on trust between individuals is therefore very important when seeking to diminish the complexity that is inherent in supply chains with many actors.

Resource-based theory: sustainable competitive advantages through resource optimization

Resource-based theory, according to Grant (1991; 1996) and Dierickx and Cool (1989), concerns the optimization of resources and capabilities as the foundation for sustainable competitive advantages. The key resources, which combine to sets of capabilities and core competencies (Prahalad and Hamel, 1990) via learning processes, are: human, financial, physical, technology (IT), reputation and organizational.

These capabilities are difficult for competitors to copy, unless they identify the combination of resources and learning processes that went in to the making of the routines.

The most difficult resource to copy are the human resources, mainly because a lot of company specific knowledge is hidden in the individual as "tacit knowledge", which by nature is very difficult to document in a formal way. A group of individuals therefore represent a set of knowledge, which cannot be directly transferred to a competing company, unless the entire group of people is transferred along with learning processes, which also includes the company culture (e.g. Nonaka, 1994). Resource-based theory

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therefore concerns the optimization of resources and consequently also the unique capabilities.

A company's supply chain strategy must be based on their current capabilities. However, the theory recognizes that a strategy must be evaluated continuously and changes are very likely to be made to the strategy over time. Therefore, the focus of the theory is to optimize the resources at all times in order to secure that long-term capabilities actually enable the company to execute necessary changes to the strategy. The combination of unique capabilities and the continuous management of resources give basis for sustainable competitive advantages that evolve over time.

The three most important resources, seen from an e-SCM perspective, are human, IT and financial. Human and IT resources are perhaps obvious, since it will require significant human resources to implement data and application integration solutions, as well as IT hardware and software to do so. Financial resources mean the fiscal ability to invest in supply chain integration on the three levels: data, application and business processes. Management must be willing to budget adequately to enable the implementation of the chosen supply chain strategy. The amount depends on to what extent the supply chain strategies enter into actual IT integration between the companies.

Resource based theory only concerns the individual firm (Grant, 1996). However, we use the theory in a broader sense. The philosophy is that a truly collaborative supply chain will be managed as a "virtual enterprise". The chain will have a clearly defined strategy and overall business objective, as it will seek to eliminate inefficiencies (transaction costs) by integrating business processes and integrating IT-systems. Therefore, it is argued that e-SCM should also include the continuous management of the combined resources in the supply chain and collaborative evaluation and planning of necessary resources in order to secure sustainability for the entire chain. This still means that each company must optimize their resources internally. The big difference, as well as a major driver for cost efficiency, is that the collaborating companies can utilize each other's resources much more effectively in a collaborating chain with a large, combined "pool" of resources instead of having to invest in individual organizational resources. A larger diversity of resources can be created and knowledge sharing between organizations will increase to the benefit of the entire supply chain.

The presentation of the e-SOM model

Figure 1 shows the proposed e-SCM Strategy Optimization Model (e-SOM), which is based on the previous discussions of the SCM concept, state-of-the-art e-business as well as the theoretical perspectives on e-SCM.

The model begins with the three integration levels in order to enable the creation of real value through business integration. This section of the model therefore has an IT perspective. The business integration section of the model focuses on strategy formulation, creation of relations between supply chain actors, optimization of resources and optimization of business processes. The combined research results form the basis for the formulation of a SCM strategy for the specific supply chain.

Validating the e-based supply chain strategy model

Methodology

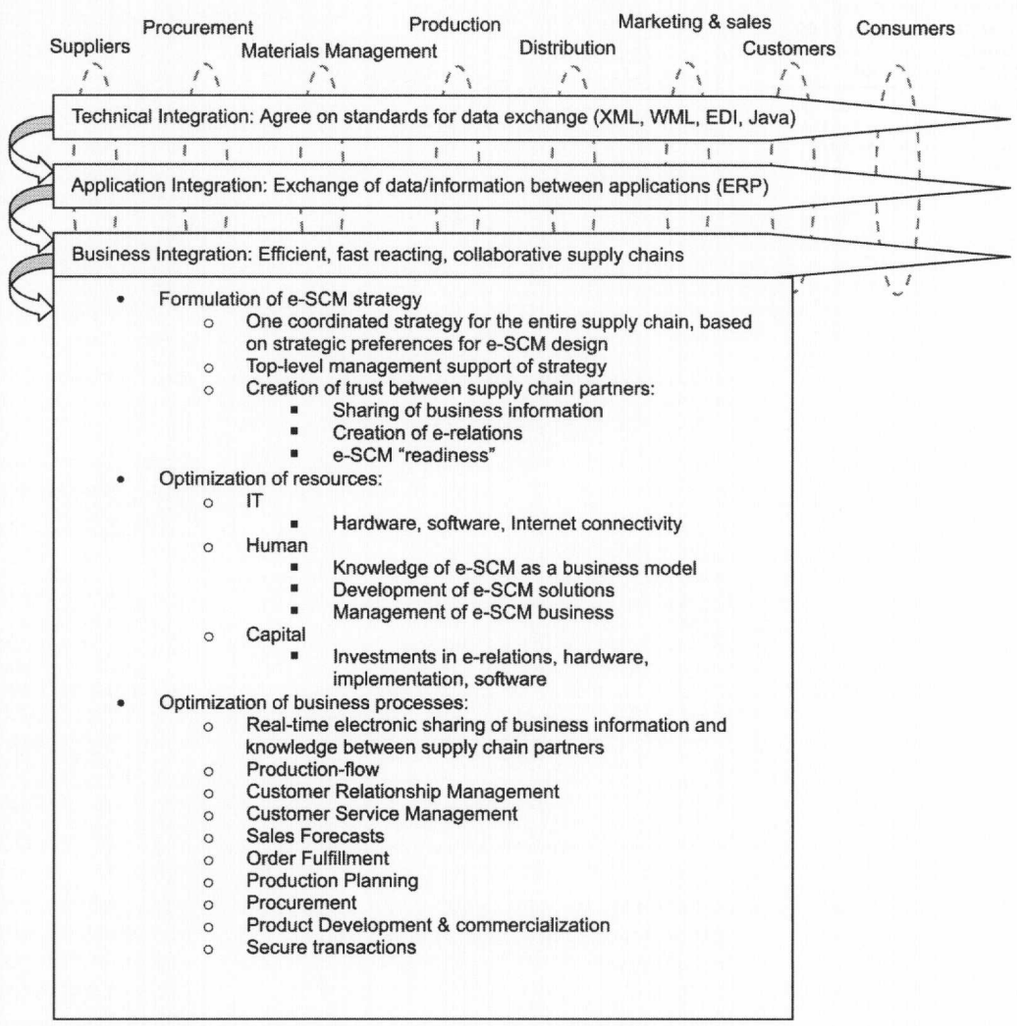
Our validation studies were conducted in June 2001 by examining two global supply chains in the agricultural chemical industry. Here, we present selected results of one supply chain (supply chain "A"). A total of 17 individual companies, primarily from the USA, but also Mexico, India and Spain, participated in the multi-method study, covering both quantitative and qualitative research methods.

The quantitative data were collected by the use of postal questionnaires, with a total of 29 valid respondents. We concentrated the studies on the focal company by collecting data from several interviews and questionnaires with respondents within the focal company. This method, also used by Cooper *et al.* (1997), was important since the focal company plays a central role in both chains, and therefore plays vital role for the SCM strategy formulation process.

Additionally, this concentrated focus on the focal company, provided a better insight in the available resources as well as the relations between the different companies in the chains, before meeting face to face with respondents from other companies. The questionnaire consisted of open and closed questions, as displayed in the Figure 2, and it also included the use of a conjoint analysis to measure strategic preferences (see Reutterer and Kotzab, 2000).

The qualitative studies were conducted through observations and hermeneutic

Figure 1
E-supply chain strategy optimization model (e-SOM) – a framework for e-SCM



Source: Vinum and Skjoldager (2001)

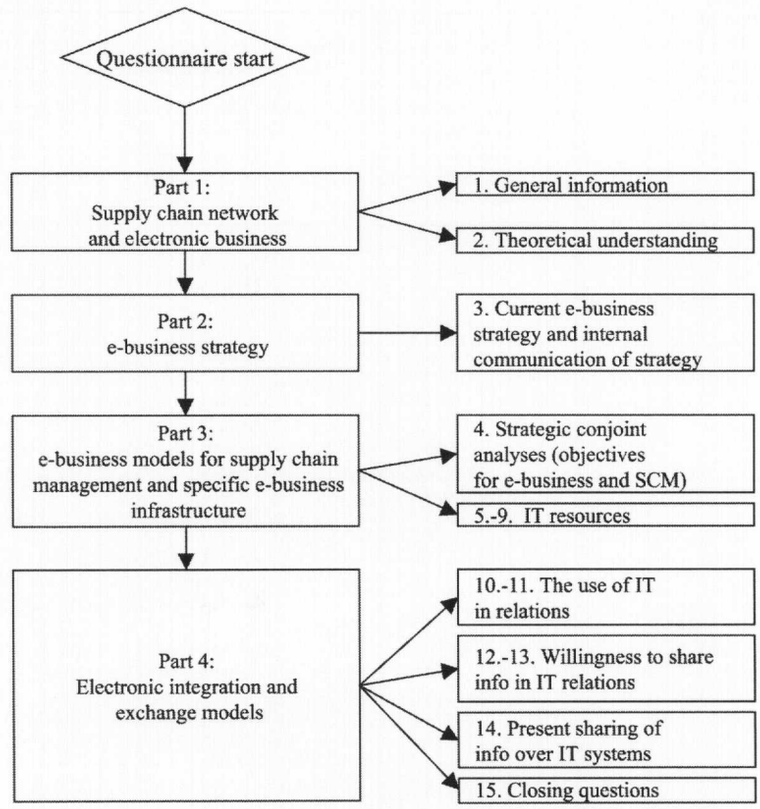
semi-structured interviews face to face with the respondents. The respondents in the survey population consisted of decision makers, primarily: presidents and VPs, CEOs, CIOs, CTOs, COOs, supply chain managers, product managers, marketing managers and general managers. The semi-structured interviewing process, with decision makers up and down the supply chains, provided a deeper understanding and insight in the different problems and opportunities that each respondent focused on. A summarized overview to our research approach is given in Figure 3.

The empirical validation of the e-SOM-model

As seen from Figure 1, the eE-SOM focus areas, resources, relations and strategic preferences, can be specified to the preferred levels that are needed to collect valid and reliable data. Explorative research about the companies had been executed before deciding on the levels in the quantitative data collection. This was especially important in the measurement of the resource levels in the companies, because differences in resource levels varied from company to company in a supply chain.

Based on this knowledge it was chosen to design the resource questions in the questionnaire by the lowest common denominator, which especially proved helpful in the collection of IT resource data among the smaller companies. The data collection process in the relation specific questions is unlike the resource questions more universal, and can therefore almost be used on any given supply chain. We emphasize that great attention should be dedicated to prevent cultural misunderstandings and linguistic

Figure 2
Questionnaire research design



Source: Vinum and Skjoldager (2001)

influences that can occur when using pseudo-metric scales in the relation-specific questions.

Selected results for supply chain "A"

Technical and application integration

Table II shows the key research results for supply chain "A".

It was identified that the supply chain had no standards for technical integration, thus no application integration across the chain. The development of an integration standard, based on XML for example, could be a possible solution, which would enable the supply chain to integrate existing IT systems and create an efficient flow of information across the chain.

The conjoint analysis showed that there are strategic preferences for supply chain integration, which focuses on cost and service, which means that the supply chain integration should focus on not only lowering processing costs, but also increasing the service-level to the customers, for example via CRM initiatives. Furthermore, the e-supply chain design and integration should focus on clicks-and-mortar, not only on "clicks". This means that existing physical structures should be kept, such as distribution channels and the systems for movement of goods. Supply chain integration is therefore not a substitute for the existing structures, but merely an enabler for efficiencies and improved service to the customers.

Analysis of the relations and resources

Table III shows the research results for the analysis of the relations and resources in supply chain "A".

The analysis of the relations in the supply chain showed that integration initiatives are driven by IT departments and not by top management. We could identify a relatively high willingness to share non-sensitive business information, but less willingness to share "private" information. The analysis also showed that information, which is already being shared, also has a higher rating in the analysis of the willingness to share the information compared to information, which is not currently shared.

This indicates that the existence of trust between the information-exchanging individuals probably has an influence on the willingness to share information. Trust must therefore be gained in order to be

Figure 3
Research process

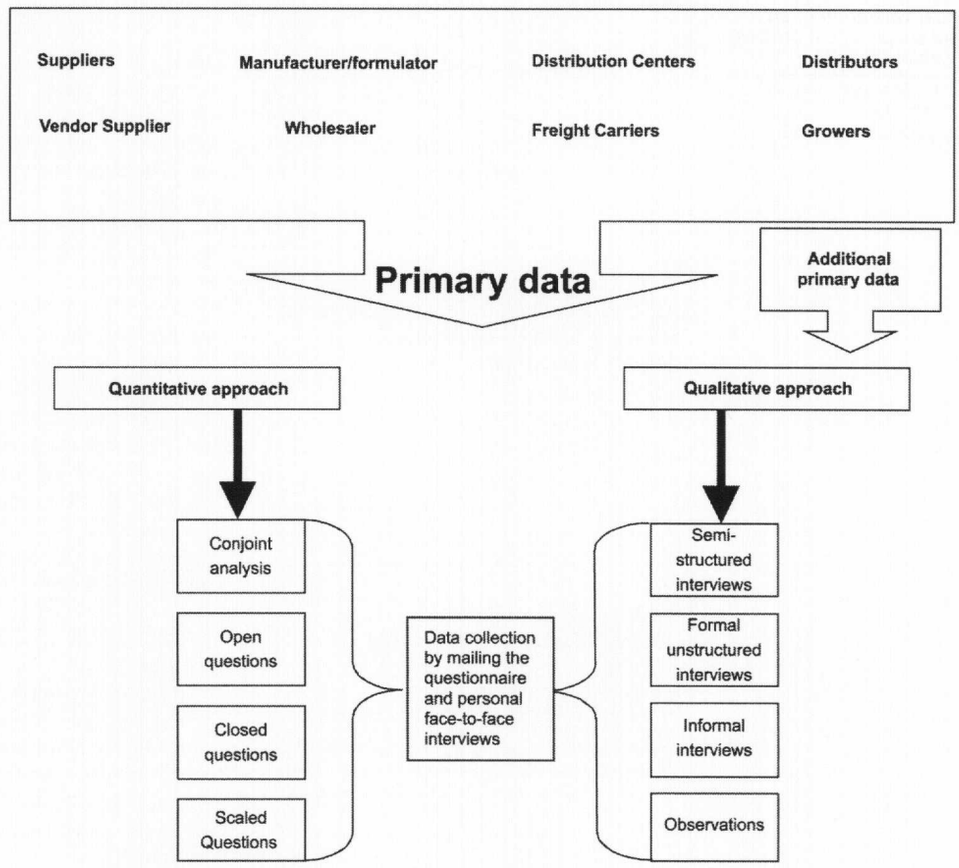


Table II
Technical and application integration, and strategic e-SCM preferences

E-SOM elements	Supply chain "A"
Technical integration	No standards→EDI→Outsourced development of XML standard
Application integration	No "end-to-end" exchange of ERP data→Exchange ERP data with tier 1 suppliers, freight carriers, distributions centers and distributors
Business Integration	
Strategic e-SCM preferences	Cost-and-service oriented→focus on creation of efficiencies through business integration and service Clicks-and-mortar→keep existing physical supply chain structures and integrate the information flow and business processes instead Supply-chain wide integration→long-term strategic focus on total supply chain integration

Source: Vinum and Skjoldager, 2001

comfortable with sharing business information. Top management should focus on creating the necessary trust in sharing information, and make this a part of the strategic planning with other supply chain executives.

The analysis also showed that existing relations between the chains' distributors and end-users prevents the focal company from selling and distributing directly to the end-users. Doing so will create channel conflicts and most likely lead to loss of overall business. Instead, electronic supply chain integration can be used to deliver information about the products more effectively to the end-users, and to create efficiencies to the distributors, thus increasing their profitability. This indicates a partnership approach rather than an arms-length approach.

The analysis of the IT, human and capital resources showed that the supply chain

Table III
Relations and resources

E-SOM elements	Supply chain "A"
Relations	
Top level management support of strategies	E-relation initiatives executed by the IT-department→Top level management should control e-relation initiatives Lack of trust to automatically share business information→Top level management must be committed, and information sharing should be a part of the strategic management Manual information sharing→Automatic information sharing and increased usage of Internet based information exchange tools
Creation of trust between supply chain partners	Distributors "own" relations to the growers→Focus on building relations to the growers and systematically gather knowledge of growers' needs (real-time)→Delivery of relevant information to distributors and growers via Web portal/Extranet Some direct sales to growers→Long-term e-relations to growers via web sales channel should be established (e-CRM)→Direct distribution in geographically defined markets and to specific crops to avoid channel conflicts (with distributors), as well as parallel distribution via the existing distributor network
Sharing of business information	
Creation of e-relations	
e-SCM "readiness"	
Optimization of IT resources	
Hardware, software, Internet access	There is a big difference between the companies' IT resources and capabilities: The "A group" has basic IT resources, hardware, Internet access and ERP software→Focus on supply chain integration of ERP modules The "B group" has low IT resources. Many lack ERP software and Internet access→Consider getting rid of "B group" suppliers and/or promote investments in basic infrastructure
Optimization of human resources	
Knowledge of e-SCM as a business model	Good understanding of e-business, but generally low conceptual understanding of SCM and knowledge of e-SCM as a business model. The focus is on logistics and processes→Promote the conceptual understanding of e-SCM internally and externally
Development of e-SCM solutions	Approximately 50 per cent of the companies have their own IT department→Create e-SCM solutions with the companies that do have in-house IT resources. Promote investments in human resources. Create internal human IT resources as a capability in combination with outsourcing
Management of e-SCM business	The development and management of SCM and "e-solutions" lack cross-organizational coordination internally and externally→Top management should decide on external strategic goals and assign internal human resources to manage the execution Unified inter-company management and communication of e-SCM does not exist→Select a project committee with participating members from all supply chain companies. Responsibility: Inter-company strategy execution coordination
Optimization of capital resources	
Investments in e-relations, IT hardware, implementation and software	Big difference between companies' capital resources and general willingness to invest in IT hardware. Investments focused on sales (e-commerce portals) rather than investments in integration tools→Promote investments in a common standard for integration, and prioritize investments in back-end systems

Source: Vinum and Skjoldager, 2001

companies can be divided into two groups: The "A group" which holds substantial IT assets, such as ERP systems and other IT infrastructure, as well as internal human IT resources and the willingness to invest in integration, and the "B group", which does not have the necessary IT assets to integrate electronically with the other supply chain companies. The "B group" poses a big problem to the overall objective of integrating the supply chain. Therefore it is suggested that IT, human and capital resources, as well as the overall willingness to integrate and electronically share business information should be a parameter when choosing suppliers, just as cost and quality concerns are parameters.

Analysis of business processes within the supply chain

Table IV shows how business processes can be optimized in supply chain "A".

Lack of coordination in the supply chain leads to high transactions costs levels. The variable willingness to share business information with other companies makes it possible to integrate some processes, and nearly impossible to integrate other processes, depending on the information necessary to integration specific processes and the willingness to do so. The above table shows which processes are possible to integrate short-term and which processes require increased trust in the relations between the supply chain companies in order to share the necessary process information. The importance of the creation of trust in relations can simply not be overemphasized.

Consequences for formulating an "end-to-end" supply chain strategy

Finally, the optimal e-SCM strategy was formulated for supply chain "A", as can be seen in Table V.

The strategy accounts for all of the research results, and uses this valuable information to formulate a strategy, which is executable across the chain.

Discussion and conclusion

In the case of supply chain "A" the application of e-SOM showed that the chain should only be partially integrated to the extent that the supply chain companies have the necessary resources, and the strategic willingness to do so. The focal company should especially concentrate on integrating their suppliers, freight carriers and distribution centers, while keeping a focus on reducing processing costs as well as improving the service-levels to the customers.

It should be stressed that the strategy for supply chain "A" is only valid for this specific chain.

Similar research in other chains would likely lead to different strategies. The strategy optimization model should therefore be applied to each chain, and profiles of each chain will then be established. Investments in supply chain integration technology should therefore allow for enough flexibility to use the same technology in many supply chains, but remain completely customizable at the same time. This way each chain will have its unique set-up, the IT assets can be used in many relations and the promising efficiencies of e-SCM can be realized.

The application of our suggestion can be consolidated into a single, executable, optimal strategy for a specific supply chain. Optimal supply chain strategies can now be formulated for each supply chain, instead of having a "generic" strategy for all supply chains, which may not be executable in complex environments. These conclusions are based on the partial results of the research design, measuring overall strategic preferences from the conjoint analysis, and the resource data, measuring the "practicable" technical, human and financial possibilities. This information combined with the relation data, measuring the willingness to share different types of information, allows the user of the strategy optimization model framework to create a unique profile of the current supply chain situation, and the future possibilities in any given supply chain.

By assembling and consolidating partial results, such as the strategic preferences from the conjoint analysis or the IT resource measurements, the applicator of the model is able to isolate problems in the supply chain. The complexity of analyzing a full supply chain can by the application of the strategy optimization model be broken down into isolated problems. The applicator of the strategy optimization model will be able to see whether the identified problems are related to a specific company in the supply chain or if the problems are related to the majority of the participating companies in the supply chain.

From an ROI perspective the strategy optimization model framework seems like a promising tool to evaluate new SCM and e-business investments, as well as increasing the survival rate for current e-business initiatives. The pitfalls of over- and

Table IV
Business processes

E-SOM elements	Supply chain "A"
Optimization of business processes	
Real-time electronic sharing of business information and knowledge between supply chain partners	Lack of coordination of processes through the supply chains→Establish e-relations with supply chain partners via business integration:
Production flow	Process-integration, short term:
Customer relationship management	Upstream: strategically important companies that have resources: procurement, secure transactions
Customer service management	Downstream: companies that have resources and IT-integration through the chain, including some distributors: CRM, customer service, order fulfillment, secure transactions
Sales forecasts	Process-integration, long term:
Order fulfillment	Total supply chain integration: production flow, sales forecasts, production planning, product development and commercialization
Production planning	Willingness to integrate should be a criteria when selecting suppliers as well as price/delivery/quality concerns
Procurement	Specific electronic sharing of business information:
Product development and commercialization	Lack of formalized sharing of information through the supply chains→
Secure transactions	Short term: sharing of information that pertains to product and delivery:
	Order status
	Shipment tracking
	Product prices
	Promotion plans
	Invoices
	General product information
	Long term: when sufficient trust has been created – increased sharing of "sensitive business information":
	Sales forecasts
	Inventory data (real-time)
	Production plans (MRP)
	R&D plans
	Product specific information (BoM)

Source: Vinum and Skjoldager, 2001

Table V
Optimal e-SCM strategy

E-SOM elements	Supply chain "A"
Formulation of optimal e-SCM strategy	
Unified, coordinated strategy for the entire supply chain, based on strategic preferences for SCM design	Integrate the supply chain gradually over time. Integration with suppliers, freight carriers and distribution centers should be prioritized short-term
	Focus on cost minimization, maximize overall service level and value to the customers, but increase direct customer contact and sales via the Internet, based on systematic market segmentation via geographic and crop variables. Keep existing supply chain structure parallel with the creation of efficient on-line customer relationship management, sales and distribution models

Source: Vinum and Skjoldager, 2001

under-investing in IT infrastructure, such as ERP and e-business initiatives, can be avoided when the decision makers have a complete picture of the overall possibilities and threats for their current and future SCM strategies.

By aligning electronic strategies with actual possibilities in the current supply chain, decisions can be made based on structured analysis instead of on the flavor of today's "electronic fantasy strategy" and "trial and error methods".

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