The design of supply chains

A literature study and a preliminary model

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Abstract *Argues stability is a design objective for supply chain design alongside cost, lead time and responsiveness. Performs an extensive literature study on supply chain design, identifies methods, theories and objectives in the existing literature. Describes the concept external specificity and how it's used to design supply chains. Using the concept upstream, archetypes of risk minimal and maximal design are identified. Downstream the concept describes two viable scenarios, one minimizing the impact, the other minimizing the probability of (intended) departure of a supply chain partner. Finally, principles for supply chain design are described and managerial outlined.*

Introduction

Since the introduction of Supply Chain Management (SCM) (Oliver & Webber, 1982), the businesses internationally have reduced inventory, shortened lead times, outsourced non-core activities, and segmented the customer portfolios at the same time as product life cycles have become shorter, supply chains have become longer and the demands from the customers have increased significantly in terms of quality, agility and customization (Schary & Skjoett-Larsen, 2001). This has left the companies more vulnerable to disturbances in the product flow, competency flaws in product development and competition between networks, to name but a few risks. The leaner supply chain has definitely increased profitability, but has at the same time introduced a need to better manage the flow of products, the development of relationships and the procedures to design the company's network.

From the earliest contributions to the field, there has been an emphasis on stability and robustness. The aim is to balance resources and

> *"that an integrated systems strategy that reduces the level of business vulnerability is developed and implemented" (Oliver & Webber, 1982, p. 66).*

The fragility of the supply chain is duly noted in another early contribution:

> *"If one activity fails, the chain is disrupted, creating poor performance and destabilizing the workload in other areas, thereby jeopardizing the effectiveness of the supply chain." (Stevens, 1989, p. 3).*

More recently, Fine (1998) has emphasized the importance of supply chain design (SCD), here with the aim of distributing activities along the supply chain:

> *"The ultimate core competency of an organization is 'supply chain design', which I define as choosing what capabilities along the value chain to invest in and develop internally and which to allocate for development by suppliers." (p. 213).*

The disruption of the supply chain is most notably described as "the bullwhip effect" by Forrester (1961) and later by Lee, Padmanabhan and Whang (1997). These contributions focus on the demand amplification due to insufficient information sharing and too long supply chains. Other issues within SCD have been dealt with in the literature: mismatched strategies (Tamas, 2000), lock-in (Grabher, 1993), vulnerability (Svensson, 2002) and strategy versus product uncertainty (Lee, 2002), to name but a few.

Assuming stability is one of the central aims of SCM alongside cost and lead time minimization, there seems to be a lack of focus within the literature on the risk of loosing a supply chain partner. The objective of this paper is twofold: to perform an extensive literature study of the scientific contributions within SCD and to introduce a model for the design of stable supply chains.

As for other literature studies (e.g. Bechtel & Jayaram, 1997)Brown & Eisenhardt, 1995; Harland et al., 2001; Krishnan & Ulrich, 2001; Tan, 2001, the intended audience fall in two categories: the experienced researchers interested in the field looking for research opportunities, and the new researchers (e.g. doctoral students) entering the fields of SCM and/or SCD. Hopefully the model will inspire practitioners to take a closer look at their business environment and academics to challenge the assumptions and conclusions to further develop and improve the suggested model.

Research method

The literature study performed is based on a list of relevant journals identified as a compromise between other literature studies performed within the field (e.g. Croom, Romano, & Giannakis, 2000; Tan, 2001) and evaluations of the usefulness of journals (Gibson & Hanna, 2003; Jahre, 2003; Vokurka, 1996). All journals investigated are available in e-databases and fall in three categories, listed in Table 1 below.

Table 1: Relevant journals, e-databases and periods investigated.

Journal Name	Abbrev.	E-database	Period investigated
SCM/Logistics			
European Journal of Purchasing and Supply Management[1]	EJPSM	Science Direct	1994 [vol 1, no 1] – 2002 [vol 8, no 4]
International Journal of Logistics Management	IJLM	ABI/INFORM	1998 [vol 9, no 1] – 2002 [vol 13, no 1]
International Journal of Logistics: Research and Application[2]	IJL-RA	Business Source Premier	1999 [vol 2, no 1] – 2002 [vol 6, no 3]
International Journal of Physical Distribution & Logistics Mgmt[3]	IJPDLM	Emerald	1989 [vol 19, no 1] – 2003 [vol 33, no 6]
International Journal of Purchasing and Materials Management[4]	IJPMM	ABI/INFORM	1971 [vol 7, no 4] – 1998 [vol 34, no 4]

[1] The journal changed name to "Journal of Purchasing and Supply Management" in 2003.
[2] Last 12 months available as abstracts only.
[3] Vol 19 – vol 23 available as abstracts only.
[4] The journal changed name to "Journal of Supply Chain Management" in 1999.

Journal of Business Logistics	JBL	Business Source Premier	1978 [vol 1, no 1] – 2003 [vol 24, no 1]
Journal of Purchasing and Supply Management	JPSM	Science Direct	2003 [vol 9, no 1] – 2003 [vol 9, no 4]
Journal of Supply Chain Management	JSCM	ABI/INFORM	1999 [vol 35, no 1] – 2003 [vol 39, no 3]
Supply Chain Management: An International Journal	SCM-IJ	Emerald	1996 [vol 1, no 1] – 2003 [vol 8, no 3]
Supply Chain Management Review	SCMR	Business Source Premier	2000 [vol 4, no 1] – 2003 [vol 7, no 4]
Operations Management			
Interfaces	I	Business Source Premier	1971 [vol 1, no 1] – 2003 [vol 33, no 3]
Integrated Manufacturing Systems	IMS	Emerald	1990 [vol 1, no 1] – 2003 [vol 14, no 8]
International Journal of Production Economics	IJPE	Science Direct	1991 [vol 22, no 1] – 2003 [vol 86, no 1]
International Journal of Operations & Production Management	IJOPM	Business Source Premier	1980 [vol 1, no 1] – 2003 [vol 23, no 6]
Journal of Operations Management	JOM	Science Direct	1980 [vol 1, no 1] – 2003 [vol 21, no 4]
Production and Inventory Management	PIM	ABI/INFORM	1983 [vol 24, no 1] – 2002 [vol 43, no 4]
Production and Operations Management	POM	ABI/INFORM	1999 [vol 8, no 1] – 2003 [vol 12, no 2]
Production Planning & Control	PPC	Business Source Premier	1990 [vol 1, no 1] – 2003 [vol 14, no 7]
Management			
California Management Review	CMR	Business Source Premier	1958 [vol 1, no 1] – 2003 [vol 45, no 3]
Decision Science[5]	DS	ABI/INFORM	1988 [vol 19, no 1] – 2002 [vol 33, no 4]
European Management Journal[6]	EMJ	Science Direct	1988 [vol 6, no 2] – 2003 [vol 21, no 4]
Harvard Business Review	HBR	Business Source Premier	1922 [vol 1, no 1] – 2003 [vol 81, no 9]
Industrial Marketing Management	IMM	Science Direct	1971 [vol 1, no 1] – 2003 [vol 32, no 7]
Journal of Occupational Behaviour[7]	JOCB	JSTOR	1980 [vol 1, no 1] – 1987 [vol 8, no 4]
Journal of Organizational Behavior	JORB	JSTOR	1988 [vol 9, no 1] – 1997 [vol 17, no 7]
Scandinavian Journal of Management	SJM	Science Direct	1988 [vol 4, no 1] – 2003 [vol 19, no 3]
Sloan Management Review	SMR	Business Source Premier	1970 [vol 12, no 1] – 2000 [vol 42, no 1]

Since the aim is to perform an exhaustive literature study, the use of key word searching is rejected, as relying on the key word Supply Chain Design would imply the immediate

[5] Vol 3 – vol 18 available as abstracts only.
[6] Vol 6, no 2 is the first available issue in Science Direct.
[7] The journal changed name to "Journal of Organizational Behavior" in 1988.

institutionalization of the term upon introduction. Conversely, it is the perception of the researcher that SCD is evolving in parallel with other sub-themes within SCM. Relying on the key word search would thereby result in missing a number of contributions. Whether this assumption is correct or not will be tested by the "completeness check" performed across databases following the focused search.

Instead of using the key word search, the researcher might have chosen to search in the abstracts for the exact phrase "Supply Chain Design", but has chosen a method likely to result in a much broader collection of articles: searching in abstracts for articles with the combination of the words Supply, Chain and Design. The latter will include an article with the text "…the **design** of **supply chains**…", the former will not. On the other hand, the latter will include an article with the text "…the **supply** of **chain designs**…", the former will not. Using the databases, the difference between these two very different searches is quite subtle. The former would be "Supply Chain Design", whereas the latter does not use quotation marks: Supply Chain Design[8]. Choosing the latter approach means that the articles identified will have to be investigated for relevance, an effort deemed justifiable in this context.

The completeness check mentioned above will use all the e-databases represented in Table 1 above, the search performed is for the key word Supply Chain Design. The number of relevant hits and the journals in which they are published will determine the "completeness" of the list of relevant journals mentioned above and the search method itself.

Results

The search resulted in 83 hits, distributed over the categories of journals as follows: SCM/Logistics 44, Operations Management 26 and General Management 13. Of the 27 journals investigated seven had no identifiable contributions. Proof reading the articles for relevance revealed a wide variation of subjects and methods, most articles rejected for lack of relevance (for this study) fall into the following categories:

1. methodological frameworks (e.g. Larson & Gammelgaard, 2001; Zografos & Giannouli, 2001),
2. implications of various techniques/methods (e.g. Anumba, Siemieniuch, & Sinclair, 2000; Nynke Faber, de Koster, & van de Velde, 2002),
3. various (static) modelling frameworks (e.g. Giddings, Bailey, & Moore, 2001; Vidal & Goetschalkx, 2000), and
4. narrowly defined sub-disciplines/areas (e.g. reverse logistics: Guide Jr & Van Wassenhove, 2002; Walker, 2000).

Of the total 83 articles found, 55 were rejected due to lack of relevance. The remaining 28 articles fall into two categories:

1. articles on design of supply chains/networks (structure), and
2. articles on design of supply chain processes (content).

As the aim of this article is the identification, evaluation and selection of players in the supply chain, the focus is on the first category. The identified articles of the second category might be a starting point for other researchers interested in the design of processes within supply chain management.

[8] Effectively equivalent to "Supply" AND "Chain" AND "Design".

Thirteen of the identified 28 articles not rejected are dealing with the structure/membership issue in supply chain management, representing a mere 16 % of the total of 83 articles. All of the articles and their classifications are listed in Table 2 below.

Table 2: Articles identified and analyzed[9]

Abbrev.	Article	Relevance	
		Subject ?	Structure ?
SCM/Logistics			
EJPSM	None		
IJLM	**Anderson & Katz, 1998**	**Yes**	**Yes**
	Christopher & Towill, 2002	**Yes**	**Yes**
	Claycomb, Droge, & Germain, 1999	Yes	No
	van der Horst, van Dijk, & Beulens, 2001	Yes	No
	van Hoek & Weken, 1998	Yes	No
	Wilding, 1998	Yes	No
	Wouters, Sharman, & Wortmann, 1999	Yes	No
IJL-RA	Larson & Gammelgaard, 2001	No (1)	
	McGovern, Hicks, & Earl, 1999	Yes	No
	van der Horst & Beulens, 1999	**Yes**	**Yes**
	Zografos & Giannouli, 2001	No (1)	
IJPDLM	Anumba, Siemieniuch, & Sinclair, 2000	No (2)	
	Christiaanse & Kumar, 2000	**Yes**	**Yes**
	Elliman & Orange, 2000	No	
	Giddings, Bailey, & Moore, 2001	No (3)	
	Mason et al., 2002	No (2)	
	Nynke Faber, de Koster, & van de Velde, 2002	No (2)	
	Towill, Naim, & Wikner, 1992	No (3)	
IJPMM	Carter & Hendrick, 1997	No	
	Hines, 1996	No (2)	
	Walton, Handfield, & Melnyk, 1998	No (2)	
JBL	Schwarz & Weng, 2000	No (2)	
	van Hoek, Commandeur, & Vos, 1998	No (2)	
	Vidal & Goetschalkx, 2000	No (3)	
JPSM	Towill et al., 2003	No (3)	
JSCM	Carter & Ellram, 2003	No (1)	
	Hallenbeck Jr., Hautaluoma, & Bates, 1999	No	
	Vonderembse & Tracey, 1999	No (2)	
SCM-IJ	Brunnermeier & Martin, 2002	No (2)	
	Chandra & Kumar, 2000	**Yes**	**Yes**
	Hammel, Phelps, & Kuettner, 2002	**Yes**	**Yes**
	McIvor, 2000	**Yes**	**Yes**
	Towill, 1996	Yes	No
	Tracey & Tan, 2001	No (1)	
	Wilson & Clarke, 1998	No (2)	
SCMR	Arntzen & Shumway, 2002	Yes	No
	Boyson & Corsi, 2001	No (2)	
	Cargille & Bliss, 2001	No	
	Dershin, 2000	Yes	No
	Herman, 2002	Yes	No
	Kopczak, 2001	**Yes**	**Yes**
	Martha & Subbakrishna, 2002	Yes	No

[9] Numbers in brackets refer to the reason for rejection described earlier.

	Shankar, 2001	No (1)	
	Walker, 2000	No (4)	
Operations Management			
I	Lee, Billington, & Carter, 1993	No (3)	
	Sodhi, 2001	No (2)	
IJPE	Herer, Tzur, & Yücesan, 2002	No (3)	
	Korpela et al., 2002	**Yes**	**Yes**
	Olhager & Selldin, 2003	No (1)	
	Persson & Olhager, 2002	Yes	No
IJOPM	Barker, 1994	No (2)	
	Voordijk, 2000	No	
IMS	Macbeth & Ferguson, 1991	No (4)	
JOM	None		
PIM	**Vokurka, 1998**	**Yes**	**Yes**
POM	Anderson Jr, Fine, & Parker, 2000	Yes	No
	Boyler & Olson, 2002	No	
	Fine, 2000	**Yes**	**Yes**
	Fleischmann et al., 2001	No (4)	
	Parker & Anderson Jr, 2002	No (4)	
	Tatsiopoulos et al., 2001	No (2)	
PPC	Bhattacharya, Coleman, & Brace, 1995	Yes	No
	Korhonen, Huttunen, & Eloranta, 1998	No (2)	
	Lee & Sasser, 1995	No (2)	
	Olhager, 2002	No (3)	
	Onwubolu et al., 1999	No (2)	
	Sadeh et al., 2001	No (2)	
	Taylor & Whicker, 2002	No (3)	
	Towill, 1997	No	
	Towill & Del Vecchio, 1994	No (3)	
	Trienekens & Beulens, 2001	No (1)	
Management			
CMR	None		
DS	Bapna et al., 2002	No (3)	
	Curkovic, Vickery, & Droge, 2000	No (2)	
	Jayaram, 1998	No (3)	
	Mabert & Venkataramanan, 1998	No	
	Robinson Jr & Satterfield, 1998	**Yes**	**Yes**
	Swaminathan, Smith, & Sadeh, 1998	**Yes**	**Yes**
EMJ	None		
HBR	Guide Jr & Van Wassenhove, 2002	No (4)	
	Stock, Speh, & Shear, 2002	No (4)	
IMM	Lancioni, 2000	No	
	Reutterer & Kotzab, 2000	No (1)	
JOCB	None		
JORB	None		
SJM	None		
SMR	Kopczak & Johnson, 2003	No (1)	
	Lee & Billington, 1992	No (2)	
	Lee, Padmanabhan, & Whang, 1997	Yes	No

Performing the completeness check revealed nine hits from two of the five databases: ABI/INFORM contained six of the nine articles, the remaining three was found in Science Direct. Of the nine articles identified five had been identified in the previous search, leaving four articles to

be added to the population. Two of these come from journals investigated: IJOPM (Boardman & Clegg, 2001) and IJPE (Reiner & Trcka, 2003). The other two come from the two journals: *European Journal of Operational Research* (Goetschalkx, Vidal, & Dogan, 2002) and *Information Systems Frontiers* (Harrison, 2001).

Two of the four additions to the population were classified not relevant (reason 3, modeling frameworks), leaving the articles "Structured engagement in the extended enterprise" (Boardman & Clegg, 2001) and "Global Supply Chain Design" (Harrison, 2001). As the titles indicate, both articles are relevant and focused on the structural aspect of SCD.

From these results the author concludes that the search in the identified journals has been sufficiently complete, and that the choice of method is justified.

Table 3: Completeness check

E-database	**Article**	**Relevance**	
		Subject ?	**Focus ?**
ABI/INFORM [10]	*Anderson Jr, Fine, & Parker, 2000* [11]	-	-
	Boardman & Clegg, 2001	**Yes**	**Yes**
	Fine, 2000 [11]	-	-
	Harrison, 2001	**Yes**	**Yes**
	Swaminathan, Smith, & Sadeh, 1998 [11]	-	-
	van der Horst, van Dijk, & Beulens, 2001 [11]	-	-
Business Source Premier	None		
EMERALD	None		
JSTOR [10]	None		
Science Direct	Goetschalkx, Vidal, & Dogan, 2002	No (3)	
	Persson & Olhager, 2002 [11]	-	-
	Reiner & Trcka, 2003	No (3)	

The search for articles on the structural aspect of SCD thereby resulted in 15 hits. The next step is to perform an analysis according to the chosen classification framework.

Classification is always a compromise between the observable attributes of the data available and context or intended argument. Here the contributions are classified according to article type (case study/framework/discussion), orientation (internal, upstream, downstream and network), theories explicitly used and design objective. The context is obvious in the orientation classification as it references frameworks for SCM directly. The other three classifications are considered generic, as they might be applied to any literature study.

Almost all (12) of the identified articles present a framework of some sort, either a process model (e.g. Anderson & Katz, 1998), a descriptive model (e.g. Boardman & Clegg, 2001) or an analytical model (e.g. Korpela et al., 2002). Exceptions are the articles "The re-engineering of Hewlett-Packard's CD-RW supply chain" (Hammel, Phelps, & Kuettner, 2002), "Supplier partnership: A case study" (Vokurka, 1998) and "Global Supply Chain Design" (Harrison, 2001), the first two case studies, the last a discussion of principles and methods for global supply

[10] This database does not have key word search. Instead the search was performed with the search string "Supply Chain Design" in the abstracts.
[11] Article already identified.

chain design. Of the 12 articles presenting some sort of framework five are supporting the arguments by multiple case studies.

Classifying the articles according to orientation reveals that a majority (8) of the articles are focusing on the network level. One article (van der Horst & Beulens, 1999) has the internal orientation, thereby disqualifying itself from the SCM perspective. The remaining six articles have a dyadic perspective; two (Anderson & Katz, 1998; Vokurka, 1998) are oriented upstream, four are oriented downstream (Christopher & Towill, 2002; Kopczak, 2001; Korpela et al., 2002; Robinson Jr & Satterfield, 1998).

The explicit use of theories is quite scarce, as six of the articles make no reference to theory. Of the 15 articles, only two make explicit reference to theory: one (Christiaanse & Kumar, 2000) uses transaction cost economics, the other (McIvor, 2000) uses TCE and resource-based theory. Two other articles use modelling (Robinson Jr & Satterfield, 1998; Swaminathan, Smith, & Sadeh, 1998), one uses systems analysis (Chandra & Kumar, 2000), one uses mixed integer programming (Korpela et al., 2002), and one references the concept of TQM (Vokurka, 1998). Finally, two articles (Boardman & Clegg, 2001; Fine, 2000) make references to the concept of "clock-speed" introduced by Charles Fine (1998).

The final classification, design objective, displays more commonality than the other categories, as two meta-objectives can be identified: alignment and efficiency. Christopher & Towill (2002) aim to match the pipeline with the market, Fine (2000) advocates the alignment of supply chain structure with product and process, Kopczak (2001) advocates alignment with consumer preferences, and Vokurka (1998) aims at reducing the supplier base. Besides Anderson & Katz (1998), who advocate sustainable growth, and Harrison (2001) who does not have a design objective, the rest of the contributions aim to improve efficiency or performance.

Table 4: Relevant articles and their classifications

Article	Type	Orientation	Theories	Design objective
Anderson & Katz, 1998	Framework	Upstream	None	Sustainable Growth
Boardman & Clegg, 2001	Case studies Framework	Network	"Clockspeed"	Efficiency in the "Extended Enterprise"
Chandra & Kumar, 2000	Case studies Framework	Network	Systems analysis	Minimization of Waste
Christiaanse & Kumar, 2000	Framework	Network	TCE	Efficiency and responsiveness thru use of IT
Christopher & Towill, 2002	Case studies Framework	Downstream	None	Efficiency by matching pipeline with market
Fine, 2000	Framework	Network	"Clockspeed"	Optimization thru alignment with product and process
Hammel, Phelps, & Kuettner, 2002	Case study	Network	None	Minimize cycle time (order and cash)
Harrison, 2001	Discussion	Network	None	N/A

Kopczak, 2001	Case studies Framework	Downstream / E-tail	None	Match consumer preferences
Korpela et al., 2002	Framework	Downstream	AHP / MIP	Production capacity optimisation
McIvor, 2000	Framework	Network	TCE, RBT	Performance (outsourcing)
Robinson Jr & Satterfield, 1998	Framework	Downstream	Modeling	Profit maximization
Swaminathan, Smith, & Sadeh, 1998	Framework	Network	Modeling	Performance
van der Horst & Beulens, 1999	Case study Framework	Internal	None	Supply Chain Performance
Vokurka, 1998	Case study	Upstream	TQM	Supplier base reduction

It is now evident, that the available literature on SCD does not have stability as a design objective - no contributions mention stability and only two mention risk. In "Strategic Sourcing" (Anderson & Katz, 1998), business risk is one of the explaining variables – and is defined as the extent to which a purchase category can influence customers' perception of value. Korpela et al. (2002) use "risks related to a supplier-customer relationship" as an additional parameter for optimising production capacity allocation and supply chain design.

Obtaining Stability

Stability implies the absence of unwanted, unanticipated events. Planned change thereby does not qualify as lack of stability; the rule of thumb in forecasting: "the longer the horizon, the higher the uncertainty" applies to strategic management as well. As only the largest companies have full-time risk managers, risk management is an integral part of management in any area of any company.

The relevance and practice of risk management is very much dependent on the view on strategic decision making and path dependency. In case one believes there are critical decisions that will change the chances of survival of a company in the long run, risk management becomes an impossible task. The information needed in this context is infinite as is the resources to evaluate them. If, on the other hand, one believes that the future is uncertain and less deterministic, risk management becomes the continued effort to balance the opportunities and threats that continually emerge.

The time horizon for risk management is thereby of relevance. Short-term risk management is basically the usage of control mechanisms and procedures, whereas the long-term risk management is non-distinguishable from general management. In the long term, risk management is a completely embedded element in the strategic decision making, hypothesizing on future scenarios and aiding the evaluation of scenarios through expected probabilities, outcomes and counter-moves.

Table 5: Time horizon and risk management

Time Horizon	Management	Risk Management
Short-term	Operational	Control
Medium-term	Tactical	Design
Long-term	Strategic	Embedded

Designing the supply chain to align with (long-term) strategies consists of the design of context and content both. So, when implementing e.g. an outsourcing solution, focus must be on a multiplicity of issues concurrently. Processes need to be re-designed, documentation of processes and products will need to be updated, at the same time as the integration with the external partner is put in place. Content and context is modified at the same time to minimize implementation inconveniences. But it is rarely the goal of a company to change context and content at the same time, the one is normally the consequence of the other. Staying with the outsourcing example, it is the goal of the company to change the content (activities performed), the contextual (or structural) changes are a consequence of making the content modification. An example of a context change might be supplier base reduction. Reducing the supplier base might only be a viable strategy if e.g. inventory information is made available, or if improved quality assurance procedures are put in place.

Focusing on the structural aspects of SCD thereby does not mean the author regards the content to be of secondary importance. The stance taken in this article is simply that the consequences of a structural change might be mitigated or supported by changes in content.

Combining this perspective with the aspiration to increase the robustness of the business environment, as the quote from the introduction claimed to be the intention of SCM in the first place, lead the author to define the unwanted event in question as the departure, intended or un-intended, of a partner in the chain. The risk relevant to manage in order to improve the robustness of the supply chain is the risk of loosing a critical supply chain partner.

Definition of risk

The simplest definitions of risk contain two variables only: consequence and probability. Originating from The Law of Averages and Regression to the Mean (Bernstein, 2001), it was one of the building blocks of the work of Markowitz (1952) and Black & Scholes (1973), who introduced portfolio theory and options theory, respectively. One problem with the model, though: it is quite static, as it does not take corrective measures into consideration. A more sophisticated, dynamic definition is:

> *The quantum of total risk can more simply be described as: the scale of the potential harm* adjusted by *the likelihood of that harm occurring* net of *the ability of an effective response to be put into place* adjusted by *the likelihood of that response mechanism being deployed effectively." (Daniell, 2002, pp.10-11)*

The problem with this definition is that it, for this specific type of risk, places unrealistic demands on the user. The complexity in process and context of the business environment today and the pace of development makes it impossible to obtain the "correct" values for even the simple model. Obtaining a measure for the consequence of the departure of a supply chain partner might be viable, but getting a measure for the probability is unrealistic. Performing internal (or local) analysis of consequence is possible, albeit complicated and time-consuming, analysis of external (or remote) factors is unrealistic due to the complexity of the environment. Therefore, adding more variables describing the risk management competencies of the company is simply not the solution.

But this does not mean that the companies should be disinterested in managing this risk, on the contrary. Current trends such as outsourcing are increasing the risks, apparently with nothing to match the increased risk potential. Only the very large multinational corporations are able to guarantee the survivals of their partners, the rest of the world is placing their fate in the hands of the gods, and their own ability to manage the unavoidable risks.

The overarching principle in obtaining stability when integrating with other entities in a supply chain is to keep the correct level of external specificity up- and down-stream. External specificity is a characteristic of both inputs, potential inputs (competencies) and interfaces. External specificity is increasing when the resource (physical or otherwise) is unique and decreasing when it is common. Relying on a sole supplier has very high specificity, whereas using a commodity supplier is low specificity. Designing distinct IT-systems for communicating with a specific supplier is increasing the specificity, whereas placing a tender on an E-Market is decreasing it. In short: external specificity is high when resource, competence, raw material, component or interface is unique, otherwise it's low.

External Specificity - Upstream

Using the concept of external specificity on the portfolio of suppliers makes it possible to distinguish between the unique and the trivial suppliers. Furthermore it enables the analysis of actual versus needed integration, this issue will be dealt with in a later contribution.

Two archetypes can be constructed to describe the supply side. The risk minimal archetype has almost all activities in-house, thereby minimizing the risk of disruption, and using only commodity suppliers of very basic input types. The integration is kept at a minimum, basically treating the suppliers as anonymous players in the market. The figure below illustrate the archetype.

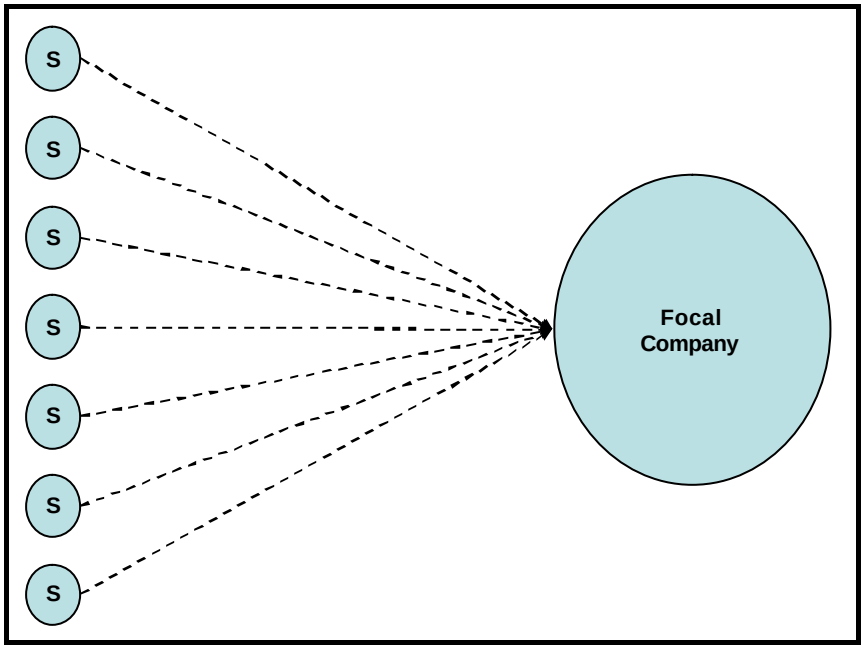

Figure 1: The Risk Minimal Archetype

The risk maximal archetype most closely resembles an extreme form of "The Virtual Enterprise" (Pires et al., 2001). In the extreme form, the focal company does not perform any (or only very few) activities, thereby relying heavily on systems suppliers. Knowledge of the supply chain is

non-existent as the systems suppliers are working according to specification and has free hands to choose their own sub-suppliers.

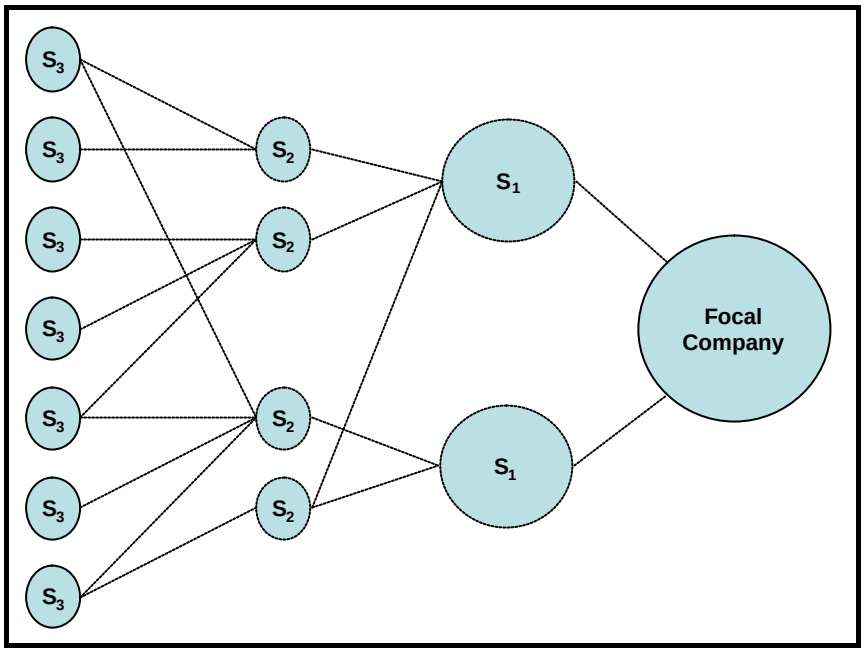

Figure 2: The Risk Maximal Archetype

Both archetypes are unrealistic, but useful to illustrate the trade-off. The risk minimal archetype is unrealistic for several reasons, one being the complexity of the products in the marketplace today. In case all activities should be performed in-house, the portfolio of competencies and technologies each company would need to have updated knowledge of and operational experience with is enormous. It would also contradict all existing evidence on the advantages of specialization. The risk maximal archetype is unrealistic, as it would require the focal company to have long-term dominance over the systems suppliers. In the long run, the focal company *ceteris paribus* will lose its competitive advantage, be it a brand name, proprietary access to the market or patent rights of various types.

The challenge on the upstream side of the chain is thereby to design the optimal portfolio of suppliers and decide whether an activity is to be performed in- or out-house. When possible (and economically viable) all activities specific to the company and either not readily accessible at alternative suppliers or easily replicated should be in-sourced as to minimize external specificity. For all input (materials, components, sub-assemblies, competencies etc.) alternative suppliers should be identified and monitored on a continual basis.

External Specificity - Downstream

Intuitively, the most risk minimal downstream situation is to have a large, homogeneous customer portfolio, with customers demanding the same products and preferably not influenced by the same economic drivers. In that case there can be no downstream external specificity. Unfortunately, in most cases the customer portfolio is heterogeneous, containing a few dominating customers demanding special attention and accommodation. The normal "cure" for this situation is to implement mutually committing initiatives such as co-ownership of the production capacity, shared

product development and the like. This might take care of the intended departure – but is no cure for the unintended departure from the chain. The alternative approach, to accept downstream external specificity for all customers might result in the lock-in of the customer portfolio, definitively also a viable scenario. In fact what has just been described from a risk or stability perspective is Fisher's (1997) taxonomy of supply chain types: functional versus responsive. The first strategy is to reject all downstream external specificity; the other is to implement responsiveness as the mechanism to accommodate all customers' demands.

It appears that the guiding principle is to avoid dependency of few customers, and to either (per supply chain?) accept or reject downstream external specificity. Translating these two alternatives into "risk language", the former minimizes the probability of the intended departure of a supply chain partner, the latter minimizes the consequence.

Principles for Supply Chain Design

Improving on the existing frameworks for SCD means first and foremost, that analysis must be made on the network level. Optimization the supplier base against a portfolio model might be profitable, but does not match the demand with the supply. The risk is that the supplier base is optimized against an outdated image of the market – thereby creating a sub-optimal situation. Since the optimization often includes making long-term commitments, making this mistake might prove disastrous.

Secondly, improving on the design of the supply chain mean improving the stability, cost and responsiveness, concurrently and as appropriated by the overall strategy. Stability thereby does not mean no change, but no un-anticipated change! Responsiveness should not be implemented without good justification, and the tradeoffs between stability, cost and responsiveness should match the strategy of the individual company and its supply chains.

Principles for SCD aiming at obtaining the above mentioned are presented below.

Identify Supply Chains. The first principle is to identify supply chains. As suggested by Fisher (1997) there is a relationship between the characteristics of the individual product, and the optimal supply chain type. Analyzing the product portfolio will therefore often reveal the need for both functional and responsive supply chains. Other reasons for creating separate supply chain might include the situation where two competing customers are sharing the same supplier. Another might be the situation where a customer is highly visible in the public eye due to lack of compliance to environment regulations. In that case, the focal company might want to create a distance to the customer through e.g. longer supply lines (more tiers), separate branding or perhaps isolating the business for quick resolution.

The multiplicity of distribution channels place a variety of demands on the focal company. Choosing which demands to meet is a critical decision as it may result in long-term commitments. Choosing the accommodate demands in the wholesale distribution channel for e.g. large-size orders might conflict with the demands in the retail channel for e.g. more flexible packaging solutions, small order sizes and mixed-SKU pallets. Ultimately, identifying supply chains might result in the dropping of distribution channels and/or products, and is therefore a prerequisite for identifying supply chain partners.

Identify Supply Chain Partners. The second principle is to identify the optimal supply chain partners for each supply chain, creating the desired level of redundancy. A prerequisite to doing this is a thorough analysis of the internal supply chain identified as a consequence of principle one. The possible introduction of more internal supply chains might result in fewer compromises in supply chain partner selection. The downside of splitting the purchase is the loss of economies of scale and loyalty, only further analysis will reveal viable solution(s).

As suggested by Ritter (2000) the relationships between companies might have an impact of the feasibility of cooperation in networks. Taking all other identified supply chain partners into account when evaluating each partner is therefore a critical step. Prior history or current competition between supply chain partners might severely damage the efficiency of the supply chains. Being aware of the relationships between potential partners might result in a win-win-win, where both external partners and the focal company gain from the cooperation.

The process of identification and analysis of supply chain partners might result in the re-definition of supply chains. If so, re-doing the first principle is critical and should not be considered a failure. The second principle challenges the company's perception of its supply chains, and hopefully adds to the understanding of both context and content.

Distribute Activities Across The Chain. The third principle is to distribute the activities according to the desired degree of up- and downstream external specificity. As dependencies and cost structures both will vary from supplier to supplier, the results of principle two and three influence each other and the exercise will have to be repeated until an acceptable solution is found.

Measuring the viability of each solution must take cost, lead time, responsiveness and stability into consideration as a whole and match it against the goals for the each supply chain.

Continued Monitoring and Evaluation. Perhaps the most importantly principle, the continued monitoring of the supply chains and the network external to the supply chains is a critical activity. As described in Grabher (1993), the consequence of too close ties and a feeling of self-efficacy might result in the downturn of an entire industry or supply chain. Keeping an eye on the environment and making continued adjustments is key to staying competitive. The principles are illustrated in the figure below.

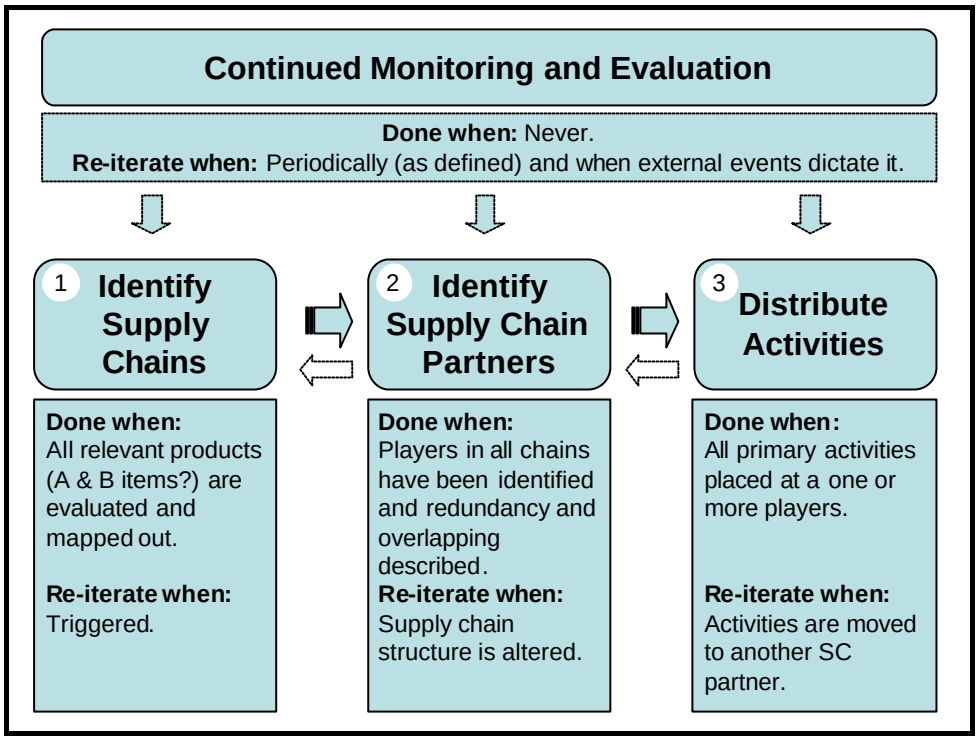

Figure 3: Principles for SCD.

Managerial consequences and further research

Implementing the proposed principles hopefully will help the companies to design a more stable business environment at minimal cost. Accepting the company might participate in a series of supply chains is the first step towards better understanding the dynamics effecting the company when integrating with other entities. The managerial challenge in managing multiple supply chains might lead to the implementation of a true process-oriented organization. The continued monitoring and evaluation of the business environment should not be a new challenge for management, as boundary spanning is critical for competency development and internal and external investments. Using risk management proactively when evaluating alternatives on a continual basis on the other hand, seems to be a very rare occurrence. Accepting the risk perspective might thereby alter the procedures and practices for organizational development and external reporting amongst others.

Besides an empirical test of the model, it requires further research, especially in terms of creating metrics to measure/compare the combination of cost, lead time, responsiveness and external specificity. Perhaps the Total Cost of Ownership concept is a viable tool, combining the objective cost element with the subjective risk element for each combination of product/product group and supplier (or customer).

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