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IJMBE International Journal of Management, Business, and Economics

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Abstract

The supply chain resilience literature is mainly influenced by big disasters. But results from different studies suggest that instead of disasters more likely risks with lower impact are much more important for the resilience of a SC. Especially the transportation task is often neglected in the field of resilience studies. Therefore, this paper investigates in the question of what are the ordinary drivers of resilience and vulnerabilities in international supply chains. We conducted a survey in the international garments supply chain taking into account that often developing countries are part of SC that are exposed to different risks than industrial nations are. About 100 responses from practitioners reveal that logistics is a main influencer of SC resilience. As a consequence, managers who aim to make a supply chain more resilient should put the focus more on the logistics part of a supply chain.

Keywords: Supply Chain Management, Risk Management, Resilience, Developing Countries

1. Introduction

Globalisation exerted high pressure on enterprises to improve efficiency, reduce costs and keep prices low (Christopher and Rutherford 2004). As a consequence, sourcing and production was often relocated into countries with low labour costs, namely developing countries like Pakistan, Bangladesh etc. Therefore, nowadays not only big enterprises are part of international supply chains (ISC) but nearly each enterprise acts – be it as a customer or a supplier – in such an arrangement (Jaehne 2009; Thun and Hoenig 2011). The advantages are obvious: tariff and trade concessions, low cost direct labor, capital subsidies, or reduced logistic costs (Ferdows 1997). But in return, supply chains (SC) also face serious challenges like logistics and transportation costs or longer lead times (MacCarthy and Atthirawong 2003). Therefore, working in ISC requires a high coordination of services, information, flow of goods etc. (Manuj and Mentzer 2008). Especially, when developing respectively underdeveloped countries are part of the business the coordination of the ISC becomes difficult due to underdeveloped transportation and communication infrastructure, inadequate workers skills, supplier availability, supplier quality, equipment, or technology (Meixell and Gargeya 2005). Instable political situations, cultural and economic circumstances, environmental hazards or other more or less unpredictable disruptions may also seriously affect the functioning (Oke and Gopalakrishnan 2009). Aggravating, the more markets, regions or countries are included and the higher the social, cultural and economic differences between participating regions are, the more unclear the risk situation becomes (Wu et al. 2010).

Although the risk exposure is very high and the ISC is affected by many risk events every day, business is generally functioning to a high percentage. Otherwise, we would face severe disturbances all the time. What makes ISC work despite risks and disruptions, is called resilience. Even if a system of SC partners fluctuates greatly and has a low stability, it can be very resilient (Holling 1973). Several authors have investigated in the phenomenon of SC resilience (see section 3) but the knowledge about resilience, its influencing factors and relations between resilience, risk measures, risk exposure etc. is still scarce. Many papers are of theory building nature and focus on severe, catastrophic disruptions (e.g. Blackhurst et al. 2011; Dalziell and McManus 2004; Fiksel 2003; Gallopin 2006; Jüttner 2005; Peck 2005; Pettit et al. 2010; Ponomarov and Holcomb 2009; Sheffi 2005). But different investigations show that such disruptions are of lower importance for the resilience of a SC (Peck 2005; Thun and Hoenig 2011; Wagner and Bode 2006, 2008). Although logistics is a key factor for a functioning SC, its role for resilience is hardly been analyzed (Colicchia et al. 2010). Therefore, we conducted an empirical study to identify the influencing factors of SC resilience that explicitly considers the role of logistics. Object of investigation is the garments industry that is typical for ISC with partners in developing as well as in industrial countries. We concentrated our survey on the production in Pakistan as a developing country that is prone to sudden and long disruption because of unstable political situations and underdeveloped infrastructure (Kleindorfer and Saad 2005). Especially in such developing countries, the vulnerability of the ISC must regularly be balanced so that we are facing an ideal environment for analyzing the ISC resilience. In this survey, we asked about 100 garments manufacturers in Pakistan in a direct interview based on a questionnaire that was developed in advance. The questionnaire consisted exclusively of closed questions so that all interviews are directly comparable.

The remainder of this paper is organized as follows. In section 2, we characterize the garments SC and its risk exposure before we give an overview over the related literature in section 3. In section 4 we derive the theoretical framework for the survey and develop its underlying model and hypotheses. The results of the survey are presented in section 5. In section 6 the analysis and the implications that can be derived from the survey are presented. The paper closes with a conclusion in section 7.

2. Risks in the international garments supply chains

Pakistan is well known for its cotton and garments production and an important garments supplier for Europe and North America (Aziz 2002). Most members of the Pakistan Readymade Garments and Export Association (PRGMEA) and the Pakistan Hosiery Manufacturers Association (PHMA) are located in the three cities Karachi, Lahore and Sialkot. The quality of locally produced fabric, dyeing material and processes as well as low prices make it competitive in the international market although the quality of Pakistani cotton is substandard (Salam 2008). The production is make-to-order because of the customer's requirements for the type and color of the fabric, design of the garment including type, model and sizes. The raw fabric is procured from the weaving mills in Pakistan. The packing material, accessories and labels are procured from within the local market as well as from international markets. The dyeing usually is done separately. Cutting, stitching, fastening, threading and ironing are done together in one enterprise. The finished goods then are packed and shipped to the customers (see Figure 1).

Usually, a developing country is often exposed to natural risks like severe weather or natural disasters. This may lead to insufficient availability (quality and quantity) of raw or material, preliminary products and may also influence the production and transportation. The political situation is often not stable and therefore may influence the trading between countries or the production of products. Strike and riots for example lead to downtimes of production and transportation problems. Also corruption and problems with the government often are severe problems. The social situation and with this the cultural behavior are completely different in parts to those of industrial nations. Many employees underlie social obligations or are bound by part time farming so that they are suddenly missing for the production. Local or religious festivities have a similar effect. The infrastructure of developing countries usually faces problems of stability and availability. Gas and oil are often not available so that longer disruptions of power supply occur. Additionally, technical problems and old technology regularly lead to disturbances.

On the procurement side, the main risk is not getting the needed quantity of goods with the desired quality at the planned costs in time (Zsidisin 2003). Due to natural disasters the availability of cotton often is impaired. Political unrest for example may result in closure of weaving mills for several days. Depending on the season (especially in winter), the production of the weaving mills is affected and reduced by disturbances of the gas supply. Also other political and social problems may affect the production continuity and capacity as well as energy shortages and machine breakdowns so that there is not enough fabric produced. Concerning the production, the main problem lies in the availability of skilled workers. Because of the competitive environment, workers are changing their employment from one day to another. The number of skilled workers is limited so that less skilled workers whose productivity is much less has to be employed. Additionally, the general risks also hold for the production. Political, social, structural and environmental risks affect the garments production itself in the same way like the production of raw material and preliminary products. The same is with the distribution side. The main risk consists of the danger that the goods cannot be delivered in time to seaport so that big delays in delivery time occur. A delay does not cause a deterioration of quality but the longer the transportation lasts, the more the probability of loss of products rises due to theft, corruption etc. Besides, the garments industry produces seasonal products that are strongly influenced by fashion trends. That means that if a delivery date is not met, the products may be outdated and less valuable. When facing time problems enterprises can switch to overtime production or sub-contracting. Also the use of alternate faster transport is feasible. A higher production intensity is usually not possible or only in a very narrow range because the stitching is handmade and can hardly be expedited.

3. Literature Review

Although risk management and resilience have already been discussed much earlier, they came back into the focus of research after several disasters and crisis occurred in the beginning of the new century (Manuj and Mentzer 2008). Especially the phenomenon of resilience lacked a comprehensive understanding so that several authors investigated in the general understanding of resilience (e.g. Fiksel 2003; Jüttner 2005; Peck 2005; Sheffi 2005). Bhamra et al. (2011) as well as Pettit et al. (2010) give an overview over the related literature. Most of the papers in the field of SC resilience is normative, case study-based or of qualitative nature (Wagner and Bode 2006).

Jüttner (2005) focused solely on the supply chain risk management (SCRM). The main purpose of her study was to discover the state of the art of SCRM in companies the requirements towards it. Therefore, she conducted a survey of 137 quantitative questionnaires. The analysis of the questionnaire was descriptive and its result was discussed with six focus groups of senior level SC managers. Peck (2005) used a case study followed by interviews of 47 managers in the air craft industry to identify the main drivers and sources of risks in SCs. Manuj and Metzer (2008) used qualitative interviews of 14 managers from eight companies. Their focus was on six strategies to mitigate risks in SCs and when they should be used. They also identified the two moderators' complexity and inter-organizational learning that influence the implementation of risk management in companies. Oke and Gopalakrishnan (2009) analyzed in a case study the typical risks and mitigation strategies in a retail SC. They collected their data via interviews and observations of distribution centers and headquarters. They found that most of the identified risks are either low-impact frequently or high-impact infrequently occurring risk.

By analysing the related literature, Pettit et al. (2010) derived a conceptual framework of SC resilience consisting of vulnerabilities and capabilities. They identified a zone of resilience between a too high exposure to risks and the erosion of profits. Subsequently, they tested and refined their framework with the help of eight focus groups. All groups were composed of SC managers of a big apparel company. Within the groups, they identified 50 examples of vulnerabilities and 96 specific capabilities. Pettit et al. (2013) used the findings of their former paper to implement an assessment tool. This tool should help enterprises to subjectively measure their level of resilience. For this, a participant has to assess the capabilities and vulnerabilities of his company. Seven companies were selected to use the assessment tool. This was followed up by a qualitative validation via focus groups. As a result, Pettit et al. (2013) were able to link vulnerability factors with capability factors but without giving a quantification of the relations.

Blackhurst et al. (2011) conducted a case study in the automotive industry focusing on the supply side of an automobile manufacturer. They interviewed key informants at the manufacturer as well as at two first-tier suppliers and at a distribution center. In addition, they interviewed executives at six firms of different industries to broaden the knowledge that they gained during the case study. They identified resiliency enhancers and reducers that both affect the resilience of the SC. As with the other papers mentioned above, because of the qualitative nature of the research methods no quantifications of and linkages between enhancers and reducers could be made.

Thun and Hoenig (2011) conducted a survey with 67 manufacturing plants of the automotive industry. They identified and analyzed the most typical internal and external SC risks. They categorized the firms into companies with a high and low degree of SCRM implementation and the SCRM measures in reactive and preventive. Then, they analyzed which combination of firms and SCRM affects the SC performance in which way.

Wagner and Bode (2006) investigated in the relationship between SC risks and SC vulnerability. For this they conducted a survey with 760 practitioners from different industries. They differentiated after demand-side, supply-side and catastrophic risks and identified different drivers for SC vulnerability. With their model, they could explain only a small portion of the variance in the dependent variables. In Wagner and Bode (2008), they used the same survey but changed their setting. They introduced two more risk classes and changed their hypotheses. Instead of measuring the relation between vulnerability drivers and risk level, they measured the risks and their impact on the SC performance. However, the result was similar to their first investigation and did not improve significantly.

Colicchia et al. (2010) focus their research on the transportation task in SCs that is said to be the most critical phase of the sourcing process. They identify different vulnerability areas and categorise these areas into three classes. In addition, several mitigation strategies are derived. Then, they conduct a simulation study and analysed several scenarios for a home appliance retailer with suppliers located in China. They found a significant reduction of the variability of supply lead time when applying the mitigation strategies.

4. Theoretical Framework and Model Development

The term resilience is referred to as 'the capacity of a system to absorb disturbance and reorganize while under-going change so as to still retain the same function, identity and feed backs' (Walker et al 2004). This means that a resilient SC in case of disruption and its output may be affected by disruptions so that SC partners recognize deviations. But the SC itself does not stop to work. Resilience is a product of two factors: Vulnerability and adaptive capacity also referred to as adaptive capability (Dalziell and McManus 2004; Gallopin 2006). Vulnerability is referred to as the degree to which a SC is prone to disturbances (Pettit et al. 2010). This comprises all factors that make a SC weak and that are starting points where risks can take effect. Adaptive capability is 'the extent to which a system can modify its circumstances to move to a less vulnerable condition' (Luers et al. 2003). This can be reached for example by measures that make the SC more flexible in cases when disturbances occur. Then, processes shift from one mode to another so that risks do not take effect (Blackhurst et al. 2011). The effects of vulnerability and adaptive capability on the SC resilience are adverse: While vulnerability decreases the resilience, adaptive capability increases it (Pettit et al. 2010). In general, we get a three factor model of resilience, adaptive capability and vulnerability.

While Wagner and Bode (2008) found that 'supply chain risks only partially explain the variance in supply chain performance' Hendricks and Singhal (2005) empirically proved a significant relation. Because severe disruptions are of lower interest (Peck 2005; Thun and Hoenig 2011; Wagner and Bode 2006, 2008), we focus on more frequently risks with less impact. An ISC can be affected by many risks from inside and outside. That means, from the point of view of one enterprise, risks result from respectively affect the production (inside) and the in- and outbound logistics (outside). Especially the logistics/transportation part is usually neglected (Colicchia et al. 2010) although it can lead to high competitive advantages (Ponomarov and Holcomb 2009). For both parts, the three factor resilience model is applied and culminates in a global SC resilience.

From a business point of view, risks can affect the four factors time, quantity, quality and costs, respectively prices (Lockamy and McCormack 2010; Manuj and Mentzer 2008). All of them are critical factors for sustainability, profitability, and the functioning of the ISC (Hussain et al. 2009). Deviations in three of the factors lead to deviations in the fourth factor costs. If the quality is inadequate, there are usually more rejects and more items have to be produced. Then, also possibly time schedule deviations may occur due to the necessity of producing more than planned. If there are not enough items produced or shipped, the time schedule for the missing items is violated and the enterprise faces penalties. The same is with deviations from agreed dates because then the customer gets fewer items than ordered so that a fine is applicable. Therefore, we can divide the four factors into three groups: the costly result, the timely deviation and the two cause's quantity and quality.

The costs level is the result of the global supply chain resilience. That means the higher the resilience of the supply chain is, the less deviations from planning the supply chain has to face (Pettit et al. 2010) and therefore the lower the costs (production risk costs C1, transportation risk costs C2) are that are caused by risk events (hypothesis H1). If an enterprise does not manage to deliver the correct amount of items or the correct quality this finally leads to deviations in the time schedule.

Therefore, the global resilience of the supply chain can be measured by deviations from the time schedule (unmet production schedules G1, unmet transportation schedules G2).

The global resilience is then divided into the two resilience subsystems of production and transportation. The more resilient the production is, the more resilient the SC is (H2) and the more resilient the transportation is, the more resilient the SC is (H5). As stated above, quantity and quality are evident for the functioning of the supply chain (Hussain et al. 2009; Lockamy and McCormack 2010; Manuj and Mentzer 2008). Therefore, resilience for production is measured by its qualitative (PR2) and quantitative output (PR3) and the transportation resilience by losses and (TR1) and capacity limitations (TR2). In addition, the production resilience may be affected by the general production capacity. The higher the capacity is, the better it usually can respond to risk situations. Therefore, the production per day (PR1) as well as the workers machine ratio (PR4) is considered.

Production risks like necessities of extra lead time (PV1), shortages of raw material (PV2), shortage of workers (PV3), machine closure (PV4), or utilities break downs (PV5), define the vulnerability of the production side. The more these risks are experienced the more vulnerable the production part is (Manuj and Mentzer 2008; Pettit et al. 2013; Wagner and Bode 2006, 2008). And the more vulnerable the production is, the less resilient it is (H3). But the risk exposure of the production can be mitigated by adequate risk measures like the use of alternate suppliers (PA1), alternate production methods (PA2), or alternate utility sources (PA3) (Colicchia et al. 2010; Pettit et al. 2010). The more measures can be taken into account, the more flexible the production is and the better it can respond to risk situations. Thus, the available measures define the adaptive capability of the production. The more capable the production is, the more resilient it is against risk events (H4).

The transportation suffers from extra lead time (TV1). In addition, delays can occur at different points in the shipping process: at shipping service providers (TV2), at road haulage (TV3), at processing of shipment (TV4) or at departure schedules (TV5). The less the transportation is vulnerable due to these risks, the more resilient the transportation is (H6). However, the transportation resilience is positively affected by its logistic capabilities (Ponomarov and Holcomb 2009). Especially flexibility is seen as a main driver of the adaptive capability (Blackhurst et al. 2011; Colicchia et al. 2010; Pettit et al. 2010, 2013). Therefore, the transportation's capability is measured by alternative shipping service provider (TA1) and methods (TA2). The more capable the transportation is, the more resilient it is (H7).

The resulting model for the survey is depicted in Figure 3.

The corresponding hypotheses can be summarised as follows:

H1: The higher the supply chain resilience is, the lower the supply chain risk costs are.
H2: The higher the production resilience is, the higher the supply chain resilience is.
H3: The less vulnerable the production is, the higher the production resilience is.
H4: The higher the production's adaptive capability is, the higher the production resilience is.
H5: The higher the transportation resilience is, the higher the supply chain resilience is.
H6: The less vulnerable the transportation is, the higher the transportation resilience is.
H7: The higher the transportation's adaptive capability is, the higher the transportation resilience is.

5. Model Analysis

In 2013, we conducted a survey to answer our research questions concerning the SC resilience, its influencing factors and its cost implications in the international garment industry. 91 enterprises from Pakistan completed the questionnaire of 25 questions during a personal interview. We used a 5-point Likert scale for all questions. Because the questions in our questionnaire are negatively formulated concerning the resilience, we later inverted the scale for indicators C1, C2, G1, G2, PR2, PR3, TR1, and TR2 so that the constructs represent the resilience and not the weakness of the SC.

To identify and analyze the relationship between unobserved constructs we used a structural equation model (SEM). The objective is to examine the correlation between the theoretical assumption and the econometric analyses (Fornell and Larcker 1981; Chin 1998a) so that one receives a "parameter estimation and hypothesis testing in causal models" (Fornell and Larcker 1981). The SEM can be divided into two parts. The outer model named measurement model specifies the relationship between the constructs and their indicators. The inner model is referred to as structural model with whom the relation between the constructs will be analyzed (Chin 1998b).

5.1 Outer Model

In the construct "Risk Costs" only the indicator C2 is significant (see in the following Table 1) and has a positive influence on the construct. Also the construct "Supply Chain Resilience" has only one significant indicator (G2) with a positive influence. Concerning the "Production Resilience" three (PR1, PR3, PR4) of four t-statistics exceed the limit of 1.65. PR3 and PR4 exceed the limit of 0.1 positively and PR1 negatively. Two (PV2, PV5) of five indicators of the construct "Production Vulnerability" are significant. Regarding the construct "Production's Adaptive Capability", PA1 and PA3 satisfy the limit of 1.65 for the t-statistics as well as the weight limit of 0.1. Only PA2 does not have a significant influence on the construct. Concerning the "Transportation Resilience", the t-statistic criterion of both indicators (TR1, TR2) as well as the weight criterion is fulfilled. Two (TV2, TV3) of five indicators have a significant positive influence on the construct "Transportation Vulnerability", one indicator influences the construct negatively, two indicators (TV4, TV5) are not significant. Concerning the "Transportation's Adaptive Capability", all indicators (TA1, TA2) are significant and have a positive influence on the construct.

The criterion discriminant validity is fulfilled for the formative constructs: The highest latent variable correlation that is between transportation resilience and supply chain resilience is 0.8872 in our model. This does not exceed the allowed maximum of 0.9. Thus, all indicators are sufficiently different and independent.

5.2 Inner Model

For the significance of the relationship between the constructs, it is evident that there is no multi-collinearity so that the regression analysis is performable (Weiber and Mühlhaus 2010, 207). The variance inflation factor VIF=1/(1-R^2) indicates whether there is multi-collinearity or not and should therefore be lower than 10 (Diamantopoulus and Winkelhofer 2001; Huber et al. 2007). The coefficient of determination R2 is substantial if R2 exceeds the limit of 0.67 and said to show a moderate level if R2 exceeds the limit of 0.33. A weak level is achieved if R2 exceeds the limit of 0.19 (Chin 1998b). Table 2 shows the values for the different criteria of our model. VIF is much lower than 10, and R2 is average for risk costs and substantial for the supply chain resilience.

The accuracy of our hypotheses is determined by the t-statistics and the path coefficients. For the t-statistics, it is essential to exceed the limit of 1.65 in order to be meaningful (Weiber and Mühlhaus 2010, 259) and the path coefficients have to exceed the limit of 0.1 (Lohmöller 1989; Chin 1998a, claims a limit of 0.2). To confirm a negative relation between the constructs the path coefficient has to be less than -0.1 (Weiber and Mühlhaus 2010).

Table 3 shows the path coefficients and the t-statistics of the four endogenous constructs supply chain resilience, risk costs, production resilience and transportation resilience. Concerning the t-statistics, only the relation between production resilience and supply chain resilience is not meaningful, all the other are meaningful.)

6. Results and Implications

We will first have a look at the general result of the model and our hypotheses. The general result is very satisfying. The coefficient of determination of 81% for the supply chain resilience is quite high. That means that the constructs can explain the supply chain resilience very well. Similar with risk costs whose coefficient of determination still shows a moderate level with 58%. Besides these endogenous latent variables the constructs production resilience and transportation resilience show a weak R-square with 32% and 25%. All this means, that we can use the model to develop strategies for an amelioration of the supply chain resilience. Concerning the hypotheses, we discover positive, negative or no influences. See Table 4 for the relevant criteria. According to these criteria, we have to preliminarily reject hypotheses H2. All remaining hypotheses fulfil the constraints. Hypotheses H3 and H6 are confirmed with a small influence as well as H5 with a large effect (Chin 1998b).

Not surprisingly, the negative relation between supply chain resilience and risk costs is confirmed by the model (H1). This implies that investments in more robust SC processes and a better resilience will pay off in lower risk costs. However, like always it is crucial not to overinvest (Pettit et al. 2010). In particular, the transportation part is evident for this pay off because the significant indicator for the risk costs construct is shipping risk costs. A high resilience predominantly avoids shipping costs. 80% of the interviewed practitioners agree to this. The predominance of the shipping part goes on with the SC resilience that is best measured by the shipping indicator.

The production resilience is significantly influenced by the production per day (PR1), the met output quantity (PR3) and the workers machine ratio (PR4). The met output quality (PR2) is not significant for the production resilience. The influence of PR1 is negative. That means the higher the production quantity per day is the lower the production resilience is. This result is reasonable because a high production quantity per day means a high degree of capacity utilisation. If the unused capacity is low, the flexibility to react on disruptions is also low and therefore also the production resilience. About 96% of the interviewees indicate a production quantity of maximum 500 units. 80% report that production quantity targets are met and still 70% usually meet their production schedules. 80% of the enterprises have 51 to 100 workers per machine. Most probably because of the high production resilience, hypotheses H2 (influence of production resilience on SC resilience) cannot be confirmed. The effect size of H2 is quite low. However, hypotheses H3 and H4 are confirmed. Hereby, the production vulnerability has a weak effect on the production resilience. Disruptions concerning the supply of raw material (PV2) and the utilities (PV5) are of significance for the vulnerability. Only 12% of the firms experience delays in the procurement of raw material and 21% often utilities break downs. Also the shortage of workers (12%) and the closing of machines for repair (10%) are on a comparable level. The breakdown of utilities often cannot be influenced. But especially the procurement of raw material can be improved. Concerning this, it would be interesting to investigate in the reasons for this quite low performance. If the bad performance of suppliers is the reason, several measures can lead to improvements. One could intensify the relation to the suppliers and establish long-term relationships. In addition, a multi-sourcing strategy would also be feasible. Another reason for the delays in raw material procurement could be problems with the logistics.

As the analysis shows, the transportation is of high importance for the SC resilience. The effect size of H5 is the highest. Therefore, the positive effect of the transport resilience on the SC resilience is confirmed. Hereby, all indicators of the transportation resilience are also significant for the construct. Thus, when taking actions to make a SC resilient the focus should be on the transportation part. This result may be surprising because often the production and supply part is optimized with regards to resilience and risk management. But we have to recall that we examine the resilience of ISC with partners spread all over the world and long transportation routes. Therefore, the logistics has a much greater share in the value creation than in national SC. In addition, garments SCs have many partners in developing countries that typically have underdeveloped transportation infrastructures with bad routes, unreliable shipping service providers, poor haulage means, and insufficient transportation capacities. Therefore, the SC management should focus on ameliorating the transportation resilience. Hypotheses H6 and H7 provide insights where it is worthwhile to start with amendments and investments in the transportation part.

As assumed, the transportation vulnerability has a negative effect on the transportation resilience (H6 is confirmed). Especially delayed shipping requests and shipping delays due to haulage influence the vulnerability. Therefore, the relation to the shipping service providers should be in the focus. A faster and more reliable communication with the provider should be established so that transportation problems can be identified more quickly. Internally, delays should be minimized by standardizing and monitoring the processes involved. Besides, it is feasible to install a suitable logistics information system. Due to external factors, the haulage delays can only partially be influenced. At the most, the selection of transportation service providers can be done more accurately. For example, the reliability can be measured by the availability of modern means of transportation or the use of satellite based monitoring systems.

However, also the transportation's adaptive capability positively influences the transportation resilience (H7 confirmed). Alternate shipping service providers as well as alternate shipping methods both improve the adaptive capability and therefore the transportation resilience. About 60% of the enterprises already use alternate shipping service providers and about 50% use alternate shipping methods. Even if the capability level seems to be already high, there is still room for improvement.

7. Conclusion

Our analysis confirmed the hypothesis that the logistics part plays a very important role for the resilience of a SC (Colicchia et al. 2010; Ponomarov and Holcomb 2009). If we combine this result with former awareness's that severe disruptions are of lower importance for the resilience of a SC (Peck 2005; Thun and Hoenig 2011; Wagner and Bode 2006, 2008), we can state that SC management should focus more on improving the general functioning of SCs instead of preparing for the big disaster. This does not mean to be unprepared for this. But it is comprehensible that a firm should not 'over prepare' (Pettit et al. 2010).

However, there are also some limitations concerning our research. First of all, the survey concerned the garments SC with its special conditions so that the results cannot be transferred identically to other industries. Secondly, the survey addressed exclusively enterprises in Pakistan. Thus, it reflects the view of enterprises in a developing country. It is conceivable, that partners of industrial nations have a slightly different look on the problems and the estimations of the Pakistani companies. It is conspicuous that the qualitative output is seen as high and that the great majority does not experience unmet production schedules. Future research should therefore investigate in the question how SC partners in different countries judge the performance and the resilience of the garments SC.

Acknowledgements

We thank all volunteers, and publications support and staff, who wrote and provided helpful comments on previous versions of this document. Some of the references cited in this paper are included for illustrative purposes only.

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Appendices

Appendix A Questionnaire

Construct	Indicator	Question
Risk Costs	C1	How often excess manufacturing costs are experienced?
	C2	How often excess shipping costs are experienced?
Supply Chain Resilience	G1	How often unmet manufacturing schedule targets are experienced?
	G2	How often unmet shipping schedule are experienced?
Production Resilience	PR1	Production per Day
	PR2	How often excess manufacturing rejects are experienced?
	PR3	How often unmet manufacturing quantity targets are experienced?
	PR4	Workers Machine Ratio
Production Vulnerability	PV1	How often extra lead time is negotiated in the manufacturing plan?
	PV2	How often delays in procurement of raw material are experienced?
	PV3	How often shortage of workers is experienced?
	PV4	How often machines are closed for repair/maintenance work?
	PV5	How often utilities break down occurs?
Production's Adaptive Capability	PA1	How often alternate suppliers of raw material are used?
	PA2	How often alternate production methods are used?
	PA3	How often alternate utility sources are used?
Transportation Resilience	TR1	How often excess transportation losses are experienced?
	TR2	How often shipping capacity limitations are experienced?
Transportation Vulnerability	TV1	How often extra lead time is negotiated in the transportation plan?
	TV2	How often shipping requests are delayed at shipping service provider?
	TV3	How often shipping delays occur during road haulage to/from ports?
	TV4	How often shipping delays occur during processing of shipment?
	TV5	How often shipping delays occur in departure schedules of shipment?
Transportation's Adaptive Capability	TA1	How often alternate shipping service providers are used?
	TA2	How often alternate shipment methods are used?

Table 1 Significance of the Outer Model

Construct	Indicator		Weight	t-Statistic
Risk Costs	C1	Unmet Production risk costs	0.123	0.574
	C2	Unmet Transportation risk costs	0.978	6.355
Supply Chain Resilience	G1	Met Production Schedules	0.112	0.540
	G2	Met Transportation Schedules	0.983	6.712
Production Resilience	PR1	Production per Day	-0.325	1.654
	PR2	Met Output Quality	0.076	0.596
	PR3	Met Output Quantity	0.644	3.489
	PR4	Workers per Machine	0.452	2.682
Production Vulnerability	PV1	Extra Lead Time	-0.275	1.642
	PV2	Shortages of Raw Material	0.359	2.149
	PV3	Shortages of Workers	0.091	0.615
	PV4	Machine Closure	0.270	1.595
	PV5	Utilities Breakdown	0.308	2.108
Production's Adaptive Capability	PA1	Alternate Suppliers	0.515	3.313
	PA2	Alternate Production Methods	0.226	1.210
	PA3	Alternate Utility Sources	0.374	2.002
Transportation Resilience	TR1	Unmet Transportation Losses	0.447	3.478
	TR2	Unmet Capacity Limitations	0.596	4.979
Transportation Vulnerability	TV1	Extra Lead Time	-0.322	2.160
	TV2	Delay Shipping Service Providers	0.466	2.301
	TV3	Delay Road Haulage	0.385	2.403
	TV4	Delay Shipment Processing	-0.021	0.138
	TV5	Delay Departure Schedules	0.085	0.369
Transportation's Adaptive Capability	TA1	Alternate Shipping Service Providers	0.684	4.319
	TA2	Alternate Shipping Methods	0.389	2.330

Table 2 Factor Analysis of the Inner Model

Construct	R Square	VIF
Supply Chain Resilience	0.8097	1.5085
Risk Costs	0.5806	1.1127
Production Resilience	0.3183	2.9037
Transportation Resilience	0.2447	1.0637

Table 3 Structural Model

from	to	Path coefficient	t-statistic
Supply Chain Resilience	Risk Costs	-0.762	25.543
Production Resilience	Supply Chain Resilience	0.151	0.849
Production Vulnerability	Production Resilience	-0.412	4.223
Production's Adaptive Capability	Production Resilience	0.220	2.813
Transportation Resilience	Supply Chain Resilience	0.875	6.467
Production Vulnerability	Transportation Resilience	-0.326	4.420
Production's Adaptive Capability	Transportation Resilience	0.217	3.015

Table 4 Hypotheses

	t-statistic		Path coefficient	
	result	fulfillment	result	fulfillment
H1	25.543	>1.65	-0.762	<-0.1
H2	0.849	–	0.151	>0.1
H3	4.223	>1.65	-0.412	<-0.1
H4	2.813	>1.65	0.220	>0.1
H5	6.467	>1.65	0.875	>0.1
H6	4.420	>1.65	-0.326	<-0.1
H7	3.015	>1.65	0.217	>0.1

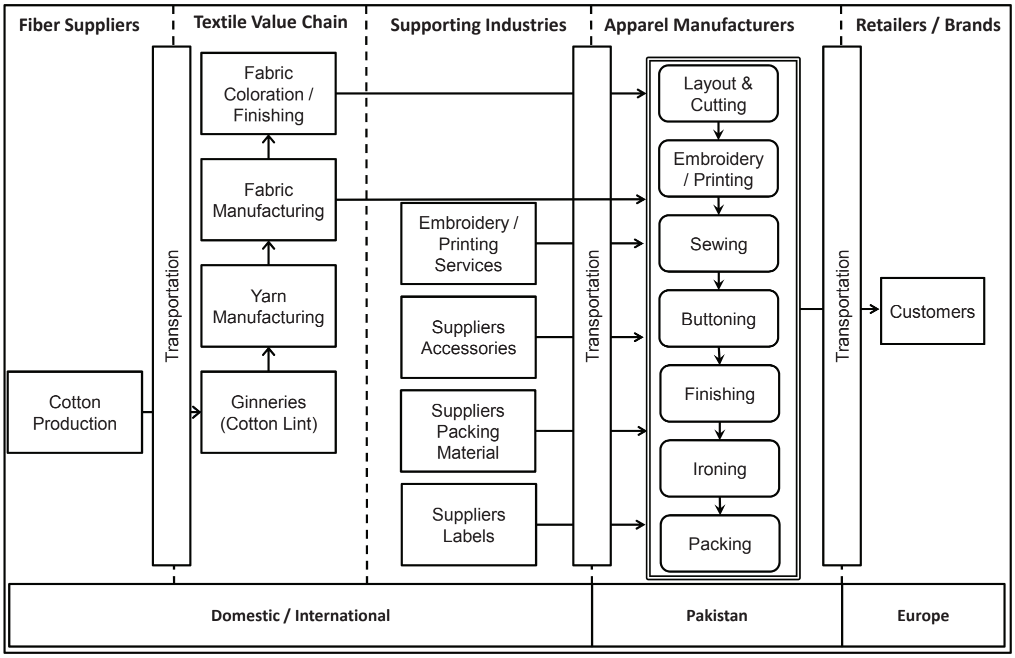

Figure 1 Supply Chain Structure

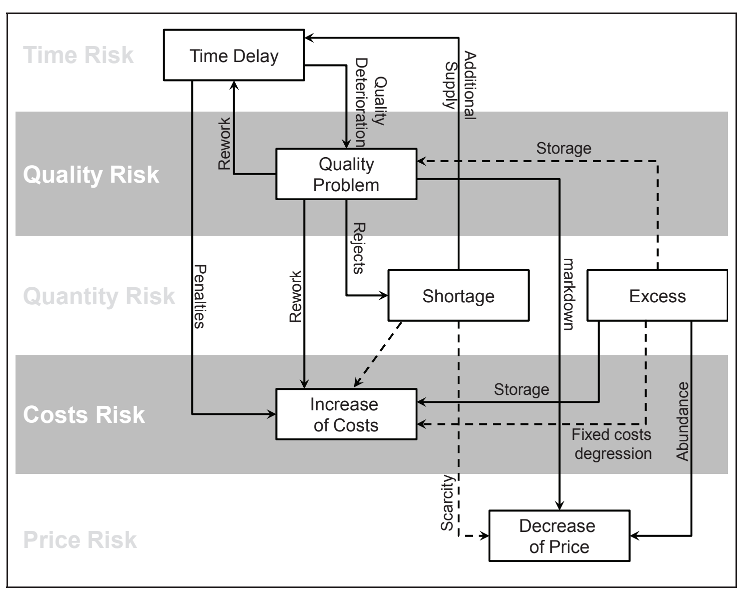

Figure 2 Risk Cause-Effect-Network

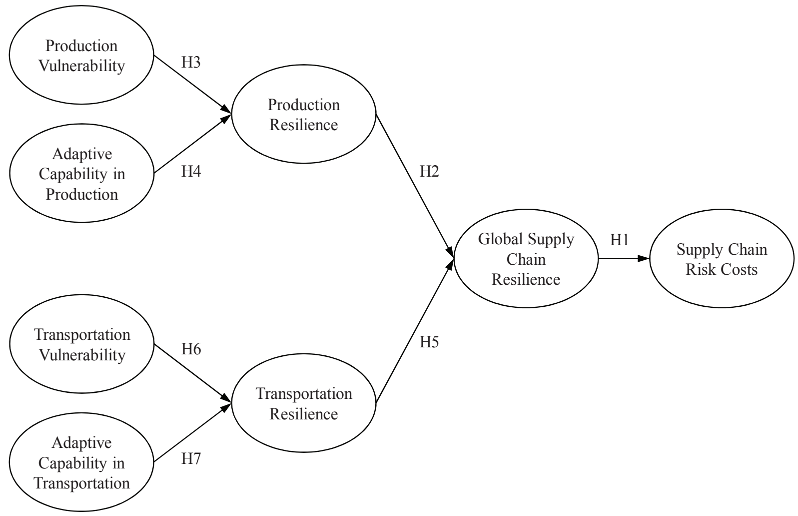

Figure 3 Research Framework