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CAN SUPPLY CHAIN RISK MANAGEMENT IMPROVE FIRM PERFORMANCE? A FOCAL FIRM PERSPECTIVE

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Abstract

The purpose of this research is to investigate the relationship between supply chain risk management practices and performance from a focal firm perspective. While considering supply chain risk, the study focuses on how the individual firm can benefit from SCRM. Firstly, a comprehensive literature review is carried out, showing that considerable effort has been spent on the proposal of models and strategies for managing supply chain risks. Contrarily, a lack of empirical studies on the impact of SCRM emerges from the analysis of current literature. We then introduce our hypotheses on SCRM, the moderating role of innovation, and performance. A major distinction is made between factors on which a firm can invest to enhance its SCRM capacity (modifiable factors), and those that mainly depend upon the market, and cannot be externally influenced (unmodifiable factors). A survey on a sample of 100 companies operating in the Italian industry is used to collect data to test our hypotheses. The analysis reveals a positive relationship between the level of implementation of SCRM practices and the firm's performance. Additionally, by analyzing the relationship between SCRM and green supply chain management, the potential role of SCRM in environmental sustainability emerges from the research. Finally, our findings highlight the relevance of strategic alignment with supply chain objectives and information sharing (which are both modifiable factors according to our classification) for the achievement of higher SCRM capacities, thus enhancing a firm's performance.

Keywords: supply chain management, supply chain risk management, risk management, empirical research, performance.

Sommario

Il presente studio si pone lo scopo di analizzare il legame tra supply chain risk management e performance da una prospettiva incentrata sulla singola azienda. Quindi, nonostante venga considerata la gestione dei rischi di supply chain, la ricerca si focalizza su come una singola azienda possa trarre benefici dall'SCRM. Innanzitutto, viene effettuata una estensiva ricerca bibliografica, dalla quale emerge un significativo sforzo di ricerca per l'introduzione di strategie e modelli per gestire il rischio nella supply chain. Contrariamente, la ricerca bibliografica evidenzia una scarsa disponibilita' di studi empirici volti a determinare i reali effetti dell'SCRM. Successivamente, introduciamo le ipotesi sull'SCRM, sul ruolo dell'innovazione e sulle performance. Viene inoltre introdotta una importante distinzione tra i fattori sui quali un'azienda puo' investire per aumentare la capacita' di gestire i rischi di supply chain, e quelli che sono invece piu' difficilmente influenzabili, in quanto dipendono in larga misura dal contesto in cui l'azienda si trova ad operare. Viene quindi effettuato uno studio basato sui dati raccolti da un campione di 100 aziende operanti nell'industria italiana per verificare le ipotesi introdotte. L'analisi dei dati rivela una relazione positiva tra SCRM e performance. Inoltre, tramite l'analisi del legame tra SCRM ed aspetti legati al filone di ricerca sul green supply chain management, lo studio conferma che l'SCRM potrebbe giocare un ruolo potenzialmente importante nella sostenibilita' ambientale. Infine, i risultati dimostrano che l'allineamento strategico e l'information sharing, entrambi classificati come fattori modificabili, sono positivamente correlati all'SCRM. Pertanto, tali fattori possono essere utilizzati per migliorare le capacita' di gestione dei rischi di supply chain e quindi le performance.

Parole chiave: supply chain management, supply chain risk management, gestione del rischio, ricerca empirica, prestazioni.

Introduction

Over the last years Supply Chain Risk Management has become an increasingly important research field due to different factors. Natural disasters such as earthquakes as well as epidemies, strikes and economic cycle uncertainties have caused frequent supply chain disruptions, with a significant impact on firms' performance.

According to Hendricks and Singhal (2005), companies experiencing supply chain disruptions suffered from 33-40% lower stock returns relative to their industry benchmarks. Nonetheless, the last decades have been characterized by the spread of initiatives such as outsourcing, delocalization and increase in product variety, leading to a significant increase in firms' vulnerability to unpredictable circumstances.

In this sense, the ability to manage risk has become a fundamental concern, allowing companies to damp the variability of their earnings caused by uncertain events. Furthermore, as stated by Keizer et al. (2002) and Aloini et al. (2007):

> *"No risk, no reward.*
> *Companies must risk both to launch new products and to innovate themselves. However risk processes do not require a strategy of risk avoidance but an early diagnosis and management."*

Many examples are available in literature regarding the disastrous effect of unpredicted events on companies' performance:

- In 2000, Ericsson lost 400 million Euros after their supplier's semiconductor plant caught on fire

- In 1999 Apple lost many customer orders after an earthquake hit Taiwan, causing a shortage in the supply of DRAM chips. Contrarily, Dell was able to mitigate the impact of this significant disruption by shifting the demand of its customers towards products that utilized components from other countries by offering special price incentives. According to Veverka (1999), this enabled Dell to improve its earnings in 1999 by 41%.

Similarly, fluctuations in financial and economic variables and cycles have threatened the survival of several firms:

- In 1986, oil and energy prices fell by 50% and 24% respectively, and companies such as Dresser Industries, supplying machinery to energy producers, faced a severe reduction in customer demand; Dresser's operating profits dropped from $292 million to $139 million in one year
- In the first years of the 80's, the dollar appreciated by around 50%, forcing US exporters to cut prices and consequently profits, and causing a significant loss in market share to other countries' producers.

Thus the need for instruments to manage risk, which lead to the proposal of a multitude of methods to mitigate the impact of risk on supply chains.

While risk management can be generally defined as the identification, analysis and control of risks, supply chain risk management is characterized by a cross company orientation aiming at the reduction of risks throughout the whole supply chain.

Even though several studies focus on techniques and models that would empower companies to manage risk in the supply chain, with a continuous evolution of risk management practices, there is still limited empirical evidence of the impact of firms' risk management capacity on their performance and their ability to create competitive advantage. This study examines the relationship between supply chain risk management and performance, investigating whether a real performance-enhancement effect exists. Furthermore, the analysis is carried out from a focal firm perspective, highlighting firm-specific implications and benefits.

Firms operating in different markets and with different assets are characterized by different risk management capabilities; some companies are able to

outperform in markets characterized by high instability, but can this be associated with effective SCRM practices? In our study we carry out an empirical analysis of a cross sectoral sample of companies operating in the Italian market, in order to study the SCRM-performance relationship on a broad scale. Additionally, we investigate the relationship between supply chain risk management and green supply chain management, in order to determine whether SCRM plays a potential role in environmental sustainability.

Chapter 1

Literature review

During the last decades, supply chain management practices have been going through a deeply innovative process, moving towards a more lean process, reducing wastes and lead time throughout the entire supply chain. On the other hand though, the reduction of costs achieved through the application of techniques such as just in time, virtual inventory and outsourcing, lead to an increased risk.
In literature, several definitions for supply chain risk management are available:

"Supply Chain Risk Management can generally be defined as a strategic management activity in firms given that it can affect operational, market and financial performance of firms (Narasimhan, 2009)"

"Supply Chain Risk Management is a discipline of Risk Management which attempts to identify potential disruptions to continued manufacturing production and thereby commercial financial exposure (Institute of Risk Management)"

"Supply Chain Risk Management is the identification and evaluation of risks and consequent losses in the global supply chain, and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following – losses, probability, speed of event, speed of losses, the time for detection of events, frequency, or exposure – for supply chain outcomes that in turn lead to close matching of actual cost saving and profitability with those desired (Manuj and Mentzer, 2008)"

"Supply Chain Risk Management is the management of supply chain risks

through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity (Christopher, 2002)"

While some definitions focus more on the operational aspects of risk management (e.g., Christopher, 2002), other definitions focus more on the potential effects of supply chain disruptions (e.g., Institute of Risk Management).
Based on the definitions mentioned above, we can analyze SCRM in the following way:

- defining which operational risks characterize the supply chain;
- analyzing the different possible approaches for the mitigation of such risks.

In this chapter we will analyze the different risks that characterize different sectors of supply chain management and the corresponding risk management approaches used, based on the review of current literature. Tang (2006) provides a comprehensive classification of the research that has been done on SCRM. Also, Narasimhan et al. (2009) carry out a useful review of currently available studies on SCRM. We will then follow the classification proposed by Tang, completing the literature review with the contribution from Narasimhan and other authors.

Regarding the possible risk mitigation approaches, Tang (2006) identifies four basic categories: supply management, demand management, product management and information management. The first category, supply management, addresses all the issues regarding operational relationships with upstream partners,

1.1 Supply management

According to Tang's classification, supply management mainly deals with five issues: supply network design, supplier relationship, supplier selection, supplier order allocation and supply contract.

1.1.1 Supply network design

The design of a supply network is a complex issue, since many variables need to be defined: which are the available suppliers, the manufacturing plants, warehouses, transportation and production planning. Many studies focused on the proposal of different models to aid the decision making process, but until recently few of them took into account the risks connected to supply network design. Levy (1995) identifies the risk connected to demand uncertainty and supplier reliability, and proposes a model to analyze the impact of these risks on different supply network designs. Another risk identified in literature affecting supply networks is the uncertainty in exchange rates. The model proposed by Huchzermeier and Cohen (1996) tries to transform this risk into an opportunity, by shifting production within the supply network to gain advantage from the variation in the exchange rates. They also show how an increased flexibility of the supply network can reduce the exposure to the risk connected to exchange rate fluctuations. Lee and Tang (1998) develop a stochastic inventory model to examine the tradeoff between the consignment and turnkey arrangements under demand uncertainty. This model was utilized by Hewlett Packard to determine specific arrangements with different manufacturers in Singapore and Malaysia.

1.1.2 Supplier relationship

From the 80's, firms started to understand the importance of supplier relationships, and different types of relationships spread, such as virtual integration, also thanks to the development of the IT sector. Several studies assess the importance of choosing the type of supplier relationship consistently with the market conditions (Dyer and Ouchi, 1996; Tang, 1999; Cohen and Agrawal, 1999). Another result of these studies is the evidence that

firms usually source from multiple suppliers, also to reduce the operational and disruption risk.

1.1.3 Supplier selection process

Following the framework proposed by Boer et al. (2001), it is possible to divide the supplier selection process into 3 phases: definition of selection criteria, determination of selected suppliers and final supplier selection.

1.1.3.1 Supplier selection criteria

Choi and Hartley (1996) conduct an empirical analysis of the criterias adopted by several supply chain partners in the automotive industry in the supplier selection process. A main finding from this research is that the supplier's agility in terms of production volume is not considered of primary relevance, showing how little consideration is given to the possibility of supply chain disruptions.

1.1.3.2 Supplier approval/selection

At this stage, the purpose is to determine which suppliers can be approved. Boer et al. (2001) propose some methods for determining a set of approved a case-based-reasoning method. Other authors (Weber and Current, 1993; Weber et al., 2000; Dahel, 2003)

Most the proposed models are deterministic, while few studies take into account operational risks. Some models try to address the issue of supplier quality by analyzing the interaction between the buyers internal manufacturing process and the supplier's quality (Tang, 1998; Tagaras and Lee, 1996). Kouvelis (1998) presents a model that considers the fluctuations of the exchange rate in the selection process, recommending to shift the order quantity among different suppliers dynamically to take advantage of these fluctuations; the model also determines a tradeoff with the switch over costs.

1.1.4 Supplier order allocation

In order to allocate the order quantity among the selected suppliers, Tang (2006) identifies four types of operational risks:

- uncertain demands;
- uncertain supply yields;
- uncertain supply lead times;
- uncertain supply costs.

1.1.4.1 Uncertain demand

Extensive literature is available on the issue of determining the optimal order quantity for single and multiple suppliers under demand uncertainty.

Minner (2003) carries out a complete literature review regarding this topic. The analytical models that hypothesize deterministic lead times assume that the supplier with a shorter lead time charges a lower cost per unit. Due to the complexity of the analysis of the multiple-supplier case, many researchers restrict their analysis to certain types of ordering policies. For example Janssen and de Kok (1999) analyze an ordering policy in which the buyer will always order Q units from one supplier in each period, and orders (S-Q)+ units from the second supplier so as to bring the inventory position to S.

1.1.4.2 Uncertain supply yields

Agrawal and Nahmias (1998) present a model for determining the tradeoff between the fixed costs associated with each supplier and the costs associated with yield loss. Assuming that demand is known, they show how to determine the optimal number of suppliers with different yields.

Bassok and Akella (1991) consider a two-stage-multiple-period model, where the first stage is characterized by yield uncertainty. They show that the optimal production quantity and the optimal ordering quantity depend upon whether the sum of finished goods and raw materials is larger or smaller than two critical points, respectively.

With regard to multiple-product-multiple-period-multiple-stage models, since the analysis of these systems is untractable, not much has been done in this area. Akella et al. (1992), for the case of a multi-stage-multiple-product

facility with rework, determine the optimal production rule that minimizes the total inventory and backorder cost.

1.1.4.3 Uncertain lead times

Most of the studies proposed in this field restrict the analysis to the case of deterministic demand, in order to decrease the complexity of the research. For example Ramaseh et al. (1991) considers an ordering policy in which the order quantity is evenly split between two suppliers, if the two suppliers have identical lead time distributions. Sedarage et al. (1999) further develop this model, extending it to the case with more than two suppliers, showing that it may be convenient to order from some suppliers with poor lead time performance.

1.1.4.4 Uncertain supply capacity

One of the risks that may affect the supplier's capacity to fulfill the agreed orders is the uncertainty in supplier's capacity, which may be due to events such as machinery breakdowns, strikes, etc. Little research has been carried out in this field; for example Wang and Gerchak (1996) consider a model with uncertain supply capacity, uncertain yields and uncertain demand. With the aim of minimizing the total discounted expected costs, they show that the order-up-to policy is optimal.

1.1.4.5 Uncertain supply cost

Gurnani and Tang (1999) study the case in which the uncertainty in supply cost is imposed by an upstream supply partner. In particular, the retailer has two instants to order a seasonal product from a wholesaler, and both the wholesale price and the demand at the second instant are uncertain. Their findings are that there is an optimal way to allocate the optimal order quantity to be placed at the first and second instant. Many researchers carry out studies whose aim is to exploit fluctuations in currency exchange rates. Kogut and Kulatilaka (1994) develop a stochastic model to examine the possibility to shift the production between two production units located in different countries. They hypothesize unlimited manufacturing capacity for the two

plants, and through their model they determine the benefit of having two units in different locations instead of one of greater capacity. Dasu and Li further develop this model considering the capacity limitations and they determine two critical points a and b so that it is convenient to shift the production between the two manufacturing locations when the exchange rate is below a or above b. When the exchange rate is between a and b, it is more convenient not to shift the production so not to incur in switch-over costs. Huchzermeier and Cohen (1996) extend the analysis to the case with more than two countries; they exploit the uncertainty in the exchange rate to maximize the after-tax profit for 16 different examples characterized by different supply network designs.

1.1.5 Supply contracts

Phenomena such as opportunism and the tendency to maximize a firm's own objectives can lead to decisions that are not aimed at the optimization of the supply chain, thus causing operational inefficiency throughout the whole supply chain. Two studies highlight the disadvantages resulting from a disintegrated supply chain. Lee et al. (1997) show that if each supply chain partner places their order independently (assuming that the customer demand follows an autoregressive process), this will result in bullwhip effect, with consequent operational inefficiency. The second study by Bresnahan and Reiss (1985) regards the case in which each supply chain partner places their order with the goal of maximizing their own profit, assuming that demand is deterministic and decreasing function of the retail price. The results highlight that these locally optimal decisions lead to a lower total profit for the entire supply chain.

There is extensive literature available on the topic of supply contracts, but we will consider the aspects correlated with SCRM. Following the scheme proposed by Tang (2006), we will review the literature regarding risks in supply contract management considering two different scenarios: uncertain demand and uncertain price.

1.1.5.1 Uncertain demand

Wholesale price contracts. Babich et al. (2004) are among the first researchers to analyze supply contracts with supplier default risk. Their model considers a single product wholesale price contract, with different suppliers competing for business with the retailer. The suppliers establish the unit price, then the retailer determines the order quantity from each supplier by considering both demand uncertainty and supplier uncertainty. The study shows that it is optimal for the competing suppliers to increase the wholesale price at a similar value and it is convenient for the retailer to order from supplier with highly correlated rates.

Buy back contracts. Another policy adopted by manufacturers to induce the retailer to order more is to offer the possibility to return a certain percentage of the excess inventory (buy back contracts). In this way the two supply chain partners can share the risk connected to uncertain demand. A research conducted by Pasternack (1985) demonstrates that such a policy, considering the case in which the retailer can return up to a 100% of the order, can help achieve supply chain coordination. An interesting study by Lariviere (1998) analyzes the effect on the firms' profits under different types of return policies that improve channel coordination. The findings of the research proposed by Emmons and Gilbert (1998) are that return policies cannot improve supply chain coordination, but they also find evidence of the fact that some types of buy back contracts can increase both partners' profits.

Revenue sharing contracts. Another contract policy that can distribute the risk through the supply chain is revenue sharing. Just like buy back contracts, revenue sharing contracts are used by manufacturers to provide incentive for the retailer to stock more. The retailer gets a lower price but is required to remit a certain sum (percentage) for each unit sold to the supplier. A typical example of the adoption of this policy is the video rental industry. According to Mortimer (2004), Blockbuster shares probably between 30% and 45% of the rental revenue, obtaining in return a wholesale price which is probably around 8$ instead of 65$ per unit. The advantage of this policy is quite obvious if we consider that in this way the retailer is able to provide customers with a higher number of copies of new releases and popular titles, thus

reducing the stock-out risk and earning higher revenues, especially for these products. Mortimer's findings validate this hypothesis. Furthermore, Pasternack (2002) analyzes the effect of revenue sharing showing that this contract policy can achieve channel coordination.

Quantity-based contracts. When demand is uncertain, each supply chain partner would try to shift the risk connected to demand uncertainty to another partner; for example the manufacturer would like to receive the retailer's orders in advance, while the retailer wants to place orders when necessary. One possibility is to adopt quantity flexibility contracts. With this type of contract, the retailer can adjust his order, by increasing or decreasing the order quantity by a certain amount. Several studies focus on quantity flexibility contracts; Lariviere (1998) also considers the effect in terms of channel coordination, showing that it can be achieved if the wholesale price and the quantity adjustment parameters are characterized by certain values.

1.1.5.2 Uncertain price

As stated by Tang (2006), little work has been done to consider uncertainty in price. Li and Kouvelis (1999) study how the retailer can mitigate the risk by choosing among three different types of contracts, namely "time flexible contracts", "time inflexible contracts" and the case in which they can place orders to two different manufacturers.

1.2 Demand management

In the field of SCRM, many approaches have been proposed to manage the risk connected to demand management when capacity is fixed. Under these conditions, many firms try to mitigate the risk by manipulating uncertain demands dynamically so that the demand will match the capacity. Among the several studies available in literature, the research carried out be Van Mieghem and Dada (2001) compares different demand management strategies in order to determine which one, under uncertain demand and fixed capacity, awards the best results. Among the various strategies that they consider, price postponement seems to award the best results. The firm defines the order

quantity in the first period and then observes the demand in order to define the price in a second period. In this way, firms are able to modify the demand to match the supply, which has already been fixed.
Generally speaking, another approach adopted by companies to mitigate the risk due to uncertain demand is to shift the demand across time, markets and products. We will now analyze these three categories by reviewing the literature regarding these strategies.

1.2.1 Shifting demand across time

A strategy commonly adopted by firms in order to shift demand across time is revenue management. It consists of changing the price dynamically depending on the period, with the purpose of shifting demand from peak seasons to off peak seasons. This strategy also enables firms to increase their profits by capturing customers in different segments who are willing to pay different prices in different times (Tang, 2006).
The approach adopted by researchers to address this issue is usually to define a certain demand curve and type of demand uncertainty, then to determine the pricing policy that can optimize the company's profits, considering a fixed capacity. As stated by Xie and Shugan (2001), the advantage of adopting this strategy to manage the risk due to uncertain demand and fixed capacity is that firms can increase their sales by serving different market segments; while at the same time enabling customers to obtain a lower price. Xie and Shugan (2001) focus their research on the practice adopted by several firms to offer price discount to customers who make their purchase in advance. In their two-period model, during the first period the price of the second period is not announced, but customers are aware that price will increase during the second period. The reservation price is unknown to customers, who would then commit their purchase during the first period if they expect to pay a higher total price in the second period. This model is used to determine under which conditions the company should offer advance purchase discount. Similar benefits can be obtained in the case in which the firm announces the prices for both advance purchase and conventional purchase (Weng and Parlar, 1999). A further advantage of the advance-discount policy is shown by Tang et al.

(2004). They show how advance-commitment purchases can be used by the retailer to improve the demand forecast, reducing over-stocking and under-stocking costs. Gilbert and Ballou (1999) demonstrate that firms can benefit from this policy even with non-seasonal products. In particular, they propose a model for calculating the optimal discount price based on the analysis of the profits before and after the launch of the advance commitment discount program.

Weng and Parlar (2005) consider the case in which the manufacturer produces both a standardized product and a make-to-order product. An advance commitment discount policy is adopted by the manufacturer so that customers who commit their orders for the standardized product in advance can benefit from a lower price. Weng and Parlar determine the conditions under which the manufacturer should adopt this policy and show that this strategy enables the manufacturer to increase demand and reduce uncertainty. In order to manage uncertain demand under fixed supply capacity, another pricing policy used to shift demand across time is “demand postponement”. Under this policy, the manufacturer offers a discount to a fraction of customers who are willing to accept shipment of their orders in a later period. Iyer (2003) analyzes the benefits of this policy and determine under which conditions a firm should adopt it. Moreover, they also determine the optimal fraction of customer orders to postpone.

1.2.2 Shifting demand across markets

Firms operating in different markets and managing products with short life cycles need to implement appropriate product rollover strategies in order to mitigate the risk connected to demand uncertainty in different markets. Billington et al. (1998) propose a strategy called “solo-rollover by market”. Under this strategy, a firm can stock a certain amount of product during the first period for the first market, and then transfer the unsold inventory to the second market during the following period. The model presented in Kouvelis and Gutierrez (1997) considers a firm operating in two markets with non-overlapping selling seasons, and calculates the optimal production quantity for the two periods and the optimal amount of the remaining

inventory to be shipped to the second market after the first season. As articulated by Petruzzi and Dada (2001), a further development of the solo-rollover policy consists of the improvement of the demand forecast for the second period through the observation of the actual sales in the first market. Using this updated forecast, the firm can then determine the transshipment quantity, the stocking level and the pricing policy for the second market.

1.2.3 Shifting demand across products

Several researchers focused on the study of marketing policies and strategies that could induce customers to switch brands or products. Raju et al. (1995) consider the case in which a retail store introduces a store brand to compete with existing brands, and present a model that for determining the optimal retail pricing policy for both the existing brands and the store brand in order to maximize the store's revenue. Another example of how marketing policies can be used to shift demand across products and brands is provided by Chong et al. (2001), who show how a retailer can maximize revenue by adjusting product assortments and pricing so that the right products can be offered to the customers at the right prices. A vast majority of these marketing models though, do not deal with supply chain management issues.

1.2.3.1 Product substitution

With regard to supply chain management, an approach that allows to shift demand across products is product substitution. For example, Chong et al. (2004) examine the strategy of selling products with similar attributes, showing how this can increase the product substitutability. Furthermore, they determine which specific combination of products with similar features can be used to increase substitutability, and they show how this can reduce the variance of the aggregate demand. When managing the demand for two substitutable products, Rajaram and Tang (2001) show how a firm can use a product with surplus inventory as a substitute for out of stock products. They also determine how a firm can use product susbstitutability to reduce the effects of demand variability for each product. Finally, they show that

increased product substitutability can increase the optimal order quantity of each product and the retailer's profit. Bitran and Dasu (1992) and Hsu and Bassok (1999) consider the case when one of the two products is characterized by higher quality/performance. Considering integrated circuit manufacturing, where higher grade chips can be used as substitutes for lower grade chips, they introduce models for determining the optimal production quantity at a production facility with random yields. Pricing can be used to shift demand between two substitutable products. Parlar and Goyal (1984) show how discount can shift demand between an old and a new product, and they determine the optimal order quantity for the new product in each period. Chod and Rudi (2005) examine the case in which the firm has to decide on the production quantity of two similar products in the first period. They assume that the firm can postpone the pricing decision of each product until the second period, and show that the firm can achieve higher profits thanks to this postponement.

1.2.3.2 Product bundling

Another solution adopted for managing demand is to sell product bundles. Common examples of product bundles are food, cosmetics (shampoo and conditioner), electronics (computers and printers). By adopting such strategy, firms can aggregate demand by forcing customers to buy multiple products at the same time and in a predetermined combination. Ernst and Kouvelis (1999) consider the case in which products are sold both as a bundle and as individual products. Their study investigates how product bundling affects the inventory ordering decisions of a firm, and they establish the conditions for optimal ordering quantities. Finally, Ernst and Kouvelis demonstrate that when inventory decisions are made without considering the substitutability between individual products and bundles, profit are sub-optimized.

McCardle et al. (2005) calculate the demand for product bundles starting from the demand for individual products. They then determine how product demand, costs, and the relationship between demands for different products can affect optimal bundle prices and profits, showing when it is beneficial for a firm to adopt product bundling.

1.3 Product management

A cross-sectoral trend started in the 1980's and currently in place is the expansion of product variety. As reported by Quelch and Kenny (1984), the number of stock keeping units in consumer packaged goods has been increasing at a rate of 16% per year between 1985 and 1992. Marketing research shows that product variety is an effective strategy to increase market share because it enables a firm to serve heterogeneous market segments and customers with different behavior. On the other hand an increased product variety will lead to increased manufacturing complexity and cost, as well to an increased inventory. MacDuffie et al. (1996) show empirically that manufacturing and inventory costs increase together with product variety. It is therefore necessary for a firm to determine an optimal trade-off between product variety and increase in costs so to maximize profits. A commonly adopted strategy for increasing product variety while at the same time limiting the increase in design and manufacturing costs, is developing different variants based on the same platform. The products would then share common characteristics, which can also contribute positively to product substitutability and bundling, further increasing flexibility in terms of demand satisfaction. Several researchers have examined product variety issues. However, as stated by Ulrich et al. (1998), there is no explicit analytical model for determining an optimal product portfolio with substitutable products. By considering a study of the mountain bike industry, Ulrich et al. suggest that firms need to take into account their internal capabilities (distribution channel, supply chain network, etc.) when making decisions regarding product variety.

Martin et al. (1998) propose a model for determining the effect of product variety on replenishment lead time. Chong et al. (2004) present a model for calculating the mean and variance of the sales associated with different compositions of a product portfolio by considering the attribute levels of different products. In order to maximize profit over a finite time horizon, Caro and Gallien (2005) present a model for selecting the optimal product portfolio.

In the field of SCRM, a main concern is how to reduce inventory cost associated with a product portfolio. In the case of the order-up-to policy, the

average inventory level depends on the mean and the standard deviation of the demand over the replenishment lead time. Several researchers tried to address this issue, presenting different approaches for reducing the variability of the demand over the replenishment lead time. One possible way of reducing uncertainty is product substitution, as previously shown. Other approaches that can reduce demand uncertainty are postponement strategy and process sequencing.

1.3.1 Postponement

A typical postponement approach consists of delaying product differentiation via the standardization of components and subassemblies and modular design (Lee and Tang, 1997). Postponement models can generally be classified according to operating modes (MTS and MTO) and demand forecasts (with forecast updating or with forecast updating).

1.3.1.1 MTO systems without forecast updating

Lee (1996) considers the benefits of postponement in an MTO and an MTS system without demand forecast updating. In his study, Lee measures the benefits of postponement in terms of mean response time and probability of the response time being less than the target response time. He shows that if the point of differentiation along the MTO system is delayed, the optimal order-up-to point decreases. Correspondingly, the WIP inventory cost increases as the differentiation point is delayed. Lee then determines the conditions under which postponement is beneficial by considering the tradeoff between the increase in inventory cost and the decrease in the optimal order-up-to point. Swaminathan and Tayur (1998) consider the case in which there are multiple points of differentiation. Depending on the customization capacity and the demand scenario, Swaminathan and Tayur determine the optimal configuration of semi-finished products held at differentiation points that minimizes both stock-out cost and inventory cost.

1.3.1.2 MTS systems without forecast updating

For MTS systems, Lee (1996) considers the case in which demand distributions are independently normal, but may be correlated within a time period. Lee assumes that inventory is only used to store finished product, and determines the base-stock level and the average inventory level for each end-product. Lee demonstrates that delaying the differentiation point leads to a decreased inventory level. Su et al. (2005) extend Lee's study by considering the total supply chain costs associated with postponement in an MTO and an MTS system, showing that MTO is a better solution when the number of products exceeds a certain level. Garg and Tang (1997) extend the model proposed by Lee (1996) by considering an MTS system with multiple differentiation points, showing that the postponement of the differentiation points would result in inventory savings.

Lee and Tang (1997) consider a system where WIP can be stored at every stage of the manufacturing process. They assume that the manufacturing process can be decomposed into N independent stages, each following an order-up-to policy. By considering investment cost, unit processing cost, and inventory holding cost at each stage, they determine under which conditions postponement is not beneficial.

Gupta and Benjaafar (2004) consider both MTS and MTO systems in a context characterized by limited production capacity. They determine the effect of limited production capacity by introducing a queuing model for examining the benefits of postponement under such conditions. When the product demand is random and periodical, Aviv and Federgruen (2001) show that the inventory model can be structured as a Markov decision process, and that delayed product differentiation is beneficial even in the case of limited production capacity.

1.3.1.3 MTS systems with forecast updating

A common assumption in the postponement literature is that product demands in each period are random, but they are independent across time and their distributions are known. Under these conditions, all stages upstream of the differentiation point would plan according to the aggregate demand instead of

the individual product demand. Postponement enables a firm to make the final decision for product quantities as late as possible by delaying product differentiation. In this way, the risk due to demand uncertainty can be reduced by observing the updated forecast, supposedly more accurate. For example Whang and Lee (1998) present a model in which demand forecast can be updated on the basis of the observed values of certain parameters in a given period, namely economic trends, random noises, etc. This parameters can then be used to determine more accurate demand forecast. Whang and Lee show that significant benefits in terms of inventory cost reduction can be achieved even when the point of differentiation occurs in an early stage, and that accurate demand forecast can reduce finished product inventory.

Aviv and Federgruen (2001) consider the case in which the parameters characterizing demand are unknown. Assuming that demand forecast is updated in a Bayesian manner, they show that the standard deviation decreases as the differentiation point moves downstream along the manufacturing process. Their findings highlight that it is more beneficial to use updated demand forecast when using postponement.

1.3.2 Process sequencing

As stated by Lee and Tang (1998), variability can also be reduced by reversing the sequence of manufacturing processes in the supply chain. Benetton gave significant proof of this strategy by reversing the typical dye-first-knit-later sequence typical of the garment industry. They reversed the process by knitting first and dyeing later. Clearly, when the number of styles is significantly higher than the number of colors, the first strategy is more beneficial, since it allows a higher degree of delayed product differentiation. However, when there are multiple colors and multiple styles it is not clear which processing strategy would be more convenient. Lee and Tang (1998) propose a model for the case in which each product has two features (i.e., two processing stages that can be reversed), each of which has two choices. If the demand is stable ($\mu > \sigma^2$), the optimal process sequence depends on which of the two features has the lowest variability. Lee and Tang demonstrate that the feature with the lowest variability should be processed first. Kapuscinski and Tayur (1999) show that it

is always beneficial to process the less variable feature first, regardless of the value of μ and σ^2.
Several researchers developed the model proposed by Lee and Tang to include more general conditions. For example Jain and Paul (2001) generalize Lee and Tang's model by incorporating heterogeneity among customers and unpredictability of customer preferences. Yeh and Yang (2003) present a model to determine the process sequence that minimizes the total expected cost. In their simulation, they also include additional factors such as lead times, ordering policies and inventory holding costs.

1.4 Information management

The information strategy adopted depends upon the different types of products to be managed. Fisher (1997) states that most consumer products can be classified as fashion products or functional products. Intuitively, fashion products are characterized by shorter life cycles and higher levels of demand uncertainties than the functional products. In the following paragraphs, we will examine different information sharing strategies according to the classification provided by Fisher.

1.4.1 Strategies for fashion products

Reducing the standard deviation of the demand over the replenishment lead time would lead to reduced inventory for the entire supply chain. Several studies focus on the situation in which a retailer can place two orders during the selling season: one prior to the selling season and one during the selling season. The second order allows the retailer to use updated demand forecast on the basis of actual sales. Fisher and Raman (1996) present a model for this ordering policy showing that it can reduce inventory level while at the same time increasing customer service level.
For the case in which the unit cost for the second order is unknown Gurnani and Tang (1999) propose a two-period dynamic programming model, showing that an order-up-to policy is optimal. Iyer and Bergen (1997) examine the effect of

this strategy on the inventory level of both retailer and supplier. They determine the conditions under which it is beneficial for both retailer and supplier to implement this policy. When the retailer can place the orders choosing between low cost with long lead time and high cost with short lead time, Donohue (2000) determines the optimal ordering policy that coordinates the supply chain.

Signorelli and Heskett (1984) consider the case when the manufacturer may not be able to fulfill the second order, and more recently Smith et al. (2002) determines the retailer's profit, the retailer's optimal order quantities and the manufacturer's profit for the case when the supplier can fulfill the second order only partially. They show analitically that partial fulfillment is never beneficial for the supplier.

1.4.2 Strategies for functional products

As articulated in the previous paragraphs, functional products are characterized by longer life cycles. This implies that market information is critical for generating accurate demand forecast. Usually though, wholesalers, distributors and manufacturers do not have access to first-hand market information on customer demand, preferences and behavior. Therefore, they mainly generate their demand forecast based on the orders placed by their downstream partners. Sterman (1989) shows that this behavior creates a phenomenon called “bullwhip effect”, causing increasing inventory level along the supply chain. This may lead to other problems such us lower customer service level, inefficient use of production and transportation facilities, etc. Information management emerges as a critical tool for mitigating the risk generated by this phenomenon. Lee et al. (1997) show that the bullwhip effect can occur even when every supply chain partners operate optimally and rationally. They consider a two-level supply chain in which the demand distribution (which follows an auto-regressive process) and characteristics are known to the retailer. They show that, even if the retailer acts rationally in terms of ordering policy, the variance of the order quantity is higher than that of the demand, thus generating the bullwhip effect. Li et al. (2005) consider a more general case in terms of demand process and propose a simulating model, showing that

bullwhip effect does not always occur. Contrarily, they determine the conditions under which variance decreases when moving upstream along the supply chains. Chen et al. (1998) investigate the case when the retailer does not know the process followed by the demand, and uses a moving average or an exponential smoothing method for demand forecasting. They show that with both methods bullwhip effect will occur, but it will be larger when the retailer uses an exponential smoothing method to forecast demand. Lee et al (1997) identify four causes of the bullwhip effect: demand forecasting, batch ordering, supply shortage and price variations, and propose four strategies for mitigating its effects: information sharing, vendor managed inventory, collaborative forecasting and replenishment planning.

1.4.2.1 Information sharing

Lee et al. (2000) consider a two-level supply chain in which the retailer knows the characteristics of the demand and orders using an order-up-to policy. When information is not shared, the manufacturer knows the demand distribution but is not aware of the actual sales in a certain period. Contrarily, if information is shared, the manufacturer knows the actual demand. For this case, Lee et al. show analitically that information sharing does not affect the retailer (assuming that the manufacturer can always fulfill the retailer's orders), while it is beneficial for the manufacturer. They also suggest policies for incentivating information sharing, such as price discount and lead time reduction. Cheng and Wu (2005) generalize Lee et al.'s model by considering the case when the manufacturer receive orders from multiple retailers, and they show how information sharing would lead to inventory level and cost reduction for the manufacturer. Raghunathan (2001) shows that information sharing is less important if the manufacturer uses the retailer's historical orders to forecast demand, considering the case when demand follows an auto-regressive process. Gavirneni et al. (1999) develop a model to examine the benefits of information sharing for the case in which the manufacturer has limited production capacity. They assume that demand distribution is known to the retailer, and that the retailer places an order when inventory level falls below a certain level. Without information sharing, the manufacturer only knows the retailer's inventory level

for each period. The findings highlight that information sharing is particularly beneficial for the manufacturer when demand uncertainty is low or the manufacturing capacity is relatively high. Cachon and Fisher (1997, 2000) study the multiple-retailer case with limited production capacity. They show that both retailers and manufacturer can benefit from information sharing; however, they also show that lead time reduction is more beneficial than information sharing. Zhao et al. (2002) consider a supply chain with one supplier and multiple retailers and analyze the effect of different forecasting methods on the value of information sharing. They show that sharing information on future orders is more beneficial than sharing information on the demand. However, even though the positive effects of information sharing have been widely assessed by both researchers and companies, there are still several barriers that prevent supply chain partners from sharing information. These barriers include for example confidentiality of information and fear of information leakage. Terwiesch et al. (2005) examine other factors that obstacle effective information sharing between retailers and manufacturers. They show that on certain occasions the manufacturer may ignore the retailer's revisions of demand forecast. When a manufacturer does not fulfill the retailer's orders in one period, the retailer may inflate future orders as a reaction to the unfulfillment. Terwiesch et al. show empirically that such behaviors can lead to significant losses for both the retailer and the manufacturer even if information is shared.

1.4.2.2 Vendor managed inventory

Since information sharing is significantly more beneficial for the manufacturer than for the retailer, several manufacturers adopted strategies to entice the retailer to share information. One of these strategies is the vendor managed inventory. With VMI, manufacturers manage the retailers' inventory and manage orders and replenishment planning. The manufacturer guarantees that the inventory level and customer service level will satisfy given conditions, and in exchange gains access to all the information regarding actual demand and inventory level. VMI provides the opportunity to create a win-win solution for

the retailer and the manufacturer. Indeed, the retailer can benefit from reduced operating costs and inventory costs, while the manufacturer can avoid the occurrence of bullwhip effect and reduce production, inventory, logistics and transportation costs.

By the use of a simulation model to analyze the impact of VMI on bullwhip effect, Disney and Towill (2003) show that VMI can reduce the bullwhip effect by 50%. When the manufacturing capacity is limited, Johnson et al. (1999) show that VMI can help reduce the manufacturer's and the retailer's inventory level, in the case when some retailer adopt VMI, while some others use information sharing. Aviv and Federgruen (1998a) present a model to determine the effect of both information sharing and VMI on the manufacturer's operating cost. In the first case, the retailer decides on orders and replenishment, while in the second case, the manufacturer manages the retailer's ordering and replenishment planning decisions. Aviv and Federgruen show that the manufacturer can achieve cost reduction under both information sharing and VMI. Cetinkaya and Lee (2000) develop a model for determining optimal replenishment and delivery plans for retailers in different geographical regions under the VMI initiative. Their model minimizes production, transportation and inventory costs, while ensuring that a certain customer service level is maintained.

Several companies successfully implemented VMI. Clark and Hammond (1997) provide an example of the benefits of VMI. In the case they analyze, Campbell Soup and its retailers successfully implement VMI.

1.4.2.3 Collaborative forecasting

Another way of mitigating the risk connected to uncertain demand, the Voluntary Inter-industry Commerce Standards association developed an initiative called Collaborative Planning, Forecasting, and Replenishment. CPFR consists of the joint development of demand forecast by the manufacturer and the retailer. Each party would generate a demand forecast based on its own knowledge of the market, and then they would develop a common forecast. Then, the retailer generates a replenishment plan and the manufacturer generates a production plan based on the jointly developed

demand forecast.

Aviv (2001) develops a framework for modeling the collaborative forecasting between the retailer and the manufacturer. In the case when collaborative forecasting is not adopted, Aviv considers the correlation between the forecast adjustments made by the retailer and the manufacturer. Then, he shows how this correlation can be used for collaborative forecasting to adjust demand forecast. Aviv determines the variance of the total demand over the replenishment lead time when collaborative forecasting is adopted and when it is not adopted. Similarly, he determines the mean and the variance of the retailer's orders placed to the manufacturer under both conditions. By considering a supply chain performance measure based on the variance of the entire system (the variance of the demand over the retailer's replenishment lead time and the variance of the order quantity over the manufacturer's replenishment lead time), Aviv shows that collaborative forecasting reduces the total variance of the system. He then extends the analysis to the case in which the demand is autocorrelated, and to that in which the supply chain requests smoother production. The analytical study of the effect of collaborative forecasting is intractable, so most studies evaluated the benefits of this initiative numerically. To obtain more realistic results, Boone et al. (2002) propose a simulation model to compare performances under collaborative forecasting and under no collaborative forecasting. For their model, they use data collected from a Fortune-500 company to run their simulation model and determine that collaborative forecasting increases customer service level while at the same time reducing inventory level for both the manufacturer and the retailer.

1.5 Robust strategies for mitigating risks

The models reviewed in the previous paragraphs are mainly designed for managing operational risks, not disruption risks. Few models in fact, focus on the issue of managing disruption risks. Tang et al. review qualitative analyses presented in various risk management and SCRM articles in order to determine how disruption risks are managed in practice. Their findings on managers' attitude towards risks highlight three key points (Sharpira, 1986; March and Sharpira, 1987):

- Managers are quite insensitive to estimates of the probabilities of possible outcomes.
- Managers tend to focus on critical performance targets, which affect the way they manage risks.
- Managers make a sharp distinction between taking risks and gambling.

The first statement can be explained by the lack of trust, understanding and precision in probability estimates. March and Sharpira (1986) conclude that managers are more likely to define risks in terms of the magnitude of loss instead of expected loss.

The second statement is based on the observation that managers are usually evaluated on the basis of performance measures that influence the attitude of managers towards risks.

The third statement is based on the fact that managers are usually rewarded on the basis of the outcomes, rather than the decisions taken.

Other relevant findings that emerge from the studies conducted by McGarrell (2004), Rice and Caniato (2003) and Zsidisin et al. (2001, 2004) are the following:

- Most companies acknowledge the importance of risk assessment and adopt different methods for assessing risk. Few of them though spend considerable effort on mitigating supply chain risks.
- It is difficult for a firm to perform a cost-benefit analysis for risk management initiatives, since an accurate estimation of the probability of risk occurrence is difficult to obtain.

- Firms tend to underestimate disruption risk when a reliable risk assessment in not available. Kunreuther (1976) reports that managers tend to ignore risks that are very unlikely to occur.

1.5.1 Properties of robust strategies

Tang (2005) shows that firms will be more willing to implement robust supply chain risk management strategies if these strategies possess the following properties:

- They are efficient, in the sense that that they will allow the company to manage operational risk even in case disruptions occur.
- They are resilient, in the sense that they will enable the company to continue operating even in when major disruptions occur, and they will allow the company to recover quickly.

Tang bases his statement on several factors:

- Efficiency and resiliency are critical aspects for firms in order to ensure profitability and continuity.
- It is easier to perform cost-benefit analysis for efficient SCRM strategies.

1.5.2 Robust supply chain management strategies

As an effective way of managing supply chain operational and disruption risks, Sheffi (2001) and Kleindorfer and Saad (2005) recommend the adoption of the multi-supplier strategy. This may allow, for example, to manage currency exchange fluctuations by selecting different suppliers in different geographical regions (Huchzermeier and Cohen, 1996). Multi-supplier strategy can also increase resiliency when major disruption occur. When Indonesian Rupiah depreciated by 50% in 1997, many manufacturers were unable to pay for imported components, therefore unfulfilling their customers' orders. Li and Fung however, was able to mitigate the effect of this disruption by shifting orders to other Asian suppliers.

When the multi-supplier strategy cannot be adopted, other policies, such as risk sharing contracts can help managing uncertain demand and making the supply chain more resilient and efficient. For example, to address the issue of the lack

of flu vaccine doses (Brown, 2004), the US government could offer risk sharing contracts to vaccine makers to entice them to enter the market. This could enable the US government to choose from a larger number of suppliers in case of major disruptions.

1.5.2.2 Robust demand management strategies

A robust strategy for demand management consists of the possibility to shift demand across products. Shifting demand across products can improve efficiency by increasing a firm's profits (Chod and Rudi, 2005). Also, it can increase resilience, as demonstrated by Dell in the event of the earthquake that hit Taiwan in 1999. Indeed, Dell was able to shift the demand of its customers towards products that utilized components from other countries by offering special price incentives. According to Veverka (1999), this enabled Dell to improve its earnings in 1999 by 41%.

Another robust strategy for managing demand risks is the demand postponement strategy previously described. We already discussed the operational efficiency of this strategy. However, demand postponement can be equally beneficial in case of disruptions, by enabling the firm to shift customer demand in time.

1.5.2.3 Robust product management strategies

Lee (1996) states that postponement is an effective strategy for improving supply chain efficiency when facing uncertain demands for different products. Nokia's case provides a clear example of how postponement can also increase resiliency. When Philip's semiconductor plant caught on fire in 2000, Nokia was able to manage the disruption's consequences by postponing the insertion of Philip's radio frequency chips to the end of the assembly process. Also, Nokia modified the design of some basic phones, making it possible to use different chips provided by other suppliers.

1.5.2.4 Robust information management strategies

We previously described how some strategies, namely, information sharing, VMI and CFPR, can coordinate the supply chain by improving the information

available to supply chain partners, in terms of inventory levels and actual demand. These strategies enable firms to decrease inventory levels and to maintain customer service levels high, thus increasing supply chain efficiency. Even though specific examples of how information sharing, VMI and CFPR could improve resiliency are not available, it is reasonable to assume that CPFR can enable a supply chain to develop a production strategy that would improve resiliency (Tang, 2006). Tang describes a scenario in which the supply chain partners develop a common demand forecast, share inventory information and adopt a common ordering rule, based on the "proportional restoration rule". Denardo and Tang (1997) prove that this ordering rule is efficient, and that it would restore the inventory level at each stage of the supply chain to its target even when the demand forecast is inaccurate. Tang (2006) then argues that CPFR can improve both supply chain efficiency and resilience.

1.6 Conclusion

In this chapter we carried out a comprehensive review based on Tang's classification on SCRM methods commonly adopted by companies, and on the different models proposed by several researchers. What emerges from our literature review though, is the significant lack for empirical studies on risk management in general and, more specifically, on SCRM. As stated by Andersen (2008), not much research has been done on the real effectiveness of risk management. With regard to SCRM, this lack of empirical studies is even more relevant, and a vast majority of the empirical studies in this field focus on sector-specific issues (e.g., Thun and Hoenig, 2009). Thus the need for an investigation on the effects of SCRM on a broad scale. In the following chapters, we will propose a research framework for an empirical study on SCRM, and based on a sample of 100 firms operating in the Italian industry, we examine the performance relationship of SCRM.

Chapter 2

Research framework and hypotheses

In this chapter, in order to design our research framework, we introduce some assumptions and hypotheses on the factors influencing SCRM.

2.1 Strategic alignment

As stated by Nolan (2006) a main issue in risk management is the capacity to keep critical business aspects such as strategy, goals and performance aligned. Joshi et al. (2003) investigate the relationship between alignment and performance, and together with other authors (Homburg et al., 1999; West and Schwenk, 1996) find alignment to influence performance indirectly, either through a mediating variable (Lindman et al., 2001), or in the presence of some moderating variables. Lee (2004) extends the analysis by considering the entire supply chain and highlights how misalignment can cause havoc among supply chain partners. In his work "The Triple-A Supply Chain", Lee provides a good example of the risks that may arise as a consequence of nonalignment:

"All through the 1990s, everybody regarded Cisco's supply chain as almost infallible. The company was among the first to make use of the Internet to communicate with suppliers and customers, automate work flows among trading partners, and use solutions such as remote product testing, which allowed suppliers to deliver quality results with a minimum of manual input. Cisco outsourced the manufacturing of most of its networking products and worked closely with contract manufacturers to select the right locations to support its needs. If ever there were a supply chain that was agile and adaptable, Cisco's was it. Why then did Cisco have to write off $2.5 billion of inventory in 2001? There were several factors at play, but the main culprit was the misalignment of Cisco's interests with those of its contract manufacturers. The contractors accumulated a large amount of inventory for months without

factoring in the demand for Cisco's products. Even when the growth of the U.S. economy slowed down, the contractors continued to produce and store inventory at the same pace. Finally, Cisco found it could not use most of the inventory of raw materials because demand had fallen sharply. The company had to sell the raw materials off as scrap."

As Cisco's example shows, if a firm's goals and assets are not consistent with the goals of the entire supply chain (usually defined by the major actors of the supply chain), we can assume that the firm will face higher operational risk. Indeed, if the main goal of the supply chain is lead time reduction but the firm aims at reducing costs as a primary goal, the consequent lack of alignment will increase the amount of risk faced by the company.

A major distinction should be made between the case in which the firm's alignment depends on a firm's own strategic planning, and the case in which alignment is caused by SC partners' directives. In the first case, a firm is strategically aligned with SC objectives, but it may benefit from the possibility of dictating directives to business partners in terms of strategic goals. In the second case, a firm has to keep strategy aligned with the one imposed by the major actors within the supply chain. Therefore, we distinguish between a firm's alignment and a firm's alignment capacity, defined as the capacity to keep strategy aligned with the supply chain's strategy by either adapting to changes in supply chain objectives, or by inducing business partners to align with the firm's own strategic goals. Indeed, while a firm's actual strategic alignment may depend upon several factors and does not necessarily imply a high capacity to keep strategic objectives aligned with those of the supply chain, strategic alignment capacity can provide relevant information on a firm's agility and capacity. Therefore, even though strategic alignment provides additional information, our framework will rely on alignment capacity to describe a firm's alignment. These factors may be regarded as modifiable factors, since we may assume that a company is able to increase the degree of alignment and the alignment capacity by undertaking initiatives aimed at increasing strategic agility. In this study we investigate this issue empirically by hypothesizing a positive correlation between alignment capacity, alignment and SCRM. Thus,

the following hypotheses are introduced.

Hypothesis 1. Firms strategic alignment capacity is positively correlated to SCRM capacity.

Hypothesis 2. Firms strategic alignment with supply chain goals is positively correlated to SCRM capacity.

2.2 Supply chain partner dominance

Several factors affect the way in which firms interact with their business partners. For example, their position along the supply chain may enable them in dictating directives to supply chain partners, or they may be forced to follow directives imposed by other firms because of a highly competitive business environment. We may assume that firms with a higher level of dominance over business partners will be less interested in developing SCRM tools, because of a lower exposure to risk. This effect may be mitigated by the fact that often larger firms have higher dominance over their smaller partners. If firm size positively affects SCRM capacity, then these two aspects could hide the relationship between SCRM and dominance. Our purpose is then to verify whether a significant relationship among these variables exists.
Dominance can be hardly influenced by the firm on the short-medium term, therefore we regard this variable as an unmodifiable factor. These statements lead to our third hypothesis.

Hypothesis 3. Dominance and SCRM capacity are negatively correlated.

2.3 Information sharing

Several studies assess the importance of information sharing throughout the supply chain for effective SCRM and for firm performance. Zhao et al. (2002)

conduct a study on the benefits of information sharing across a supply chain, showing that the cost savings for the entire supply chain are more significant when information regarding future orders is shared.

Even though many studies assess the positive effects of sharing information on customer demand, inventory level and demand forecast, there are still many barriers that prevent supply chain partners from sharing information. These obstacles regard issues such as bargaining power and confidentiality of information as well as uncertainty in the reliability of shared information. Openness, partnering, trust and particularly sharing of information has often been cited as one way to reduce supply chain risk (Faisal et al., 2007; Guo et al., 2006). For example, Lee et al. (1997) consider a series of companies in a supply chain, each of whom orders from its immediate upstream member. In this setting, inbound orders from a downstream member serve as a valuable informational input to upstream production and inventory decisions. They show that the distortion of the information transferred can misguide upstream members in their inventory and production decisions. In particular, the variance of orders may be larger than that of sales, and the distortion tends to increase as one moves upstream-a phenomenon termed "bullwhip effect".

Information sharing can contribute to dealing with issues such as demand uncertainty, supply uncertainty and breakdown of production facilities of upstream players (Ryu et al., 2009). Reducing uncertainty via the transparency of information flow is a major objective in external SC collaboration. Unpredictable or non-transparent demand patterns have been found to cause artificial demand amplification in a range of settings (Holweg et al., 2005). Investigating the influence of information sharing on SCRM can be interesting for two reasons. Firstly, it can promote the adoption of information sharing methods in supply chains by further highlighting the benefits deriving from information sharing. Secondly, should a positive correlation between information sharing and SCRM be confirmed, it could provide guidance for the enhancement of SCRM capacity, especially considering that this factor can be regarded as a modifiable factor.

Considering the above statements, we introduce the next hypothesis.

Hypothesis 4. Information sharing is positively correlated to SCRM capacity.

2.4 Replaceability

Replaceability, which is strictly connected to opportunism and to calculative trust in supply chain relationships (Larson, 1992), can play a major role in the management of risk throughout the supply chain. If the firm in question has many other firms in the market beside their current partner that could provide comparable business, the level of replaceability of the supply chain partner is high (Hallikas et al, 2005), thus generating a risk for the firm itself, especially if specific asset investments have been made in the business relationship between the two companies. Hallikas et al. find empirical evidence of the influence of replaceability on moderating supply chain relationships. Indeed, when there are many firms within an industry producing and/or selling similar products and/or services, they face substantial risk of not earning a sustainable level of profits (Gordon et al., 2009). Also, under these conditions there are higher chances that the firm will be replaced by direct competitors in SC business relationships. Furthermore, as stated by Andersen (2008), if a publicly traded company is ignorant about how it manages various exogenous risks, this is likely to affect its important stakeholder relationships, as it becomes a more vulnerable counterpart to many essential business transactions where goods, services and human efforts are exchanged. We may then hypothesize that firms with higher SCRM capacities will be less likely to be replaced. In evaluating the data collected from the sample, a relevant aspect that should be considered is the possible bias characterizing firms with high SCRM capacity. These companies' judgement on the level of replaceability may be inflated by a higher awareness of the risks faced. At the same time, these companies will be less likely to be replaced. We may then expect that, if a positive correlation exists, it may be mitigated by the previously mentioned bias.
Finally, on the short-medium term, it is difficult for a firm to modify its assets so to decrease its level of replaceability. Therefore, in our analysis this factor will be regarded as an unmodifiable factor.
Considering the above statements, we introduce our fifth hypothesis.

Hypothesis 5. There is a positive correlation between the degree of replaceability and SCRM capacity.

2.5 Supply chain risk management

SCRM aims at mitigating external disturbances and tries to manage certain risks within supply chains. Companies try to meet the requirements of competition through the intensive implementation of concepts streamlining supply chain processes (Childerhouse et al., 2003). This trend towards lean supply chains results in low inventories achieved by close collaboration with customers and suppliers on the one hand, but leads to high vulnerability on the other hand since turbulences in the supply chain can barely be compensated without safety stocks (Thun and Hoenig, 2009). Another reason for increasing supply chain risks is the trend towards outsourcing due to the fact that additional dependencies are created and the complexity in the network rises (Jüttner et al., 2003). The more complex a network is, the more interfaces do exist and the higher the vulnerability will be (Peck, 2005). In a similar way, Berry (2004) shows that globalization increases supply chain risks because aspects such as transportation risks, cultural risks or exchange rate risks gain importance. It is therefore reasonable to assume that firms may benefit in terms of performance from the implementation of supply chain risk management, since it increases the ability to manage risks, increasing the company's overall financial stability, and can improve supply chain relationships by reducing the impact of unfulfilment of a firm towards other supply chain partners. This can also encourage stakeholders in committing resources in firm specific investments, thus creating stable, long term relationship with the main stakeholders of a supply chain. As for other types or risk management, another effect which should be considered is the decrease in the cost of capital due to the decrease in bankruptcy risk, which should increase the availability of capital, broadening the firm's business opportunities.

Some studies focus on the relationship between risk management and

performance on the company level (Gordon et al., 2009; Andersen, 2008), finding positive results on the effects of risk management. Few authors though, try to address the issue of whether SCRM can yield similar results in terms of performance, while the vast majority of the studies available in literature focus on the proposal of new SCRM approaches and models. This study tries to investigate empirically the performance relationship of SCRM by positing the following hypothesis.

Hypothesys 6. Firms with higher supply chain risk management capacity are associated with higher performance outcomes.

Hypothesis 6, together with hypothesis 2, is fundamental to define our research framework, since the relationship strategic alignment-SCRM-performance represents the basis of our study.

2.6 Innovation

To introduce our next hypothesis, we focus on the connection between risk and innovation. Firms need to continuously innovate themselves in order to stay competitive, by launching new products, investing on research, or adopting new strategies. This applies not only to companies, but to national and international organizations as well. The following statement (Tony Blair, 2004) clearly summarizes this concept:

> *"We need to improve how we identify and address risks to successful delivery. Innovation is essential if we are to continue improving public services....*
> *We need to take risks with new policies to reap the rewards. But too often in the past, change has been initiated in ignorance of risks, and of*

what might be done to deal with them.
In future, we need to ensure that risks
have been adequately considered."

Firms operating in innovative business environments, such as computer products, machinery, measuring equipment, highly depend upon firm specific investments made by essential stakeholders for the development of innovative initiatives. Innovation leads to the creation of new business opportunities and new ways to achieve competitive advantage and to increase efficiency, by investing on new products, services and processes. This implies that firms with a strong focus on innovation are highly exposed to risk; therefore the need for an effective risk management policy.
A high bankruptcy risk may prevent important stakeholder investing in firm specific innovative projects, while a high risk management capacity may encourage them to engage in such investments. Andersen (2008) investigates the moderating role of innovation in the relationship between total risk management and performance, finding evidence that firms investing on innovation achieve higher benefits in terms of performance from the adoption of risk management techniques. This means that innovation plays a moderating role between risk management on a company level and performance. We now want to test whether it can play a similar role in the relationship between risk management on a supply chain level and performance. However, it is difficult to assess whether firms investing on innovation achieve higher benefits from risk management, or if firms with higher SCRM capacity can achieve better results from innovative initiatives. Considering the previously cited literature on the topic, we decide to consider the first approach. Thus we posit our next hypothesis.

Hypothesis 7. SCRM has a higher positive correlation with performance outcomes among firms investing in innovation.

2.7 Research framework

We identified two unmodifiable factors (SC dominance and replaceability) and three modifiable factors (alignment, alignment capacity and information sharing) that could affect SCRM. We then posited a hypothesis on the positive correlation between SCRM and performance, hypothesizing that innovation plays a moderating role in this relationship.

Among these five factors, three of them (SC dominance, replaceability and alignment) describe static properties of the firm, while two (alignment capacity and information sharing) describe dynamic properties. These two factors can be used by firms as a lever to obtain specific outcomes.

As previously stated, our research framework is mainly defined by the relationship between alignment capacity, SCRM, and performance.

The following research framework summarizes the purpose and the structure of the study conducted.

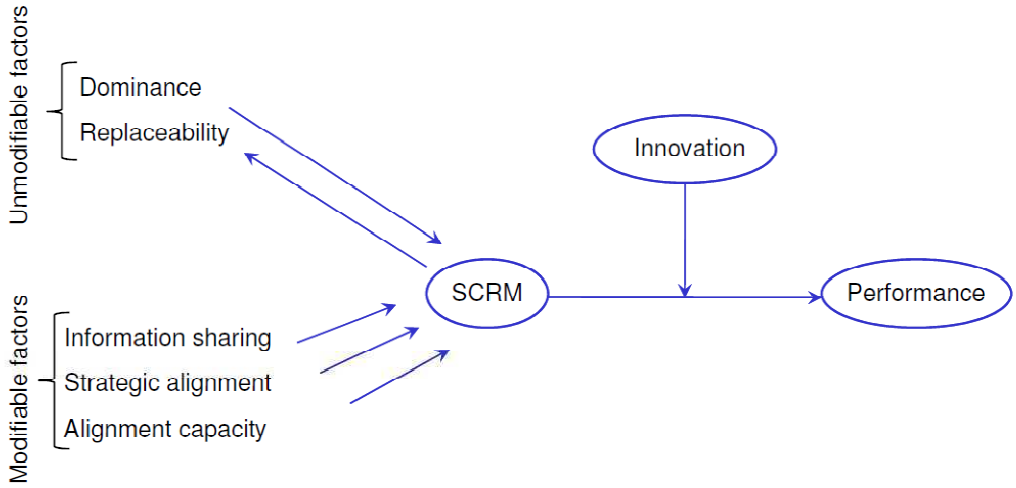

Figure 2.1. Research framework.

Chapter 3

Methodology

The empirical study is based on a sample of 100 firms operating in the Italian market; in particular, the research focuses on the manufacturing sector.
This chapter describes the methodology for defining variables and factors, acquiring the data and for the preliminary data analyses conducted.

3.1 Variables

The instrument developed to conduct the empirical research is a survey questionnaire including questions pertaining to SCRM issues and to performance measurement. Starting from our framework, we defined the appropriate variables in order to test our hypotheses.
Some researchers propose measurement instruments for risk management practices implementation (Gordon et al., 2009; Thun and Hoenig, 2009). However, the shortage of empirical studies assessing the implied performance effects of effective risk management is partly related to the difficulties of developing appropriate and consistent measures of risk management (Andersen, 2008). Since there is no universally accepted method for measuring SCRM, a different approach was chosen to conduct this study. To address this issue, we directly relayed on the respondent's in depth knowledge of the firm, formulating questions as they can be directly derived from the research framework previously described. It may be argued that this procedure could introduce a bias, since it is not based on an objective measurement of a given variable. To minimize this bias, the choice of the respondent has been carefully carried out, selecting senior managers with high-level management experience and a thorough knowledge of the firm's business. Furthermore, this approach enabled us to avoid an intermediate conversion step of the research variables into specific methods and practices, thus avoiding a possible bias. We can then

assume that this choice, if the selection of the respondent is appropriately carried out, may lead to a reduction of the degree of distortion of the data acquired, when a widely accepted measurement instrument is not available. Another reason for this choice is that it would have been extremely difficult to measure variables such as strategic alignment and partner dominance by means of objective measurement tools, while experienced managers are more likely to provide reliable information on these aspects. Consistently with this hypothesis, the same approach was adopted for performance measurement.
Therefore, the following variables were chosen to describe the factors needed to test our hypotheses:

- dominance over supply chain partners;
- firm's replaceability within the supply chain;
- firm's alignment and alignment capacity with supply chain objectives;
- degree of information sharing with supply chain partners;
- supply chain risk management capacity;
- innovation;
- performance.

Dominance over supply chain partners. In order to measure this variable, we formulated the question so as to understand how the respondent's firm interacts with supply chain partners. We determined five possible ways of interacting with supply chain partners, thus the question was formulated as follows:

“How would you define the way your company interacts with other companies in your most relevant supply chain (receives directives, passive cooperation, peer to peer cooperation, active cooperation, dictates directives)?”

Firm's replaceability within the supply chain. As previously stated, a firm's level of replaceability is correlated to the availability of cuncurrent firms who can provide similar products/services. Therefore, the following question was included in the questionnaire:

“What is the level of replaceability of your company within your 4 most

relevant supply chains, measured in terms of the degree to which your partner firms have potential partners, others than you, who could provide comparable business (very low, low, average, high, very high)?"

Firm's strategic alignment with supply chain objectives. This question was formulated directly in terms of strategic alignment, providing a brief example in order to clarify the meaning of the questionnaire item. As stated in paragraph xx, a major distinction was made between a firm's alignment and alignment capacity. Therefore, to investigate this area two distinct questions were included in the questionnaire.

"Are the objectives of your company (e.g., reducing costs or delivery time) aligned with those of your 4 most relevant supply chains (not at all, mainly not, partially, mainly yes, yes)?"

"To which degree is your company able to keep its objectives aligned with those of your 4 most relevant supply chains, by both adapting to variations in supply chain objectives or inducing the other companies in the supply chain to adapt to the changes in your objectives (very low, low, average, high, very high)?"

Degree of information sharing with supply chain partners. To investigate information sharing practices, the question was formulated with an explicit referral to supply chain risk management, i.e. the respondents were asked the following question:

"With regard to supply chain risk management, to which degree is information shared through your 4 most relevant supply chains (very low, low, average, high, very high)?"

Supply chain risk management capacity. This variable was introduced in the questionnaire by asking the manager's opinion on their firm's supply chain risk management capabilities; the question was formulated as follows:

"Which is, in your opinion, your firm's supply chain risk management capacity (very low, low, average, high, very high)?"

Innovation. This variable was measured in terms of R&D assets, since this can provide information on the effort spent in developing new products/services. The following question was then introduced in the questionnaire:

"What is the product design capability of your company (ranging from no product design to advanced R&D) (very low, low, average, high, very high)?"

Company performance. Consistently with the approach followed for the other variables, a question regarding overall company performance was introduced in the questionnaire. Furthermore, in order to avoid the bias due to the current economic context (e.g., global economic crisis) and/or market-specific trends, the respondents were asked to define their firm's performance in comparison with competitors and without considering the current economical conditions. Thus, the following question was formulated:

"Given the current economic context, what is the current company performance when compared to your competitors (very poor, poor, average, good, excellent)?"

For additional analyses, the questionnaire also included questions regarding trends in certain variables. In fact, in order to extend the study to time-related effects, we investigated whether e relationship exists between the three-years trends in alignment, information sharing, SCRM and company performance.
The following questions were then introduced in the questionnaire.

"With regard to strategic alignment, what has the trend (in terms of increase or decrease of alignment) been like for the past three years (very negative, negative, stable, positive, very positive)?"

"With regard to alignment capacity, what has the trend (in terms of increase or decrease of alignment capacity) been like for the past three years (very negative, negative, stable, positive, very positive)?"

"With regard to information sharing, what has the trend (in terms of increase or decrease of information sharing) been like for the past three years (very negative, negative, stable, positive, very positive)?"

"With regard to supply chain risk management, what has the trend (in terms of increase or decrease of alignment) been like for the past three years (very negative, negative, stable, positive, very positive)?"

"With regard to performance, what has the trend (in terms of increase or decrease of performance) been like for the past three years (very negative, negative, stable, positive, very positive)?"

3.2 Survey questionnaire development

The survey questionnaire was initially developed in English by the Department of Management Engineering of the Politecnico di Milano. It was then translated into Italian in order to facilitate its comprehension by the respondents. The questionnaire included questions pertaining to company characteristics, to the SCRM issues previously mentioned and to company performance. The same research team also developed a framework for an empirical research on green supply chain management; consequently two sections of the questionnaire were dedicated to investigating GSCM practices. Members of the research team were available to the respondents to clarify any possible doubt which could arise while filling in the questionnaire. Furthermore, a pilot test was conducted to verify whether the questions could be easily understood by the respondents. An unidimensional scaling method was adopted for the questionnaire, namely, a five-point Likert scale. This measurement scale has been adopted in several empirical studies (e.g., Zhu and Sarkis, 2004) based on the distribution of questionnaires.

3.3 Data and sample characteristics

The study focuses on the Italian manufacturing industry, therefore the industrial sectors were selected on the basis of the classification provided by the Italian National Institute for Statistics (ISTAT). Table 3.1 shows the categories included in the research. These sectors have been selected in order to provide a complete description of the Italian manufacturing industry. Firms were then selected from the AIDA database published by Bureau van Dijk Electronic Publishing, containing information about 700,000 companies operating in the Italian market.

Questionnaires were administered by email to 16,430 companies; in most of the cases the email was followed by telephone interview. As previously stated, respondent were selected among middle and high level managers. A total of 100 questionnaires were received; the distribution of respondent enterprises in terms of industry is shown in table 3.2, while table 3.3 shows the distribution in terms of firm size. The sample is characterized by a broad range of companies belonging to different sectors; however the distribution of the sample does not resemble the Italian manufacturing industry. As a matter of fact, a high percentage of the respondent firms has more than 50 employees (59 % of the sample), while according to statistics (ISTAT, 2009) only 2.3% of the companies operating in the Italian manufacturing industry belongs to this category. This may be explained by the lack of resources that prevents small firms from applying SCRM and GSCM methods and practices, thus reducing their involvement in this research. Contrarily, larger companies show more interest in achieving a deeper consciousness of the performance implications of the supply chain management instruments adopted.

Industrial sectors
Food
Beverages
Textile products
Lumber & wood products (no furniture)
Paper & allied products
Petroleum refining
Chemical & allied products
Plastic materials, synth resins & nonvulcan elastomers
Metal products (no machinery & equipment)
Computer equipment, optical & electronic products, electromedical apparatus, measurement equipment & watches
Electrical equipment & non electrical household equipment
General industry machinery & equipment, NEC
Automotive
Means of transport (no automotive)
Furniture
Power & distribution

Table 3.1. Industrial sectors involved in the research.

Industrial sectors	Total	Percentage
Food	6	6
Beverages	1	1
Textile products	6	6
Lumber & wood products (no furniture)	6	6
Paper & allied products	9	9
Petroleum refining	6	6
Chemical & allied products	12	12
Plastic materials, synth resins & nonvulcan elastomers	9	9
Metal products (no machinery & equipment)	9	9
Computer equipment, optical & electronic products, electromedical apparatus, measurement equipment & watches	5	5
Electrical equipment & non electrical household equipment	8	8
General industry machinery & equipment, NEC	10	10
Automotive	7	7
Means of transport (no automotive)	0	0
Furniture	6	6
Power & distribution	0	0
Total	100	100

Table 3.2. Sample distribution.

Size (employees)	Total	Percentage
1-9	1	1
10-49	40	40
50-249	40	40
>249	19	19
Total	100	100

Table 3.3. Sample distribution by company size.

3.4 Analysis and results

3.4.1 Descriptive statistics

Table 3.4 shows the descriptive data for questionnaire items, including means, standard deviations and number from sample.

Variable	Mean	StDev	N
SC interaction	3.40	0.97	96
Replaceability	3.12	0.96	97
Alignment	4.24	0.85	95
Alignment trend	3.51	0.65	96
Information sharing	2.98	0.84	95
Inf. sharing trend	3.26	0.55	94
Alignment capacity	3.49	0.71	95
Align. capac. trend	3.56	0.63	96
SCRM capacity	3.07	0.86	97
SCRM capac. trend	3.38	0.68	97
SC performance	3.21	0.58	98
Firm performance	3.36	0.63	99
Firm perform. trend	3.37	0.74	99
IT assets	3.37	0.83	99
R&D assets	3.55	0.93	99
QM assets	3.94	0.64	99
HR assets	3.37	0.66	99

Table 3.4 Descriptive statistics for the sample.

3.4.2 Size effect

In order to determine whether company size plays a relevant role in our

research, we calculated Pearson's correlation coefficient between company size, measured as the natural logarithm of the number of employees (Dean and Snell, 1991), the five factors included in hypotheses 1 to 5, and SCRM capacity. Table 3.5 shows the results for this analysis.

	SC domin.	Replaceability	Alignment	Align. capac.	Inform. shar.	SCRM
Firm size	0.134	-0.024	0.087	0.138	0.175	0.354
	0.19	0.817	0.402	0.182	0.089	0.000

Table 3.5. Correlation coefficients and p-values for company size.

The value of Pearson's coefficient shows that there is a significant correlation between company size and firm's supply chain risk management ability; this may be explained by several reasons. Firstly, larger firms have extra resources that can enable them to implement more advanced risk management instruments, if compared to smaller firms. Larger firms are usually characterized by a higher number of internal functions, and more specific job tasks. In accounting, for example, researchers have found firm size to be an important factor when considering the design and use of management control systems (e.g., Haka et al., 1985; Myers et al., 1991; Shields, 1995). With respect to risk management, Beasley et al. (2005) and Hoyt and Liebenberg (2009) found firm size to be positively correlated to the adoption of enterprise risk management. Therefore, it is reasonable to assume that similar relationships will apply to SCRM.

As it can be observed from the results shown in table 3.5, size does not affect any of the five factors involved in our hypotheses; this leads to the conclusion that larger firms do not have any advantage in terms of dominance over business partners, replaceability, alignment and information sharing. This finding represents an interesting result because of its practical implications. Indeed, since there is no significant influence of firm size upon the above listed factors, the results of hypotheses 1 to 5 can provide useful guidance to a larger number of companies, regardless of their size.

3.4.3 Supply chain risk management

Hypotheses 1 to 5 posit a significant relationship between five factors and SCRM. In order to test these hypotheses, we calculated the correlation matrix among this six variables using Pearson's correlation coefficient. Table 3.6 shows the results together with the corresponding p-values. SCRM shows a positive correlation with all the variables introduced by hypotheses 1 to 5, but only some of them are statistically significant. Dominance over supply chain partners, alignment capacity, and information sharing are all positively correlated to SCRM; with a highly relevant correlation coefficient particularly for information sharing and alignment capacity. Thus, our data and results provide support for hypotheses 1, 4, and 5, but not for hypotheses 2 and 3.

Hypothesis 2 posits a positive correlation between strategic alignment and SCRM. An interesting finding is that this hypothesis is not supported, while the one on alignment capacity is supported by the high value of the correlation coefficient (0.441). We may find an explanation for such a behavior in the correlation between these two factors and SC partner dominance. Indeed, while the correlation between alignment and SC dominance (0.089) is relatively low and not statistically significant , alignment capacity and SC dominance are positively correlated (0.315). This suggests that the positive correlation between alignment capacity and SCRM is probably due to firms' capacity to keep their objectives aligned with SC strategic goals by dictating directives to other companies rather than by adapting to changes in SC strategy. Also, strategic alignment only provides a static description of the company's alignment with supply chain objectives; it is therefore reasonable to expect a higher relationship between SCRM and alignment capacity.

As explained in par. 2.4, we expected to find a mitigating effect affecting the relationship between replaceability and SCRM. This aspect seems to be confirmed by our results ($r=0.161$, $p=0.117$). It is reasonable, in this case, to accept a higher p-value when testing hypothesis 5, since this is an exploratory analysis. We may then consider this hypothesis supported by the results, but further analysis would be beneficial.

The correlation matrix also highlights other relevant correlations, which lead to

the following findings.

Supply chain dominance. Supply chain dominance shows a significant positive correlation with firm's replaceability; this may be explained by the assumption that a firm characterized by a lower level of replaceability, e.g. providing services/products which are less likely to be provided by other companies, has higher contractual power in conducting relationships with SC partner.

Alignment capacity. Alignment capacity has been previously defined as the capacity to keep a firm's strategy aligned with that of the supply chain by either adapting to strategic changes in SC objectives or inducing business partners to adapt to changes in the firm's objectives. This variable shows a positive significant correlation with replaceability and supply chain dominance. The first correlation may be explained by observing that replaceability can influence a firm's capacity to dictate directives to SC partners in order to keep the supply chain strategically aligned. Similarly, the second correlation can be explained by considering that a firm which is capable of dictating directives to supply chain partners regarding business relationships, will most probably be able to dictate directives in terms of strategic goals, in order to ensure SC coordination.

Information sharing. This variable shows considerable positive correlation with all the other variables included in the model. Due to the high value of the correlation between information sharing, alignment, and alignment capacity, we may assume that a higher degree of information sharing with business partners can lead to better supply chain alignment. The same results are confirmed by Guo et al. (2006), who demonstrate that information sharing can be used to achieve better channel coordination in the supply chain system. This finding can be considered particularly interesting, since there are still many barriers that limit the adoption of information sharing policies, e.g. confidentiality of information. This issue probably deserves further investigation.

	Replaceability	SC dominance	Alignment	Align. capac	Inform. shar
SC dominance	0.194	1			
	0.060				
Alignment	0.166	0.089	1		
	0.109	0.393			
Align. capac.	0.188	0.315	0.257	1	
	0.068	0.002	0.013		
Inform. shar.	0.241	0.236	0.405	0.424	1
	0.019	0.022	0.000	0.000	
SCRM	0.161	0.187	0.152	0.441	0.36
	0.117	0.070	0.143	0.000	0.000

Table 3.6. Correlation matrix and p-values for SC dominance, replaceability, alignment, alignment capacity, information sharing and SCRM.

3.4.4 SCRM and performance

Hypothesis 6 posits a positive relationship between SCRM and firm's performance. In order to test this hypothesis, we calculated Pearson's correlation coefficient between SCRM and performance, and Mood's median test and Kruskall-Wallis' test were used for further confirmation. Tables 3.7, 3.8, and 3.9 show the results for these analyses. A commonly used statistical tool for these kind of analyses is ANOVA, but this method is a parametric test based on the assumptions that the data is a sample from a normally distributed, continuous population. In our case, due to the nature of the data itself (distributed on a five-point Likert scale), these assumptions are not verified.

Among nonparametric tests, Kruskal-Wallis represents a valid alternative to ANOVA, but it assumes a continuous distribution. Mood's median test can be used to test the equality of medians from two or more populations and, like the Kruskal-Wallis test, provides a nonparametric alternative to the one-way analysis of variance. Mood's median test hypotheses are:

H0: the population medians are all equal

versus

H1: the medians are not all equal

An assumption of Mood's median test is that the data from each population are independent random samples and the population distributions have the same shape. Mood's median test is robust against outliers and errors in data and is particularly appropriate in the preliminary stages of analysis. Mood's median test is more robust than is the Kruskal-Wallis test against outliers, but is less powerful for data from many distributions, including the normal. However, since Kruskal-Wallis test is robust against the hypothesis of a continuous data distribution, we also report the results of Kruskal-Wallis test, which confirm the results of Mood's median test (see table 3.9).

The value of the correlation coefficient suggests a positive relationship between SCRM and performance. The results of Mood's median test (p-value<0.001) show that firms characterized by different degrees of adoption of SCRM practices achieve different performance levels. These results provide strong support for our hypothesis.

	SCRM
Performance	0.391 0.000

Table 3.7. Correlation coefficient and p-value for SCRM and performance.

SCRM	N<=	N>	Median	Q3-Q1	Chi-Square	DF	P
1	1	0	3	Not Used	19.48	3	0.000
2	25	1	3	0			
3	19	19	3.5	1			
4	13	16	4	1			
5	1	2	4	1			

Table 3.8. Results of Mood's median test.

Kruskal-Wallis Test on SCRM				
SCRM	N	Median	Ave Rank	Z
1	1	3	32.5	-0.55
2	25	3	30.8	-3.58
3	37	3	52.1	1.32
4	28	4	55.4	1.83
5	3	4	61.5	0.9
Overall	94		47.5	
H = 13.91	DF = 4	P = 0.008		
H = 17.86	DF = 4	P = 0.001	(adjusted for ties)	

Table 3.9. Results of Kruskal-Wallis test.

3.4.5 The role of innovation

We previously hypothesized that innovation plays a moderating role in the relationship between SCRM and performance, i.e., that the performances of companies investing on innovation achieve higher benefits from a better SCRM capacity. In order to verify this hypothesis, a hierarchical multiple regression was conducted. Hierarchical regression is a multivariate analysis tool that lets the researcher decide which variable should be introduced at each step of the regression. Several authors adopted this method in similar studies (Andersen,

2008; Zhu and Sarkis, 2004). Firstly, we introduce firm size as a control variable, followed by SCRM. In the third step, we introduce R&D, and in the last step we introduce the interaction term between R&D and SCRM. A major issue in this kind of analysis is represented by multicollinearity among data; therefore we calculated the VIF (variance inflation factor), which confirmed the presence of multicollinearity (a generally accepted rule suggests to carry out further investigation when VIF>10). When introducing an interaction term, multicollinearity can be caused by the relationship between this term and its parent variables. We therefore removed R&D as a probable cause of multicollinearity (since model 3 in table 3.11 shows that R&D is not significant), and performed hierarchical regression with the new model. Table 3.13 shows the statistics for the regression. The value of the standardized coefficient ß for the interaction term does not seem to support our hypothesis, showing that for our case there is no statistically significant moderating effect due to innovation. The significant model suggested by the regression includes firm size and SCRM (model 2, table 3.13). Therefore, while firms investing on innovation achieve higher benefits in terms of performance from the implementation of risk management (Andersen, 2008), they don't seem to achieve higher benefits from the adoption of supply chain risk management. This may be explained by the fact firms investing on R&D assets probably focus on product innovation, and thus their performances are more affected by internal risk management, rather than by supply chain risk management.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.423	.179	.170	.55603
2	.495	.245	.229	.53592
3	.500	.250	.226	.53699
4	.506	.256	.223	.53798

Table 3.10. Model summary for the first hierarchical regression.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.440	.206		11.867	.000		
	Lnsize	.204	.045	.423	4.551	.000	1.000	1.000
2	(Constant)	2.045	.241		8.477	.000		
	Lnsize	.157	.046	.326	3.398	.001	.875	1.143
	SCRM	.196	.068	.275	2.875	.005	.875	1.143
3	(Constant)	1.920	.289		6.644	.000		
	Lnsize	.152	.047	.315	3.252	.002	.858	1.165
	SCRM	.189	.069	.266	2.745	.007	.861	1.162
	RandD	.048	.060	.073	.790	.431	.948	1.055
4	(Constant)	1.396	.708		1.971	.052		
	Lnsize	.148	.047	.306	3.131	.002	.847	1.181
	SCRM	.378	.242	.530	1.558	.123	.070	14.322
	RandD	.200	.198	.307	1.013	.314	.088	11.332
	RandDperSCRM	-.052	.064	-.388	-.811	.420	.035	28.263

Table 3.11. Coefficients and collinearity statistics for the first regression.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.423[a]	.179	.170	.55603
2	.495[b]	.245	.229	.53592
3	.497[c]	.247	.223	.53806

Table 3.12. Model summary for the second hierarchical regression.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.440	.206		11.867	.000		
	Lnsize	.204	.045	.423	4.551	.000	1.000	1.000
2	(Constant)	2.045	.241		8.477	.000		
	Lnsize	.157	.046	.326	3.398	.001	.875	1.143
	SCRM	.196	.068	.275	2.875	.005	.875	1.143
3	(Constant)	2.068	.247		8.388	.000		
	Lnsize	.155	.047	.321	3.321	.001	.867	1.154
	SCRM	.156	.105	.219	1.491	.139	.374	2.674
	RandDperSCRM	.010	.020	.074	.504	.616	.380	2.630

Table 3.13. Coefficients and collinearity statistics for the second regression.

3.4.6 Time-related effects

In order to study time-related effects in the relationships among the variables included in our model, the questionnaire included questions regarding trends in SCRM, the 3 factors listed in hypotheses 1, 2 and 4, and firm performance.
A three years period was considered sufficient to observe the effects of management initiatives.
Table 3.14 shows the correlation coefficients with the corresponding p-values for this analysis. The trend in information sharing is significantly correlated to all the other trends, confirming our previous findings for information sharing in terms of alignment, SCRM, and thus performance. The trend in alignment capacity is positively correlated to the trend in SCRM, i.e., firms that experience an increase in alignment capacity also experienced an increase in SCRM capacity. The strong correlation between the trend in alignment and the trend in SCRM is particularly interesting, since it confirms the positive

relationship between strategic alignment and SCRM, in contrast with the results obtained for hypothesis 2. Finally, SCRM trend is positively correlated to the trend in performance, thus providing further support for hypothesis 5. These results show that firms which in the last 3 years experienced improvements in terms of alignment and information sharing also achieved positive results in terms of SCRM and performance improvements. The consistency of these findings with our previous empirical results provides further confirmation for our findings.

	Inf.shar. trend	Align. capac. trend	Align. trend	SCRM trend
Align. capac. trend	0.24 0.02	1		
Alignment trend	0.317 0.002	0.346 0.001	1	
SCRM trend	0.402 0	0.214 0.036	0.37 0	1
Performance trend	0.2 0.053	0.187 0.067	0.244 0.017	0.252 0.013

Table 3.14. Correlation matrix and p-values for time-related effects.

3.4.7 SCRM and environmental sustainability

The research team developed a questionnaire in order to investigate two main issues: supply chain risk management and green supply chain risk management. While the detailed analysis concerning GSCM diffusion among Italian companies has been developed by other members of the research team (Bruno and Bencivinni, 2009) in a separate study, in our study we tried to determine whether these two relatively recent research fields interact. A positive correlation between SCRM and GSCM could provide the starting

point for further investigation on the role of SCRM in environmental sustainability. Therefore, our aim is to verify whether a positive correlation exists between the level of implementation of SCRM and that of GSCM.
One of the main factors included in our research is strategic alignment. In terms of GSCM, we can define green alignment as the difference between the importance given to environmental issues within the company business and within the supply chain. To determine whether firms characterized by a higher level of strategic alignment, also consider green alignment in their decisional processes, we hypothesize a positive correlation between these two variables. Specifically, when choosing between alignment and alignment capacity for this analysis, we considered that while alignment provides a static description of the degree of strategic alignment, alignment capacity can provide a more dynamic description of the firm's characteristics. Thus, since GSCM is a relatively recent discipline, and as shown by Bruno and Bencivinni it is still moving its first steps in the Italian industry, it is reasonable to study the relationship between alignment capacity and green alignment. Another aspect that justifies this choice is the fact that while a high alignment capacity implies that the firm has the capacity of deciding whether to align or not in terms of GSCM, alignment alone cannot explain if the firm can align in green terms.
Based on the above arguments we posit the following hypotheses.

Hypothesis 8. SCRM capacity and GSCM are positively correlated.

Hypothesis 9. Strategic alignment capacity and green alignment are positively correlated.

To clarify how these additional variables interact with the variables previously introduced, we designed an updated framework. This framework should be considered as an exploratory framework aimed at investigating a possible relationship between SCRM and GSCM.

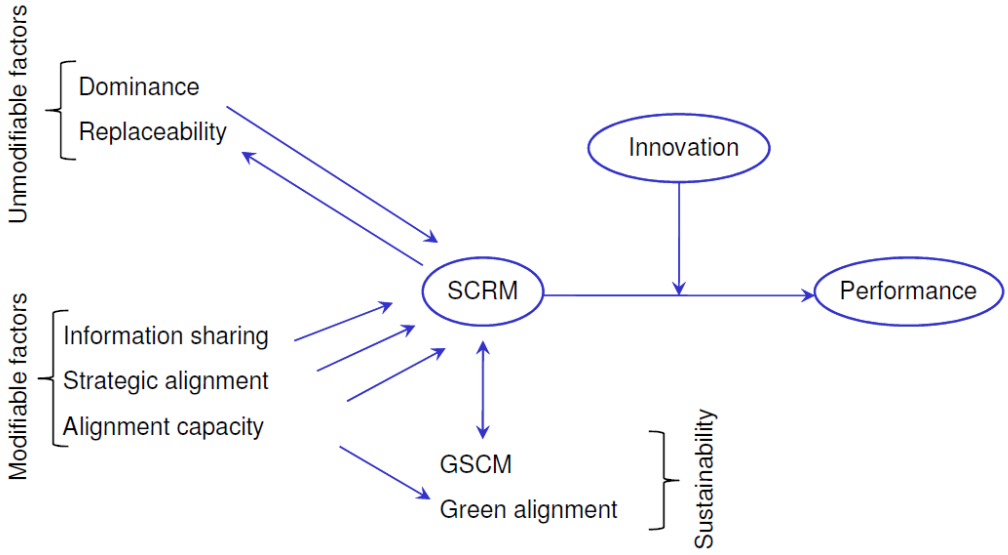

Figure 3.1. Research framework with GSCM and green alignment.

3.4.8 Environmental implications of SCRM

Hypotheses 8 and 9 posit a positive correlation between SCRM and GSCM, and alignment capacity and green alignment, respectively. In order to calculate these variables, the following questions where included in the questionnaire:

"How green is your company, when compared to competitors (much lower, lower, equal, higher, much higher)?"

"Is your primary supply chain characterized as green (not at all, mainly not, partially, mainly yes, yes)?"

To calculate green alignment, the procedure we adopted is the following:

- step 1: calculate the difference, in terms of "green", between the supply chain and the firm;
- step 2: if the firm is less green than the supply chain (i.e., the output of step 1 is either 1 or 2), a low value for green alignment is assigned; if the

firm is as green as the supply chain (i.e., the output of step 1 is 0), a high value of green alignment is assigned; if the firm is more green than the supply chain (i.e., the output of step 1 is -1 or -2), an intermediate value for green alignment is assigned.

Table 3.15 shows the conversion method used to calculate green alignment.

Step 1	Step 2
2	1
1	2
0	5
-1	4
-2	3

Table 3.15. Green alignment calculation table.

The bivariate correlation results, using Pearson correlation coefficients, are shown in table 3.16. These results show a statistically significant positive relationship, thus providing support for hypotheses 8 and 9.

In order to test the robustness of the results for hypothesis 9, we performed the same calculation using a different scale to determine green alignment. In this alternative scale, if the company is more green than its supply chain, a high value of green alignment is assigned (i.e., 5), assuming that the company is proactive in terms of GSCM. In this case a higher green level is not considered as misalignment. The results for the analysis conducted with the second scale provide similar results.

	SCRM	Alignment capacity
GSCM	0.279 0.006	
Green alignment		0.206 0.045

Table 3.16. Pearson correlation coefficients for SCRM, GSCM, alignment capacity and green alignment.

The results for hypothesis 8 confirm that firms with higher SCRM capacities also give more importance to environmental issues. This result may be interpreted in different ways. For example, it may mean that firms that are characterized by higher awareness of supply chain risks also pay more attention to environmental issues. Another possible interpretation is that firms that develop SCRM capacities also benefit in terms of GSCM, since environmental issues can play a major role in the management of supply chain risks.

The positive correlation between alignment capacity and green alignment demonstrates that firms consider green aspects when making decisions on strategic alignment issues.

However, this is an exploratory study, and the main purpose is to provide spur for future research in this field, which could focus on the role that SCRM can play in addressing environmental sustainability issues.

Chapter 4

Discussion of results

4.1 Main effects

The direct positive relationship between SCRM and company performance is a very promising result. There seem to be significant opportunities for Italian companies implementing SCRM practices. SCRM should enable firms to achieve better overall performances through supply chain management initiatives, and our results seem to confirm this expectation.

Another issue that we must take into account when considering the level of implementation of SCRM practices is the cost-benefit trade-off. Several authors highlight the necessity for a trade-off between the benefits associated with risk reduction and costs associated to risk management practices. Fatemi and Luft (2002) show that risk management should maximize firm and shareholder value while avoiding financial distress, but at the same time risk management-related costs should be considered as well. The existence of these costs makes it imperative to investigate the benefits associated with risk management practices. In this context, finding a positive relationship between SCRM and performance outcomes can provide significant incentive to the diffusion and implementation of SCRM practices.

A company's strategic alignment with SC goals has proven to be fundamental for the reduction of supply chain risks. Firms will generally try to maximize their own interest, but if a company's interests differ from those of the other supply chain partners, the performance of the whole supply chain will be negatively affected. Furthermore, lack of alignment can cause the failure of several supply chain initiatives (Lee, 2004). According to our results, firms that experienced in the last years an increase in the strategic alignment, achieved positive results in terms of SCRM. Moreover, the strategic agility represented by the capacity of keeping goals aligned with those of the supply chain has a

direct and positive impact on SCRM. This result has an important impact on our study, since it provides support for one of our main hypotheses (H1), assessing the importance of strategic alignment, which directly affects SCRM and indirectly affects performance outcomes.

The benefits of sharing information along the supply chain have been assessed by several studies (Guo et al., 2006; Chu and Lee, 2005; Ryu et al., 2008). Our empirical results indicate that information sharing has direct, positive effects on SCRM. The significant correlation between this variable and other factors such as alignment, replaceability and dominance should also be carefully considered, and probably deserves further investigation in order to fully understand the benefits of information sharing. However, results show that information sharing is not highlighted yet with the lowest mean (2.98) among the five factors included in our hypotheses. This means that even though the positive effects of sharing information with SC partners are widely recognized by both practitioners and researchers, few Italian companies have really implemented it due to some key factors that still hinder information sharing such as cost, confidentiality of information, and the fear that information will be used unfairly to the partners' advantage, thus missing the chance to create significant win-win opportunities for SC partners by sharing information. As stated by Zhao et al. (2002), in order to motivate these companies to share information, they need to be aware of the benefits that information sharing systems can bring. A main issue that emerges from our analysis is that while the positive effects of SCRM and information sharing are largely confirmed, these two factors have the two lowest mean values (3.07 and 2.98, respectively) among all the factors investigated. Hypothesis 7, regarding the moderating role of innovation, is not supported by results. This means that while the interaction between innovation and risk management is associated with higher performance outcomes (Andersen, 2008), it doesn't significantly interact with supply chain risk management in affecting performances.

Hypotheses 8 and 9 are supported by our results. These results can be interpreted in several ways; however, they provide significant evidence that SCRM and sustainability are closely related.

Hypothesis	H1	H2	H3	H4	H5	H6	H7	H8	H9
Supported?	Yes	Partially	No	Yes	Yes	Yes	No	Yes	Yes

Table 4.1. Results for hypothesis 1 to 9.

4.2 Concerns and limitations

In arriving at these final results, we must mention the limitations of this study. First, the sample is based on Italian companies. The level of implementation of SCRM initiatives among Italian organizations is still low, and it could be beneficial to investigate whether companies on an international scale achieve similar results.

Second, actual financial numbers and specific measurement tools for SCRM and the other factors were not used. Therefore, we could not confirm whether positive performance and trends actually occurred.

Third, due to difficulties in collecting the data the sample size was not as large as those used in some similar studies (Andersen, 2008), even though comparable to those used by other researchers (Gordon et al.,2009; Zhu and Sarkis, 2004). A larger sample size could increase the statistical power of our research and allow deeper analysis in terms of industrial sector differences and moderating effects.

Fourth, the possibility of reverse causality cannot be excluded. It may be argued that outperforming firms can use the slack of resources available to increase their ability in managing risk. Considering previous studies available in literature though, it is more reasonable to assume that reverse causality does not represent a serious issue in this research. However, we cannot determine the exact causality between the factors introduced in our hypotheses, SCRM and performance, but we can suggest that a significant relationship exists among these variables.

4.3 Conclusion and implications

SCRM has emerged as a fundamental tool to manage risks throughout the entire supply chain. SCRM differs from traditional risk management in that it is characterized by a cross-company orientation aiming at the identification and reduction of risks not only on the company level, but rather focusing on the entire supply chain (Thun and Hoenig, 2009). However, in many industries risk management is still understood primarily as a company-specific task as it is pointed out by Jüttner (2005): "Companies implement organization-specific risk management, but there is little evidence of the risk at the supply chain level". Various trends currently in place highlight the importance of SCRM: increase in strategic outsourcing, globalization of markets, low cost country sourcing, reduced buffers.

However, the data show that the level of adoption of SCRM in the Italian industry is still low. Moreover, our preliminary analyses determine that no statistically significant difference exists in level of SCRM implemented by firms belonging to different industrial sectors.

We investigated which factors affect a company's SCRM capacity, finding that alignment and information sharing play a major role in enabling a firm to manage supply chain risks. The findings regarding strategic alignment with supply chain goals are consistent with those of Lee (2004): "If any company's interests differ from those of other organizations in the supply chain, its actions will not maximize the chain's performance". By analyzing the correlations among factors influencing SCRM, we determined that alignment can affect replaceability and that it is affected by the degree of dominance over supply chain partners. These observations lead to the conclusions that alignment can be used to decrease the level of replaceability, and that firms characterized by a higher bargaining power can achieve better strategic alignment with the supply chain.

Furthermore, hypotheses 1 and 6, which represent the relationship between strategic alignment, SCRM, and performance, and are the main points of our research, are strongly supported by the results.

Several benefits emerged from the analysis of the effects information sharing. It

can influence positively alignment, replaceability and SCRM. We then found significant evidence of the positive correlation between the level of adoption of SCRM and company performance.

To include time-related effects in our model, we investigated the relationship among three-years trends in strategic alignment, information sharing, SCRM and company performance. The results confirm our previous findings and demonstrate that firms that experienced a positive trend in SCRM in the last three years achieved positive performance trends.

Finally, two main considerations arise from the findings. The first aspect regards the lack of implementation of SCRM and information sharing in the Italian industry, underlined by the two lowest mean values determined for these two variables, among all the variables that have been considered. This contrasts with the positive effects highlighted by our results, and we hope that our findings, together with the increasing need for risk management on a supply chain level, may encourage organizations to further develop and implement SCRM.

The second aspect that deserves particular attention recalls back to the distinction made in the first chapter between modifiable and unmodifiable factors. This distinction has been introduced in order to address a main issue in research activities, that of the gap between practice and research. Van de Ven and Johnson (2006) offer an appealing perspective on the issue, highlighting that academic research has become less useful for solving practical problems. We try to give our practical contribution to the development of the Italian industry by emphasizing the finding that two modifiable factors, namely information sharing and strategic alignment, can be used by companies to increase the level of implementation of SCRM. Therefore, with an attempt to bridge the gap between research and practice and to stress the practical implications of our research, we propose a scenario in which companies may undertake supply chain management initiatives aimed at improving strategic alignment and information sharing, thus developing the conditions for implementing SCRM and enhancing performance.

The findings from this study should be regarded as preliminary, rather than definitive. Nonetheless, we believe that the results of this research provide

important insight into the relationship between SCRM and firm performance. Future research on the topic could consider an international sample so to identify differences in the effects and in the level of implementation of supply chain risk management on a broader scale.

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ANNEX 1

Questionnaire

SECTION 1 - General Information

- Company name: _____
- Company location: _____
- Your position in the company: _____
- Number of employees in the company (2008): _____
- Company Turnover [€] (2008): _____
- Does your company belong to any group? (Yes, No)
  - Group name: _____
  - Company role within the group: _____
  - Number of employees in the group (2008): _____
  - Consolidate turnover [€] (2008): _____
- What is the primary (in terms of turnover) industrial sector (e.g., chemical, automotive, electronic/electrical, petroleum chemical, machinery, pharmaceutical, food & beverage, textile & apparel) your company operates in? _____
- How many supply chains your company belongs to? _____
- What is the role of your company along the primary supply chain?
  - ☐ OEM/Contractor
  - ☐ First-tier supplier
  - ☐ Second-tier supplier
- What are, in order of importance, the most relevant (in terms of turnover) supply chains your company belongs to/operates in?
  1. _____ 2. _____
  3. _____ 4. _____

- Is there any supply chain your company considers as strategically relevant for the near future? If yes, which ones?

1. _____ 2. _____
3. _____ 4. _____

- How would you define the way your company interacts with other companies in your most relevant supply chain (receives directives, passive cooperation, peer to peer cooperation, active cooperation, dictates directives)?

_____

- What is the level of replaceability of your company within your most relevant supply chain, measured in terms of the degree to which your partner firms have potential partners, others than you, who could provide comparable business (very low, low, average, high, very high)?

_____

- Are the objectives of your company (e.g., reducing costs or delivery time) aligned with those of your most relevant supply chain (not at all, mainly not, partially, mainly yes, yes)?

_____

- With regard to strategic alignment, what has the trend (in terms of increase or decrease of alignment) been like for the past three years (very negative, negative, stable, positive, very positive)

_____

- With regard to risk management, to which degree is information shared through your most relevant supply chain (very low, low, average, high, very high)?

_____

- With regard to information sharing, what has the trend (in terms of increase or decrease of information sharing) been like for the past three years (very negative, negative, stable, positive, very positive)?

_____

- To which degree is your company able to keep its objectives aligned with those of your most relevant supply chains, by both adapting to variations in supply chain objectives or inducing the other companies

in the supply chain to adapt to the changes in your objectives (very low, low, average, high, very high)?

_____

- With regard to alignment capacity, what has the trend (in terms of increase or decrease of alignment capacity) been like for the past three years (very negative, negative, stable, positive, very positive)?

_____

- Which is, in your opinion, your firm's supply chain risk management capacity (very low, low, average, high, very high)?

_____

- With regard to supply chain risk management, what has the trend (in terms of increase or decrease of alignment) been like for the past three years (very negative, negative, stable, positive, very positive)?

_____

Note: Please answer the following questions focusing on the primary supply chain your company belongs to.

SECTION 2 – Company business

– How would you define/What is the standard production strategy of your company?

☐ Innovate To Order (ITO) ☐ Engineer To Order (ETO)
☐ Make To Order (MTO)
☐ Assembly To Order (ATO) ☐ Make To Stock (MTS)

– How would you define/What is the capability/ability of your company in terms of production strategy?

☐ Innovate To Oder (ITO) ☐ Engineer To Order (ETO)
☐ Make To Order (MTO)
☐ Assembly To Order (ATO) ☐ Make To Stock (MTS)

– How would you define/What is the production strategy of the supply chain your company belongs to?

☐ Innovate To Oder (ITO) ☐ Engineer To Order (ETO)
☐ Make To Order (MTO)
☐ Assembly To Order (ATO) ☐ Make To Stock (MTS)

- What is the overall level of implementation of IT systems in your company (very low, low, average, high, very high)?

  _____

- What is the product design capability of your company (ranging from no product design to advanced R&D) (very low, low, average, high, very high)?

  _____

- To which degree are quality management systems (e.g., Total Quality Management) implemented in your company (very low, low, average, high, very high)?

  _____

- How would you define the importance given to HR management in your company, in terms of formation programs, etc. (very low, low, average, high, very high)?

  _____

- Is your primary supply chain characterized as green (not at all, mainly not, partially, mainly yes, yes)? _____
- Given the current economic context, what is the current performance of your supply chain, when compared to the competing supply chains (very poor, poor, average, good, excellent)? _____
- Given the current economic context, what is the current company performance when compared to your competitors (very poor, poor, average, good, excellent)?

  _____

- With regard to performance, what has the trend (in terms of increase or decrease of performance) been like for the past three years (very negative, negative, stable, positive, very positive)?

  _____

- How much are you green when compared to your competitors (much

lower, lower, equal, higher, much higher)?

_____

- How would you define the level of environmental regulatory pressures your company has to face when compared to your competitors (much lower, lower, equal, higher, much higher)?

_____