COLLABORATIVE RECOVERY FROM SUPPLY CHAIN DISRUPTIONS: CHARACTERISTICS AND ENABLERS

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Abstract Due to their growing global and complex nature, supply chains are increasingly vulnerable to natural and man-made disasters that disrupt the flow of goods. Today, recovering from disruptions represents a major challenge for supply chain professionals. In literature, most recovery methods are based on redundancy and flexibility. Their drawbacks are high inventory and coordination costs. The companies analyzed in this paper took another approach: they recovered by collaborating with their network partners, especially by temporarily sharing resources. Based on the relational view theory, this paper aims to describe whether and how companies can gain competitive advantage by relying on collaboration during the recovery process. A multiple case study with companies from the automotive and electronics industries is conducted. Six cases are analyzed with regard to the recovery characteristics and enabler. Seven propositions are derived that give potential for further research on this promising recovery method.

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1. INTRODUCTION

Supply chain disruptions are "unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain" (Craighead et al., 2007). This paper focuses on low likelihood, high severity disruptions. This focus is set based on research of Bovell (2012) which concludes that network partners are more likely to mobilize, thus collaborate, under these circumstances. Possible causes for disruptions are natural or man-made disasters (Craighead et al., 2007, Simchi-Levi et al., 2014). Immediate consequences are increases in cost as well as decreases in profitability and net sales. Long-term effects, such as negative stock market reactions, damaged brand image and decreased customer service level, may be even more severe (Craighead et al., 2007, Tang, 2006, Hendricks & Singhal, 2005).

Their growing global and complex structure makes supply chains increasingly vulnerable to disruptions due to a higher number of risk exposure points (Tang, 2006, Rice & Caniato, 2003). Global business interactions involve several network actors, such as customers, suppliers, competitors and governmental organizations. The high level of interconnectedness is amongst other factors caused by current business trends, such as lean manufacturing, just-in-time-deliveries and global sourcing (Tang, 2006). Furthermore, the severity as well as the quantity of natural and man-made disaster are expected to continue rising (Tang, 2006, SwissRe, 2012). The topic of managing supply chain disruptions becomes, therefore, increasingly important.

The trend that networks of collaborating companies, instead of individual firms, compete against each other was the basis for the development of the relational view theory. The theory complements the resource-based view of the firm by suggesting that competitive advantage can be derived from inter-organizational, as opposed to intra-organizational, resources (Dyer & Singh, 1998). Based on the relational view, this paper analyzes whether and how companies can gain competitive advantage by relying on collaboration during the disruption recovery. Six cases of successfully recovered companies from the automotive and electronics industry are analyzed and propositions are derived.

2. STATE OF THE ART

Supply chain disruptions are one of the main concerns of risk managers nowadays (Sheffi & Rice, 2005). Companies try to reduce their occurrences. However, not all disruptions can be completely avoided or eliminated (Craighead et al., 2007). Therefore, it is relevant for companies to establish reactive methods. Thun and Hoenig (2011) point out that there is a lack of reactive methods in companies' supply chain management (Thun & Hoenig, 2011). The "ability to react to an unexpected disruption […] and restore normal operations" (Rice & Caniato, 2003) is referred to as the concept of supply chain resilience. According to Sodhi, Son

& Tang, reactive methods are not sufficiently described in literature as well (Sodhi et al., 2012). Those discussed center on redundancy and flexibility. Excess inventory, multiple sourcing, postponement, rerouting of transports and/or production, flexible transportation and flexible supply base are common examples (Tang, 2006, Christopher and Peck, 2004). However, these methods have the disadvantages of high inventory and coordination costs (Blackhurst et al., 2005).

Dyer and Singh (1998), who initially developed the relational view, state that inter-firm linkages may be a source of relational rents and competitive advantage. Relational rent refers to “supernormal profit jointly generated in an exchange relationship that […] can only be created through the joint idiosyncratic contribution of the specific alliance partners” (Dyer & Singh, 1998). One of the determinants of relational rent, and thus of competitive advantage, is complementary resource endowment. They are defined as “distinctive resources of alliance partners that collectively generate greater rents than the sum of those obtained from the individual endowments of each partner” (Dyer & Singh, 1998). Similarly, Lavie argues that companies can “extract value from resources that are not fully owned or controlled by its internal organization” (2006).

Due to the increasing interconnectedness of supply chains, the importance of supply chain collaboration is growing. Companies in a supply chain work closely together “to achieve mutual advantages that are greater than the firms would achieve individually” (Cao et al., 2010). Literature provides several examples which demonstrate a positive correlation between supply chain collaboration and companies’ performance (Cao et al., 2010, Chen et al., 2004). According to Christopher and Peck (2004), collaboration is one crucial factor that should be considered when creating resilient supply chains. Sharing of resources among network partners is accentuated by Cao et al. who describe supply chain collaboration as a concept that consists of seven interconnected elements. One of them is ‘sharing of resources’ which is defined as “the process of leveraging capabilities and assets and investing in capabilities and assets with supply chain partners” (2010).

Within the limited amount of papers that deal with recovery methods, only few address the topic of collaboration by taking a relational view perspective. One example is the research of Wieland and Wallenburg (2013). They found that the relational competencies ‘communication’ and ‘cooperation’ have a positive effect on resilience. Mandal (2013) developed a relational framework for supply chain resilience. It suggests a positive effect of relational resources, like trust, commitment and interdependence, on supply chain resilience and, hence, on supply chain performance. Bello and Bovell (2012) highlight the importance of social capital by analyzing the relationship between relational closeness of supply partners and joint resolution of problems. This mobilization implies the sharing of resources which facilitates collaborative problem solving (Bovell, 2012). The results of these research approaches give reasons to further analyze this promising recovery method.

3. METHODOLOGY

Sodhi, Son and Tang (2012) identified a shortage of empirical research on recovery methods. To address this research gap, they suggest case-study-based research to investigate contemporary phenomena in depth and in their real contexts (Yin, 2014). In this research, the approach was to compare different cases and predict similar results (Yin, 2014). In order to enhance the cases' comparability, three selection criteria were defined. First, selected companies had to have experienced a low likelihood, high severity disruptions. Second, there had to be some kind of supply chain collaboration during the recovery. Third, analyzed companies had to be part of the electronics or automotive industry, where lean production, single sourcing, and JIT principles are highly apparent (Thun & Hoenig, 2011, Whitney et al., 2014) which increase their vulnerability and their need to react.

In order to achieve high consistency of the findings, several types of secondary data were consulted, such as reports, newspaper and magazine articles, as well as scientific journal papers. The data analysis was conducted following the case study procedure proposed by Yin (2014). The relational view was employed as the underlying theory in the design phase. A case study protocol was established to extract information from different sources systematically in order to increase the reliability of the research. Based on the collected data of the selected cases, the recovery processes were analyzed individually. Then, a cross-case analysis was conducted and propositions were derived. Feedback loops allowed sufficient flexibility to reconsider and modify steps or to adjust the propositions (Yin, 2014).

4. CASE DESCRIPTIONS

Table 1 gives an overview of the selected cases with regard to general company information and disruption descriptions. Furthermore, the recovery activities of each case are described in this part.

Different network actors supported the recovery of Renesas' plant. These include customers, including members of Japan Automobile Manufacturers Association (JAMA), Renesas Electronics Labor Union, major shareholders, former employees and external organizations, such as governmental agencies. Up to 2,500 employees from other companies were actively involved in Renesas' recovery. Since the other seven Renesas factories were not severely affected by the disaster, they were also able to assist Naka plant's recovery. Help was not limited to monetary support, but also included human resources, and even industrial physicians. People were assigned to certain recovery activity teams by Renesas' emergency response taskforce that was formed immediately after the earthquake. To coordinate information sharing among the teams, leaders of teams gathered on a daily basis to discuss the recovery plan, and reallocate resources, if necessary (Renesas, 2011, Olcott & Oliver, 2014). Renesas was able to reconstruct its infrastructure in 12 days and to restart its first assembly line on June 1. Thus, the time-to-recover was three months, instead of six months which was originally estimated by Renesas' engineers (Renesas, 2011, Olcott & Oliver, 2014).

Table 1 Company and disruption descriptions of case companies

Case	Company description	Disruption description
Renesas	- a leading electronics and automotive company, world market share of 44 % (Olcott and Oliver, 2014) - headquarter in Japan, subsidiaries in the US, Europe, and Asia; 27,000 employees (consolidated); net sales: 8.2 billion USD (2014) (Renesas, 2014, Renesas, 2011)	- March 2011: the Great East Japan Earthquake severely damaged Renesas' Naka manufacturing plant in Ibaraki; cleanrooms to fabricate semiconductors were destroyed; Renesas' losses were about 117 million USD - due to the large market share and high level of products' customization, numerous customers were relying on Renesas' products (Renesas, 2011)
Philips	- worldwide operating electronics company - headquartered in the Netherlands; 115,000 employees; sales: 31.9 billion USD (2013) (Philips, 2014)	- March 2000: plant in Albuquerque, New Mexico, caught a fire because of lightning - cleanrooms, used to fabricate semiconductors and chips, were ruined - Philips' loss: 40 million USD (Sheffi, 2005)
Western Digital	- a leading electronics company - headquarter in the United States; several subsidiaries in Asia (WesternDigital, 2014); 38,000 employees at Thai plant; total revenue: 15.3 billion USD (2013) - contributes 2 % to Thailand's GDP (Wai and Wongsurawat, 2013)	- October 2011: plant in Bang Pa-In Industrial Estate, Thailand, was affected by the flood which made up a quarter of world's hard disk supply (ZDNET, 2011, Wai and Wongsurawat, 2013). - Western Digital's losses were around 250 million USD (Milbourn, 2011). - Customers worldwide were affected, as the price of external hard drives increased at least by 10 % (Fuller, 2011).
Aisin	- supplies mostly automotive parts, headquarter in Aichi, Japan (Wai and Wongsurawat, 2013); one of the most trusted of Toyota's suppliers and main supplier (90 %) of P-valves, a brake-related part (Nishiguchi and Beaudet, 1998, Whitney et al., 2014) - 88,000 employees (2013, consolidated); net sales: 27.8 billion USD (2014) (Aisin Seiki Co., 2014)	- February 1997: fire in the factory in Aichi destroyed specialized equipment - Toyota announced a shut-down of its production lines within the next day - due to just-in-time principle, no stock to bridge the shortage existed (Nishiguchi and Beaudet, 1998, Whitney et al., 2014) - Aisin's loss: 80 million USD, Toyota's loss: nearly 1.58 billion USD - hundreds of suppliers, electricity, gas and transportation companies were affected because they had to wait to resume deliveries (Nishiguchi and Beaudet, 1998)
Riken	- Japan's largest supplier of piston rings in the automotive industry with 50 % market share (Whitney et al., 2014, Riken, 2015). Piston rings are small high-precision parts in internal combustion engines (Whitney et al., 2014); - 4,000 employees (consolidated); net sales: 627 million USD (2013) (Riken, 2015).	- July 2007: Niigata Chuetsu offshore earthquake affected one main plant and nine satellite companies (Whitney et al., 2014, Sasaki, 2013); operations at main plant were suspended for two weeks (Miyamoto, 2007, Whitney et al., 2014) - several automobile manufacturers interrupted their operations, such as Toyota and Honda (Sasaki, 2013, Miyamoto, 2007, Honda, 2007) - Riken's direct loss: about 12.5 million USD; Japanese automotive industry's estimated loss: about 830 million USD due disruption's ripple effects in downstream supply chain (Whitney et al., 2014, Miyamoto, 2007)
Nissan	- one of the largest automotive manufacturers in Japan with manufacturing facilities in in 20 countries; 143,000 employees (Nissan, 2015).	- March 2011: the Great East Japan Earthquake hit assembly plants in Iwaki and Tochgi; loss of production capacity of about 270,000 cars - in addition, several disrupted suppliers could not deliver as as they were affected by the disaster as well (Greenway, 2014).

After Philips informed its main customers about the disruption, Nokia decided to take action immediately while Ericsson treated the incident as a minor disturbance. Nokia recognized that this disruption could affect the production of several million mobile phones because two parts of their products could only be supplied by Philips (Sheffi, 2005). They gathered a team of 30 employees from Europe, Asia, and the US, from various backgrounds to address the issue. Philips and Nokia operated as one company in Albuquerque plant during a certain period (Sheffi, 2005, Mukherjee, 2008). The effects of this disruption took nine months to be resolved. Ericsson's market share dropped from 12 % to 9 % within six months of the disruption, while Nokia's market share increased from 27 % to 30 %. Thus, this supply chain disruption let to 'a change in the game' of market competition in cellphones (Sheffi, 2005).

Different entities were involved in the collaborative recovery of Western Digital, including its customers and governmental organizations (Wai & Wongsurawat, 2013). They were helping in their own capacities, for instance divers from Thai Navy and soldiers from Royal Thai Army assisted the salvaging of machines and equipment (Wai & Wongsurawat, 2013). Western Digital could successfully recover by the end of November 2012. In comparison, by the end of January 2012 only about half of the 90 affected factories in the area resumed production (Wai & Wongsurawat, 2013).

During Aisin's recovery, they received support from its suppliers, customers, and the Toyota group, which refers to Toyota' network of core suppliers (Nishiguchi & Beaudet, 1998, Whitney et al., 2014). More than 200 companies supported Aisin by sending machines/ equipment and human resources (Whitney et al., 2014). There were no up-front contractual agreements concerning this support (Whitney et al., 2014). Toyota itself sent at least 300 employees from production control, maintenance, production engineering, purchasing, quality control and materials handling (Nishiguchi & Beaudet, 1998). Aisin orchestrated the recovery and established emergency response units (Whitney et al., 2014, Nishiguchi & Beaudet, 1998). P-valves have a high variety but they are not complicate to produce which facilitated its production at other companies (Whitney et al., 2014). Approximately 62 of the supporting companies were asked to produce the needed parts using instructions provided (Nishiguchi & Beaudet, 1998, Whitney et al., 2014). Due to these actions, after two days, P-vales could be produced again (Nishiguchi & Beaudet, 1998). Toyotas' plants were back to regular production volumes after nine days. It is estimated that without the collaborative effort of the network partners, Toyota's losses would have been much higher (Whitney et al., 2014). It took Aisin in total two months to completely recover from the disruption (Nishiguchi & Beaudet, 1998).

Immediately after Riken's disruption, its customers, like automotive manufacturers and equipment manufacturers, provided various forms of support (Whitney et al., 2014, Riken, 2007a). Approximately 650 people were sent to Riken's plant. They assisted in engineering, repairing, cleaning, and sent aid supplies (Riken, 2007b, Riken, 2007a, Commission, 2008). Most of Riken's employees helped in the recovery of the main plant and the satellite companies even though many had lost their homes (Commission, 2008). Due to the very specialized and customized production of piston rings which precedes a design and testing phase of several years, other companies were not able to produce these parts during Riken's recovery (Whitney et al., 2014). The disruption recovery was orchestrated by Toyota, which utilized experience gained from former recoveries (Whitney et al., 2014). Riken's production resumed one week after the earthquake and was fully recovered after two weeks (Riken, 2007a, Miyamoto, 2007). According to Whitney, Luo and Heller (2014), the collaborative support of its network partners enabled Riken to restart its piston ring production much more quickly than it would have without their help.

During Nissan's recovery, hundreds of employees from other plants were mobilized to support the repair work at the damaged facilities (Nissan, 2012). Mainly internal resources from Nissan's plants worldwide were involved in the recovery. Additionally, Nissan's suppliers sent 210 employees to the Iwaki plant (Olcott & Oliver, 2014). Even in the absence of contractual agreements or intellectual property protection, there was a high willingness of the involved parties to pool resources (Olcott & Oliver, 2014). During this crisis, Nissan benefited from its strong central control and coordination competences (Schmidt & Simchi-Levi, 2013). Nissan's Iwaki plant reopened in mid-May and Tochigi plant started production again in April. It took Nissan until October to completely recover (Nissan, 2012, Olcott & Oliver, 2014). Over these six months, Nissan's production decreased by only 3.8% whereas the overall industry decreased by 24.8% (Greenway, 2014).

5. CROSS-CASE ANALYSIS AND PROPOSITION DEVELOPMENT

By analyzing and comparing the six cases, some patterns become apparent. Findings with regard to the collaborative recovery process' success, characteristics and enablers can be derived.

According to the relational view, determinants of competitive advantage include complementary resources (Dyer & Singh, 1998). In order to make statements about whether the case companies gain competitive advantage, the relative time-to-recover (Simchi-Levi et al., 2014) is analyzed. In all analyzed cases, the companies' time-to-recover was shorter than expected and/or shorter compared to their competitors in the same region or situation. Thus, from these short recovery times the ability to gain competitive advantages can be concluded.

Based on the analyzed cases, it can be stated that five different types of resources are shared during collaborative recoveries: human resources, monetary resources, equipment and machines, know-how, and information. Human resources may include employees, members of local communities, managers, or engineers. Equipment and machines are not necessarily used for production processes; they could be used for repairing factories, or in case of Western Digital, pumping out flood water from plant area. Information and know-how is often related to the exchange among engineers of different network partners. In all cases human resources are shared which gives employees an important role in the collaborative recovery. Moreover, in all cases at least two types of resources are shared. From these findings, the first proposition is derived:

P1: During collaborative recoveries, different types of resources shared

The analyzed shared resources possess one or more characteristics that enable the sharing. Three resource characteristics are identified. First, the characteristic adaptability is apparent, especially with regard to human resources. For instance, employees from Aisin's suppliers and customers could quickly adapt to new tasks, such as producing P-valves (Nishiguchi & Beaudet, 1998). Second, mobility is a crucial characteristic. According to Lavie, network relationships can serve as a means to mobilize resources (2006). In the case of Renesas, more than 2,500 engineers from other companies came to the disrupted plant which indicates mobility (Renesas, 2011). In order to exchange information, recovery activity team leaders had daily meetings where they discussed the progress of the recovery. Moreover, the supporting engineers contributed in know-how transfer (Renesas, 2011). Third, resources have to have capacity available. At Renesas, for example, because of the earthquake, there was temporarily less regular work to do and, therefore, employees had free capacity which enabled them to help in the recovery (Renesas, 2011). These findings are captured in the second proposition:

P2: During collaborative recoveries, primarily human resources are shared because of their characteristics which enable sharing, namely adaptability, mobility and capacity availability

According to the categorization of Barratt (2004), there are different types of collaborations according to the actors involved. Internal collaboration can exist, for instance, between different departments or sites of one company. There are two main categories of collaboration with supply chain partners: vertical and horizontal collaboration. The former describes the collaboration with customers and suppliers whereas the latter refers to collaboration with competitors or governmental organizations. In the analyzed cases, collaborations took place across all categories. This leads to the third proposition:

P3: In collaborative recoveries, resources are shared by various network partners, thus including horizontal as well as vertical collaboration

It is noted that collaboration among network actors is often of temporary nature as it is limited to the recovery period. Therefore, also resources are mobilized and shared temporarily. This, in turn, enables collaboration between network actors that are under normal circumstances not actively collaborating. For instance, in the case of Aisin, the recovery was strongly supported by Toyota's suppliers to which Aisin does not have a direct relationship (Whitney et al., 2014, Nishiguchi & Beaudet, 1998). This temporary nature is captured in the fourth proposition:

P4: Collaborative recovery is a temporary process which may temporarily activate latent relationships

The analyzed recoveries were always orchestrated by one actor. Most recoveries where managed by the disrupted company, such as in Renesas' and Nissan's cases (Schmidt & Simchi-Levi, 2013, Whitney et al., 2014, Nishiguchi & Beaudet, 1998). In the case of Riken, Toyota orchestrated the recovery (Whitney et al., 2014). A central control authority seems to be relevant in coordinating and allocating the various actors and resources during the recovery process. This leads to the fifth proposition:

P5: During a collaborative recovery process, a central coordination entity is required

Based on the analyzed cases, there seems to be one main trigger that motivated actors to get involved in the collaborative recoveries, namely dependency. Different kinds of dependency relations can be found in the analyzed cases. For example, Nokia depends on Philips' production because only Philips can produce specific components needed in producing a cellphone chip (Sheffi, 2005). Similarly, Aisin was Toyota's sole supplier of P-valves (Nishiguchi & Beaudet, 1998). Aisin's disruption even affected the Japanese economy, as each day Toyota was down, the Japanese annual industrial output was cut by 0.1 % (Reitman, 1997). Similarly, Thai governmental organizations depend on Western Digital, because it made up about 2 % of Thailand's GDP (Wai & Wongsurawat, 2013). These dependencies seem to be the main trigger for network partners to get involved in collaborative recoveries which is stated in the sixth proposition:

P6: Dependency is the main trigger for collaborative recoveries

Next to dependency, cultural or community characteristics may facilitate the collaborative recovery. Four of the analyzed cases took place in Japan. The location of the cases was neither a prerequisite nor a selection criterion, but rather a result of the analysis. According to Olcott and Oliver (2014), the various collaborative supports in the Japanese earthquake recovery in 2011 were "built upon an underlying foundation of trust, goodwill, and obligation". Trust, collaboration and capability sharing among firms is fostered by the Japanese industrial culture (Nishiguchi & Beaudet, 1998). Thus, collaborative efforts may be more likely in relatively high social capital societies, such as Japan (Olcott & Oliver, 2014). Based on the results of the analyzed Japanese cases, a more general proposition is derived:

P7: Cultural or community characteristics facilitate the success of a collaborative recovery

6. DISCUSSION AND CONCLUSION

The multiple case study results indicate that there is indeed an opportunity to gain inter-organizational competitive advantage by sharing resources during a disruption recovery. This is in compliance with the relational view theory. Value, i.e. competitive advantage, is extracted from network resources and their utilization which refers to the idea of Dyer and Singh (1998).

Even though only a limited amount of cases were analyzed, propositions could still be derived. For instance, the seventh proposition which focuses on cultural characteristics is a general proposition which is solely based on findings of the analyzed Japanese companies' culture. The result that most of the analyzed cases took place in Japan led to this position. Furthermore, the relevance of social capital for collaboration is supported by the findings of Bello and Bovell (2012).

Supply chain professionals can derive useful insight from the cross case analysis' results. First, when identifying resources that may temporarily be shared in case of a disruption, this paper gives a first insight into which resources' development might be beneficial to invest in. For instance, inter-organizational trainings may be helpful as it facilitates the transfer of employees to different tasks if required. A constant flow of employees across the network partners is common practice at Toyota (Nishiguchi & Beaudet, 1998). Second, collaboration is possible across all categories of network partners. Thus, involvement of all active and passive parties may be beneficial when planning for a recovery. Third, there is a huge potential for companies to plan for collaborative recoveries. Planning would include the identification of potentially supporting, often dependent, network actors and the definition of a central coordination entity.

The analysis disclosed some questions that were not answered in the course of this research. For instance, the existence of additional recovery activities, apart from collaboration, and their respective stake in the recovery were not discussed. The adequateness of the measure time-to-recover to assess the success of a recovery and to draw conclusions on the competitive advantage needs to be addressed in further research. Potential for further research also exists regarding the refinement of the analyzed resources, characteristics and actors.

Regarding the methodology applied, case study research has limitations with regard to the attainable level of generality (Eisenhardt, 1989). However, there is potential for further case studies in the field of collaborative recovery. More specifically, it would be beneficial to have in depth analyses based on the derived propositions. This could be, for instance, the analysis of cases with different community cultures or different triggers to collaborate. Furthermore, other enablers of collaborative recovery may be worth to investigate, such as the type of products that are produced by a disrupted company (Whitney et al., 2014), or the duration of a partnership between collaborating actors. After setting a comprehensive qualitative base, survey data for defined variables and statistical analysis in order to test the proposition are required.

Overall it can be stated that while still in its infancy, this research shows that collaborative recovery is a promising reactive method to enhance supply chain resilience.

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BIOGRAPHICAL NOTES

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