SUSTAINABLE AND RESILIENT SUPPLY CHAIN MANAGEMENT: SCALE DEVELOPMENT

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Abstract

Purpose: This paper reports on the status of an ongoing empirical study to enhance our understanding of factors contributing to better supply chain performance in the context of sustainable and resilient supply chain management, and updates the literature review and research framework presented in Joradon et al. (2015). That paper operationalized eight firm practices that are now being tested in a quantitative study to investigate how sustainable and resilient supply chain management might improve supply chain performance. Sustainable and resilient supply chain management requires firms to consider supply chain performance within environmental, economic, social, vulnerability, and capability parameters. This paper presents the scale development for this study which will analyse the current level of sustainable and resilient supply chain management practices in firms and help guide them to assess and amend their procedures and processes to become more sustainable and resilient in future.

Research approach: The empirical study contains measurement scale and constructs developed according to Churchill (1979) two-phase framework. The first phase was based on data gathered from interviews with nine managers across four electronic companies and two distributors in Thailand using semi-structured interviews. The data from the interviews as well as the extant literature was then used to develop measurement scales and constructs for the next phase, which was a survey with approximately 500 electronic companies in Thailand.

Findings and Originality: At the date of writing semi-structured interviews have been conducted and some opportunities to shape the measurement scale and constructs have been identified. The survey is currently being completed and the conference presentation will provide results from analysis to date. While the investigation of sustainable and resilient supply chain management together has yet to be explored in a focused way, this paper is original since it offers an investigation of these two topics and their relationship with supply chain performance.

Research Impact: The study will produce new performance measurement scales for sustainable and resilient supply chain management as well as an agenda for future research to validate the findings across other sectors and contexts. Mixed-methodologies were applied in this study to ensure face, content and construct validity.

Practical Impact: The study will provide direction for firms to measure their supply chain performance in the context of sustainable and resilient supply chain management practices, as well as a proposed set of measurement scales based on sustainable supply chain management and supply chain resilience management practices to measure the impact of these practices to the firm. The findings will help firms to understand their level of sustainable and resilient supply chain management in order to improve and adjust their procedures to be more sustainable and resilient in future.

Keywords: sustainable supply chain management, resilient supply chain management, scale development, supply chain performance

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Introduction

Sustainable supply chain management and supply chain resilience management are attractive for the modern business at this time. Some of organizations are launching these two themes in their organization. There are policies within the company about sustainable supply chain management and supply chain resilience management. However, there is not a clear definitely definition of sustainable and resilient supply chain management (SResSCM) at this moment. This paper builds on the Joradon et al. (2015) existing literature review regarding linkages between sustainability and resilience in supply chain management, and will develop scales to measure SResSCM within their extant performance measurement toolkit. This paper also report on a current empirical study investigating these measures.

The lack of a unified definition of SResSCM has contributed to unclearness of the concept of sustainability and resilience related to supply chain at the same time. According to Joradon et al. (2015), this study develop the conceptual model, scale and measurement tool that will support supply chain leaders and managers to assess their current level of sustainable and resilient supply chain management applied in their company and to guide purposeful change so that their supply chain can support, arrive, adapt, and grow in the face of disruption period (Fiksel, 2006). This paper tests these developments in the Thai Electronic industry for the definition of SResSCM. The reason to test in this context is that the electronic industry is a core element of the Thai manufacturing sector's success (BOI, 2015).

Hypotheses development

In this paper it was assumed that there are relationships between sustainable and resilient supply chain management. Moreover, it also postulates that sustainable and resilient supply chain management practices have a positive impact on supply chain performance. It has been noted that these assumptions are related to the level of SResSCM procedures applied by the firm. The hypotheses and scale were developed from relevant literature review and semi-structured interviews with seven managers across four Thai electronics' companies and two managers from two distributors in Thailand.

Sustainable and resilient supply chain management (SResSCM)

Sustainable supply chain management encompasses environment, economic, and social perspectives (Carter and Rogers, 2008). On the other hand, supply chain resilience management combines vulnerabilities and capabilities (Pettit et al., 2010). However, the interactions between these two themes are not defined at this moment, thus this study will develop suitable SResSCM definition by integrating these two ideas together.

As Pettit et al. (2013) found, connectivity and external pressure are two vulnerabilities sources that have the highest impact on firms. Moreover, recovery and low collaboration in capability provide more concerns to firms (Pettit et al., 2013). All of these sub-factors have an impact on sustainability. Hence, this study will merge connectivity, external pressure, recovery, and collaboration into triple-bottom-line (TBL) framework, including ECO-Design, green production, social responsibility, and investment recovery. The aim is to provide a SResSCM framework. Thus, the following hypothesis is proposed.

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│ Hypothesis 1                                                             │
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- H_1: A positive relationship between sustainable supply chain management and supply chain resilience management exists

Sustainable supply chain management practices

In this paper sustainable supply chain management practices are derived from the literature. This study focuses on ECO-Design (Green et al., 2012; Zhu et al., 2008), green production (Azevedo et al., 2013b; Zhu et al., 2008), social responsibility (Mellat-Parast, 2013), and investment recovery(Green et al., 2012; Rao and Holt, 2005; Zhu et al., 2008). The explanations for each construct are the following:

Environmental practices

In this study, environmental practices are ECO-Design and green production because there are some evidences from literature mentioned that these two practices have an impact to environmental performance. For instance, Zailani et al. (2012) demonstrated that ECO-Design has an impact on regulation and incentive on environmental performance in the company. Moreover, Green et al. (2012) argued that Eco-friendly design will directly and positively influence environmental performance as the impacts of the designers will be on reducing the environmental impact of the design. Moreover, some of the interviewees mentioned that their companies have been implemented ECO-design within their production already. However, some of the interviewed companies are not considering ECO-design at this moment but they have plans to implement it in the future. Furthermore, green production is one of the strategies that some of the interviewees applied in their production process.

Economic practices

In this paper, economic practices include investment recovery, which requires the sale of excess inventories, scrap, used materials, and excess capital equipment (Zhu et al., 2008). Rao and Holt (2005) studied the link between green supply chains and economic performance, and found that green supply chain management (GSCM) practices led to competitiveness and better economic performance. Interviewees also explained that investment recovery is one of the policies that their companies currently apply.

Social practices

A social practice in this study is social responsibility. The definition of social responsibility is the ability to maintain well-being of workers and social around the company and it relates to worker welfare and social impact. According to Mellat-Parast (2013)'s research, an implementation of corporate social responsibility would have a positive effect on the formation of 'moral capital' of the firm through enhancing employee involvement. Most of the interviewees pay attention in social responsibility and apply this strategy within the company's policy.

Then, the following hypothesis for sustainable supply chain management is proposed:
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│ Hypothesis 2                                                             │
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- H_2: Sustainable supply chain management positively affects sustainable and resilient supply chain management

Supply chain resilience management practices

This study adopts the supply chain resilience concept from Pettit et al. (2010), that integrated supply chain management, continuity planning, risk management, or an amalgamation of all of these disciplines. There are two constructs, i.e. vulnerabilities and capabilities to build balance of resilience in the company. The model recognizes the need to balance managerial capabilities with the inherent

vulnerabilities of the supply chain design and the environment in which it operates (Pettit et al., 2010). Also, Pettit et al. (2010) explained that supply chain resilience increases as capabilities increase and vulnerabilities decrease. The definition of each construct is as follows:

Vulnerability practices

The resilience's concept in supply chains includes with previous principles with studies of supply chain vulnerability as Svensson (2002) mentioned supply chain vulnerability as "unexpected deviations from the norm and their negative consequences". Moreover, Sheffi and Rice (2005) described that vulnerabilities can be measured in terms of risk, a combination of the likelihood of an event and its potential severity. Both these definitions have foundations in traditional risk management techniques and are expanded by other authors (Svensson, 2002). Thus, this study applied vulnerability practices, which are external pressure factor and connectivity, to decrease supply chain vulnerability. Because, Pettit et al. (2013), argued that external pressure and connectivity are the highest vulnerabilities impacting the supply chain.

Capability practices

Pettit et al. (2010) define supply chain capabilities as "attributes that enable an enterprise to anticipate and overcome disruptions". These capabilities could prevent an actual disruption (i.e. security measures deterring a terrorist attack), mitigate the effects of a disruption (i.e. stock piles of emergency supplies), or enable adaptation following a disruption (i.e. earthquake, tsunami or flooding) (Pettit et al., 2010). Moreover, Lee (2004) showed methods to overcome both short- and long-term change based on three key capabilities: agility, adaptability, and alignment. This study focuses on recovery and collaboration practices building on the study of Pettit et al. (2013) because these two key concepts are linked to TBL in sustainability and help the company to build more resilience.

Thus, the following research hypothesis for supply chain resilience management is proposed:

> Hypothesis 3

- H_3: Supply chain resilience management positively affects sustainable and resilient supply chain management

The performance measurement factors in the conceptual model

In this study, supply chain performance is measured with four variables, i.e. operational cost, business wastage, environmental cost, and customer satisfaction (Govindan et al., 2015). These measurements are tested and defined as the construct of "supply chain performance" (Azevedo et al., 2013a). This study will analyse the effect of SResSCM in the firm on supply chain performance. The definition for each variable is as follows:

- Operational cost – it is related to the expenses of running a business; it includes production costs, transportation costs and inventory holding costs, among others. It is an important aid to making judgments and decision, because its purpose is to evaluate, control and improve operational process (Jeffery et al., 2008).
- Business wastage – it is used in its broader sense including typical lean wastages, e.g. excessive inventory, excessive lead-time, excessive scrap, excessive transportation (Singh et al., 2010) and also solid and liquid wastes, percentage of materials remanufactured, recycled and re-used, hazardous and toxic material output (Govindan et al., 2015).
- Environmental cost – it is crucial to have information about environmental practice's costs to scrap/rework (Christiansen et al., 2003), disposal (Tsai and Hung, 2009) and purchasing environmentally friendly materials (Zhu et al., 2005), certification, among others.

- Customer satisfaction – the degree to which customers along the supply chain are satisfied with the product and/or service received (Beamon, 1999). It includes after-sales service efficiency, rates of customer complaints, stock-out ratio, delivery time, among others indicators (Govindan et al., 2015).

Thus, the following hypothesis is proposed:

> Hypothesis 4
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> •H_4: Sustainable and resilient supply chain management positively affects supply chain performance

Sustainable and resilient supply chain management and its impact on short- and long-term periods

This study will analyse the impact of SResSCM on short- and long-term periods of time. For the purpose of this study, if the impact occurs within 3 years after the company implemented SResSCM, it will be called short-term impact; however, if the impact occurs after 3 years of implemented SResSCM, it will be called long-term impact. There are some studies that investigated short- and long-term objectives. Li et al. (2006) classified organizational performance objectives into two categories: short-term and long-term. The short-term objectives of SCM are mostly to increase productivity and reduce inventory and cycle time, while the long-term objectives are to increase market share. Furthermore, according to Pettit et al. (2010) supply chain resilience is a mandatory characteristic of a supply chain in order to survive in the short-term, but also provides the ability to adapt to change and thrive in the long-term. Eight factors of SResSCM, which are ECO-design, green production, social responsibility, investment recovery, collaboration, recovery, external pressure, and connectivity, were analysed looking at short- and long-term impacts. Moreover, there are different measurement criteria in company's performance as average return on investment, average profit, average return on sales, market share growth and overall competitive position with its impact on SResSCM for this section. Thus, the following hypotheses are proposed:

> Hypothesis 5
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> •H_5: Sustainable and resilient supply chain management practices positive affects short-term firm's impact

> Hypothesis 6
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> •H_6: Sustainable and resilient supply chain management practices positively affects long-term firm's impact

The originally proposed model (Joradon et al., 2015) is shown in Figure 1. However, after conducting the semi-structured interviews in Thailand during October – November 2015, the proposed model was slightly recast as shown in Figure 2.

Methodology

The current research aims to develop SResSCM definition and practices for further empirical study. Then, the survey was developed by using new and existing multi-item scales (Churchill, 1979). New scales were developed and enhanced from sustainable supply chain management and supply chain resilience management to SResSCM scale with company's practices (eight practices in SResSCM), supply chain performance, and short- and long-term impacts from SResSCM practices in the company.

Pre-test procedure for sustainable and resilient supply chain management scale development

According to DeVellis (2012), measurement is of vital concern across a broad range of social research contexts. We acquire knowledge about people, objects, events, and processes by observing them. Making sense of these observations frequently requires that we quantify them (i.e. that we measure the things in which we have a scientific interest). Typically, the measurement procedure used is the

questionnaire and the variables of interest are part of a broader theoretical framework (DeVellis, 2012). This study applied the scale development approach by Churchill (1979), DeVellis (2012), and Oppenheim (2000) as the main process and also combines the appropriate steps from others researchers (Ambulkar et al., 2015; Govindan et al., 2015; Green et al., 2012). New scales were developed for SResSCM due to the lack of existing survey items.
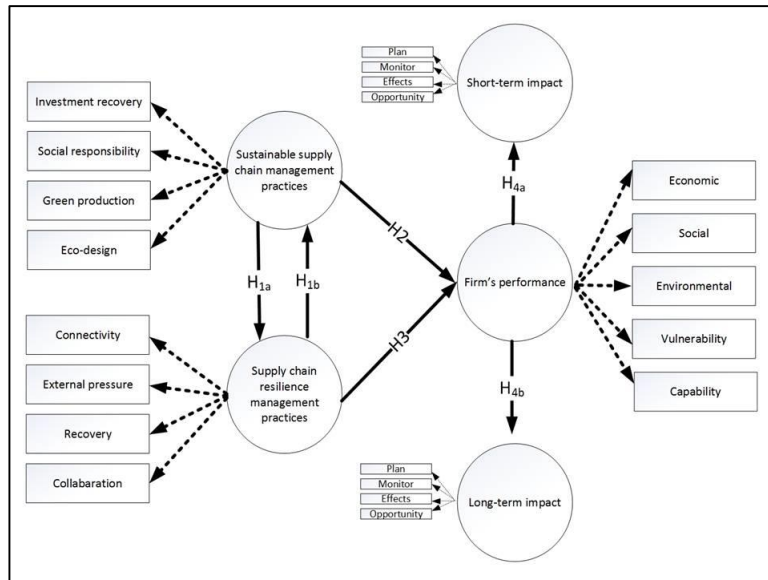

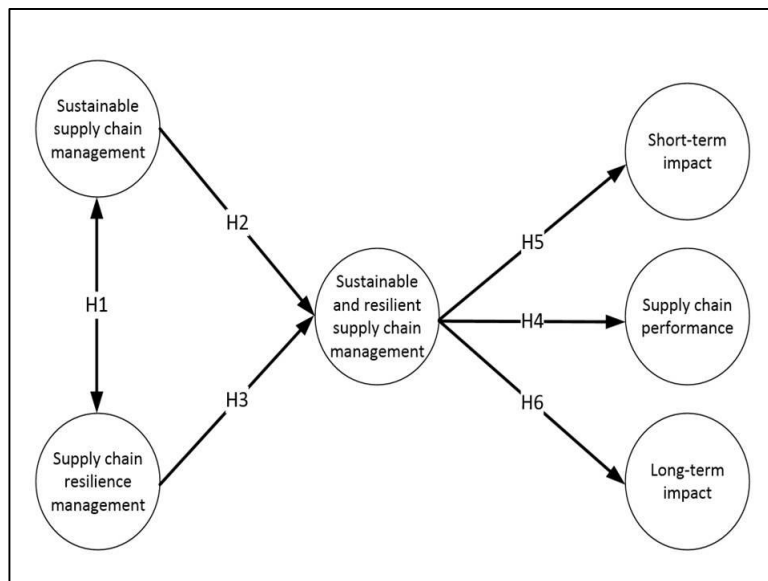**Figure 1: Original hypotheses for this study**

Figure 2 Recast hypotheses for this study

The questionnaire was initially designed in English. However, most of the companies in the Thai's Electronic industry use Thai language as their first language so the questionnaire was translated from English to Thai language. Douglas and Craig (2007) explained that researcher needs to apply a collaborative and iterative translation approach to ensure conceptual equivalence. A cross-cultural translation questionnaire is required for this study so two experts were employed as translators, one academic from one of the top universities in Thailand and one practitioner from an electronic company in Thailand. Both experts translated the questionnaire into Thai independently. Then, researcher merged these two versions together. The final Thai's questionnaire version was approved

by researcher. After that, pre-test with twelve participants in the Thai's Electronic industry was conducted for this study. Reliability of pre-test data was tested by using Cronbach's alpha (Cronbach, 1951), these values are provided in Table 1. The final questionnaire was developed for SResSCM practices in terms of performance measurement and its impacts. Both versions, English and Thai, were prepared as Microsoft Words file and on-line survey for the main survey.

Construct	Cronbach's alpha (α)
Sustainable and resilient supply chain management definition	0.860
Sustainable and resilient supply chain management practices	0.927
Supply chain performance measurement	0.933
Short- and long-term impact of sustainable and resilient supply chain management	0.966

Table 1: Scale development - pretest results

Sample and data collection

The survey was then distributed to the Thai's Electronic industry, which are in HDD brand owners (OEMs), IC design (1st-tier customer), lead frame (2nd-tier supplier), testing (1st-tier supplier), assembly (1st-tier supplier or OEMs), and distributors (3PLs), using email with attached questionnaire files and links for an online survey hosted by Google Forms. The respondents of electronic companies were obtained from websites of The Federation of Thai Industries (FTI), Department of industrial works (DIW), Electrical and Electronics institute (Thai EEI), Industrial Estate Authority of Thailand (IEAT), respectively. The companies from these websites are selected and compared in a spreadsheet to avoid duplications. The survey is being conducted in early summer 2016 and hence there are no results to report yet. However, analysis and findings to date will be reported in the conference presentation.

Measures

SResSCM relationship was operationalized using four items measured on a five-point Likert scale (1 = Strongly disagree; 5 = Strongly agree). The items measure the perception of respondents of the relationship between sustainable supply chain management and supply chain resilience management to develop the new definition of "Sustainable and resilient supply chain management (SResSCM)". SResSCM practices were developed from the literature review and a semi-structured interview by adapting existing scale from Ambulkar et al. (2015), Green et al. (2012), and Pettit et al. (2013). The scale consists of 24 items on a six-scale point Likert's scale (1 = Do not know; 2 = not considering; 3 = planning to consider; 4 = considering it currently; 5 = initiating implementation; 6 = implementing successfully). In this scale, the researchers included "do not know" in the scale because the respondents might do not have personal knowledge regarding all the SResSCM practices included in the survey.

Sustainable and resilient supply chain management and supply chain performance was operationalized through 24 items scale based on the conceptualization of supply chain performance from Azevedo et al. (2013a), Beamon (1999), Christiansen et al. (2003), Govindan et al. (2015), Jeffery et al. (2008), Singh et al. (2010) and Zhu et al. (2005). It was measured using a five-point Likert's scale (1 = Strongly disagree; 5 = Strongly agree). The items for supply chain performance construct consider the perception of the achievement of respondent's company during the past three years.

A further section was devoted to short- and long-term impacts of sustainable and resilient supply chain management in the company. The eight SResSCM practices and eight company's performance adapted from Green et al. (2012) were study in different time period between short- and long-term to assess the impact from these practices. The constructs represented by 32 items are measured on a five-point Likert's scale (1 = no impact; 5 = extremely high impact for SResSCM practices and 1 = very low impact; 5 = very high impact for company's performance).

Conclusions

The main objective of the survey is to understand the relationships between sustainable supply chain management and supply chain resilience management currently used by suppliers-manufacturers-distributors-customers. It also aims to develop measurement tools to assess the current level of SResSCM in each company to enhance the performance in the future. This study applied the literature review and semi-structured interviews to develop a new sustainable and resilient supply chain management construct and examined its relationship with eight practices in the context of supply chain management. The new scale was developed and tested with the Thai Electronic industry. However, the results from the survey are ongoing during the submission period for this paper, so this paper does not present the measurement model, the structural model and the analysis of the results.

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