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A Novel Classification of Supply Chain Risks:
Scale Development and Validation

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Abstract:

Purpose: Supply chain has become an essential element for any organization but risks are the major obstacles in achieving the performance even it can disrupt not only the organization but a whole system. Thus, it is compulsory to manage the risks efficiently and effectively. Risk cannot be managed until properly identified, there are numerous studies on risk identification, after comprehensive literature, it has been revealed that the study that identifies overall supply chain risk is scaring. The manufacturing sector of any country is considered as the backbone of any economy, in Malaysia it is the second largest sector in economic contribution and highest in productivity level. The aim of this study is to provide a reliable tool to assess the overall supply chain risks of Malaysian manufacturing through a systematic process.

Design/methodology/approach: A detail literature review has been done for categorization of overall supply chain risk sources. Then an instrument has been developed from a pool of items. The questionnaire was purified through pretesting, pilot testing (by the exploratory view) and reliability and validity tests. The data were collected by email from Federation of Malaysian Malaysia (FMM-2017) through systemic probability sampling. Total 132 final responses have been considered for exploratory factor analysis through SPSS 23.

Findings: The finding of this study revealed that overall supply chain risks can be categories into seven constructs that are supply side risks, process side risks, demand side risks, logistic side risks, collaboration side risks and environment side risks and the final questionnaire is consisting of 57 items.

Research limitations/implications: This study covered tier 1 members of the supply chain. Secondly, the supply chain of manufacturing organizations only has been considered.

Practical implications: This study will help the managers to understand what kind of risk sources they can face and which type of risks under these risk sources they should consider while decision making. This study will update the managers about the identification of risks and their potential negative effects.

Originality/value: This article will justify the need for Malaysian manufacturing by providing a validated and reliable instrument for the identification and assessment of their risks under major supply chain risk sources.

Keywords: supply chain risk management, supply chain risk sources, risk assessment, instrument development, Malaysian manufacturing

1. Introduction

The aim of supply chain is to create value by empowering compatibility between internal and external processes. Hence, manufacturing organization's effectiveness is transformed into supply chain activities because of demands for responsiveness, cost reductions and innovativeness in the customer demands (He, Zhu, Feng & Amin, 2017). Meanwhile, in a current global scenario where businesses continuously try to expand their boundaries, coverage new markets as well as distribute and seek inexpensive manufacture sites, it is essential to be well informed about possible risk that can interrupt the system and possible ways to mitigate the risks. Thus, organizations need to be able to enumerate and visualize the potential risks in order to efficiently and effectively manage it (Tazehzadeh, 2014). Accordingly, it has been argued that managing risks has become increasingly challenging because of greater uncertainties, shorter product, globalization of markets, and technology life cycles, outsourced manufacturing, distribution, and logistics make it more complex and fragile (Rao & Goldsby, 2009). This complexity and interconnectedness have a greater chance of disruption and these disruptions can badly influence the performance of the organization even a whole system. Numerous exertions have been made to quantify the risks in supply chains but no studies that identify all kind of risks in very rare, particularly risk identification in Malaysian manufacturing is scared.

The current study has two objectives first; topology supply chain risks into the dimensions/constructs and second is to identify sub-dimensions/items under these constructs. In the past many researches have categories supply chain risk sources in to various constructs like operational and disruption risks (Wagner & Bode, 2008), Operational, network and external risks (Lockamy III & McCormack, 2010) or Environmental risk, Supply risk, Demand risk and Process (Prakash, Soni, Rathore & Singh, 2017). However, after comprehensive literature it has been revealed that most of the researches categories overall supply chain risk based on the three major categories internal to organization also called organizational factors, external to organization but internal to network also known as industry factors and lastly external risk sources also called environmental factors (Basole, Bellamy, Park & Putrevu, 2016; Ellis, Shockley & Henry, 2011; Lockamy III & McCormack, 2010). Organizational factors can be categories into three kinds of flow information, financial and material flow, this flow creates information side risk, financial side risk, and logistic side risk, whereas industrial factors that include suppliers, manufacturers, and customers that can create supplier side risks, process side risks, and demand side risks. Lastly, environmental factors produce environmental side risks. Conclusively, this study argues that overall supply chain risks can be categories into seven constructs that are supply side risks, process side risks, demand side risks, logistic side risks, collaboration side risks, financial side risks, and environment side risks. Hence to confirm this argument there is sewer need to empirically prove this, for empirically verification this study develops an instrument.

There are various processes for instrument development, the current study adapts the process by (Punniyamoorthy, Thamaraiselvan & Manikandan, 2013). A pool of items has been gathered from literature review than purify them by pretesting and pilot testing from industry experts, researches and real respondents. Lastly, data final questionnaire has been distributed to all respondent industries, listed in the Federation of Manufacturing Malaysia (FMM) 2017 by email. After many reminders, 132 valid responses have been considered for data analysis. Additionally, SPSS 23 has been used for missing values, outliers, linearity, reliability and validity.

Management of this study is as follow; first understanding, concepts, and definitions of risk, supply chain, and supply chain risk have been explained. Second, a comprehensive literature review has been done for supply chain risk sources and seven risk sources have been extracted. Lastly, the instrument has been developed through a systemic process and data analysis has been mentioned before the conclusion.

2. Literature Review

2.1. Supply Chain Risk

Supply chain risk management (SCRM) is a new field that came from the juncture of the supply chain (SC) and risk management (Tazehzadeh, 2014). Being a relatively new area SCRM is being assumed as a confused and orderless field (Trkman & McCormack, 2009). Even though this area has attracted many researcher's attention still it does not have a clear definition (Ponomarov & Holcomb, 2009). The above definitions reveal that the objectives of risk management are very vast and meanwhile the supply chain but supply chain risk management has its own intentions. SCRM main objectives are an assessment of potential risks and develop an appropriate plane to avoid or mitigate it (Yaakub & Mustafa, 2015). According to the adopted definition of supply chain it focus on relationship with all upside and downside of organization that is why this study adopts the definition of supply chain risk management "the identification and evaluation of risks and consequent losses in the global supply chain, and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing the risks (Manuj & Mentzer, 2008b).
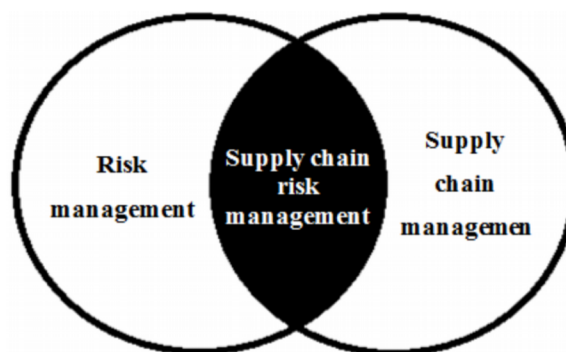

Figure 1. Supply chain risk management adapted from (Vilko, 2012)

2.2. Supply Chain Risk Sources

Identification, categorization, and mitigation are essential for the success of any supply chain. It is only possible when risks are well identified. Supply chain risk management can be categories according to its risk sources (Lockamy III & McCormack, 2010). There are numerous definitions for risk sources but the definition that best match with operational definitions is (Jüttner, 2005) risk sources are "any variables which cannot be predicted with certainty and from which disruptions can emerge" and finding of this research discovered, by consensus, that risk sources have become more essentials as supply chain become more complex and modern.

Broadly supply chain risks also known as supply chain risk sources (Wagner & Bode, 2008) can be divided into two categories internal risks/ operational risks and external risks/ disruption risks (Olson & Wu, 2011) furthermore internal risk divided into operational activities like, information risks and capacity related problem, customer demand, quality related issues and etc. Whereas external risks can be divided into the competition, economic issues, political instability, natural disasters, terrorist attacks and etc. (Shahbaz, Rasi, Zulfakar, Ahmad & Asad, 2018). Additionally, from the operational definitions of this study, the supply chain not only deals internal operations but essentially considered an external relationship with their partners. Therefore, most of the researchers categories overall supply chain risks into three internal to organization also called organizational factors, external to organization but internal to network also known as industry factors and lastly external risk sources also called environmental factors (Basole et al., 2016; Ellis et al., 2011; Lockamy III & McCormack, 2010).

Meanwhile, most studies divide organizational factors into further three types supply side, process side and demand side, on the basis on supply chain process that consists on the source, make and deliver (Chen, Sohal & Prajogo, 2013). Furthermore, industrial factors are basically the relationship among supply chain partners and these partners are linked through flow, according to the adopted definition; supply chain has three kinds of flow information flow, material flow, and financial flow. Hence, material flow creates logistic side risks (Tse, Matthews, Hua-Tan, Sato & Pongpanich, 2016) whereas finance flow cause financial side risks and meanwhile information flow originate

information side risks (Tang & Musa, 2011). Additionally, most of the researchers use information risk to cover information flow risks but this study argues that information side cover information related risks and miss relational risk like coordination or etc. to cover all these issue current study use collaboration side risk and this argument is supported by (Basole et al., 2016). Lastly, to cover external factors current study considers environmental factors like natural disasters, global issues and etc. the detail description can visualize from Figure 2.
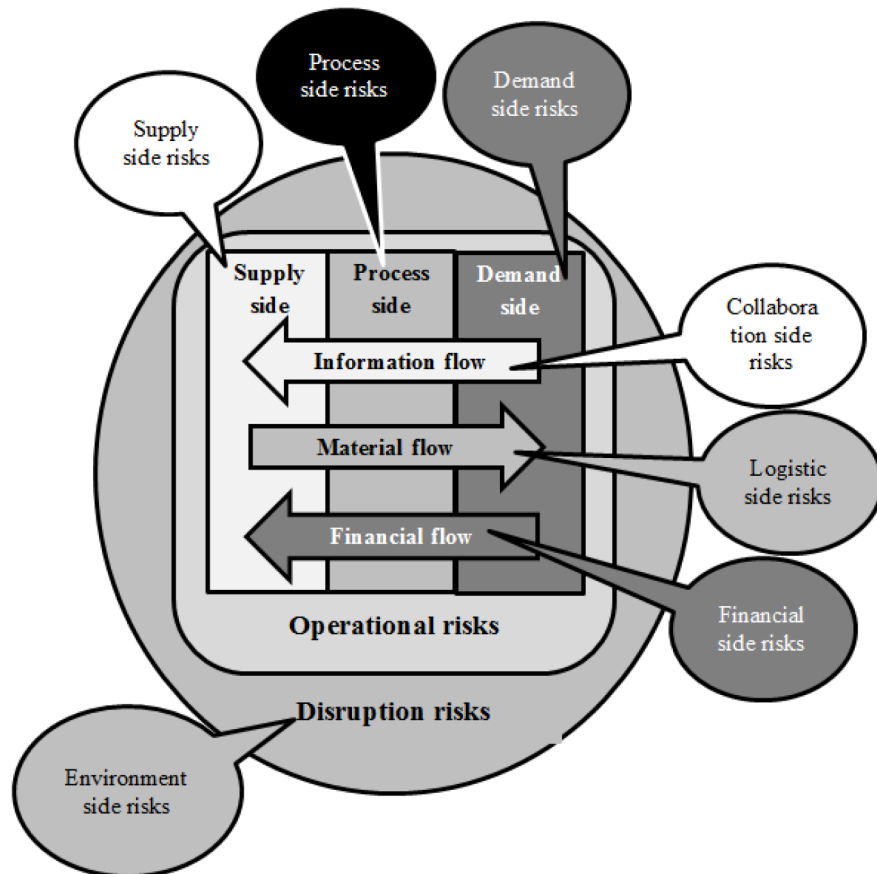

Figure 2. Distribution of all risks according to their sources (Musa, 2012)

This topology is supported by (Punniyamoorthy et al., 2013) that divide overall supply chain risks into six factors, but this study misses the financial side of risk and (Musa, 2012) this study also categories overall supply chain risks into six factors and missed logistic side risks. Finally, it can conclude to cover all supply chain risks, the organization must consider seven sides that are supply side, process side, demand side, logistic side, collaboration side, financial side and environment side risks, Figure 2 explain all these seven risk sources according to their origin. Explanation of these seven is mention below.

2.2.1. Supply Side Risks

Supply side risk is the chance of occurrence of an event in inbound supply that impacts the organizational capacity in satisfying the customers either it is due to individual or market supply side (Zsidisin, Melnyk & Ragatz, 2005). Paul, Sarker and Essam, (2016) describes the importance of supply side risks as most of the research in supply chain disruption is on supply disruptions. Toyota had to the shutdown of plants and halt its 50% assembling for six weeks just because one of its suppliers had a fire in its plant and discontinue supply (Jüttner, 2005; Shahbaz, Rasi, Zulfakar, Ahmad, Abbas & Mubarak, 2018). Supply risks may arise from the reliability of supplier (wrong understanding of ability of suppliers), moral hazards, environmental compliances, purchasing decision, multiple sourcing and security problems or it can be, sudden price change, quality issues, supplier's bankruptcy, conflicts in goals, inventory problem, delays, product complexity, problem in technology access or etc. (Manuj & Mentzer,

2008a). The supply side risks normally are poor logistics performance of suppliers, supplier quality problems, sudden default of a supplier (e.g., due to bankruptcy), poor logistics performance of logistics service providers and capacity fluctuations, shortages on the supply markets and etc.

2.2.2. Process Side Risks

Imperfect production is an important element that can impact significantly the performance of the company, firms can have a massive loss not only financial but also reputation (Paul et al., 2016). Process side risks/Infrastructure risk/operational risk is "loss resulting from inadequate or failed internal processes, people and systems or from external events" (Basel Committee on Banking Supervision, 2006). Process side risks may be inefficiency in the manufacturing process, high level of changing in the process, material shortage, outdated technology and etc. (Manuj & Mentzer, 2008a; Shahbaz, Rasi, Ahmad & Rehman, 2017). The focus of this study is downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents), Perturbation or breakdown of internal IT infrastructure (e.g., caused by computer viruses, software bugs), loss of own production capacity due to technical reasons (e.g., machine deterioration) and Perturbation or breakdown of external IT infrastructure (Wagner & Bode, 2008).

2.2.3. Demand Side Risks

Demand side risks derived from downstream of the supply chain, or from the customer sides issues (Jüttner, 2005). Demand risk is defined as "the possibility of an event associated with outbound flows that may affect the likelihood of customers placing orders with the focal firm, and/or variance in the volume and assortment desired by the customer" (Manuj & Mentzer, 2008a). Demand risks may be delays, lazy in new product development, wrong forecasting, variation in demand, inaccurate information, industrial factors further explore as input market uncertainties, product market uncertainties, and competitive uncertainties. Lastly, organizational factors also have a group of uncertainties like operating, liability, research and development, credit, and behavioral uncertainties (Rao & Goldsby, 2009). Paul et al. (2016) reveals that very limited literature is available on demand fluctuation in the supply chain. The side risks are unanticipated or very volatile customer demand and Insufficient or distorted information from your customers about orders or demand quantity and etc.

2.2.4. Logistic Side Risks

Logistics uncertainty is viewed as an uncertainty factor that causes a delay or an interruption originating from own or partners logistics system or natural disasters throughout the logistic process (Tse et al., 2016). Logistic side risks are considered, the material flow of goods from the supply side and to demand side, usually, little attention has been paid for logistic Although, it has been noted that logistic disruption is "quickly cripple the entire supply chain" (Punniyamoorthy et al., 2013; Shahbaz, Rasi, Ahmad & Sohu, 2018). Normally, logistic side risks originates from cargo damage, supply side constrictions or warehouse problem (Wilson, 2007), Delay in delivery (Wang, Jie & Abareshi, 2014), improper packaging (Zubair & Mufti, 2015), labor disputes, natural disasters, terrorist activities, and transportation infrastructure failures (Thun & Hoenig, 2011), Wrong Choice of mode of transportation (Punniyamoorthy et al., 2013), transportation complexity (Wagner & Neshat, 2012).

2.2.5. Collaboration Side Risks

Research revealed that collaboration can produce more effectual and considerable results, but also carry numerous glitches. Collaboration risk is "the apprehensive with cooperative relationships or the probability that the partner does not comply with the spirit of cooperation" (Faisal, 2009). Thus, it would be a serious issue if one member of supply chain does not obligate itself to cooperation as anticipated by the other members (Basole et al., 2016; Shahbaz, Rasi, Zulfakar, Ahmad, Abbas & Mubarak, 2018). New challenges such as collaboration risks would arise when partners are involved in the supply chain such as the decision making becomes complex when more partners involved with various interests, culture, and preferences (Zeng, 2012). It has been learned from a validated sample of 162 responses that the complexity of partnerships executes the most significant effect on supply chain risks and the collaboration risks are considered the top risks that can impact supply chain performance to the most extent. Collaboration risks arise from issues such as lack of ability to support the

operations, lack of trust, level of information accuracy, information system security and disruption, intellectual property, and information outsourcing (Basole et al., 2016). Meanwhile, leakages of core competencies by suppliers to competitors (Sharma & Bhat, 2012), Delay or unavailability of the information and communication infrastructure (Punniyamoorthy et al., 2013) or Breakdown of external/internal IT infrastructure (Wang et al., 2014).

2.2.6. Financial Side Risks

The financial side risks occur due to the flows of cash among organizations, the incurrence of expenses and the use of investments for the entire network, Accounts Payables, settlements and Accounts Receivables (Faisal, 2009). Financial side risks can also be defined as "The risk that a potential event will have a financial impact. For example, if the company is in the retail software business, then a potential patent infringement claim can occur that may result in legal costs, loss of business and etc. (Handfield & McCormack, 2008). There are various types of financial side risks, initially risk was associated with embedded costs, differing costs of capital and rates of expense incurrence, and cash movements and settlements from one firm to the next (Cavinato, 2004) and financial side risks also include interest rate fluctuations, credit rating for company's bonds, changes in currency exchange rates and changes in accounting and tax laws (Ravindran & Warsing, 2013). In many studies, it has been revealed that financial side risks negatively affect the not only the financial performance but also overall supply chain performance (Mody, 2012; Musa, 2012; Ravindran & Warsing, 2013; Singh & Abdul-Wahid, 2014).

2.2.7. Environment Side Risks

Environment side risks have low probability but high consequences (Knemeyer, Zinn & Eroglu, 2009). Natural disasters create hurdles in smooth operations (Tummala & Schoenherr, 2011). It has been mentioned previously that how nature can disrupt not only one organization but also the whole supply chain system. According to (Greenpeace Southeast Asia, 2014) fires in forest and peat have become a global threat and it also mentioned in the same report that smoke from these fires have killed about 110000 of human in Southeast Asia and caused huge global warming through carbon emission. Environment side risks further categories into political instability, macroeconomic uncertainties, social uncertainties, and natural uncertainties, political instability, (war, civil unrest or other socio-political crises), Diseases or epidemics (e.g., SARS, Foot and Mouth Disease), Natural disasters (e.g., earthquake, flooding, extreme climate, and tsunami) and International terror attacks (Wagner & Bode, 2008).

In some countries regulations are also big hurdles in starting a business or operate it effectively. Administrative decision sometimes suddenly come to execution and can affect the performance badly (Hendricks & Singhal, 2003). Regulatory laws defined as any legal enforcement and execution, supply chain related, laws and policies, like transportation and trade laws, it also include the frequency and degree of changes in these policies and laws (Wagner & Bode, 2008). According to Zsidisin, Petkova and Dam, (2015) any change in the political environment due to new laws or modification in existence cause disruption in supply chain operations. It may increase cost or even sometimes halt production. It has been proved that regulation disruptions reduce the 3.8% shareholder's wealth (Zsidisin et al., 2015).

3. Research Methodology

The aim of this study is to develop and validate an instrument that assesses the overall supply chain risks in Malaysian manufacturing. After a comprehensive literature review, a holistic framework has been proposed through a systematic process. This framework is based on previous frameworks and operational definitions of supply chain risk; according to proposed framework overall risk can be categories into seven sources that are supply side risks, process side risks, demand side risks, logistic side risks, collaboration side risks, financial side risks, and environment side risks. Now there is a need to verify this framework through the empirical process. This study adopts the empirical verification process from (Punniyamoorthy et al., 2013), moreover this process has already been used in various studies for instrument development for various industries or strategies/approaches (Cao, Vonderembse, Zhang,& Ragu-Nathan, 2010; Prakash et al., 2017; Punniyamoorthy et al., 2013; Tse et al., 2016; Zailani, Jeyaraman, Vengadasan & Premkumar, 2012; Zhu, Sarkis & Lai, 2008). First, after detail literature review seven constrict has been developed, detail of these constrict have been mentioned in Figure 2. Secondly, supply chain risk management

is growing tremendously, numerous instruments have been developed in many countries for different industries, from these similar instruments a large pool of items has been generated under pre-mentioned seven constructs. A draft questionnaire has been developed from this pool, and pre-testing and pilot testing have been applied for refinement. The improved questionnaire then distributed to all manufacturing firms listed in FMM 2017. Lastly, after manual screen and cleaning of data factor analysis and various test to validity and reliability, has been applied to finalize the instrument. The detail of the empirical verification process can be seen in Figure 3.
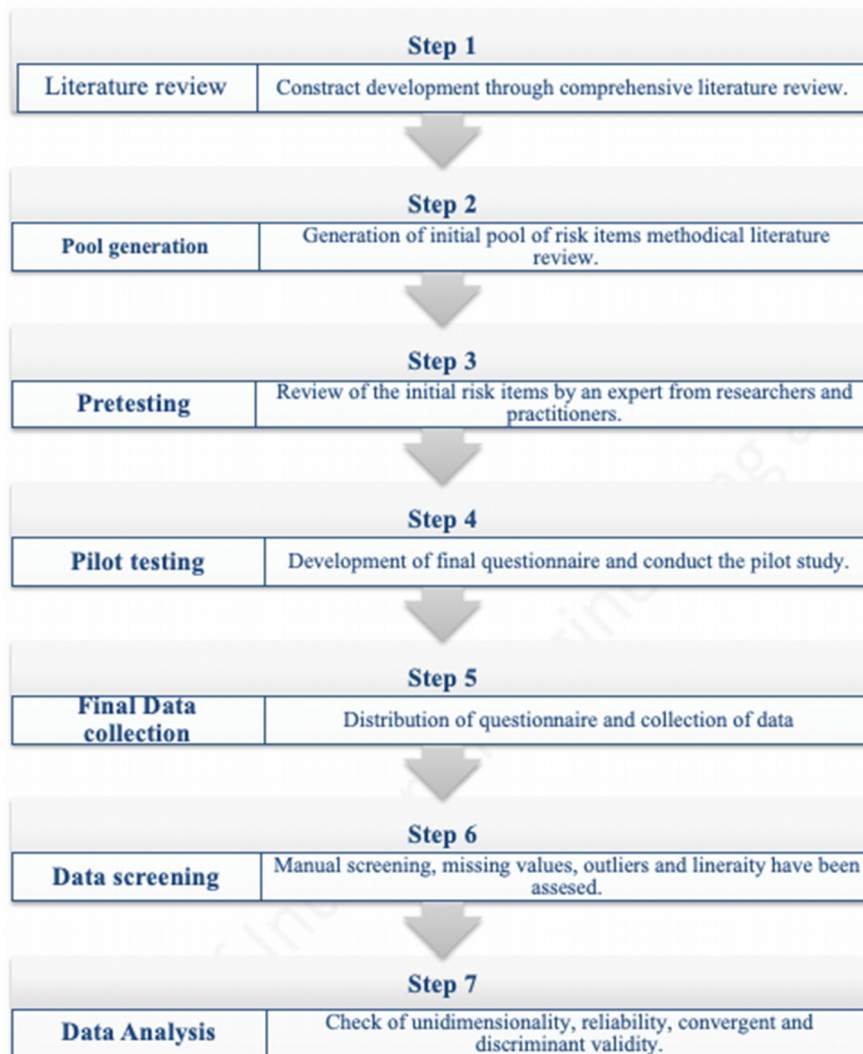
Step 1

| Literature review | Constract development through comprehensive literature review. |

Step 2

| Pool generation | Generation of initial pool of risk items methodical literature review. |

Step 3

| Pretesting | Review of the initial risk items by an expert from researchers and practitioners. |

Step 4

| Pilot testing | Development of final questionnaire and conduct the pilot study. |

Step 5

| Final Data collection | Distribution of questionnaire and collection of data |

Step 6

| Data screening | Manual screening, missing values, outliers and linerity have been assesed. |

Step 7

| Data Analysis | Check of unidimensionality, reliability, convergent and discriminant validity. |

Figure 3. Instrument development process (Punniyamoorthy et al., 2013)

3. Methodology

3.1. Pre-testing

The aim of Pre-testing is normally addressing the following issues; layout, length, format, sequences, lines and replies, qualities of questions and respondents confusion. It is not only important for problems identification but also helpful in eliminating ambituses, biases, and errors (Bryman, 2013). Pre-testing should include three types of people academic, industry experts and real respondents (Forza, 2002). Current study approached four people from academic, one professor, two associate professors, and one lecturer, who have vast experience in operational and supply chain research. For industry expert, this study approached three people. Meanwhile, for real respondents this study approached six people, those are working in operations or supply chain.

This study has used a Rubric survey instrument validation form for pre-testing. This form has ten criteria and each criterion has its own questions, to answer these questions a four-point Likert scale and a space of additional comments were provided. The ten main criteria were clarity, wordiness, negative wording, overlapping, balance, use

of jargons, use of technical language, relationship to the problem, appropriateness to response list, measurement construct. Additional space was provided at the end for suggestions. Multiple reviews, comments, suggestions had been received and all were considered very carefully like some questions were too long so it was advised to make it comprehensive, a few difficult words had been used it had been replaced by simple one and etc. had been used so it was advised to mention some examples and remove this to avoid confusion. No additional risk had been received but it was advised to rephrase and split some of the risks.

3.2. Pilot-testing

Pilot testing is being conducted from the same type of respondents who will be participating in the main study with the aim to ensure that questions, scale, and instructions are clear and respondents can easily understand and respond properly (Pallant, 2011). Pilot testing highlights the mishaps, misunderstanding or flaws of the questionnaire and makes it sure that all respondents are paying their required attention (Neuman, 2014). Pilot testing consists of a small group of respondents from the main pool with convenience sampling (Flynn, Sakakibara, Schroeder, Bates & Flynn, 1990). Current study follows the central limit theorem that states "The larger the absolute size of a sample, the more closely its distribution will be to the normal distribution" (Saunders, Lewis & Thornhill, 2009). Hence, data were collected from 32 respondents through open-ended questionnaires. This method has been used widely as respondents have the choice to add more or any new type of risks. Lastly, collected data has been reviewed, analyzed and considered very keenly.

3.3. Questionnaire

The settle questionnaire consists of two parts; the first part is about descriptive information. This part includes demographic information to know the state position of the organization, as the various demographic positions can have different types of risks, organization position, number of employees, respondent position in the organization and respondent working experience. Part 2 was about "To what extent your organization has experienced the negative impact of the following types of supply chain risks on performance in the last five years?" The seven-point Likert scale has been used; the detail about these seven points is here:

1	2	3	4	5	6	7
No impact	Negligible impact	Marginal impact	Significant impact	Critical impact	High impact	Very high impact

Table 1. Questionnaire scaling

3.4. Data Collection

The final questionnaires had sent to Malaysian manufacturing listed in Federation of Manufacturing Malaysia (FMM 2017) through email. The respondents were all strategic, operation and technical level staff related to supply chain as all kind of staff can have interacted with various risks. Meanwhile, after two weeks, a reminder email has also been sent as a result total 155 responses have been received.

4. Data Analysis
4.1. Data Screening

Data screening is first and essential part of data analysis, it provides basic understanding about the study and ensures the researches that questionnaire fulfill all requirements (Hair, Black, Babin & Anderson, 2014). It normally includes data cleaning (wrong entries), missing values, outliers, normality, linearity, and homoscedasticity (Chen, 2012). The aim of data screening is to ensure the accurateness of data entry like the out of range values, identifying missing values and management of these missing values, identify outliers and manage them and check for normality and deal with non-normality (Rasi, Abdekhodaee & Nagarajah, 2014). Current study follows the process of data screening by (Pallant, 2011) with some modification, the detail of the process is given below.

4.2. Missing Values

When a valid value on one or more variables is not available for analysis, it is considered a missing value (Hair, Black et al., 2014). How to treat these missing values it depends on its randomness and extent. For treatment, missing values (Singh., 2007) categories mission values into three types; (1) Values that are not missing completely at random (2) Values missing at random and (3) Values missing completely at random. Hence, in case 2 and 3, missing at random can be ignored but case 1 cannot be neglected, there is essential to use techniques for case 3. The current study, follow the four steps of handling missing data by Hair, Black et al. (2014). First and second is determined the type and extent of missing data, it has been found that few cases are incompletely filled by respondents. During data clearing, few responses were found incomplete or abnormal, those responses have been deleted. The third step is to diagnose of randomness of missing values, little's missing completely at random (MCAR) test has been applied (Little, 1988). It has been revealed that Chi-square is 1707.074 while DF is 2227 and p-value is 1.00, the p-value is above significant values this means missing values are completely at random and no specific pattern found. Additionally, the missing percentage is below 5% for all variables. As there is no pattern and missing values are below 5% so Expectation maximization (EM) logarithm is considered best choice for imputation when a large amount of data is missing with no pattern (Schumacker & Lomax, 2016). Conclusively, EM method has applied through SPSS version 23 and missing values have been replaced.

4.3. Outliers

Outliers are the data points that deviate evidently from the rest of the data (Aguinis, Gottfredson & Joo, 2013). Outliers can negatively affect the mean, correlation, standard deviation and correlation coefficient (Longest, 2012). There are two major types of outliers, univariate outliers, and multivariate outliers.

The univariate outliers are the data points that exist in the distribution of each variable in the analysis or those values that fall at the outer ranges either extremely high or extreme low (Hair, Black et al., 2014). This study follows the (Pallant, 2011) method for detecting the univariate outliers, SPSS 23.0 has been used and histogram, boxplot, and the difference between mean and 5% trimmed mean have been analyzed. Boxplot analysis shows that there is no extreme outlier in each variable. The difference between mean and 5% trimmed mean is very low, it also proves the absence of any extreme high or low value in each variable. Lastly, histogram with curve illustrates that although some high values there is no pattern. Conclusively there is no extreme outlier in the individual variables.

4.4. Multivariate Outliers

Outliers represent cases those scores are considerably changed from others in a specific set of data. A univariate outlier has an extreme score on a single variable, whereas a multivariate outlier has extreme scores on two or more variables. Commonly Mahalanobis distance (D2) is being used to deal multivariate outliers. Mahalanobis distance is "a measure of each observation's distance in multidimensional space from the mean center of all observations, providing a single value for each observation no matter how many variables are considered" (Hair, Black et al., 2014). The current study determined the critical p-value using the number of independent variables as the degrees of freedom and P should be less than 0.001 (Pallant, 2011). The current study uses SPSS 23 and found that no value below 0.001, that indicates no multivariate outlier in the data.

4.5. Linearity

Linearity discusses the relationship among the independent variables, the degree to which the change in one variable is related to the change in the other variables (Hair, Hult, Ringle & Sarstedt, 2014). In order to elucidate the direction and strength of the relationship along with to define the linearity, the correlation among the independent variables and scatterplot matrix are being produced (Abdullah, Yahya, Ramli, Mohamed & Ahmad, 2016). If one independent variable is highly correlated with any other variable like ≥ 0.9, then linearity exists (Pallant, 2011). Appendix 2 is the correlation values, it can be seen that no value is near 0.9. Furthermore, appendix 3 revealed that all scatterplots in the matrix explain no straight line. Thus, there is no linearity among independent variables.

4.6. Multicollinearity

The extent to which two or more independent variables are correlated with each other also termed as multicollinearity (Saunders, Lewis & Thornhill, 2016). Multicollinearity can create many problems like complication in interpretation and computational of relationships increases sampling variance in estimates of their partial relationships that ultimately increase and affect the width of confidence intervals (Hayes, 2013; Von der Heidt, 2008). Hence to find out multicollinearity two values have been calculated Tolerance and Variance Inflation Factor (VIF). The current study selected supply side risk as the dependent variable and all supply chain risk factors as an independent variable for multicollinearity through linear regression. Appendix 4 shows the values of tolerance and VIF, all the values of tolerance are greater than 0.1 and all the values of VIF are less than 10 that justify no multicollinearity issue in the data.

4.7. Instrument Reliability and Validity
4.7.1. Unidimensionality

Unidimensionalitly means a set of items/sub-dimensions can be explained by only one primary construct. It is significant when more than two constructs are involved then each item is hypothesized to narrate to only a single construct. (Hair, Black et al., 2014). Unidimensionality is considered essential for theory testing and development and constructs validity is not feasible without unidimensional scales (Seo, 2014). Unidimensionality ensure two things first is every item should be significantly associated with its particular construct and secondly, it must be accompanied with only one construct (Chen & Paulraj, 2004). Unidimensionality can be determined with either exploratory factor analysis (EFA) or confirmatory factor analysis (CFA) (Squire, Cousins, Lawson & Brown, 2009). The current study is going to explore new constructs that is why EFA has been applied.

Meanwhile, sampling adequacy has also been assessed through the value of Kaiser-Meyer-Olkin (KMO), it basically shows the adequate size of samples that are required for factor analysis (Qrunfleh, 2010; Udbye, 2014). Mostly, KMO scores below 0.5 are considered unacceptable and more than 0.90's are considered outstanding (Leech, Barrett & Morgan, 2005; Pallant, 2011). The current study found its Kaiser-Meyer-Olkin 0.0864 means sample size is adequate and Bartlett's Test of Sphericity is 0.000 that is below 0.05 means items have sufficient correlation among each other.

The current study has applied EFA to confirm the Unidimensionality. For EFA this study has used principal component with Varimax rotation to observe the specific dimensions (Okuduba, 2016; Seo, 2014). The VARIMAX technique has proved effective analytic approach for orthogonal rotation of factors (Hair, Black et al., 2014). The threshold value for factor loading should be more than 0.5 for significant consideration. If an item is not loading under a specific construct or is cross loading under more than one construct will be deleted (Hair, Black et al., 2014). Current study perform the test 63 items under seven constructs and found that 57 items have factor loading more than 0.5 and loading under its appropriate constructs, while two items, Social uncertainties, and International terror attacks, are loading under other constructs, meanwhile remaining four items, frequent product recall process, short product life cycles, corruptions and fail to reduce cost are not loading means have factor loading less than 0.5, all six items have been deleted.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.864
Bartlett's Test of Sphericity	Approx. Chi-Square	11726.921
	df	1953
	Sig.	.000

Table 2. Sample adequacy test through KMO and Bartlett's Test

4.7.2. Reliability

Reliability discusses to whether scores of items in an instrument are internally consistent or not, it is basically the ability of the instrument to measure the same thing each time. An important factor is an internal consistency; it involves correlating the responses in the instrument with each other. It thus measures the consistency of responses across a subgroup of the indicators (Saunders et al., 2016). There are various ways to measure the internal consistency but most common and famous method is coefficient alpha (Cronbach's Alpha). Coefficient alpha measures the internal consistency reliability that undertakes equal items loadings and indicates how well the indicators are positively correlated to one another (Hair, Hult et al., 2014). The largely agreed lower limit for coefficient alpha is 0.70, although it may decrease to 0.6 (Hair, Black et al., 2014). Below Table 1 revealed that all values are above the threshold limit, thus the data is internally consistent.

Construct	Items	Factor loading	Reliability and validity
Supply side risks	Supplier's human resource problems	0.596524	α = 0.898541 AVE = 0.434261343 CR = 0.883647994
	Supplier quality problems	0.800776	
	The unexpected default of suppliers	0.705234	
	Frequent delays of suppliers	0.639245	
	Dependency on a single supplier for critical time	0.593921	
	Capacity fluctuations of suppliers	0.681518	
	Vague inspection procedures of the suppliers	0.618326	
	Supplier locked (cannot easily switch to another supplier)	0.550343	
	Unethical practices of suppliers revealed in public	0.692884	
	Lack of technical expertise	0.676047	
Process side risks	High level of process variation	0.586235	α = 0.758934 AVE = 0.384160223 CR = 0.827993948
	Inflexibility in capacity	0.748159	
	High labor turnover	0.854127	
	Vague inspection procedures	0.538017	
	Improper handling/maintenance	0.566749	
	Loss of own production capacity due to local disruptions	0.507111	
	Breakdown of IT infrastructure	0.551835	
	Loss of own production capacity due to technical reasons	0.517673	
Demand side risks	Volatile customer demands	0.537681	α = 0.797996 AVE = 0.363763061 CR = 0.816334817
	Customers change specifications (time, quality, quantity)	0.546886	
	Large forecast errors in demand	0.508607	
	Frequent delays in delivery to customers	0.611602	
	Reputation risks	0.532252	
	Customers' dependency	0.645042	
	Loss due to customers' faults (Any mistake from the customer)	0.837923	
	Higher customer expectations	0.536372	
Logistic side risks	Poor logistics performance of logistic providers	0.605946	α = 0.883293 AVE = 0.343643625 CR = 0.845519516
	Poor design of transportation network	0.714032	
	Wrong choice of mode of transportation	0.594829	
	Improper packaging and marking details	0.620315	
	Breakdown of equipment, trucks and/or delivery van	0.566018	
	Delay in delivery time	0.630040	
	Lack of professionalism in the logistics sector	0.626620	

Construct	Items	Factor loading	Reliability and validity
	Processes errors	0.605961	
	Supply chain complexity	0.566018	
Collaboration side risks	Distorted information from members	0.800605	α = 0.962356 AVE = 0.514209225 CR = 0.922569719
	Inadequate security of information system	0.753235	
	Wrong choice of communication	0.775576	
	Lack of coordination among members	0.665544	
	Disruption due to high dependency	0.736854	
	Insufficient information from members	0.828885	
	Leakages of core competencies from any member	0.704607	
	Poor information sharing within members	0.805363	
	Supplier network misalignment	0.713582	
Financial side risks	Fluctuation in prices	0.616033	α = 0.771453 AVE = 0.363572853 CR = 0.773075613
	Receivable risk	0.614563	
	Customer refusing the freight charges	0.506864	
	Increase custom or taxes	0.583640	
	Economic shift	0.653133	
	Fluctuation in exchange rates	0.632553	
Environment side risks	Policy uncertainty (introduction of new laws)	0.775207	α = 0.831693 AVE = 0.3651257 CR = 0.797025023
	Poor country infrastructure (e.g., road congestion/closures)	0.559354	
	Diseases or epidemics (e.g. foot and mouth diseases)	0.562138	
	Nonavailability of skilled manpower	0.538273	
	Natural disasters (e.g. earthquake, flooding and tsunami)	0.510024	
	Technological changes	0.524647	
	Administrative barriers for the setup or operation	0.707772	

Table 3. Reliability and validity

4.7.3. Composite Reliability (Construct Reliability)

Composite reliability is a measure of internal consistency that unlikely Cronbach's alpha, does not undertake equivalent indicator loadings (Seo, 2014). Its range is between 0 and 1, higher the values higher levels of reliability. Its threshold value is considered good at more than 0. 70. The composite reliability below 0.60 indicates a deficiency of internal consistency and above 0.90 is not required as it means that all the items are measuring the same phenomenon (Hair, Hult et al., 2014). Generally, it is interpreted in the same way as Cronbach's alpha (Avkiran, 2018). Table 1 shows the values of composite reliability and all values are between the required values.

4.7.4. Average Variance Extracted (AVE)

Average variance extracted (AVE) can be assumed as a complementary measure of construct validity (Krush, 2009). Average variance extracted is the degree to which a latent construct explains the variance of its indicators. This principle is demarcated as the grand mean value of the squared loadings of the indicators associated with the construct (i.e., the sum of the squared loadings divided by the number of indicators) (Hair, Black et al., 2014). Its value can be calculated by below mention formula:

$$\Sigma \text{ Standardized Squared Factor Loading2} / (\Sigma \text{ Standardized Squared Factor Loading 2} + \Sigma e_j) \qquad (1)$$

An AVE value of 0.50 or higher indicates that the construct explains more than half of the variance of its indicators. While an AVE of less than 0.50 indicates that more error remains in the items than the variance

explained by the construct. (Hair, Hult et al., 2014). Overall, the results of AVE are satisfactory (Table 1). This also supports the satisfactory level of Unidimensionality, internal consistency, and adequate reliability for these measures (Wang, Tai & Wei, 2006).

4.7.5. Convergent Validity

Convergent validity means that multiple indicators of one construct will act alike. Convergent validity relates when multiple indicators join and are related with one another, behave similar (Neuman, 2014). High correlations among indicates in one construct mean that the scale is measuring its proposed concept should converge or indicators in one construct share a high proportion of variance in common (Hair, Black et al., 2014). Generally, two values are considered to assess convergent validity the values of average factor loading and the value of Average variance extracted (Hair, Black et al., 2014).

High factor loadings indicate convergence for a latent construct. Average of all factor loadings should be statistically significant, a good rule of thumb is that standardized loading estimations should be at least .5 or higher and 0.7 or higher is considered ideal (Hair, Black et al., 2014). Hence, Table 1 values of leading justify the convergence validity by this method.

4.7.6. Discriminant Validity

Discriminant validity is inverse or opposite of convergent validity and discriminant validity shows that the items of one construct converge together, but also are negatively related with contrasting constructs (Saunders et al., 2016). Discriminant validity exists when a construct is actually dissimilar from other constructs both in terms of correlation with other constructs and how distinctly measured variables represent only this single construct (Hair, Black et al., 2014). It can also be defined as "A type of measurement validity for multiple indicators based on the idea that indicators of different constructs diverge (Neuman, 2014). Usually, discriminant validity is measured by examining cross loading (Hair, Hult et al., 2014). Examining the cross-loadings means an indicator's outer loading on the associated construct should be greater than all of its loadings on other constructs. If an item is loading in another construct with the high value this is a problem of discriminant validity. Usually, this method is called generous in terms of establishing discriminant validity (Hair, Hult et al., 2014). Current data satisfy the discriminant validity as the items that have low outer loading have been deleted.

5. Discussion

This study has two objectives, first topologies the risks sources based on literature review and second is develop an instrument after the empirical verification of these risk sources. To cover overall supply chain risks organizations must consider three aspects of supply chain namely organizational aspect, industrial aspect, and an external aspect. First organizational factors, mostly studies divide SCR into further three types on the basis on supply chain process that consists on the source, make and deliver that are broadly considered as supply side, process side and demand side (Chen et al., 2013). Second, just of industrial factors is a relationship among supply chain partners and these partners are linked through flow, according to the adopted definition; supply chain has three kinds of flow information flow, material flow, and financial flow. Hence, material flow creates logistic side risks (Tse et al., 2016) whereas finance flow cause financial side risks and meanwhile information flow originate information side risks (Tang & Musa, 2011). Moreover, most of the researchers use information risk to cover information flow risks but this study argues that information side cover information related risks and miss the relational risk like coordination or etc. to cover all these issues, current study use collaboration side risk and this argument is supported by (Basole et al., 2016). Lastly, to cover external factors this study considers environmental factors like natural disasters, global issues and etc. This topology is supported by (Punniyamoorthy et al., 2013) that divide the overall supply chain risks into six factors, but they not covered financial side of risk. Meanwhile, (Musa, 2012) categories overall supply chain risks into six factors and missed logistic side risks. Finally, it can conclude that to cover all supply chain risks, the organization must consider seven sides that are supply side, process side, demand side, logistic side, collaboration side, financial side, and environment side risks. Second, an object of this study is to develop an instrument for assessment of supply chain risks under these seven risk sources. A questionnaire has been developed from the pool of items from previous studies and purified it through pre-testing and Pilot testing. Final questionnaire was

distributed to manufacturing organizations and collected data were analyzed through Exploratory factor analysis. It has been found that there are 57 types of risks exist under seven risk sources. This finding of this study is in line with previous literature. Punniyamoorthy et al., (2013) has adopted the same process for heavy industry of India and developed the instrument under six risk sources. Meanwhile, Musa (2012) conducted a descriptive study (bibliographic and co-citation analysis) and conclude the same findings under six risk sources and didn't cover the risks from material flow.

6. Implications

This study provides a holistic and comprehensive understanding to the practitioners about the supply chain risks. Managers can understand that risks have proliferated in the whole supply chain (Internal to the organization, external to the organization but internal to supply chain and external to supply chain), so they must need a systematic approach instead of just focusing on their own operations. Empirical verification between supply chain risk sources and supply chain performance provides a vibrant knowledge to the practitioners that every segment of the supply chain can be disrupted and risks are not equal in terms of disruptions. Some risks occur rarely but have high disruptions like a natural disaster but some occur frequently but have less disruption like price fluctuation. Generally, practitioners need to be more curious about supply side risks, demand side risks, logistic side risks and environment side risks. Thus, this study has provided practitioners a more comprehensive knowledge for decision making about risk identification and assessment for their supply chain.

7. Conclusion

The supply chain is a crucial chip for any organization. However, any disruption in the supply chain can not only disturb the organization but the whole system. Hence, it is imperative to manage the risks efficiently; it cannot be managed until properly identified. Thus, this study has developed a reliable instrument for the identification of overall supply chain risks in Malaysian manufacturing organizations through a systematic process. The development process includes a thorough a literature review that categorizes supply chain risk sources into seven constructs namely supply side risks, process side risks, demand side risks, logistic side risks, collaboration side risks, and environment side risks. Secondly, a pool of items/sub dimension has been generated from the literature review and this pool has been filtered by pretesting and pilot testing. Then a questionnaire has been developed and distributed to all FMM listed organizations by email. Similarly, 155 responses received after manual screening and data cleaning 132 considered for analysis. Missing values, outliers, linearity, Unidimensionality, reliability, validity has been assessed by SPSS 23. Conclusively, after some modification and the final, the purified and reliable tool has been developed with seven constructs and 57 items. Lastly, for future research sample size can be increased, secondly, there is need to assess the effects on these risks on performance and thirdly, risks need to prioritize the risks to know that which risk should be focused more.

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