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Supply chain resilience in the global financial crisis: an empirical study

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Abstract

Purpose – The objective of this paper is to conceptualise **supply chain resilience (SCRES)** and to identify and explore empirically its relationship with the related concepts of **supply chain vulnerability (SCV)** and **supply chain risk management (SCRM)**.

Design/methodology/approach – From a review of the literature the conceptual domain of SCRES is defined and the proposed relationships with SCRM and SCV are derived. Data from a longitudinal case study with three supply chains are presented to explore the relationship between the concepts in the context of the global financial crisis.

Findings – The empirical data provide support for a positive impact of supply chain risk (SCR) effect and knowledge management on SCRES and from SCRES on SCV. SCR effect and knowledge management seem to enhance the SCRES by improving the flexibility, visibility, velocity and collaboration capabilities of the supply chain. Thereby, they decrease the SCV in a disruptive risk event. The positive effects manifest themselves in upstream supplier networks of supply chains as well as in distribution channels to the customers.

Research limitations/implications – The recession caused by the financial crisis has illustrated the importance of SCRES in today's interdependent global economy vividly. However, the concept is still in its infancy and has not received the same attention as its counterparts SCRM and SCV. The study confirms the benefit of resilient supply chains and outlines future research needs.

Practical implications – The paper identifies which supply chain capabilities can support the containment of disruptions and how these capabilities can be supported by effective SCRM.

Originality/value – To date, there has been no empirical study which has investigated supply chain resilience in a disruptive global event.

Keywords Supply chain resilience, Supply chain vulnerability, Supply chain risk management, Supply chain disruptions, Financial risk, World economy

Paper type Research paper

Introduction

Over the last ten years, supply chain vulnerability (SCV) and its managerial counterpart supply chain risk management (SCRM) have received considerable attention by practitioners as well as academics (see for reviews Tang, 2006; Rao and Goldsby, 2009). The impact of one entity in the supply chain failing, e.g. financially can lead to a number of entities closing down and in some instances the whole supply chain shuts down. The risk implications of the entwined global marketplace that characterise today's supply chains have also been evidenced vividly in the recent global financial crisis. Moreover, incidents like the seemingly unlikely volcano eruption in Iceland make companies aware of how little control they have over many of the risks they are confronted with. Still, some companies appear to be able to weather the occurrence of hazardous events more effectively than others.

They can sustain by coming back to normality or to a new state from which they can operate.

The apparent ability of some supply chains to recover from inevitable risk events more effectively than others has more recently triggered a debate about supply chain resilience (SCRES). Whereas SCRM focuses on the identification and management of risks for the supply chain in order to reduce its vulnerability (Jüttner *et al.* 2003), SCRES aims at developing the adaptive capability to prepare for unexpected events and to respond to disruptions and recover from them (Ponomarov and Holcomb, 2009). SCRES is based on the underlying assumption that not all risk events can be prevented. SCRM is well explored and a wide range of empirical studies can be cited which investigate the SCRM approach of single companies (e.g. Norrman and Jansson, 2004) or industries (Johnson, 2001; Sinha *et al.*, 2004; Blos *et al.*, 2009), explore the current state of action across industries (e.g. Jüttner, 2005), identify risk drivers (Wagner and Bode, 2006) or confirm the risk reduction effect of strategies such as early supplier involvement (Zsidisin and Smith, 2005), supplier development (Matook *et al.*, 2009) or

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new designs (Khan *et al.*, 2008). However, for SCRES, only conceptual works can be cited to date which either review the literature and provide definitions (Rice and Caniato, 2003; Ponomarov and Holcomb, 2009; Briano *et al.*, 2009) or normative guidelines based on single best practice examples (Sheffi, 2005a). Furthermore, although SCRM has been proposed as an antecedent to SCRES (Christopher and Peck, 2004), there is no study, which investigates empirically how these concepts are related.

This paper aims at closing the gap identified in the current body of knowledge on SCRES, SCRM and SCV. The following three objectives are pursued:

- 1 to define the conceptual domain of SCRES.
- 2 to conceptualise the linkage between SCRES, SCRM and SCV.
- 3 to explore the proposed relationships empirically between:
 - supply chain risk effect as well as knowledge management;
 - the four formative supply chain capabilities “flexibility”, “velocity”, “visibility” and “collaboration”; and
 - the vulnerability of supply chains in the context of a major manifest supply chain risk event: the global financial crisis.

The paper is structured into three parts. In the first part, the literature is reviewed in order to define SCRES and to conceptualise its proposed relationships with SCRM and SCV. Next, the case study of three companies in their supply chains is analysed to explore the proposed relationships between the concepts in practice. Finally, in the third part, we discuss the findings and identify the implications of the research.

Literature review

Supply chain resilience

Supply chain resilience addresses the supply chain's ability to cope with the consequences of unavoidable risk events in order to return to its original operations or move to a new, more desirable state after being disturbed (Christopher and Peck, 2004; Peck, 2005). Although the concept is new and theoretical justifications are still in their infancy, a definition grounded in multiple disciplines has recently been proposed by Ponomarov and Holcomb (2009). They define supply chain resilience as “the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function” (Ponomarov and Holcomb, 2009, p. 131). SCRES focuses on the system's adaptive capability to deal with temporary disruptive events (Smith, 2004; Briano *et al.*, 2009). These disruptions imply a certain level of turbulence (Hamel and Välikangas, 2003) and uncertainty in the supply chain (Van der Vorst and Beulens, 2002), which together cause threats to the current operations (Sheffi, 2001). Depending on the magnitude of these threatening events, the terms disruption (Sheffi and Rice, 2005), crisis or even disaster are used (Natarajathinam *et al.*, 2009; Richey, 2009). The adaptive resilience capability has been structured along the three distinct disruption phases into the supply chain “readiness”, “responsiveness” and “recovery” (Sheffi and Rice, 2005). Furthermore, all definitions share the view that resilience means to respond and recover at the same or better state of

operations and thus includes system renewal (e.g. Peck, 2005; Briano *et al.* 2009). Whereas no conceptual differences between the definitions of the supply chain's adaptive resilience capability at the system level are apparent in the literature, the perspectives on the formative resilience elements are less consistent. The formative elements describe how the supply chain event readiness, response and recovery can be secured and is therefore relevant from a supply chain management perspective. Whereas some authors have defined the formative elements as “antecedents” of supply chain resilience (e.g. Ponomarov and Holcomb, 2009), others see them as constituting resilience elements (e.g. Christopher and Peck, 2004; Peck, 2005). Furthermore, some authors capture these formative elements at a detailed resource level and include, for example, safety staff (Sheffi, 2005a, b), while others focus on system-level re-engineering of the supply chain in order to ensure resilience (Christopher and Peck, 2004). In line with Ponomarov and Holcomb (2009), we suggest capturing these formative resilience elements at a capability level. Formative resilience capabilities are based on integrating and coordinating resources which often span functional areas and thus may become manifest in the supply chain processes. In the literature, a range of overlapping terminologies for these formative resilience capabilities is suggested (see Ponomarov and Holcomb, 2009 and Briano *et al.* 2009 for overviews). The four capabilities of flexibility, velocity, visibility and collaboration are most frequently mentioned and capture the conceptual essence of all suggestions. To add clarity to these four formative supply chain resilience capabilities, good starting points are dictionary defined definitions.

Flexibility is defined as “being able to bend easily without breaking” and, as such, has been defined as an inherent part of resilience (Peck, 2005). Flexibility ensures that changes caused by the risk event can be absorbed by the supply chain through effective responses (Skipper and Hanna, 2009). It is hence the ability to encounter, resolve and, when appropriate, exploit unexpected emergencies. Furthermore, it has been suggested that flexibility can amount to an organic capability, which also supports sensing disruptions and, as such, relates to the event readiness dimension of supply chain resilience (Sheffi and Rice, 2005). There is a consensus that flexibility needs to be designed into the supply chain and is reflected in its structure, its interorganisational processes as well as its strategies (e.g. Tang and Tomlin, 2008). Some authors propose “redundancy” as a separate formative resilience capability (e.g. Sheffi and Rice, 2005). However, in line with Rice and Caniato (2003), we propose that redundancy as “duplications of capacity so that operations can continue following failure” is rather one route to flexibility. Furthermore, other authors include “velocity” and speed into their flexibility definition and emphasise that flexibility means doing things fast (e.g. Christopher, 2005; Li *et al.*, 2006). However, we argue that both are distinct, yet mutually reinforcing capabilities.

Velocity means “speed of motion, action, or operation, rapidity and swiftness” and is defined as distance over time (Christopher and Peck, 2004). Velocity in a risk event determines the loss that happens per unit of time. Compared to flexibility, velocity places a stronger emphasis on the efficiency rather than effectiveness of the supply chain's response and recovery throughout and after a disruption (Smith, 2004). In other words, whereas flexibility refers to reconfiguration as the number of possible states a supply chain

can take and to robustness as the number of changes it is able to cope with, velocity focuses on the pace of flexible adaptations (Stevenson and Spring, 2007). Lead-time is therefore seen as a key indicator of supply chain velocity (Cranfield School of Management, 2003). From a global supply chain risk perspective, Manuj and Mentzer (2008a) differentiate three forms of velocity: the rate at which a risk event happens, the rate at which losses happen and how quickly the risk event is discovered. In a resilience context, a fourth form needs to be added, i.e. the speed with which a supply chain can recover from a risk event. Velocity thus supports the adaptive capacity in all three phases of the risk event: before, throughout and after the supply chain disruption.

Visibility refers to the capability of “being perceived by the eye or mind”. Francis (2008) provides one of the most comprehensive definitions of supply chain visibility and describes it as “the identity, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times of these events” (Francis, 2008, p. 182). Supply chain visibility addresses information about entities and events regarding end-to-end orders, inventory, transportation and distribution as well as any events in the environment (Wei and Wang, 2010; Smith, 2004; Sheffi, 2001). Visibility ensures confidence into the supply chain and prevents over-reactions, unnecessary interventions and ineffective decisions in a risk event situation (Christopher and Lee, 2004). As such, visibility is related to effective disruption response and recovery. Furthermore, the ability to see from one end of the pipeline to the other is an important element of event readiness because the right signals are picked up in a timely manner (Van der Vorst and Beulens, 2002). Visibility, velocity and flexibility together are sometimes captured under “agility” (Li *et al.*, 2009; Christopher and Peck, 2004; Chopra and Sodhi, 2004; Faisal *et al.*, 2006; Tang and Tomlin, 2008). However, in order to have a clear view on all dimensions of resilience we decide to target all three formative capabilities separately.

Collaboration means “to work with another or others on a joint project”. Since supply chain resilience is a network-wide, interorganisational concept, its formative capabilities have to adopt the attitudinal predisposition of the parties to align forces in the case of a risk event. Collaboration is related to visibility in the sense that it includes the parties’ willingness to share even sensitive risk and risk event-related information (Faisal *et al.*, 2006). As such, collaboration contributes to reduced uncertainty and event readiness (Cranfield School of Management, 2003). Furthermore, collaboration has been suggested as the “glue that holds supply chain organisations in a crisis together” (Richey, 2009, p. 623). It prevents opportunistic behaviour on behalf of individual parties which would adversely effect the whole system’s response capability. For example, decision synchronisation and incentive alignment as two of the architectural elements of supply chain collaboration (Simatupang and Sridharan, 2008) are essential for effective system-level disruption responses. Finally, Sheffi (2001) stresses that collaboration is equally important after a disruption was overcome in order to share experiences among the parties. Such post disruption collaboration is likely to have an effect on the system’s ability to deal with future disruptions along all three phases: before, throughout and after the event.

Overall, the four formative resilience capabilities echo rather than contradict widely accepted principles of good supply chain management. However, the literature suggests that disruptions are a strong moderator for the positive effect of these formative capabilities on smooth supply chain operations.

The relationship between SCRES, SCV and SCRM

Supply chain resilience and supply chain vulnerability

SCV is the susceptibility of the supply chain to the likelihood and consequences of disruptions (Blos *et al.*, 2009; Svensson, 2000, 2002; Christopher and Peck, 2004). It therefore captures the risk exposure of the supply chain and is often conceptualised together with supply chain risks (e.g. Wagner and Bode, 2006). As Peck (2006, p. 132) states: something that is “at risk, is vulnerable”. By addressing the vulnerability of the supply chain, the supply chain risks are addressed.

Supply chain risks are anything that may disrupt or impede the information, material or product flows from original suppliers to the delivery of the final product to the ultimate end-user (Peck, 2006). Stated simply, supply chain risks refer to the possibility and effect of mismatch between supply and demand (Jüttner *et al.*, 2003). Based on the generic risk concept, supply chain risks also combine the two risk dimensions: the likelihood/probability of a loss with the impact/effect of that loss for the company or supply chain (Manuj and Mentzer, 2008b). Supply chain risks may or may not become manifest, i.e. a supply chain with severe vulnerability may in fact never experience a disruption. A supply chain disruption is an unintended, untoward and exceptional situation that leads to the occurrence of risk (Wagner and Bode, 2006). Since supply chain risks are defined as something that exists, whether it is managed or not, a supply chain will always display a certain degree of vulnerability (Peck, 2006). Furthermore, since some contemporary supply chain management practices, such as, global sourcing and single sourcing increase the supply chain risks (e.g. Jüttner, 2005; Wagner and Bode, 2006), a certain degree of vulnerability may deliberately be taken into account.

To summarise, SCV as the exposure of the supply chain to risks is a characteristic of any supply chain system. SCV is a latent condition which only becomes manifest if a disruptive event occurs. However, the higher the SCV, the more likely a disruptive event and/or the more severe its consequences. As a latent condition, SCV can be analysed by measuring the exposure of the supply chain to environmental, supply network and organizational risks (Briano *et al.*, 2009). As a manifest condition, the impact of a supply chain disruption indicates the degree of vulnerability. Since lowering the impact of a supply chain disruption is also the key target of SCRES, it can be assumed that both concepts are related. More specifically, if SCRES decreases the negative consequences of supply chain risk events by ensuring a fast return to its original or improved operation, it should, at the same time, decrease the SCV in the case of a manifest risk event.

Supply chain resilience and supply chain risk management

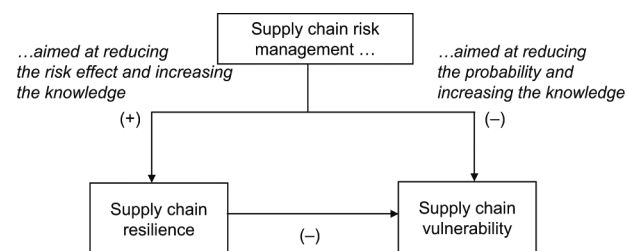
The most commonly accepted definition in the fast-growing body of literature on SCRM was proposed by Jüttner *et al.* (2003). They define SCRM as “the identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain risk members, to reduce supply chain vulnerability” (Jüttner *et al.*,

2003, p. 201). One main objective of SCRM is thus to reduce the SCV. However, other authors also emphasise that SCRM aims at increasing the resilience of the supply chain (e.g. Sheffi, 2005a, b; Rao and Goldsby, 2009). From this perspective, the emphasis is on managing and mitigating risks and, thereby, fostering the resilience of the supply chain. Although both outcome perspectives appear reasonable, they are not identical and have not yet been reconciled. For example, a supply chain risk measure does not necessarily impair the vulnerability of the supply chain and, at the same time, increase its resilience. Likewise, a supply chain with high vulnerability could either have high or low resilience.

We suggest that the risk dimension which is primarily addressed by the SCRM actions can help to clarify the relationship with both concepts, SCV and SCRES. In line with Tang and Tomlin (2008), Ellegaard (2008) and Manuj and Mentzer (2008a, b), we distinguish between three types of risk management actions: firstly, those addressing primarily the probability of supply chain risks (e.g. avoidance), secondly, risk actions focusing on the risk effects (e.g. risk sharing or continuity plans) and, thirdly, any actions which increase the knowledge about supply chain risks (e.g. accessing online portals or company visits to learn about external supply chain partners). If a SCRM initiative only lowers the probability, the SCV as the supply chain's latent exposure to supply chain risks is reduced but it will not have an effect on the SCRES. In this sense, a supply chain risk strategy which avoids certain geographical risk areas has lowered the likelihood of a disruption caused, e.g. by political instability in the region. It has, however, not increased its capability to response to and recover from a disruption if it still occurred. However, if a supply chain risk initiative successfully addresses the risk effects, the SCRES increases. For example, joint business continuity plans developed together with suppliers are likely to have a positive impact on the supply chain's capacity to respond to and recover from a disruption through collaboration. In a similar vein, a globally dispersed portfolio of suppliers is likely to positively effect the SCRES in the case of a risk event. The supply chain can fall back onto suppliers from other regions if only one region is effected by the risk event, and, thereby, ensure a flexible response to the event. Finally, a risk approach, which aims at increasing the knowledge about supply chain risks should also have a positive impact on SCRES. Supply chain risk knowledge can improve the event readiness because it increases the visibility and shortens the time for detection of the events (see Manuj and Mentzer, 2008b). Furthermore, it has also been suggested that risk knowledge management can decrease the SCV because knowledge is an important prerequisite to take counteractive measures prior to a risk event. This, in turn, decreases the likelihood of a risk event (Ellegaard, 2008). To summarise, it can be assumed that SCRM is related with both, SCRES and SCV. Depending on the primary target of the specific risk strategy or action, either the SCRES, the SCV or the SCRES and SCV should be positively effected by SCRM.

Figure 1 summarises the literature review by providing an illustration of the proposed relationships between the three concepts.

Figure 1 The relationship between SCRES, SCRM and SCV



The case study

In order to empirically explore the relationship between SCRES, SCRM and SCV, an explanatory multiple case study was conducted (Seuring, 2008). In line with the focus of this paper, the case study concentrates on gaining further knowledge on SCRES as the main concept and its relationship with SCRM and SCV. The two research objectives for the empirical study are therefore:

- 1 to understand whether and how supply chain risk effect and risk knowledge management influence the resilience of the supply chain; and
- 2 to understand whether and how SCRES effects the vulnerability of the supply chain in a situation with a manifest risk event.

We excluded the relationship between SCRM and SCV and, furthermore, limited our analysis of SCRES to the four formative capabilities. In other words, no differentiated analysis of the adaptive SCRES capability in the three distinct phases prior to an event (event readiness), throughout the event (response) and after the event (recovery) was included. Figure 2 illustrates the concepts upon which we focused in the empirical study.

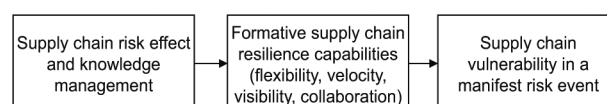
Case methodology and case companies

A case study approach is the most appropriate for exploring the research objectives for three reasons:

- 1 the nature of the objectives which involve “how” and “why” reasoning in the exploration;
- 2 the fact that the investigator has little control over events; and
- 3 the focus on a contemporary phenomenon within a real-life context (Yin, 2003).

A comparative, explanatory study of three case companies with a longitudinal research design was applied, which adheres to the guidelines for case research proposed by Yin (2003), Seuring (2008) and Ellram (1996). In line with most qualitative research, the selection of the three case companies followed a non-probability sampling approach based on theoretical and convenience sampling (Strauss and Corbin, 1998; Bryman and Bell, 2007). First, and in line with theoretical sampling, the choice of the case companies and data sources was controlled by the research concepts of

Figure 2 Concepts focused in the empirical study



SCRM, SCRES and SCV. Initially, the study aimed at investigating the SCRM approaches of the companies. Here, a convenience sampling approach was applied, based on company access and a proven interest of the companies in the topic of SCRM. When the financial crisis became manifest, the companies were contacted again. This time, data gathering was driven by the two additional concepts of SCV and SCRES as well as their relationship with SCRM. Such an ongoing data gathering process is typical for a theoretical sampling approach. All three companies agreed to provide renewed access in the phase following the financial crisis.

The companies represent three global supply chains from different industries, namely a cabling supplier (Cable Co[1]), a global supplier of specialty chemical products (Chemical Co) and a wood/timber wholesaler (Timber Co). Cable Co is a 3rd generation family-owned cabling supplier with 650 employees and a 370 Million Euro turnover. A total 78 per cent of the revenue is export-based. Chemical Co supplies processing materials for sealing, bonding, damping, reinforcing and protecting load-bearing structures in construction and other industries and generates 1.8 billion Euro turnover with 8,500 employees worldwide. Timber Co is a leading national timber wholesaler with 350 employees and an annual revenue of 120 million Euro. They only serve the national market but deal with approximately 500 global suppliers. Despite the differences in terms of industries and company size, all three companies share some fundamental commonalities regarding their overarching business models and supply chain strategies. They:

- have concentrated on core competencies, outsource non-competence related activities and are therefore dependent on their suppliers;
- serve business customers and not end consumers (business-to-business markets);
- work with suppliers from low cost countries;
- follow a high quality differentiating strategy with lead time and availability as order-winning factors; and
- operate a global supply chain.

Data collection

As mentioned above, data collection was conducted in the context of the recession caused by the financial crisis. In the literature, recessions are qualified as normal, economic accidents or crisis (Mitroff and Aulaslan, 2003). From the perspective of our study, the financial crisis can be seen as a major demand risk event, which affected all three case companies. It started with a sudden and unexpected trough in demand and was followed by a period of high demand fluctuations in time and across regions as well as an extremely high demand uncertainty. The data collection occurred prior to the recession in 2007 as well as at the end of 2009, just after the low point of the recession. In the first phase prior to the recession, the data collection aimed at investigating the risk management actions employed by the three companies along their downstream and upstream supply chain processes. In the second phase in 2009, the interview and secondary data explored the performance of the supply chains throughout the recession, i.e. the effects for the supply chain operations as well as the factors, which helped to absorb its effects. Table I summarises the data sources used in the three case studies.

As shown in Table I, both phases included extensive data-gathering efforts. Overall, 28 semi-structured interviews were conducted, most of them were tape-recorded and transcribed, six company-internal workshops were run and extensive notes (e.g. in the form of flip-charts) taken. Furthermore, around 200 pages of company internal documents (such as internal strategy or process documents, supplier evaluation tools and supplier questionnaires or business continuity plans) were screened. The data represents multiple perspectives within the companies because managers from different functions along the supply chain and from different hierarchical levels are included. Supplier or customer representatives have not been involved in the interviews but secondary data from suppliers as well as customers were included (e.g. supplier responses to a vulnerability survey).

Data analysis

Consistent with the research objectives, the data analysis was carried out in two steps in order to, firstly, match the raw data with the main concepts of interest and, secondly, to identify the patterns and relationships between the main concepts. In a first step, the data were analysed using content analysis following the procedures suggested by Krippendorff (1980); Weber (1990) and Kolbe and Burnett (1991). The qualitative data coding simplifies the analysis complexity by labelling data sources according to the coding scheme, which is developed for the concepts SCRES, SCRM and SCV. Here, “a priori coding” was applied, i.e. the categories were established prior to the analysis based upon definitions of the theoretical concepts from the literature (Weber, 1990). The *a priori*, literature-derived coding scheme comprised:

- two SCR effect management categories (i.e. sharing risks and hedging risks);
- SCR knowledge management;
- the four SCRES capabilities; and
- three SCV categories (see Table II).

The classification scheme for supply chain risk effect and knowledge management was informed by the structures proposed by Ellegaard (2008) and Manuj and Mentzer (2008a). Categorising SCRES data was based on the literature-derived definitions of the four capabilities (see Table II for definitions and references). Finally, for SCV, we adopted the three dimensional risk effect scheme from Oehmen *et al.* (2009). The authors define manifest vulnerability or risk effects as defected supply chain targets and distinguish between first, failed revenue targets, second, failed cost targets and third, failed lead time and/or availability targets (Oehmen *et al.*, 2009).

The raw data with references first, to any supply chain risk management activities of the case companies; second, to the resilience of the supply chain; and third, to the impact of the financial crisis on the supply chains, were structured into recording units (Krippendorff, 1980) and coded along the predefined categories. Tables III and IV provide examples of recording units, i.e. summaries of raw data from the interviews, which were coded. The data from the combined data sets of both phases were coded independently by two experienced researchers. The coefficient of agreement between both judges was 78 per cent for the SCRM categories; 76 per cent for the SCRES and 68 per cent for the SCV categories.

Table I Case study data

Year	Company	Interviewees' roles/business functions	Data sources		
			No. interviews	No. workshops	Secondary data
2007 and 2009	Cable Co.	Company owner	11	3	Internal documents Secondary data from customers and suppliers
		Head of Corporate Procurement			
		Supply Chain Manager			
		Sourcing managers			
		Logistics managers			
		Product managers			
		Sales managers			
2007 and 2009	Chemical Co.	Production managers	9	2	Internal documents Secondary data from suppliers
		Sourcing Director			
		Sourcing Manager			
		Logistics Manager			
		Product Manager			
		SOP Manager			
		Head of Production			
2007 and 2009	Timber Co.	Head of Sales Organisation	8	1	Internal documents Secondary data from suppliers
		Marketing Manager			
		Supply Risk Manager			
		Head of Support Team – Global Sourcing Strategic Projects			
		Sourcing Director			
		Sourcing Manager			
		Head of Logistics & Transport			
		Sales Manager			
		Warehouse Manager			
		Product Manager			

Table II Coding scheme

Code	
SCRM	
1. SCR effect management	Code definition
1.1 Sharing risk	Any risk management actions aimed at sharing losses with external supply chain parties (adapted from Ellegaard, 2008; Manuj and Mentzer, 2008a)
1.2 Hedging risk through redundant resources	Any risk management actions aimed at preventing disruptions of supply chain operations through redundant tangible (e.g. transport or production capacities) or intangible (e.g. processes, skills) resources (adapted from Ellegaard, 2008; Manuj and Mentzer, 2008a)
2. SCR knowledge management	Any risk management actions aimed at creating knowledge about supply chain risks (adapted from Ellegaard, 2008; Manuj and Mentzer, 2008a)
SCRES	
1. Flexibility capability	The ease with which a supply chain can change its range number (i.e. the number of possible "options") and range heterogeneity (i.e. the degree of difference between the "options") in order to cope with a range of market changes/events while performing comparably well (adapted from Stevenson and Spring, 2007; Skipper and Hanna, 2009).
2. Velocity capability	The speed with which a supply chain can react to market changes/events (adapted from Christopher and Peck, 2004).
3. Visibility capability	The extent to which actors within the supply chain have access to or share timely information about supply chain operations, other actors and management which they consider as being key or useful to their operations (adapted from Barratt and Oke, 2007; Wei and Wang, 2010).
4. Collaboration capability	The level of joint decision making and working together at a tactical, operational or strategic level between two or more supply chain members. Scalable through the magnitude of relationship strength, quality and closeness (adapted from Zacharia <i>et al.</i> 2009; Singh and Power, 2009; Barratt 2004).
(Manifest) SCV	
1. Revenue targets	(Non-)achievement of any supply chain revenue targets (adapted from Oehmen <i>et al.</i> , 2009)
2. Cost targets	(Non-)achievement of any supply chain cost targets (adapted from Oehmen <i>et al.</i> , 2009)
3. Lead time/availability targets	(Non-) achievement of any lead time and/or availability targets (adapted from Oehmen <i>et al.</i> , 2009)

Table III The relationship between SCRM and SCRES – evidence from the case companies

Supply chain risk management	Positive impact on supply chain resilience capabilities			
	Flexibility	Velocity	Visibility	Collaboration
SCR effect management				
1. Sharing risks	(+)		(+)	(+)
Examples of coded data from the case studies:				
Index-based pricing				
Joint business continuity plans				
Outsourcing agreements				
2. Hedging risks through redundant resources	(+)	(+)		
Examples of coded data from the case studies:				
Regional distribution centres or warehouses				
Decentralised supply chain management organization				
Dual and/or multi sourcing				
SCR knowledge management			(+)	
Examples of coded data from the case studies:				
Formalised supplier risk management process				
Human resources dedicated specifically to supply chain risk management				

Table IV The relationship between SCRES and SCV – evidence from the case companies

Supply chain resilience capabilities	Positive impact on manifest supply chain vulnerability throughout the financial crisis			Evidence in firms
	Revenue targets	Cost targets	Lead time/availability targets	
Flexibility	(+)	(+)		
Examples of coded data from the case studies:				
Response to unpredictable demand change				Cable Co.
Shifting to cost-effective supply sources				Chemical Co.
Optimised capacity utilisation				Timber Co.
Velocity	(+)			
Examples of coded data from the case studies:				
Quick response to unpredictable demand change				Cable Co.
Visibility		(+)	(+)	Chemical Co.
Examples of coded data from the case studies:				
Shifting to cost-effective supply sources				Cable Co.
Counteractive measures to avoid non-availability				Chemical Co.
Optimised capacity utilisation				
Collaboration		(+)	(+)	
Examples of coded data from the case studies:				
Lower sourcing costs				Cable Co.
Counteractive measures to avoid non-availability				Chemical Co.
				Timber Co.

In a second step, patterns between the main concepts of interest were detected through selective coding (Strauss and Corbin, 1998). Here, patterns were sought out and analysed in order to explore the relationship between SCRES, SCRM and SCV. Pattern matching is considered one of the best techniques in case study analysis (Ellram, 1996). Tables III and IV indicate the patterns between SCRM and SCRES (Table III) and between SCRES and SCV (Table IV), which will be further explained in the next section.

A case study protocol was written in order to support the preparation, execution and follow-up of the multiple-case study. The structured documentation of the research design, data collection procedures and outline of the case study report facilitates the replication of the researcher's approach and thus increases the reliability of the research (Yin, 2003; Ellram, 1996). Construct validity was increased by

triangulating data from multiple sources and the use of key informants to review and validate draft reports (Seuring, 2008; Ellram, 1996). Like in many other case studies, external validity is limited, given that the paper draws only from three cases. However, the multiple case studies augment external validity and help guard against observer bias. Furthermore, our aim is to generalize to the theoretical concepts and not to populations or universes and, therefore, analytic generalization to existing concepts in SCRES and SCRM and not statistical generalization is our main concern (Yin, 1981). Internal validity is ensured by using two independent judges (Miles and Huberman, 1994). Furthermore, longitudinal research designs can increase the internal validity by enabling one to track cause and effect (Leonard-Barton, 1990).

Discussion of the findings

The following presentation of the findings is structured along the two research objectives and investigates, first, the relationship between SCR effect as well as knowledge management and the four SCRES capabilities and, second, the relationship between the SCRES capabilities and the SCV throughout the recession.

Relationship between SCR effect and knowledge management and the SCRES capabilities

The findings from the case data analysis provide support for a relationship between the concepts of SCRM and SCRES. More specifically, the case data supports a positive impact of risk effect-oriented actions on all four resilience capabilities as well as a positive impact of knowledge-oriented actions on visibility. A summary of the findings is illustrated in Table III and explained as follows.

SCR effect management – sharing risks

All three firms maintained either operational-level or strategic-level agreements with suppliers as a means to share the supply chain risks. Risk sharing enables loss dispersion and is a widespread supply chain risk mitigation approach (e.g. Ellegaard, 2008; Ritchie and Brindley, 2007; Manuj und Mentzer, 2008a). In our case study, the risk sharing agreements had a positive impact on the supply chain flexibility, visibility and collaboration capabilities. For example, Cable Co set up an agreement with its copper suppliers to link prices to the index-based pricing of the London Metal Exchange. Since the supply of copper has been extremely unpredictable in the past, they also set up joint continuity plans. Both measures supported the supply chain visibility because copper prices could be confidently monitored real-time from all points within the supply chain (Wei and Wang, 2010; Van der Vorst and Beulens, 2002). The joint business continuity plans additionally strengthened the willingness to share the consequences emerging from the volatility of this critical raw material and to restrict opportunistic behaviour (Simatupang and Sridharan, 2008). Strategic-level risk sharing agreements were introduced by Timber Co, when the company started to outsource part of its logistics to an external service provider. Whereas the firm traditionally ran its own fleet and fully controlled the outbound logistics process, local incidents in the past revealed the vulnerability of the supply chain to any logistics process failures. The strategic outsourcing agreement can be interpreted as a measure to build flexibility into the re-configured supply chain so that disruptions can be absorbed through a joint effort of both parties (Stevenson and Spring, 2007). Such a coincidence of collaboration and flexibility is in line with recent studies, which found that a lack of trust and collaboration are major barriers to successfully introducing flexibility into the supply chain (Chan *et al.*, 2009).

SCR effect management – hedging risks through redundant resources

A second group of risk management activities employed by all three companies concerns investments into redundant supply chain resources. The underlying risk management principle, which attempts to exploit the law of large numbers so that a single event does not effect all entities at the same time and/or with the same magnitude, has been referred to as a “hedging” strategy (Manuj and Mentzer, 2008a). Our case findings are

in line with the literature and suggest that the approach positively impacts the SCRES flexibility and velocity capabilities (Tang and Tomlin, 2008; Ellegaard, 2008). In the case companies, investments into redundant resources concern tangible (e.g. regional distribution centres or warehouses), organizational (e.g. decentralised supply chain management organization) as well as intangible resources (supplier relationships). For example, Cable Co set up five regional operational supply chain hubs as a means to supply regionally for regional demand. Although the responsibility for planning remained at the central headquarter, the decentralised structure increased the velocity of the shorter operational supply pipelines. It also allowed them to maintain a dual sourcing strategy for selected critical components, which secured flexibility. Chemical Co as well as Timber Co invested into additional warehousing capacity. Thereby, Chemical Co reacted to a former severe supply chain disruption caused by an IT failure in its centralised warehouse. Timber Co, however, aimed at improving its delivery time and restricting the risk related to non-availability in the time-sensitive market. Splitting up the market into two regions shortened the lead-time and increased the downstream velocity of the supply chain. They also started working with new Chinese suppliers, which had positive flexibility, yet negative upstream velocity implications.

SCR knowledge management

In the case study, risk knowledge management expressed the desire of the companies to monitor closely the contingencies from the various risk resources. The most prominent monitoring measures focused supply side risks and concerned the integration of formalised risk management into the supplier management processes and into the procurement structure. Such an upstream focus of the companies’ risk knowledge management is in line with the literature (e.g. Jüttner, 2005; Matook *et al.*, 2009). In all three firms, the close monitoring of supply risks had a positive impact on the supply chain visibility. For example, Cable Co introduced a formalised, standard supplier management process with an integrated risk perspective in all five-supply chain management hubs. Among other measures, the process also included a periodic “supplier vulnerability evaluation”. According to the interviewees, the company has always been aware of the risk associated with its large base of SME supply companies. Still, they were surprised about the additional information they gained regarding vulnerable bottlenecks in the supply network caused, for example, by second tier suppliers. Chemical Co had a small team attached to the global sourcing organisation, which was dedicated to risk management issues. The team was introduced because the company had substantially expanded its international operations over the past ten years and felt vulnerable to contingencies in distant regions. Moreover, they were acutely aware that the global expansion had increased the complexity in the supply chain organisation. Therefore, the risk management team was assigned to deal with the complexity risk by increasing the visibility within the international supply network.

To summarise, the different risk management actions carried out by the case companies had a positive yet differentiated impact on the four resilience capabilities. Whereas sharing risks appears potentially to impact the three resilience capabilities of flexibility, visibility and

collaboration, redundant resources seem primarily to address the flexibility and velocity of the supply chain. Furthermore, in our case companies, knowledge creating risk management proved to impact the SCRES by improving the supply network visibility. We will now proceed by presenting the findings for our second research objective: the relationship between the four SCRES capabilities and the vulnerability of the supply chain throughout a disruption event.

Relationship between the SCRES capabilities and the SCV throughout the financial crisis

In all three companies, the magnitude of the demand risk caused by the financial crisis was comparable. Internationally, the demand declined by an estimated 20-30 per cent within six months and, through ripple effects, the prices at all stages of the supply chain decreased by up to 40 per cent. From a supply chain perspective, the recession was therefore initially a demand risk. However, in the wake of the collapsing prices, it spread into an additional supply risk due to the high number of supplier insolvencies. The bottom of the demand slump was in the second quarter of 2009 but the following months were characterised by high uncertainty and forecasts were almost impossible. Whereas some markets seemed to recover a lot quicker, others, like the US market, for example, lagged behind.

The following analysis of the findings from the three case companies supports the proposed relationship between the four SCRES capabilities and the SCV in a situation with a manifest risk event. Furthermore, the data analysis revealed that the four resilience capabilities helped the companies to contain the negative effect of the recession (see Table IV).

Flexibility

Throughout the recession, the supply chain flexibility helped to contain the negative effect on the case companies' cost targets and revenue targets. On the cost side, the flexibility to shift to cost-effective supply sources was a key enabler. Flexibility supported by dual as well as multiple sourcing was actively used either to move part of the purchasing volume to cheaper sources or, alternatively, to strengthen the companies' bargaining power in price negotiations with their suppliers. The findings support and complement those by Fantazy *et al.* (2009), who found that sourcing flexibility has a positive effect on net profit in normal, non-disruptive supply chain operations. Furthermore, flexibility to reallocate capacity and to optimise capacity utilisation within the internal and/or external network helped to contain costs. Flexibility also had a positive impact on revenue targets. It enabled two of the case companies to respond to unpredictable changes in demand or, more specifically, to satisfy the rising demand for low cost products. For example, Timber Co used the new Chinese supplier to launch a cheap "private label" product line which accounted for almost 30 per cent of the revenue in the year 2009.

Velocity

As predicted in our conceptualisation of SCRES above, in the findings, velocity was closely related with flexibility. Velocity also had a positive impact on the companies' revenue targets and supported flexibility by adding pace to the supply system's adaptability. The redundant resources within the supply chain enabled two of the case companies to use the fast access to regional capacity in order to exploit unexpected regional or local demand pick-ups. The demand pick-ups

were difficult to predict and could be driven by different events, ranging from public spending, a temporary rebound of the stock market to the insolvency of a competitor. According to the interviewees, especially demand pick-ups due to competitor insolvency were "strategic windows" because market share was reallocated among the incumbent players. They predicted that the post-recession phase, when demand rises back to pre-recession levels, would equally present opportunities for the competition. These findings support the conceptual literature on SCRES which suggests that resilience not only supports the system's return to its original state but potentially to a new, more desirable state (Christopher and Peck, 2004; Ponomarev and Holcomb, 2009). Furthermore, they stress the crucial role of velocity for SCRES because disruption events seem to entail potential "first mover advantages". Here, not only flexible adaptations, but the speed of the supply chain adaptations is crucial.

Visibility

For the case companies, visibility was an important driver of the effective timing of intervening actions throughout the risk event. In line with the literature, it was therefore related to improved decision making (Barratt and Oke, 2007). Unlike short disruptive events such as an earthquake, the disruption caused by the recession lasted for a longer term and its development was unpredictable. Therefore, the timing of supply chain responses throughout the disruption was crucial. In two of the case companies, effective responses supported by supply chain visibility helped to offset non-availability and mitigated the negative impact on cost targets. For example, by closely monitoring its suppliers and by sharing information regarding risk exposure, Cable Co was able to identify financially vulnerable suppliers at the beginning of the financial crisis. This, in turn, extended the reaction time and enabled them to take counteractive measures against the possibility of delivery failure caused by supplier insolvency. The example also supports the notion in the literature that visibility is an outcome of information sharing activities between supply chain partners (Wei and Wang, 2010). This may, however, create a potential barrier to visibility in a risk event because vulnerable firms may see the release of sensitive information as an additional threat to their survival. In support of this argument, Cable Co used the visibility in one case for the premature termination of a supplier contract. Finally, within Chemical Co, the risk management team in the global sourcing organisation leveraged its visibility of the sourcing network in order to substitute a pricey raw material (adhesive) through a low cost alternative, which permitted cost savings of up to 20 per cent in a major business line.

Collaboration

In the literature, collaboration is often seen either from an operational perspective with an emphasis on its supporting role for the smooth functioning of an efficient supply chain or from a strategic knowledge or innovation perspective, as a means to access complementary skills which are essential to meet competitive challenges (e.g. Soosay *et al.*, 2008; Simatupang and Sridharan, 2008). Our findings from the case studies seem to suggest that in a crisis situation, the positive collaboration impact on the smooth supply chain functioning predominates. Collaborating with supply chain parties helped all three case companies to contain the negative impact on the cost as well as availability targets by maintaining operations. On the availability side, the joint

continuity plans, which Cable Co set up proved to be extremely valuable when one of its big suppliers had to close down capacity and, as a consequence, started to deliver on the basis of an emergency priority plan. The collaborative continuity plan ensured that Cable Co was among the customers supplied with first priority. On the cost side, the LME index-based material pricing eased Cable Co's finances. When their own market prices were down by 35 per cent, they relied heavily on suppliers who were willing to pass the lower raw material prices on to their customers. Extreme peaks and troughs of sourcing and market prices were also a major challenge for the other two companies and the collaborative agreements had a parachute effect by dampening the impact for each individual player. These findings appear to suggest that a disruption caused by a risk event triggers a bullwhip effect for the supply chain. The level of collaboration between the parties defines whether the effect is aggravated through independent and opportunistic decision making or alleviated through joint decision making and risk sharing. In the light of this argument, supported by our case research, the apparent reluctance of firms to collaborate in risk situations seems alarming (Jüttner, 2005).

To summarise, all three case studies provide support for a relationship between SCRES and SCV in a risk event. All four resilience capabilities helped to avoid or limit the negative consequences of the risk event for the revenue, cost and lead time/availability targets of the focused supply chains.

Implications and conclusions

The essence of resilience is the containment of disruptions and recovery from them (Sheffi, 2005b). To date, there is no empirical research which has investigated resilience of extended supply chains in a global disruption event in order to identify which supply chain capabilities can support the containment of the risk consequences and how these capabilities can be supported by effective SCRM. This paper conceptualises SCRES and explores its relationship with the related concepts of SCRM and SCV. Furthermore, it investigates empirically, in the context of the recent global recession, how the resilience of extended supply chains can be strengthened by the companies' SCRM strategies and how SCRES can positively influence the vulnerability of their supply chains. It has both managerial and research implications.

Managerial implications

Recent events like the financial crisis or the volcano eruption have demonstrated again that risk events are inevitable and that they are even more likely to effect today's supply chains with their increasing global stretch and complexity. Still, as emphasised by Christopher and Peck (2004), many organizations are unaware of the need to consider the resilience of their supply chains. Instead, they seem to be prone to address the probability of adverse events in their SCRM rather than the effect (Ellegaard, 2008). Especially risks with low probability yet high impact tend to be tolerated because the potential sources appear to be too manifold and the ability to control them too limited. The paper argues for a stronger emphasis on SCR effect and knowledge management. We have been able to provide evidence that this can support the four resilience capabilities and, ultimately, lower the destructive impact of inevitable risk

events. For managers, the advantage of SCRES is twofold. First, as characteristics of the supply chain system, the four resilience capabilities appear to be able to cope with risk events from varied sources. Therefore, they can eventually have a strong impact on a company's SCR portfolio by addressing a range of risks simultaneously.

Second, recent studies suggest that flexibility (see Fantazy *et al.*, 2009), collaboration (see Soosay *et al.*, 2008) and visibility (see Wei and Wang, 2010) are intangible dynamic supply chain capabilities that can not only contain supply chain disruptions but, moreover, generate competitive advantage also in normal, routine operating times. The rich data from the qualitative case studies can point managers at some of the managerial principles of SCRES. For example, it appears as if centralised supply chain planning with decentralised local capacity could be one of these overarching principles. Moreover, having slack resources in strategic supply chain project roles appears to be another principle for resilience building. Because resilience requires a "just in case" perspective on the supply chain, it cannot easily be reconciled with the responsibilities and mindset required for routine operations. Both of these principles challenge some of the trends in supply chain management in the last years and should trigger debates among supply chain managers.

Limitations and research implications

The conceptualisation of SCRES and the empirical findings regarding its relationship with SCRM and SCV are the main contributions of the paper to the body of knowledge in this research area. These contributions as well as the limitations of our study suggest the following areas for further research.

First, our findings indicate a differentiated relationship between the SCRM actions and the four dimensions of SCRES. For example, whereas supply chain risk knowledge management only appeared to be related to improved visibility within the supply chain, sharing risks as a risk effect-oriented action had a positive impact on flexibility, visibility as well as collaboration. These findings suggest that a more refined relationship between SCRM and SCRES and a tighter specification of research propositions should be investigated through further empirical research. Second, our study did not investigate any antecedents to SCRES. For example, the literature suggests trust as joint antecedent to collaboration, visibility and flexibility (Zacharia *et al.*, 2009; Wei and Wang, 2010). Further research should help to identify additional behavioural antecedents and, thereby, support companies in their endeavours to improve the resilience of their supply chains. Third, our conceptual framework proposes that SCRM actions that only address the probability of risk events should not be related SCRES. This relationship was not considered in our empirical study and, therefore, needs to be addressed in future research. Fourth, our research design did not enable us to explore the resilience of the case companies' supply chains systematically in each of the three phases: before, throughout and after the disruption. Some initial evidence provides support for the assumption that the resilience might differ in the three disruption phases. For example, all three case companies did not feel prepared for the financial crisis. Instead, after several years of steady growth, it caught them by complete surprise. The response and recovery capability throughout and after the event, however, was judged differently. Although they suffered severe

revenue and profit losses, which also caused redundancies, compared with their main competitors, all three companies did well. Given that resilience in all three phases is often stressed in the SCRES definitions (Ponomarov and Holcomb, 2009), further research should compare and contrast its development throughout the course of a disruption. Fifth, future research should also compare the attitude of organizations before and after a disruptive event. The literature stresses that attitude and risk perception influence the willingness to take any precautions (e.g. Jüttner, 2005; Zsidisin, 2003). Risk perception, in turn, appears to be influenced by past crises (e.g. Norrman and Jansson, 2004). Attitude changes might therefore be an important driver for the SCRES capability acquisition over time[2]. Sixth, our paper studies SCRES in only one risk event. The literature seems to suggest that SCRES might be a dynamic capability, which is able to absorb the negative effects from a range of different risk sources (Briano *et al.*, 2009; Teece, 2007). More work is needed which takes a contingency perspective and investigates the impact of situational factors on SCRES. Seventh, a contingency perspective could also help us confirm the tentative finding from our study that resilience capabilities may exert a different impact on the supply chain in a disruption situation compared with a routine situation. In the latter, the focus is not primarily on achieving competitive advantage but on fast recurrence to normal operations. Finally, the literature as well as our findings highlight trade-offs which might be related to the four SCRES capabilities (Sheffi, 2001). For example, setting up the regional supply chain organizations improved Cable Co's flexibility but, at the same time, the initial investment had a negative impact on its costs. When demand declined, the opening of one of the planned regional supply chain organizations had to be postponed, otherwise the flexibility might have been offset by an imminent liquidity risk. Future research should explore these trade-off decisions related to supply chain resilience management[3].

Notes

- 1 We will disguise the names of the companies throughout the paper and refer to these synonyms.
- 2 We would like to thank one reviewer for this helpful advice.
- 3 This helpful comment was also made by one of the reviewers.

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Appendix. Base case protocol

I. Research questions/issues

Research questions/issues and tasks covered in the workshops – first data collection phase 2007

- 1 Understanding/defining the supply chain (supply chain mapping exercise).
- 2 Defining the main processes and process responsibilities in the supply chain.
- 3 Brainstorming on the risks that could potentially effect the supply chain.

- 4 Process-based analysis of the risk sources and consequences.
- 5 Assessment of the risks identified based on the probability of occurrence and the perceived business impact.
- 6 Discussion of all existing risk management actions implemented by the company.
- 7 Evaluation of the risk management actions based on their perceived effectiveness.
- 8 Discussion of all risk management actions planned in the future.

Research questions/issues covered in the semi-structured interviews which followed the workshops – first data collection phase 2007

- 1 Do the workshop notes and supply chain risk analysis accurately represent the situation in your company/in the supply chain?
- 2 From the perspective of your supply chain process responsibility, are there any:
 - risk sources?
 - risk consequences?
 - existing risk mitigation actions?
 - planned risk mitigation actions which are not listed in the workshop notes?
- 3 Are archival data available?
- 4 Any follow-up comments?
- 5 Additional contacts?

Research questions/issues covered in the semi-structured interviews – second data collection phase 2009

- 1 Compared with the last data collection in 2007, which have been the major:
 - Industry/market changes?
 - Supplier market changes?
 - Changes in your supply chain?
 - Changes in your company?
- 2 To what extent and how has the financial crisis affected:
 - your industry (on a global, regional and national level)?
 - your supply chain and supply chain targets?
 - your company and company targets?
- 3 Would you say that your supply chain was prepared for the financial crisis? ... reacts well to the challenges related with the financial crisis? ... will soon recover from the impact the financial crisis has had on your supply chain?
- 4 Compared with your main competitor(s), how well is your company/supply chain dealing with the financial crisis?
- 5 From a supply chain perspective, which are the major management challenges triggered by the financial crisis?
- 6 Which are the major resources/skills/capabilities of your supply chain which help to control or restrict the impact of the financial crisis?

II. Methodology/case study design

A. Multiple case study design

- 1 Each case as a replication, not as a single response to a survey.
- 2 Write up each case – develop a standard case format and an overall case database.
- 3 Relationship between key concepts will be explored from a practitioner perspective.

- 4 Different mindsets of functional representatives will be captured but then convergence regarding an agreed supply chain view will be sought.

B. Case study selection

Companies meet the relevant concept-derived criteria of the research:

- 1 Firms known to have an interest in SCRM.
- 2 Cooperation from managers of the key supply chain processes (Sales/marketing/distribution; product management, production, logistics, sourcing).
- 3 Willingness to participate in at least one cross-functional workshop.
- 4 Firms in different industries.
- 5 Firms from an industry (strongly) affected by the financial crisis.
- 6 Willingness to share information on the supply chain effects of the financial crisis in 2009.

III. Data collection – sources of evidence

- 1 *Documentation:*
 - internal presentations on supply chain (risk) related strategies and actions;
 - internal documents (e.g. supplier vulnerability questionnaire and findings, supplier evaluation tools or business continuity plans) and memos related to SCRM;
 - flip charts, Power Point presentations with workshop results.
- 2 *Interviews:*
 - *Phase 1* – 2007: respondents who are not able to participate in one of the workshops are interviewed to

corroborate/complement/augment the workshop findings.

- *Phase 2* – 2009: key informants – open ended interview; key events within the two years since the last data collection and effect of those events for the industry, supply chain and the firm.

IV. Data analysis

- 1 *A priori coding* – based on the literature-derived code definitions:
 - define coding scheme and code definitions for the main concepts of interest;
 - define/delineate recording units and context units;
 - code raw data; and
 - assess inter-judge reliability.
- 2 *Selective coding* – associations/pattern building:
 - associations/patterns between the codes within each concept; and
 - associations/patterns between the codes of different concepts.
- 3 *Explanation building:*
 - No intention to generalize the findings – but – to unpack and describe the causal powers between the concepts investigated.
 - Link theory/literature review to the case findings.

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