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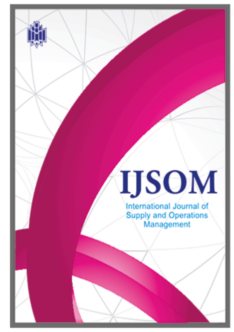

Optimizing diamond structured automobile supply chain network towards a robust business continuity management

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Abstract
This paper presents an optimized diamond structured automobile supply chain network towards a robust Business Continuity Management model. The model is necessitated by the nature of the automobile supply chain. Companies in tier two are centralized and numerically limited and have to supply multiple tier one companies with goods and services. The challenge with this supply chain structure is the inherent risks in the supply chain. Once supply chain disruption takes place at tier 2 levels, the whole supply chain network suffers huge loses. To address this challenge, the paper replaces Risk Analysis with Risk Ranking and it introduces Supply Chain Cooperation (SCC) to the traditional Business Continuity Plan (BCP) concept. The paper employed three statistical analysis techniques (correlation analysis, regression analysis and Smart PLS 3.0 calculations). In this study, correlation and regression analysis results on risk rankings, SCC and Business Impact Analysis were significant, ascertaining the value of the model. The multivariate data analysis calculations demonstrated that SCC has a positive total significant effect on risk rankings and BCM while BIA has strongest positive effects on all BCP factors. Finally, sensitivity analysis demonstrated that company size plays a role in BCM.

Keywords: Business Continuity Plan, Diamond supply chain, Automobile supply chain network, Supply Chain cooperation, Risk ranking, Competitive Advantages, Recovery time.

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1. Introduction

The 21st century has presented the automobile industry with unprecedented operational challenges. According to the National Highway Traffic Safety Administration (published in 2013), in 2012 the auto industry recalled close to a third more vehicles in the U.S. The report further states that recalls were increased 25% from 2012 to 2013, which is the industry's highest rate since 2004 when 30.8 million vehicles were involved in such campaigns. Apart from recalled cars, we note that the global production system has become a complex, networked system that has operated efficiently under normal conditions (Kazemi et al, 2015; Mohamadi et al, 2015; Darvish et al, 2014; Poorbagheri and Akhavan, 2014). Nevertheless, disasters remain the biggest threat to the gains made over the years. Recent mega disasters around the world have revealed the networked world's vulnerability to major disasters. Companies in disaster-affected areas are part of the network and therefore crucial in the flow of information, goods and services within the supply chain network. Therefore, any supply chain disruption may force manufacturers across the world to suspend their operations. Morris et al. (2011) concluded that these operational challenges are very complicated to address, as there are both internal and external. Thus, a broad and detailed business appreciation of the sector is a requirement. Harryson (2006, p.91) states that, enterprises have to be up to date with latest knowledge and technology *(which are dynamic)* for significant benefits. Consistent improvement is crucial for innovative, scientific and engineering breakthrough towards competitive advantages. Externally, enterprises are to prepare for 'the unknowns' and out of enterprises' power, *(sometimes faults of others within the supply chain network)* a task that has proven particularly difficult. Morris et al. (2011) states that due to increasingly turbulent external environment, companies are to continually adapt, adjust and redefine their value proposition. Scholars and industry professionals pay attention to finding or establishing the most effective and efficient ways to address these critical challenges.

1.1 Background of the study

The automobile industry is one of the complicated supply chains. There are so many companies involved in the production of a single automobile unit and as a result, network players cannot usually identify all companies in their network. On average, an automobile unit consists of about 35,000 parts, from companies trading in completely different industries. Some of the industries include electrical and electronic, computer programming and software engineering, smith and upholstery, chemical technology and engineering, thermos fluid dynamics and mechanical engineering, fuel control system etc., among others. In this regard, producing a single unit involves efficiently and chronologically bringing all the parts together. To simplify this extensive supply chain network, the supply chain is made of up of four tiers and a dozen companies under each tier and comprises of small, medium and large companies. Understanding this supply chain network is crucial for smooth manufacturing processes as the supply chain structure presents both challenges and opportunities to the sector. Fujimoto et al. (2014) discussed the Great East Japan Earthquake effects on the Japanese Automobile sector particularly Toyota Motors. They explained that certain consumables (items for sale intended to be used up and then replaced) did not remain in the final product such as detergents or catalysts in the parts manufacturing process, as a result, when the 2011 Tohoku earthquake struck, such supplier were badly damaged and halted operations and the entire production process stopped. Mackenzie et al. (2012) observed that these invisible suppliers were not listed in the engineering bill of materials. Fujimoto et al.

(2014) recorded that it took Toyota a week to list 500 parts sourced from 200 locations, which would be difficult to secure and recover to the normal production level. As if that was not enough, an excessively long time (about 1 month) to totally grasp locations and situations of the damaged suppliers at the second tier and lower during the Great East Japan Earthquake.

2. Review of the literature

2.1 Automobile diamond structured supply chain network

To respond to this unique supply chain network, automobile companies throughout the world have adopted a diamond structured supply chain network. The need for high and trusted quality coupled with complex nature of the supply chain informed this supply chain structure. As Tokuda (2008) explained, for the industry to be content with the quality of parts makers, a few companies *(highly specialized and manufacturers of the best quality parts)* can only manufacture some specialized car parts. While quality is important for the industry, He recorded a situation in which major Japanese car assemblers were found to be sourcing their parts from the same MCUs semiconductor company, Renesas Electronics and even worst, from the same factory of Naka Plant, which was severely damaged by the earthquake, in the process making automobile production to come to a stoppage. Another related issue is that of non-transferable nature of embedded software encoded in the automotive MCUs. There have been efforts for standardizing embedded software and coding in the industries using MCUs (Tokuda, 2008). However, the company-specific coding is necessary to the extent that a buyer of MCUs cannot expend cost and efforts to develop two different software programs to replicate the same functions. These unique cases resulted in this specialized type of supply chain.

Figure 1 shows how goods and information flows through the supply chain network, typical of the automobile industry. Procurement from tier two companies to tier one is very crucial because of some risks in the supply chain. Centralized tier two companies, makes the flow of goods and information to tier one vulnerable, in the event these few specialized, companies experience any disruption the whole production process halts, not only in one car assembler but also in multiple ones.

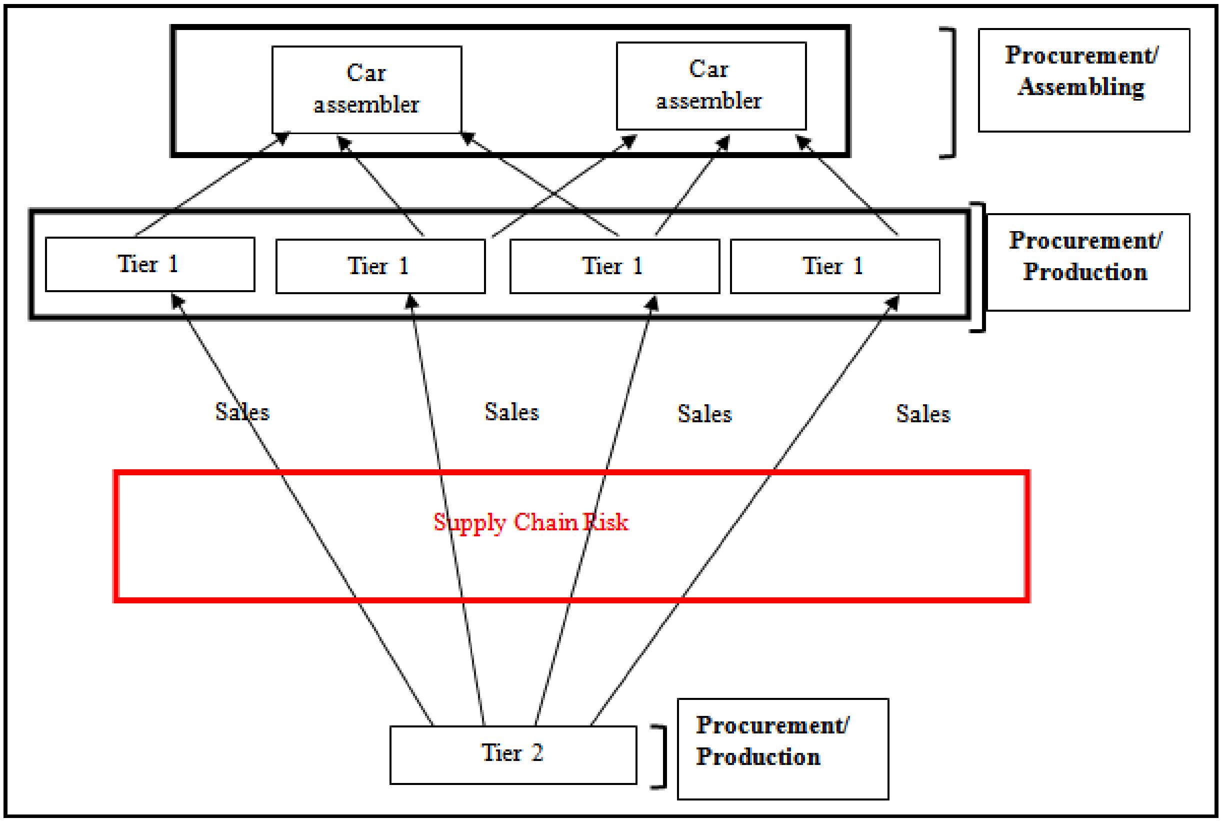

Figure 1. Diamond structure structured supply chain network

2.2 Globalization

While the automobile supply chain structure shows how distinct the sector is, in terms of coordination, this supply chain network is made even more complicated by globalization. This concept has been discussed extensively by a number of scholars among them (Aizenman and Sun, 2010; Curtis, 2009; Ferrer- Figueras and Caselles- Moncho, 2010; Leidner, 2010; Milanovic, 2003; Moshirian, 2003; Wilpert, 2009). This study takes particular interest on how globalization shaped the supply chain and risk management. Estimations are that about one-fourth of all auto parts used in the United States are imported from Asia or Europe (Klier and Rubenstein, 2008). We also note that in Asia, Japanese automobile parts makers are most preferred dealers as they supply Europe and North America with high quality car parts due of their advanced production systems and affordable prices, therefore any disruption in these car parts makers can bring the automobile industry to its knees. Even though opportunities and benefits from globalization are realized, the supply chain network has become more fragile in the process.

Because of the above challenges, there have been increased research activities regarding effective and efficient crisis and risk management strategies. Many scholars like (Harris, 2010; S.A. Torabi, 2015; S. Okabe and A. Nagahira, 2014; Q.Y. Sun and X.Y. Li, 2014; V. Cerullo and J.M. Cerullo, 2004; B. Herbane et al, 2010; J. Sharp, 2008; P.Skidar, 2011) are paying particular attention to BCM. BCM is identified as a viable option for organizations seeking to add value, creating competitive advantages, saving money, time and resources. According to Herbane

(2010), BCM has evolved as a form of crisis management since the 1970's in response to the technical and operational risks that threaten an organizations' recovery from hazards and interruptions. Gibb and Buchanan (2006) also note that during the last 2 decades, BCM has evolved as an effective tool for ensuring the delivery of organization's key products and or services. ISO 22301 (2012) defines BCM as a management process which identifies possible internal and external threats and or risks and their impact to business processes and provides a framework for organizational resilience. Bhamra et al. (2011) noted that the level of organizational business continuity directly relates to its resilient ability. For an effective BCM, BCP needs to be reviewed, modified and improved regularly. This is particularly essential in more challenging sectors like the automobile industry.

2.3 Aim of study

This study intends to:
(1) Presents a BCM framework suited for a complex automobile supply chain by modifying the BCP concept to accommodate globalization.
(2) Evaluate each BCP component and reveal its interaction with other crucial BCM framework factors.

3. Research methodology

The study employed correlation, regression and Smart PLS 3.O analyses. These analysis techniques have complementary properties. While correlation analysis establishes association among individual variables, regression seeks to identify a causal relationship of these variables and Smart PLS 3.0 finds out the direct and total effect multiple variables have on each other. More details are given below;

3.1. Correlation Analysis

It is crucial to note that two variables may be associated without having a causal relationship. Even though correlation has a limited value of causative inference, it is important because even if correlation does not imply causation, causation does imply correlation. That is, although a correlational study cannot definitely prove a causal hypothesis, it may rule one out (Stanovich, 2007). Once correlation is known, it can be used to make predictions. When we know a score on one measure, we can make a more accurate prediction of another measure that is highly related to it.

3.2. Regression Analysis

Regression analysis is one of the most important statistical techniques used in scientific and business applications. It helps estimate the strength and direction of the relationship between two or more variables. This includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. This technique can be employed because of its strength, which are as below;

One of the primary advantages of regression-based forecasting techniques is that they the analysis to predict what is likely to happen in the future, according to Studenmund (2011) regression and forecasting techniques can lend a scientific angle to management of small businesses, reducing large amounts of raw data to actionable information. Large data sets have the potential to yield valuable new information about small businesses and their operations. Regression and forecasting techniques can yield new insight for managers by uncovering patterns and relationships that they had not previously noticed or considered.

3.3. Smart PLS calculations

Smart PLS 3.0 was used to analyze the data. Considering the data and model characteristics, the algorithmic properties and model evaluation issues the Partial least squares structural equation modeling (PLS-SEM) approach (Smart PLA 3.0 statistical software package) was employed over Covariance- based structural equation modeling (CB- SEM) approach. This is so because of several benefits PLS- SEM offers benefits in terms of data size, distribution and algorithm properties. For instance, Chin (1998) stated that small numbers of minimum observations are applicable for analysis and was ideal for a study, which had 75 number of observations valid for analysis. Smart PLS 3.0 do not account for any distribution, thus bootstrapping resampling technique was used to get *t* values (Efron and Tibshirani, 1986). Missing data in a questionnaire exceeding 15% was removed, while observations containing less than 15% of missing data was treated using a group average method. The questionnaire adopted a 5 point Likert- type scales ranging from 1= strongly disagree to 5= strongly agree.

3.4. Data collection policy and procedure

Since the questionnaire was in Japanese, questionnaires that were sent to Europe, the US and other Asian countries were translated to English language and a batch sent to Chinese companies were translated into Chinese language and the translations were verified. The pilot study was done by sending questionnaires to some Japanese companies. Some modifications were introduced to the initial questionnaire before large-scale data collection.

4. Profile of surveyed companies

A total number of 151 survey questionnaire were sent to companies and 92 companies replied making a response rate of 61%.Majority of surveyed companies were from Asia, accounting for 60% whereas 40% of the companies were from North America; Canada, US and Mexico. The upper part of Table 1 shows companies operating in a single tier in which 18% of the companies were tier 1 companies, 9% in tier 2 and 12% in tier 3. The lower part shows companies dealing in more than one tier, with 9% representing tiers 1 and 2, 15% accounted for companies in tiers 1 through 3 while 19% noted companies in tiers 1 and 3, the remain 18% were unknown. The figures demonstrate the diamond structure of the automobile supply chain network as discussed above in 1.2.

Table 1. Companies' tiers

Tiers	Percentage (%)
1	18
2	9
3	12
1 and 2	9
1,2 and 3	15
1and3	19
Unknown	18
Total	**100**

Table 2 demonstrates that the Automobile industry is a manufacturing dominant industry. In this survey, 96% of the companies were manufacturing companies and services represented by 3% while import/ export companies represented only a percent.

Table 2. Industry type

Industry type	Percentage (%)
Manufacturing	96
import/export	1
Services	3
total	**100**

We adoptedone1 factor for categorizing company size from the Center for Strategy and Evaluation Services report (2012), which was a recommendation to EU member states, the European Investment bank (EIB) and European Investment Fund (EIF). The report provided framework for statistical definitions on EU policies that supports SMEs (structural fund, framework program for research and development, competitiveness and innovation program etc.) in the role governing state aid, being; net turnover (annual sales). From our survey, 78% represented large companies, medium companies not represented while small companies were accounted for by 20% and the remaining 2% represented only micro companies by annual sales.

5. Conceptual framework

According to Cha et al (2008) and Fasolis et al (2013), traditionally BCP consists of two main aspects, being Business Impact Analysis (BIA) and Risk Analysis (RA) figure 2. However, this approach does not seem to be sufficiently addressing the complex and elaborate nature of supply chain network in the automobile industry. To address this insufficiency, we replace RA with Risk Ranking (RR) and introduce a new term Supply Chain Cooperation (SCC) to our BCP figure 3

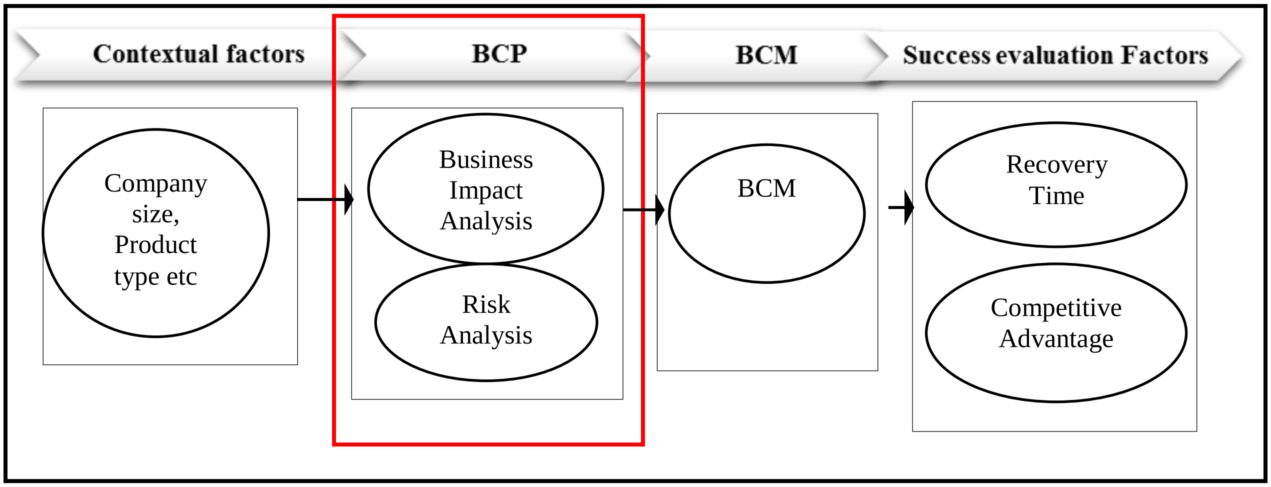

Figure 2. Traditional BCM framework

In order to provide an in-depth analysis, this section defines and discusses operationalization of the factors in our conceptual model. The proposed conceptual model provides a holistic approach towards BCM and covers four phases in the process, being contextual factors, Business continuity plan (BCP), BCM and success evaluation factors. The conceptual model is adopted from ISO 22301 (2012), but strikes a significant variation from the standard. It also has limited similarity with the one by (Torabi et al, 2014).

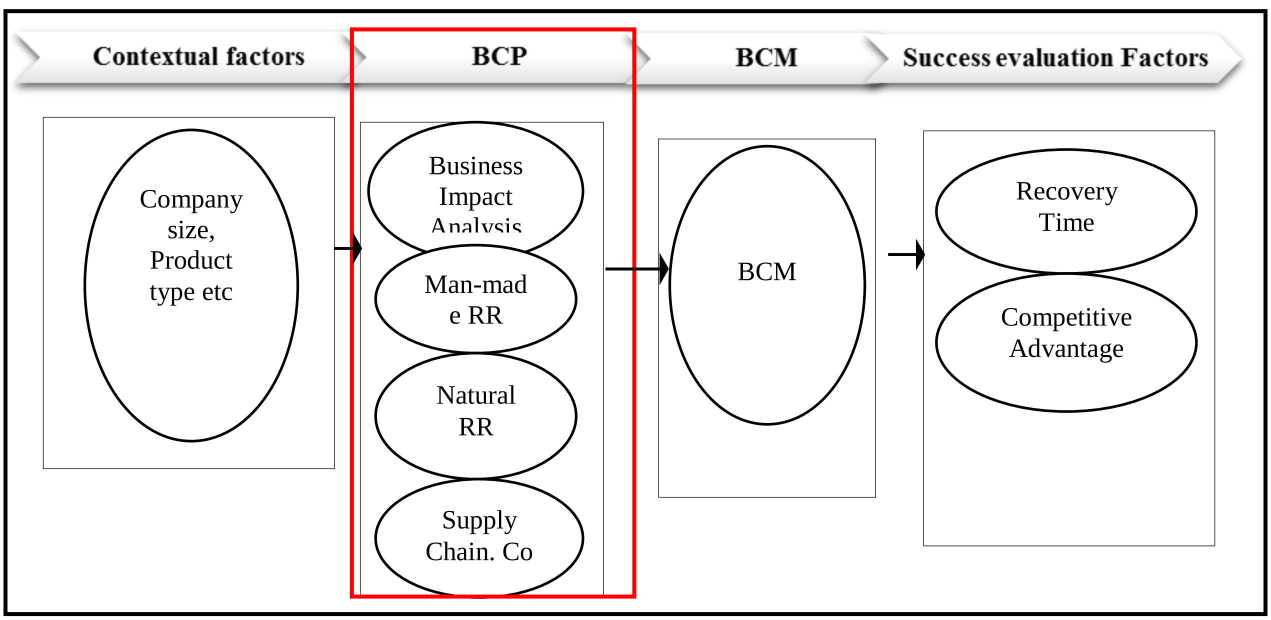

Figure 3. Study's original BCM framework

In this conceptual model, the first thing to consider is what we term as contextual factors. These are factors unique to every companies and usually influenced by the companies' culture, mission and vision. Once the contextual factors are identified and established, the model introduces the second phase, which is business continuity plan (BCP). The logic is that, no effective plan can be realized until a thorough command of the 'contextual factors' is established. Under this phase, we established that Cha et al. (2008) found that the relationship between Business Impact Analysis (BIA) and Risk Analysis (RA) was crucial because the results of BIA and RA are merged to develop a suitable BCP. This significantly shaped what constitute our BCP, being BIA, risk ranking and supply chain cooperation (SCC). BIA was adopted directly from Cha et al. (2008) and RA was modified into risk ranking. The reason for this modification was that, while we appreciate the value of RA in BCP, we realized it might be made cost effective. We are of the view that risk ranking can be the common ground between companies' ambitions of maximizing profit and inventory consideration to ensure continued supply (customer satisfaction) even during and after disruption. For instance, a company's risk are to be ranked by taking a number of factors, which exposes it to risks like place of operation, complexity of supply chain, size of the company, and the company product. Risk ranking was further divided into 2 (manmade and natural risk ranking) for compatibility issues. Refer to 6.3.1 Model testing and results for a detailed explanation. The last component under this phase is SCC. This is term possibly has great potential in informing the final BCP outcome. As is discussed earlier, companies are part of a huge supply chain networks and developing an effective BCP should take into consideration this view. The studies by Fujimoto et al. (2014) and MacKenzie (2012) highlighted the integral significance of supply chain network during disruption. We, therefore, reference made was to that effect in our BCP. Given the importance of supply chain network in the flow of goods, services and information through the network in the automobile industry the study is of the view that introducing SCC is pivotal in BCP.

5.1 Measures and Hypotheses

5.1.1. Recovery time

When a disaster strike an area, rescue mission is dispatched immediately to save lives and salvage whatever possible, this is done to mitigate the severity of the disaster in the immediate aftermath. However, this stage marks just, but the beginning of a tedious and usually long process of recovery. It must be understood that in this regard, recovery will not be an isolated effort by each company, but an integrated process by all stakeholders, through which the affected community thrive to bring its state to pre- disaster conditions. This will not only be limited to facilities restoration, human resource accountability, financial capability etc. in a business enterprise, but road networks, water supply, electricity restoration and access to business suppliers and or consumers. In a sense, the recovery effort starts within an enterprise and reaches out to the entire community. Herbane at el. (2004) recorded that the concept of time as a resource to organizational advantage is long held in management field and the ability of an organization to achieve more quickly than rivals has been long considered a source of competitive advantage. Equally valid is the ability to recover more quickly than rivals who face the same crisis or interruption. The logic is that quick recovery time is likely to impress customers and investors and establishing trust in them, in the process an organization will hugely benefit from such scenario.

5.1.2. Competitive Advantages

Another evaluation factor is competitive advantages. In this study, these are defined as a number of circumstances/ conditions that puts a company in a favorable or superior business position relative to its competition. Such conditions includes quick recovery time after disaster strikes (as discussed above), increase of sales share and profits before, during and after a disaster event and maintaining an intact company image during uncertain times. Herbane et al. (2004) concluded that BCM's potential contribution to the firm is that of value preservation, of which competitive advantage is crucial towards the desired value preservation.

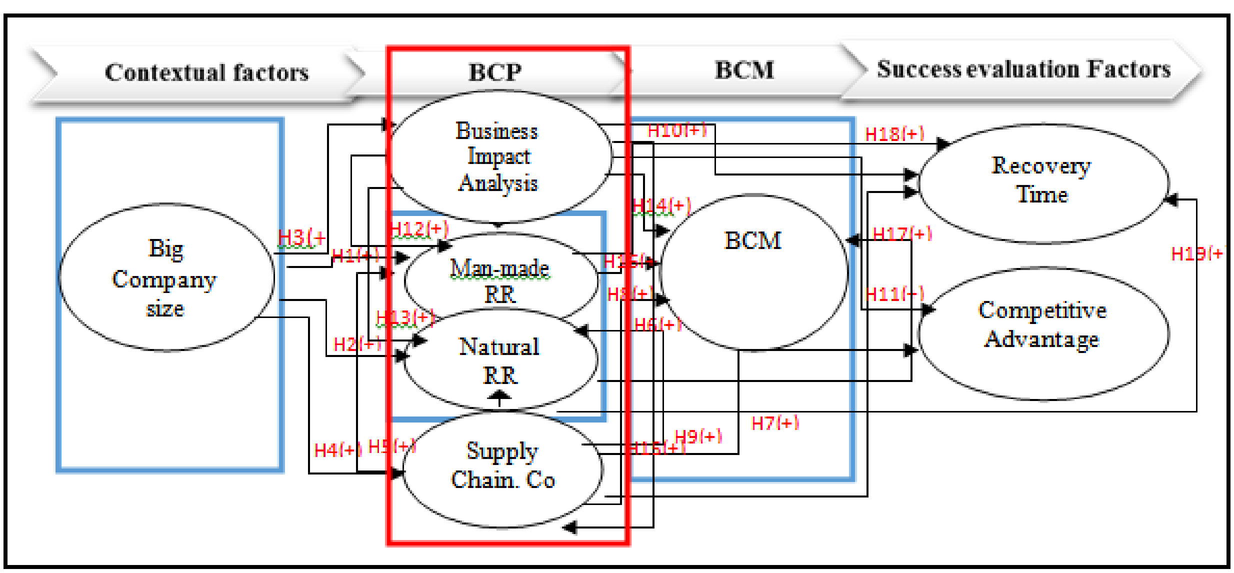

Figure 4. Hypotheses

5.2. Literature informing "size of company" hypotheses formulation

Previous studies by Jayaram et al. (2014) and Akkiraju at al. (2004) provided an insight into these set of hypotheses. In their study Jayaram et al. (2014) concluded that most of the SMEs are family owned and as such limited in growth as the family has total control in regards to strategic decisions, control and operation management. In this scenario, Sharma (2004) explained that due to the nature of their operations, small businesses tend to have limited supply chain capabilities and exposed to major damage in the event of supply chain disruption. On the other hand, large companies are thought to have strong supply chain capabilities and in the process eliminate many risks associated with the supply chain network. From these studies, we were able to formulate hypotheses, which show how the company size affects BCP factors. The hypotheses are as below;

Hypothesis 1: *Big company size has positive effects on manmade risk ranking*
Hypothesis 2*: Big company size has positive effects on natural risk ranking*
Hypothesis 3*: Big company size has positive effects on BIA*
Hypothesis 4*: Big company size has positive effects on supply chain cooperation*

5.3. Literature informing "supply chain cooperation" hypotheses formulation

As Andersson (1998, p64) observed, the main message of the network view is that cooperation is more efficient than competition for the firms development. Andersson (1998, p 91) continues to state that If companies trust each other and develop bonds and communication channel between the different actors in the network, the resources and activities in the network can be organized in a more efficient way. From this observation, we were able to note that previous studies did not make mention SCC at all in their BCM framework and models even though its benefit to the supply chain network is thought to be more efficient and promote companies' development. From this literature, were able to form the following sets of hypotheses.

Hypothesis 5*: Supply chain cooperation has positively effects on manmade risk ranking*
Hypothesis 6*: Supply chain cooperation has positively effects on natural risk ranking*
Hypothesis 7*: Supply chain cooperation has positive effects on recovery time*
Hypothesis 8: *Supply chain cooperation has positive effects on BCM*
Hypothesis 9*: Supply chain cooperation has positive effects on competitive advantage*

5.4. Literature informing 'BIA' Hypotheses formulation

The British standard BS25999 (2006) defines BIA as the process of analyzing business functions and the effect that a business disruption might have on them. This definition relates very well with the American National Fire Protection Agency (NFPA) 1600 (2010), which defines BIA as an analysis which measures the effect of resource loss and escalating losses over time in order to provide the entity with reliable data upon which to base decisions concerning hazard mitigation, recovery strategies and continuity planning. The good practice guidelines (GPG) 2007 of the Business continuity institute (BCI) (2010), which is a management guidelines for implementing BCM following the lifecycle of BS 25999 mentioned that BIA identifies, qualifies and quantifies the business impacts of loss, interruption and disruption of business processes on an organization and provides data from which appropriate continuity strategies can be determined. This then suggest that BIA forms the core of BCP as this plan (BCP) significantly relies on the BIA outcome. From, this literature, the following hypotheses we formulated;

Hypothesis 10*: BIA has positive effects on recovery time*
Hypothesis 11*: BIA has positive effects on competitive advantages*
Hypothesis 12*: BIA has positive effects on manmade risk ranking*
Hypothesis 13*: BIA has positive effects on natural risk ranking*
Hypothesis 14*: BIA has positive effects on BCM*
Hypothesis 15*: BIA has positive effects on supply chain cooperation*

5.5. Literature informing "risk ranking" Hypotheses formulation

This set of hypotheses were informed by Tjoa et al. (2008) who stated that identifying scenarios leading to severe impacts on the company's reputation, assets or financial position is very important. However, despite this observation, no practical solutions have been offered to effectively identify scenarios that lead to severe impacts on the company. Existing solutions, which discussed disaster preparation methods like virtual dual sourcing by Fujimoto and Park (2014) are expensive to conduct and as such discourages companies to employ BCM as a form of preparedness. In fact, a survey by Woodman (2011) revealed that despite the known benefits of BCM, its adoption is still lagging behind mainly due to the cost of implementation. This study introduces risk ranking as a practical solution in identifying scenarios leading to severe impacts while at the same time providing a common ground to optimize both inventory and profit making ambitions. From this literature, the study proposes the following sets of hypotheses.

Hypothesis 16*: Manmade risk ranking has positive impact on BCM*
Hypothesis 17*: Natural risk ranking has positive impact on BCM*
Hypothesis 18*: Manmade risk ranking has positive impact recovery time*
Hypothesis 19*: Natural risk ranking has positive impact recovery time*

6. Data analysis

6.1. Correlation Analysis results

We applied this correlation technique to investigate the interrelationship among BCP Factors (Risk ranking, supply chain cooperation and BIA) we carried a correlation analysis. Tables 3 and 4 present the results.

The questionnaire asked 7 question groups of 34 questions, all written in 5 point Likert scale format except for company profile. However, we narrow our analysis only to BCP factors. The correlations analysis was carried at 5% significant level. Table 3 demonstrates correlation of risk ranking (manmade and natural) and supply chain cooperation. In this study manmade risk ranking questions (Q18-2 and 18-3) investigated degree of implementing earthquake resistant strengthening and enforcement measures while natural risk ranking questions (18-6, 18-9, 18-10, and 18-11) investigated degree of flooding, snow damage and cold wave, thunderbolt and heatwave respectively. Supply chain cooperation questions (Q3, 14, 15 and 16) investigated sufficient planning in the supply chain network, sufficient disaster and damage risks surveys, sufficient implementation of countermeasure at suppliers and measures in place to guarantee supplies to customers respectively. Q 18-3 demonstrated strong correlation with all supply chain cooperation questions. This means that companies which have strengthened their earthquake resistant measures enjoyed more cooperation within the supply chain network. It could be because once companies make their infrastructure earthquake resistant, such companies does not suffer more damage during disruption and as a result continues to operate, promoting smooth flow of goods and information within the network during disruption. Also Q 15 (countermeasures against risks at suppliers had strong correlation with both natural and manmade risk ranking (Q.18-3, 18-6, and 18- 11). Other correlations were weak (Q18-9, 18-6 1nd 18-10). This shows that the level of risk a company faces may be transferred from risks at suppliers and other stakeholders within the supply chain. The correlation results between these two factors (risk ranking and Supply chain cooperation) confirm the importance of ranking risks in developing BCP because majority of companies, which ignore the risk often, suffer more supply chain disruption as the 2 are correlated.

Table 3. Correlation Analysis (Risk ranking and Supply chain cooperation)

	Q18-2	Q18-3	Q18-6	Q18-9	Q18-10	Q18-11
Q14		*** 0.371				
Q15		*** 0.556	*** 0.362	** 0.339		*** 0.353
Q16		*** 0.519	** 0.343			
Q3	*** 0.355	*** 0.462			** 0.304	

Note; *p<0.05, **p<0.01, ***p<0.001

Table 4 analyses the correlation between risk ranking and BIA. As was expected, Q 18-3 (degree of implementing earthquake resistant strengthening and enforcement measures) had correlation properties with BIA questions (Q2, 4 and 5), which investigated sufficient plans of securing electricity, gas, water, communication etc., sufficient priority plans for operation restoration and management resource, securing and sufficiently establishing crisis management system respectively. This correlation was expected, as Q 18-3 is part of BIA. Other questions which demonstrate a similar correlation are Q 18-10 (risk of thunderbolt) and BIA questions (Q2, 5 and 6), which also focuses on sufficient pre disaster planning. The correlation suggests that degree of implementing earthquake resistant strengthening and enforcement measures is an important aspect of pre disaster planning. The results also provide us with a crucial finding because we realized that most of the companies, which are not satisfied with their BIA, tend to pay less attention to risk and vice versa. This is so because risk ranking is instrumental to pre disaster planning, which constitutes BIA largely.

Table 4. Correlation Analysis (risk ranking and BIA)

	Q18-2	Q18-3	Q18-9	Q18-10	Q18-11
Q 1			** 0.346		
Q 2		** 0.349		** 0.332	
Q 4		** 0.327			
Q 5		** 0.330		** 0.329	
Q6	** 0.337			*** 0.402	** 0.303
Q 21	* 0.241				
Q 28					
Q29	* 0.203				
Q 31					** 0.320

Note; *p<0.05, **p<0.01, ***p<0.001

6.2. Regression Analysis
6.2.1 Business Impact Analysis

Business Impact analysis strongly and positively affected BCM with Q.1 recording a (***) with Q.7, 8 and 9 of BCM (which investigated level of drills implementation by a company in case of disaster, opinion on BCM performance and ability of emergency control system to be effective respectively). Q.1 recorded a (**) significant level with Q. 11, 12 and 13 of BCM (opinion on risk reduction by BCM, implementation of proactive countermeasures to avoid parts supply risks and implementation of proactive countermeasures with production equipment against disasters respectively). Another interesting relationship is between BIA and recovery time. While Q.1 of BIA recorded a weak positive relation with recovery time Q.19 and 21 with a (*) significant level, Q. 27 and 29 recorded a moderate significant level of (**) with recovery time Q. 21 and 23. It can also be observed that Q. 27 recorded a moderate negative relationship with Q. 19 at a (**) significant level. From Table. 5 we understood that BIA has more strong correlation with other BCP factors and by far the most BCM influencing factor while also significantly implicating recovery time.

6.2.2 Risk ranking

Man-made risk ranking has recorded more significant relationships than natural risk ranking. This is an interesting trend. Q. 18-2 positively affected BCM Q. 10 (*), Q. 11 (**) and recovery time Q. 19 (*), whereas Q. 18-3 positively affected BCM Q. 7 (**), Q. 8 (*) and Q. 13 (**) Table. 5 (continuation) On the contrary, natural risk ranking recorded only one relationship, in which Q. 18-11 has a positive effect on BCM Q. 12 (*), Table. 5. This observation suggests that even if a company may rank very high in terms of risks, the effect of such a risk is significantly associated with BCM. Perhaps, this underscores the importance of management in averting some risk effects. For instance, Japan is located in a highly risk region frequently hit by earthquakes, tsunamis, volcanic eruptions and flooding’s but have a flourishing automobile sector mainly because of risk management through BCM. A robust BCM can be a very powerful risk averting management engagement.

6.2.3 Business Continuity Management & Recovery time

BCM demonstrated a positive relationship with recovery time as BCM Q.8 positively affected recovery time Q. 19 (*) and Q. 23 (**). Recovery time Q. 23 established (*) negative relationship with comparative advantage Q. 32. Table. 5 (continuation)

Table 5. Regression analysis

		Dependent variables												
Independent variables		**Man- made risk ranking**		**Natural man- made risk ranking**			**Business Continuity Management**						**Recovery time**	
Specific question		18-2	18-3	18-9	18-10	18-11	7	8	10	11	12	13	2	3
Supply Chain cooperation	3						**2.516	**3.409		**2.904			**2.518	***3.598
	14							**3.492					*2.022	
	15		*2.482	*2.335	*2.392	*2.079			*2.008	*2.159	*2.406	**3.349		
	16													
R			0.582	0.363	0.5	0.357	0.606	0.752	0.6	0.675	0.566	0.664	0.485	0.512
R-square			0.338	0.131	0.25	0.128	0.368	0.565	0.36	0.456	0.32	0.44	0.235	0.262
Adj.R-square			0.3	0.082	0.207	0.078	0.332	0.54	0.323	0.425	0.281	0.408	0.191	0.22
F-value			8.941	2.649	5.819	2.564	10.183	22.75	9.845	14.659	8.235	13.76	5.377	6.21
n			75	75	75	75	75	75	75	75	75	75	75	75

Note; *p<0.05, **p<0.01, ***p<0.001

Table 5. Continued

		Dependent variables								
Independent variables		**Business Continuity Management**						**Recovery time**		
Specific question		7	8	10	11	12	13	1	2	3
Business Impact Analysis	1	***9.686	***4.374	***3.796	**2.736	**2.584	**2.829	*2.099	*2.446	
	2		**3.071							
	5		*2.008	*2.425						
	27							**-2.525		
	29		*2.032		**3.352				**2.573	**2.574
R		0.846	0.855	0.79	0.782	0.621	0.657	0.575	0.539	0.494
R-square		0.716	0.732	0.623	0.612	0.385	0.431	0.33	0.291	0.244
Adj.R-square		0.687	0.704	0.584	0.571	0.321	0.372	0.26	0.216	0.166
F-value		24.752	26.09	15.84	15.083	5.993	7.256	4.719	3.921	3.098
n		75	75	75	75	75	75	75	75	75
Man- made risk ranking	18- 2			*2.102	**2.768			*2.119		
	18- 3	**2.869	*2.239				**2.673			
R		0.42	0.3	0.407	0.438		0.458	0.306		
R-square		0.176	0.09	0.166	0.192		0.21	0.093		
Adj.R-square		0.154	0.051	0.143	0.169		0.188	0.068		
F-value		7.712	2.335	7.153	8.528		9.571	3.709		
n		75	75	75	75		75	75		
Natural risk ranking	18- 11					*2.266				
R						0.463				
R- square						0.214				
Adj.R-square						0.157				
F-value						3.763				
n						75				

Note; *p<0.05, **p<0.01, ***p<0.001

6.3. Smart PLS

6.3.1. Model testing and results

Common criteria to evaluate reflective measures of PLS path models are the average variance extracted, the composite reliability and the communality (Stone- Geissers Q2) (Chin, 1998). The results of these measures are in table 5. A major challenge we faced had to do with the risk-ranking construct. As mention earlier, this factor is an original idea, meaning that it has not been discussed before in this regard, and as such, there was no literature to get insight from. Therefore, during model formulation and testing, we realized that risk-ranking construct has to further be divided as we realized that including all the indicators in one constructs significantly reduced internal consistency reliability and validity. In this regard, risk ranking was divided into manmade risk ranking and natural risk ranking. Further to that, some indicators were removed entirely to enhance internal consistency. Measurement models assessment was done by evaluating internal reliability and validity. The two traditional criteria for evaluating the two are Cronbach's alpha and composite reliability. All latent variables have values above suggested thresholds of 0.7 of Cronbach's alpha and above 0.7 of composite reliability (Jayaram et al, 2014).

Table 6. Results for Measurement Model Evaluation Criteria

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality
Business Continuity Management	0.667	0.9231	0.7671	0.8998	0.667
Business Impact Analysis	0.6044	0.9131		0.8874	0.6044
Comparative Advantage	0.8688	0.9298	0.2934	0.8489	0.8688
Company Size	0.8046	0.925		0.8788	0.8046
Manmade risk ranking	0.7884	0.8817	0.3405	0.7319	0.7884
Natural risk ranking	0.5525	0.8595	0.2074	0.8022	0.5525
Recovery time	0.6725	0.8911	0.3858	0.8383	0.6725
Supply Chain cooperation	0.7617	0.9274	0.5345	0.8952	0.7617

Average variance extracted (AVE) value of 0.5 or higher is acceptable as it indicates that the latent variable explain more than half of its indicator variance (Hair Jr et al, 2014). Considering the values in table 5, we can conclude that all the measures are well above the required minimum thresholds and acceptable. Fornell- Larcker criterion was used for evaluation of discriminant validity of the latent variables (uniqueness of the latent variable), following recommendations by Hair Jr et al 2014), we performed Fornell- Lacker analysis Table 7.

Table 7. Latent variable correlations (calculation with Smart PLS 3.0)

	Business Continuity Management	Business Impact Analysis	Comparative Advantages	Company size	Manmade Risk Ranking	Natural Risk Ranking	Recovery time	Supply chain cooperation
Business Continuity Management	1							
Business Impact Analysis	0.8409	1						
Comparative Advantages	0.4019	0.2292	1					
Company size	0.0943	0.0043	0.3264	1				
Manmade Risk Ranking	0.4902	0.3833	0.3097	0.2053	1			
Natural Risk Ranking	0.374	0.3705	0.2027	0.1163	0.2377	1		
Recovery time	0.6014	0.4997	0.245	0.1058	0.2734	0.258	1	
Supply chain cooperation	0.7606	0.7209	0.1997	0.1202	0.5661	0.4449	0.5371	1

7. Discussions

7.1 Hypothesis 1 & 2 *[Partly Supported]*

As expected, big company size has positive effects on both man-made and natural risk ranking. However, these positive effects are not significant. Both the correlation and regression analysis could also not prove the significance of these relationships. This could be because both the big and small companies face their own unique challenge in as far as risks are concerned and as such, no significant relationship observed.

7.2. Hypothesis 3 *[Partly Supported]*

Indeed, this hypothesis proved to be positive but was not significant, further to that correlation and regression analysis could not establish the significance of this relationship. This could be because a well-assembled management team can develop a very good and BIA policy regardless of the size of the company. Some small companies are known to be more efficient because of little bureaucratic administration involved, while some big companies are known to be inefficient and usually take long to change due to the bureaucracy involved.

7.3. Hypothesis 4 *[Partly Supported]*

As expected, big company size has positive effects on supply chain cooperation, it can also be observed that correlation and regression analysis did not establish the significance of this relationship, and as such, this hypothesis is not significant. A possible explanation could be that large companies face more challenges due to their extensive and complicated supply chain network. Once a company has many companies in their supply chain network, its risk of disruption significantly increases making it highly vulnerable.

7.4. Hypothesis 5 and 6 *[Supported]*

As expected, supply chain cooperation has a significant positive effects on risk ranking (both manmade*** and natural**) in both the direct and indirect effects. The correlation and regression analysis also established the significance of this relationships, see **table 3 and 5**. These results are pivotal in understanding the most effective and efficient way to handle risks, be they man-made or of nature. In this regard, we refer to the works of Andersson (1998) who concluded that a cooperative network will not only eliminate risks but promotes companies' development.

7.5. Hypotheses 7 and 9 *[Partly Supported]*

Supply chain cooperation's total effects on recovery time and competitive advantages indicated a positive relationship, though not significant. However, the regression analysis results showed a direct significant relationship between supply chain cooperation and recovery time. The difference in these results is interesting and justifies why it is important to employ different statistical analysis to further probe relationships. An explanation to these differences could be that the regression analysis calculated direct relationships between these variables but Smart PLS 3.0 calculated total relationships, taking into account all factors in the model in the process reducing significance of these relationships.

7.6. Hypothesis 8 *[Supported]*

We also realize that Supply chain cooperation has a significant positive effect on BCM. The total effects showed a strong significant level of (***). This significant relationship was also proved by the regression analysis results in table 5. A possible explanation to this significant relationship could be because, normally a cooperative supply chain network takes care of the risk- as in hypotheses 5 and 6, which is a crucial aspect to be handled in order to develop a BCM that can withstand a serious or intense disruption.

7.7. Hypotheses 10 and 11 *[Supported]*

BIA has a positive and significant total effects on both recovery time (***) and competitive advantages (*), the same results were also calculated by the regression analysis in table 5 (continuation). This suggests that BIA has more effects than supply chain cooperation in as far as recovery time and competitive advantages are concerned. We also note that BIA has stronger effects on recovery time than competitive advantages. This could be because competitive advantages has more factors constituting it whereas recovery time is a single factor concerned with the aspect of time, thus easy to establish recovery time association with other factors than it is with competitive advantages.

7.8. Hypotheses 12 and 13 *[Supported]*

The total effects of BIA on both manmade and natural risk ranking is positive and significant (**) for manmade and (***) for natural risk ranking. Indeed correlation (table 4) and regression analysis table 5 (continuation) also established this relationships. A possible explanation could be that BIA report informs organization about potential risks and the organization responds accordingly. We think that risk ranking is an excellent way to accomplish this mission. We also note that BIA significance is relatively weak in manmade risk ranking than in natural risk ranking. A possible explanation could be that most of the companies avert any potential risks facing their organization, hence BIA having a moderate impact on manmade risk. However, BIA strongly affects natural risk ranking because such risks are usually outside the companies control in the process been affected more by BIA.

7.9. Hypothesis 14 *[Supported]*

One of the strongest positive relationship in this study is that BIA has positive total effects on BCM at (***). Also, see this relationship from the regression analysis **table 5 (continuation)** BIA report is very crucial in the BCM formulation as it the foundation of a relevant BCM and this relationship confirms what we have expected in this study.

7.10. Hypothesis 15 *[Supported]*

BIA has a strong (***) positive impact on supply chain cooperation in the total effects as expected. Indeed regression analysis established this relationship in **Table 5 (continuation).** We are of the view that BIA report identifies any impacts within and outside the company. Therefore, supply chain cooperation is analyzed by this report as an 'outside' the company factor, making this relationship very significant.

7.11. Hypotheses 16 and 17 *[Partly Supported]*

Both risks (manmade and natural) have very important contribution but insignificant to BCM as indicated by the results in Table 9. However, the regression analysis results showed a direct significant relationship between both risks (manmade and natural) and BCM Table 5 (continuation. The same reason as in hypothesis 7 and 9 can be given for this differences. This results suggest that even though some companies with high risk ranking usually develops a good BCM program suited to their conditions, such a good BCM program is not only limited to high risk ranking companies as some companies with lower risk ranking can develop a good BCM well suited to their conditions.

7.12. Hypothesis 18 and 19 *[Not supported]*

Contrary to our expectations both natural and manmade risk ranking has negative total effects on recovery time, but a weak positive significance (*) from the regression analysis results, this positive significant relationship seems to have been lost during Smart PLS 3.0 calculations. It can be reasoned that when risks are high frequency of disruption will be high resulting in constant challenges to recovery time and possible delay.

Smart PLS 3.0 results analysis for both the direct and total effects are as shown in Table 8. The results are discussed below (4.0)

Table 8. Smart PLS 3.0 Direct and total effect Analysis results

	Direct effects					**Total effects**				
Hypotheses	Original Sample	Sign level	Standard Deviation	Standard Error	T Statistics	Original Sample	Sig Level	Standard Deviation	Standard Error	T Statistics
1	0.1381		0.0932	0.0932	1.4816	0.2081		0.1066	0.1066	1.9523
2	0.0701		0.1234	0.1234	0.5679	0.1048		0.1383	0.1383	0.7573
3	0.0044		0.142	0.142	0.031	0.005		0.1397	0.1397	0.0358
4	0.1222		0.1436	0.1436	0.8511	0.1222		0.1436	0.1436	0.8511
5	0.5707	***	0.155	0.155	3.6811	0.5706	***	0.1669	0.1669	3.4195
6	0.3558	**	0.1425	0.1425	2.5977	0.349	**	0.1363	0.1363	2.5602
7	0.255		0.2309	0.2309	1.1043	0.3463		0.1979	0.1979	1.7503
8	0.2479	**	0.0943	0.0943	2.6295	0.3069	***	0.0904	0.0904	3.3968
9	-0.2387		0.1347	0.1347	1.7719	0.0073		0.1504	0.1504	0.0484
10	-0.0736		0.279	0.279	0.2638	0.5016	***	0.1066	0.1066	4.7035
11	-0.2343		0.153	0.153	1.5309	0.2272	*	0.1065	0.1065	2.1323
12	-0.0296		0.1735	0.1735	0.1706	0.3818	**	0.1091	0.1091	3.499
13	0.1116		0.1489	0.1489	0.7499	0.3685	***	0.1023	0.1023	3.6027
14	0.623	***	0.0741	0.0741	8.4053	0.8405	***	0.0391	0.0391	21.5247
15	0.7215	***	0.0607	0.0607	11.891	0.7208	***	0.0649	0.0649	11.1042
16	0.1029		0.0713	0.0713	1.443	0.103		0.0687	0.0687	1.4996
17	0.0154		0.0763	0.0763	0.2015	0.0154		0.0763	0.0763	0.2015
18	-0.1093		0.1266	0.1266	0.8637	-0.0552		0.131	0.131	0.4212
19	-0.0048		0.1187	0.1187	0.0402	-0.013		0.1209	0.1209	0.1077

Note; *p<0.05, **p<0.01, ***p<0.001

7.13 Sensitivity Analysis

As it is shown in Table 9 below are the results; the change in the values of parameters may happen due to uncertainties induced by forces beyond the management’s control. In order to examine the implications of these changes, the sensitivity analysis was carried out. We now study how changes in the company size affect our model. Generally, the analysis indicates that an increase of 20% to company size yields six strong (***) significance levels to hypotheses 5, 10, 12, 13, 14, and 15 compared to four strong (***) significance levels to hypotheses 5, 13, 14 and 15 when reducing company size by 20%. Overall, an increase of 20% yielded 10 significant levels of varying degree while the 20% reduction yielded 8 significant levels of varying degree. Comparing this with our data, an increase of 20% seems to be more effective as it yields 10 significance levels while the unaltered (study) data yielded 9 significant correlation of varying degree. A reduction of 20% of company size is not effective as it lower than unaltered data.

Table 9. Sensitivity Analysis results at minus (-) 20% and plus (+) 20% of Company size

	Decease of company size by 20%							**Increase of company size by 20%**				
	Sign level	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)	Original Sample (O)	Sign level	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
1		0.12	0.11	0.1	0.0949	1.2373	0.1911	*	0.19	0.109	0.11	1.7495
2		0.1	0.11	0.1	0.1409	0.7445	0.14		0.15	0.134	0.13	1.0428
3		0.02	0.03	0.1	0.1395	0.131	-0.0041		0	0.144	0.14	0.0288
4	*	0.13	0.14	0.1	0.0864	1.5514	0.0842		0.1	0.155	0.15	0.5437
5	***	0.57	0.56	0.2	0.1576	3.6251	0.5775	***	0.58	0.149	0.15	3.8718
6		0.02	0.04	0.1	0.1401	0.131	-0.0041		0	0.139	0.14	0.0388
7		0.25	0.23	0.2	0.2233	1.1358	0.3565	*	0.34	0.19	0.19	1.8787
8	*	0.24	0.23	0.1	0.0983	2.4295	0.306	**	0.3	0.089	0.09	3.4523
9	*	-0.25	-0.2	0.1	0.139	1.7897	0.0139		0.02	0.151	0.15	0.0919
10		-0.08	-0.1	0.3	0.2628	0.32	0.5029	***	0.53	0.111	0.11	4.5424
11		-0.23	-0.2	0.2	0.1608	1.405	0.2318	*	0.24	0.115	0.12	2.0158
12		-0.03	-0	0.2	0.1719	0.1847	0.3836	***	0.39	0.101	0.1	3.7871
13	***	0.37	0.39	0.1	0.1022	3.6247	0.373	***	0.39	0.103	0.1	3.6283
14	***	0.62	0.63	0.1	0.0775	8.004	0.8414	***	0.84	0.038	0.04	22.2493
15	***	0.72	0.72	0.1	0.0679	10.6	0.7223	***	0.72	0.065	0.06	11.1841
16	*	0.1	0.1	0.1	0.0691	1.5126	0.106		0.11	0.073	0.07	1.4439
18		-0.1	-0.1	0.1	0.119	0.8448	-0.0509		-0.04	0.122	0.12	0.4159
17		0.02	0.03	0.1	0.0718	0.2674	0.0188		0.02	0.07	0.07	0.2679
19		-0.02	-0	0.1	0.1169	0.135	-0.0114		-0	0.125	0.13	0.0914

Note; *p<0.05, **p<0.01, ***p<0.001

8. Conclusions

Unique contributions of the paper

The study adopted the application of 3 statistical analysis techniques, which proved to be very helpful as the techniques complemented one another and in the process reveal relationships that cannot be revealed by any one technique. For instance, correlation revealed associations among variables while regression established the relationships' significance and direction (dependent and independent) of variables and Smart PLS 3.0 gave direct and total effects of variables in the whole model.

To address the challenge of an elaborate and complicated automobile supply chain network (diamond format), the paper introduces a different school of thought to the traditional BCP by replacing Risk Analysis with Risk Ranking and adding a new term (Supply Chain Cooperation). This was done in an effort to further strengthen the resilience of the vulnerable networked automobile supply chain in a more globalized world.

The study established that if the company size increases by 20%, more significant levels of varying degrees are achieved while the 20% reduction of company size reduces the number of significant relationships.

Theoretical and managerial implications

Companies, which have strengthened their earthquake resistant measures, enjoyed more cooperation within the supply chain network. It could be because once companies make their infrastructure earthquake resistant; such companies do not suffer more damage during and after disruption, promoting smooth flow of goods and information within the network during disruption. Disaster recovery or risk managers can take heed to these findings in making their plans more resilient.

The study also established that the degree of implementing earthquake resistant strengthening and enforcement measures is an important aspect of pre disaster planning. Most of the companies, which are not satisfied with their BIA, tend to pay less attention to risk and vice versa. This is so because risk ranking is instrumental to pre disaster planning, which constitutes BIA largely.

Even if a company may rank very high in terms of risks, the effect of such a risk is significantly associated with BCM. Perhaps, this underscores the importance of management in averting some risk effects. For instance, Japan is located in a highly risk region frequently hit by earthquakes, tsunamis, volcanic eruptions and flooding's but have a flourishing automobile sector mainly because of risk management through BCM. A robust BCM can be a very powerful risk averting management engagement.

BIA report identifies any impacts within and outside the company. Therefore, supply chain cooperation is analyzed by this report as an 'outside' the company factor, making it a crucial BCP factor.

BIA's contribution to the development of BCP, BCM and the outcome is the most significant among all BCP factors. BIA has strong positive total significant impacts on Evaluation factors

recovery time (t- statistic, 4.7035)******* and competitive advantages (t- statistic, 2.1323)*****, BCP factors (natural (t- statistic, 3.6027)******* and manmade (t- statistic, 3.499)****** risk ranking & supply chain cooperation (t- statistic, 11.1042) ******* and BCM (t- statistic, 21.5247)*******
A robust BCM can be a very powerful risk averting management engagement.

Managers should always mind the size of their companies as it significantly affects the efficiency of their business continuity agenda.

Limitations of the research and
The study encountered hurdles during data collection, as it covered regions thousands of miles from each other. The coordination of the exercise was particularly cumbersome and it took an excessively long time to get feedback from companies, which took part in the survey.

Future research directions

If the automobile industry is to be profitable, resilient and relevant, more BCM theoretical frameworks, model and approaches should be proposed and applied. This will advance the recovery and risk management profession.

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APPENDIX A

<B: BCM (Business Continuity Management), BCP (Business Continuity Plan) of a company>

B1) Status of your BCP (Business Continuity Plan)

Q1: Have you formulated sufficient measures to prevent disasters to suppress the damage to internal infrastructure such as important buildings, equipment, and machines?

Not done at all — **halfway done** — **prepared perfectly**

① — ② — ③ — ④ — ⑤

Q2: Have you sufficiently formulated plans of securing electricity, gas, water, communication, etc. in case of a disaster?

Not done at all — **halfway done** — **Prepared perfectly**

① — ② — ③ — ④ — ⑤

Q3: Have you sufficiently planned securing supply chains such as suppliers and customers

Not done at all — **halfway done** — **Prepared perfectly**

① — ② — ③ — ④ — ⑤

Q4: Have you sufficiently planned priority for operation restoration and securing essential Management resources?

Not done at all — **halfway done** — **Prepared perfectly**

① — ② — ③ — ④ — ⑤

Q5: Do you think crisis management system in case of disaster occurrences established sufficiently (emergency response headquarters, restoration headquarters, etc..)?

Not established at all — **Medium** — **Perfectly established**

① — ② — ③ — ④ — ⑤

Q6: Have you sufficiently formulated the plans of alternative equipment, alternative manufacturing location, responsible organization in case of disasters?

Not established at all — **Medium** — **Perfectly established**

① — ② — ③ — ④ — ⑤

B2）Implementation of BCM (Business Continuity Management) training

Q7: Level of implementing training/drills by a company in case of disasters.

Simple simulation only Or not implemented — **Medium level** — **Implemented drills considering actual condition**

① — ② — ③ — ④ — ⑤

B3) BCM evaluation of a company

Q8: Do you think "initial measures to resume business" after disasters will fully function?

Will not function at all **Medium level** **will function perfectly**

① ― ② ― ③ ― ④ ― ⑤

Q9: If the answer of Q8 is ③, ④, ⑤, please enter the time required for the emergency control system/organization can start from the occurrence of a disaster. <u>hours</u>

Q10: There are enough members designated to BCM (including investigation of BCP) support

Not at all **Medium level** **Secured sufficient members**

① ― ② ― ③ ― ④ ― ⑤

Q11: Do you think "measures of avoiding/reducing risks of parts/materials supply" will fully function?

Will not function at all **Medium level** **will function perfectly**

① ― ② ― ③ ― ④ ― ⑤

B4) Investment/cost to continue production continuance as preventive measures against disasters.

Q12: Idea of proactively implementing countermeasures to avoid parts supply risks.

No need to do at all **Medium level** **it is essential**

① ― ② ― ③ ― ④ ― ⑤

Q13: Idea of proactively implementing measures with production equipment against disasters (preparation at a back-up production site, etc).

No need to do at all **Medium level** **It is essential**

① ― ② ― ③ ― ④ ― ⑤

B5) Supply chain cooperation

-Measures against disaster at supplier locations.

Q14: Have you sufficiently conducted supplier surveys about risks of disasters and damages?

Have not done at all **Medium level** **Conducted completely**

① ― ② ― ③ ― ④ ― ⑤

Q15: Have you sufficiently implemented countermeasures against risks at suppliers (e.g. keeping inventories)?

Have not done at all **Medium level** **Implemented completely**

① ― ② ― ③ ― ④ ― ⑤

- Measures concerning supplies to customers (including our company)

Q16: Level of implementing countermeasure to guarantee supplies to customers (including our company).

Completely lacking measures **Medium level** **Perfect**

① ― ② ― ③ ― ④ ― ⑤

Q17: If the answer to Q16 is ④, ⑤, describe the specific measures________________________

＜C. Degree of risk＞

C1) Risks of natural disasters in the location of the plant manufacturing (occurrence possibility and impact)

Q18-1) Risk degree of earthquake occurrence

None **Very low** **Medium** **High** **Extremely high**

① ― ② ― ③ ― ④ ― ⑤

When you answer ④, ⑤, how many days will take till 100% recovery of the production? (Enter the actual number of days if your company has the experience, if not enter your estimation） ______________________Days

Q18-2) **Conditions of plant building**

Current earthquake-resistant strength of a building (magnitude)

4 or lower **5** **6** **7** **8 or higher**

① ― ② ― ③ ― ④ ― ⑤

Q18-3) Degree of implementing earthquake-resistance strengthening, enforcement measures (buildings, production equipment, testers, warehouse shelves, production IT, etc.)

Perfect **Medium** **completely lacking**

① ― ② ― ③ ― ④ ― ⑤

Q18-4) Risk degree of Tsunami occurence

None **Very low** **Medium** **High** **Extremely high**

① ― ② ― ③ ― ④ ― ⑤

Q18-5) Distance from a nuclear plant (from Fukushima, Japan nuclear plant hazard map)

More than 50Km (30mliles) 30-50Km (20-30miles) 20-30Km (12-20miles) 10-20Km (6-12miles) Less than 10km (6miles)

① ― ② ― ③ ― ④ ― ⑤

Q18-6) Risk degree of flooding (flood, flash flood (violent flow), flooding of rivers and lowlands)

None **Very low** **Medium** **High** **Extremely high**

① ― ② ― ③ ― ④ ― ⑤

Q18-7) Risk degree of volcanic eruption

None **Very low** **Medium** **High** **Extremely high**

① ― ② ― ③ ― ④ ― ⑤

Q18-8) Risk degree of tornado

None **Very low** **Medium** **High** **Extremely high**

① ― ② ― ③ ― ④ ― ⑤

Q18-9) Risk degree of snow damage, cold wave

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー③ ー ④ ー ⑤

Q18-10) Risk degree of thunderbolt

None **Very low** **Medium** **High** **Extremely high**

① ー ②ー ③ ー ④ ー ⑤

Q18-11) Risk degree of a heat wave

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-12) Risk degree of a typhoon

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-13） Risk degree of a drought

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-14) Risk degree of a wildfires

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-15) Risk degree of a landslide and the debris flow

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-16) Risk degree of Other (Other estimated risk______(please give a concrete example))

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-17) Risk degree of Other (Other estimated risk___(please give a concrete example))_

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

Q18-18) Risk degree of Other (Other estimated risk_____(please give a concrete example))

None **Very low** **Medium** **High** **Extremely high**

① ー ② ー ③ ー ④ ー ⑤

<D. Time necessary for recovery in case your plant is damaged by a natural disaster>

Q19) Do you investigate/assess the impact of the damages in case of a natural disaster, estimate the time when the production stops, and periodically evaluate the information?

Not doing the above at all Barely doing the above Neither of them Doing the above Doing the above frequently

① ② ③ ④ ー ⑤

Q20) Items that restoration will become necessary in order to re-start production when a disaster strikes your company's plant

Q20-1) Restoration of the infrastructure (electricity) Number of days ____

Q20-2) Restoration of the infrastructure (water and sewer services) Number of days _______
Q20-3) Restoration of a building Number of days______
Q20-4) Procurement of the standard equipment Number of days______________
Q20-5) Procurement of the special equipment (assembly machines, inspection machine, etc.) Number of days__________
Q20-6) Funding (internal(if not external)) Number of days______________
Q20-7) Tooling build Number of days______________
Q20-8) Return of employees (direct, indirect) Number of days______________
Q20-9) Securing parts from suppliers affected by a disaster Number of days_____________
Q20-10) Other items requiring countermeasure and the number of days (you can enter multiple items) ____
Q20-11) In case of your company's plant is striken by a disaster, what % is a minimum target when re-starting the production and how many days required till then？
____ ％ （ or not determined ） days

Among answers to Q20-1~10, what item determines the time of Q20-11?______________

Q21) Is the time till recovery you answered by Q20-21 the satisfactory level? P6

Extremely dissatisfactory	Dissatisfactory	neither of them	Satisfactory	Very satisfactory
①	②	③	④	⑤

Q22) Items that restoration will become necessary in order to return to current 100% production when a disaster strikes your company's plant (Calculate by 1 month =30days)

Q22-1) Restoration of the infrastructure (electricity) Number of days ______
Q22-2) Restoration of the infrastructure (water and sewer services) Number of days _________
Q22-3) Restoration of a building Number of days__________
Q22-4) Procurement of the standard equipment (or internally made) Number of days__________
Q22-5) Procurement of the special equipment (assembly machines, inspection machines, etc.) Number of days___________
Q22-6) Funding (internal) Number of days______________
Q22-7) Tooling build Number of days______________
Q22-8) Return of employees (direct, indirect) Number of days______________
Q22-9) Securing parts from suppliers affected by a disaster Number of days______________

Q22-10) Other items requiring countermeasure and the number of days (you can enter multiple items) ____

Q22-11) In case of your company's plant is striken by a disaster, time required to return to 100% production before the disaster.______________ days (calculate as 1 month: 30 days)

Among answers to Q22-1~10, what item determines the time of Q22-11?______________

Q23) Is the time till recovery you answered by Q22-21 the satisfactory level?

Extremely dissatisfactory	Dissatisfactory	neither of them	Satisfactory	Very satisfactory
①	②	③	④	⑤

Q24) When the answer to Q23 is ①②, what improvement measures do you plan to shorten the time required till recovery.

Details of improvement measures: ____________________

Q25) Do you think further target reduction (reduced timeline) against the time required to return to current 100% production.

Unnecessary		Medium level		Essential
①	②	③	④	⑤

Q26) When the answer to Q25 is ④⑤, how many days of reduction is in the target?

____________________ Days （Calculate by 1 month=30 days）

＜E. BCP(Business Continuity Plan)＞

Q27) Magnitude of damages when a disaster strikes a company in the future and supplies of products stops (damages and risks of the company itself will suffer, loss compensation risks from other companies, losing trust of customers, not being able to fulfill social responsibilities, etc.)

No		Medium level		Enormous
①	②	③	④	⑤

Q28) Will shortening the time till production recovery lead to what degree of loss amount reduction(Q2)?

Will directly lead to the loss reduction		Medium level		Will not lead to the loss reduction at all
①	②	③	④	⑤

Q29) What is the current level of BCP(Business Continuity Plan) / BCM(Business Continuity Management) of the company if you evaluate?

Extremely dissatisfactory	Dissatisfactory	Neither of them	Satisfactory	Very satisfactory
①	②	③	④	⑤

Q30) When the answer to Q29 is ①,②, enter the specific concerns.

Concerns: ____________________

Q31) Do you think it is necessary to set up a target with shorter number of days till resume of company operations?

Not necessary		Neither of them		Essential
①	②	③	④	⑤

Q32) Will formation of BCP and execution of BCM lead to establishment of competitive advantage of your company?

Will not lead to it **D**ifficult to lead to it **N**either of them **W**ill lead it slightly **W**ill lead to it directly
① ― ② ― ③ ― ④ ― ⑤

Q33) When the answer to Q32 is ④, ⑤, what is the reason? Please reply one main reason.

____

Q34) When the answer to Q32 is ④, ⑤, in order to establish compete advantage, will you review the direction such as your production strategies (e.g. Production at multiple sites), new product development (e.g. Reduce the number of parts, modulation, communize parts), purchasing strategy (e.g. multiple sourcing, switching to low-risk suppliers)?

Will review **D**ifficult to review **N**either of them **R**eview as far as we can **F**undamental review
① ― ② ― ③ ― ④ ― ⑤

Q35) When the answer to Q32 is ④, ⑤, enter the specific contents of policy review.

____

＜Risk by part＞ Sheet No. 2

Please enter this sheet by individual part (Please use a separate sheet for each part.)

(Even though answers to these questions are the same as Common questionnaire sheet No. 1, please enter by part number.)

* Part numbers and types we purchase are listed in a list. Please provide your answers in the Excel sheet.

Q36) Part type: 1,Commercial parts, 2,Processed parts, 3,Materials.

Q37) Name of a plant actually manufacturing the part: Please enter the name of the plant who manufactures the part number.

Q38) Process

When production locations are different by "front end", "back end" and "inspection process" for example, please add lines to enter the information. If the part is manufactured at only one location, you do not have to do so.

Q39) Process conducted:

1.Front end / 2.Back end / 3.Inspection process / 4.Molding / 5,Press / 6.All processes.

Q40) Address of a plant.

Please enter the address of the manufacturing location. Please include the building number also.

Q41) Availability of alternate part.

Please let us know if there is an alternate part that is equivalent to the subject part when the production becomes disrupted. Please enter "2" if there is available parts, and "1" if there is no part available.

Q42) The number of days to start up the alternate part.

If there is an alternate part for the subject part, please enter the delivery lead-time (number of days)

Q43) Time required for recovery to resume current production condition (Q20-11 for the entire plant).

The number of days required for resuming the100% production of the subject part in the event that the plant is damaged by a disaster.

____________________________________Days (Calculated by 1 month=30 days)

Q44) Time required for recovery to return to current 100% production(Q22-11 for the entire plant)

Please enter the number of days when the production volume of the subject part to our company is return to the normal condition.

____________________________________Days (Calculated by 1 month=30 days)

Q45) The number of days held in stock on hand for the subject part number.

____________________________________Days (Calculated by 1 month=30 days)

Thank you for your cooperation to this survey.

If you have any problem, please contact our person in charge.