

SUSTAINABLE AND RESILIENT SUPPLY CHAIN MANAGEMENT: A SURVEY OF THAI MANUFACTURERS

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Introduction

Supply chain management (SCM) requests the integration and coordination of business processes and strategy alignment throughout the supply chain for the purpose of satisfying the final customers of the supply chain (Green et al., 2008; Green et al., 2012). In a volatile, high-demand market, sustainability and resiliency in an SCM context can lead organizations to achieve competitive advantage (Govindan et al., 2014). However, the incorporation of sustainability and resiliency across supply chains is a greater, more challenging issue than consolidating these concepts (Ahi and Searcy, 2015).

Manufacturing organizations have begun to implement sustainable supply chain management (SSCM) and supply chain resilience management (SRES) practices in response to customer demand for products and services. Therefore, the challenge of this study is to investigate how to integrate sustainability and resiliency in SCM, develop tools to measure the implementation level, and then suggest possible practices to enhance supply chain and organizational performance. This study was developed from extant literature which provided linkages between SSCM and SRES (Joradon et al., 2015) and allowed development of a measurement scale (Joradon et al., 2016). This paper will provide results and insights from a survey of Thai manufacturers in the electronic, electrical and automotive sectors as these industries have been vulnerable in recent years.

For example, in 2011 Thailand suffered huge flooding which had a high impact on Thai manufacturing. Some organizations permanently closed after the period of disruption or else needed a long time to recover their manufacturing processes, while other organizations were able to recover their production lines faster than their competitors. Furthermore, we believe that sustainability, which is quite a new concept in Thailand, could improve organizational production processes, making them more sustainable, and helping it to become the number one place of interest to do business in the world. Therefore, we advocate that if Thai manufacturing can apply concepts of sustainability and resiliency in its organizations, it will enhance supply chain performance in Thailand, which in turn is related to the Thai government's Manufacturing Logistics Development Plan.

Literature review

According to Joradon et al. (2015), integration between SSCM and SRES still lacks in existing literature. However, we argue that the combination between SSCM and SRES in a new concept of sustainable and resilient supply chain management (SResSCM) will support organizations to be both more sustainable and resilient in the future. Joradon et al. (2016) developed a measurement scale to measure SResSCM practices, supply chain performance, and organizational performance as shown in Figure 1, which was based on the Joradon et al. (2015) literature review and extant frameworks of Carter and Rogers (2008) and Pettit et al. (2010). The empirical study applied these hypotheses and tested them in a survey of Thai manufacturers in the three sectors noted above, i.e. electrical, electronic and automotive industry.

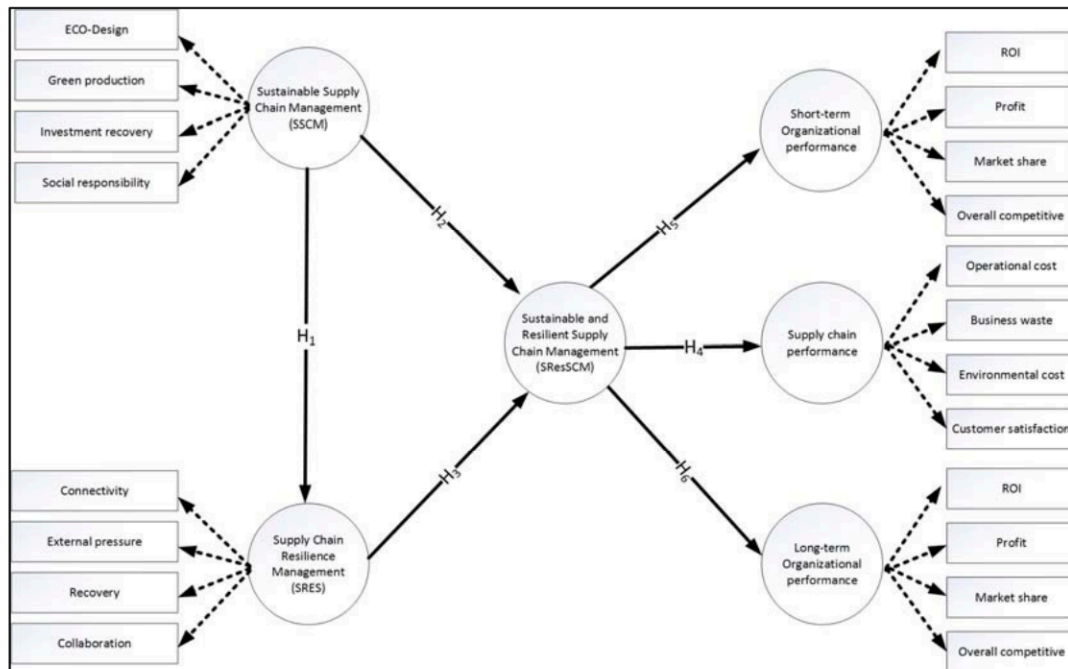


Figure 12: Conceptual model

Survey process

Sample and survey information

This survey was composed of five parts. The first part included questions about definitions of SSCM and SRES in respondent organizations while the second part consisted of different questions about SResSCM practices which could be applied in organizations. The third part consisted of questions about supply chain performance in term of operational cost, business wastage, environmental cost, and customer satisfaction while the fourth part comprised questions about the short- and long-term impact from SResSCM practices on organizational performance. Lastly, the fifth part included general questions about respondents and their organization. A five-point Likert's scale was used in this survey, with different anchors in each part. As a first step twelve practitioners in Thai manufacturing were invited to evaluate whether the individual items appeared to be appropriate measures for their respective constructs (Anderson and Gerbing, 1991). Then, the final survey, initially generated in English, was translated from English to Thai and back-translated (Douglas and Craig, 2007). There were two experts for translation and two experts for back-translation.

The survey was sent to around 2,500 Thai manufacturing organizations via email with a link to an online survey. A total of 113 usable questionnaires were received which represents a response rate of 0.05%. It consisted of electronic organizations (91), automotive organizations (14) and electrical organizations (8). The distribution of firm size was: up to 50 employees (30), from 51 to 200 employees (24) and more than 200 employees (59). Most respondents are in Bangkok and Central Region (79), with the East Region (23), North Region (5), North-East Region (3) and West Region (3) also represented. Over 80% of respondents are in 1st-Tier suppliers (34), 2nd-Tier suppliers (26), manufacturing or focal firm (17), or 3rd-Tier supplier (15). To test the eligibility of the respondents, they were asked about their profession and the length of working experience in supply chain as well. Over 85% are in managerial positions, i.e. managing director (22), operation managers (20), purchasing managers (9) and over 56% of respondents had worked for more than ten years in their industry.

Assessment of bias

Non-response bias was assessed by comparing early responses and late responses. There were 67 respondents who responded to the survey immediately, and 46 respondents who were assigned as late responses. The Mann-Whitney U test was applied to compare the difference between the medians for

each question for early responses and late responses, since the majority of the variables in this survey had non-normally distributed data (Pallant, 2016). The results presented that these groups did not differ from each other at the 0.05 level of statistical significance. In these responses, missing value were pairwise deletion, because this approach still calculates valid data in the model, and ignores missing data from each respondent. However, the analysis may be based on different sample size, which can bias the results (Pallant, 2016). Further, the results were also tested for common method variance, which can pose problems for survey research that relies on self-reported data (Podsakoff et al., 2003). Post-survey, a Harman's single factor test was conducted (Harman, 1976) due to the exploratory factor analysis for this study and revealed that eigenvalues greater than 1 for all the total variance in each construct. These findings suggest that non-response and common method variance do not represent a serious problem for this data.

Data Analysis

Measurement development

The first step was preliminary correlation analysis using nonparametric correlations for each construct from the SPSS programme. The second step was to create constructs by using exploratory factor analysis (EFA) with SPSS. The results from the EFA were subsequently employed in the last two steps to evaluate the reliability and validity of scales, variables and resultant constructs by using partial least squares (PLS) analysis with the smartPLS 3.0 programme. Since there were some new questions from qualitative pilot testing translated into Thai, a measurement model was assessed. An assessment of convergent and discriminant validity was conducted since the unidimensionality of a scale must be established before its reliability can be examined (Gerbing and Anderson, 1988). Then, to assess unidimensionality, factor analysis was conducted using the principal component analysis with Varimax rotation (Pallant, 2016). Hair et al. (2010) recommend factor loading based on sample size and for this study factor loading should be 0.55. Therefore, items which have factor loadings less than 0.55 were deleted. Consequently, remaining items for this study are four for SResSCM construct, 16 for SResSCM practices construct (internal and external plan (IEP_01 – 08), investment recovery (IR_01 – 03), ECO-design (ECO_01 – 03), collaboration (COL_01 – 02)), 15 for supply chain performance constructs (customer and operational cost (COC_01 – 06), environmental cost (ENV_01 – 04), business wastage (BUS_01 – 03) and customer satisfaction (CS_01 – 02)) and 32 for SResSCM impact construct (SResSCM practices impact (SRESPI_01 – 16), long-term organizational performance (LOP_01 – 08), short-term financial (STF_01 – 04) and short-term growth (STG_01 – 04)).

Because the sample size of 113 does not allow using structural equation model based on a covariance matrix, a path analysis was investigated using a partial least squares structural equation model (PLS-SEM), more specifically SmartPLS 3.0 programme (Hair et al., 2016). To further ensure the sample size is adequate for the analysis, the researchers used the G*Power 3 software (Faul et al., 2007) to conduct a power analysis, as proposed by Cohen (1988) for the F-test, pertaining to the R² value for the endogenous constructs. For this study, the researchers employed a medium effect size ($f^2 = 0.15$) for six predictors, a significance level of 0.05 and a desired power of 0.80. It was found that the minimum sample required for the validity of this study would be about 98 responses. Consequently, the 113 fully completed respondents were sufficient for this study achieved. For this reason, this study applied PLS and the SmartPLS 3.0 programme to test both the reliability and validity of the measurement and structural models (Hair et al., 2016). The measurement model represents the relationship between manifest variables (measurement items) and the unobserved latent variables, while the structural model focuses on hypothesized relationships between latent variables (Hair et al., 2010).

Measurement model

The quality criteria used to confirm the quality of the measurement model were in accordance with Hair et al. (2016), assessing internal consistency reliability (or composite reliability), convergent validity and discriminant validity, as shown in Table 1. All composite reliabilities are well above the recommended threshold, ranging from 0.86-0.98 (Nunnally, 1978). Furthermore, Cronbach's alpha was also well above the average threshold of 0.88, ranging between 0.67-0.98. To evaluate convergent validity the outer loading of the indicators, (preferably above 0.70) and as well as the average variance extracted or AVE (for which a suggested threshold is above 0.50) were conducted (Fornell and Larcker, 1981). All reflective indicators had a loading of more than 0.70. The assessment focused only on the outer loadings of the

reflective constructs. Finally, examining the degree of divergence of each construct is known as discriminant validity analysis (Hair et al., 2016). For this study, the square root of the AVE scores for each construct was compared with their correlation with the other constructs (Fornell and Larcker, 1981). It is recommended that the square root of AVE scores should be greater than their correlation with the other constructs (Chin, 1998). According to this test, there was no problem with composite reliability, convergent validity and discriminant validity, which indicates the proposed measurement model is both valid and reliable.

Construct	Indicators	Mean	SD	Loadings	CR	α	AVE	Sustainable and resilient supply chain management impact	2 nd order construct, repeated items measuring, SRESPI, LOP, STF, and STG were employed	0.964	0.961	0.457			
Sustainable and resilient supply chain management (SResSCM)	SRESSCM_01	4.160	0.727	0.955	0.922	0.892	0.749	SResSCM practices impact (SRESPI)	SRESPI_01	3.020	1.282	0.925			
	SRESSCM_02	4.120	0.765	0.809					SRESPI_02	2.900	1.246	0.914			
	SRESSCM_03	4.110	0.760	0.876					SRESPI_03	2.910	1.162	0.884			
	SRESSCM_04	4.040	0.870	0.707					SRESPI_04	3.020	1.261	0.899			
Sustainable and resilient supply chain management practices	The repeated indicator approach with mode B (reflective-formative hierarchical latent variables)								SRESPI_05	3.030	1.306	0.915			
	Internal and external plan (IEP)	IEP_01	4.610	0.784	0.819	SRESPI_06	2.980		1.157	0.904					
		IEP_02	4.420	0.933	0.903	SRESPI_07	3.060		1.227	0.906					
		IEP_03	4.500	0.955	0.884	SRESPI_08	3.030		1.292	0.897					
		IEP_04	4.330	1.047	0.852	SRESPI_09	2.810		1.192	0.888					
		IEP_05	4.460	0.900	0.822	SRESPI_10	2.990		1.191	0.860					
		IEP_06	4.260	1.081	0.873	SRESPI_11	2.860		1.238	0.875					
		IEP_07	4.620	0.750	0.795	SRESPI_12	2.810		1.148	0.903					
IEP_08		4.100	1.239	0.811	SRESPI_13	2.860	1.093		0.841						
Investment Recovery (IR)	IR_01	4.020	1.379	0.927	0.904	0.841	0.759		SRESPI_14	2.850	1.096	0.792			
	IR_02	3.680	1.676	0.794	0.876	0.793	0.708		SRESPI_15	2.800	1.240	0.813			
	IR_03	4.460	1.106	0.889	0.856	0.671	0.749		SRESPI_16	2.710	1.024	0.761			
ECO-design (ECO)	ECO_01	2.980	1.503	0.744	Long-term Organization performance (LOP)	0.933	0.923	0.485	LOP_01	3.230	0.817	0.885			
	ECO_02	3.790	1.187	0.876					LOP_02	3.300	0.804	0.876			
	ECO_03	3.600	1.340	0.889					LOP_03	3.300	0.827	0.927			
Collaboration (COL)	COL_01	3.150	1.622	0.805					LOP_04	3.270	0.762	0.898			
	COL_02	3.880	1.332	0.918					LOP_05	3.270	0.820	0.877			
	Supply chain performance	2 nd order construct, repeated items measuring, COC, ENV, BUS, and CS were employed							LOP_06	3.290	0.755	0.855			
Customer and operational cost (COC)		COC_01	4.300	0.565					0.829	LOP_07	3.330	0.813	0.924		
		COC_02	4.290	0.636					0.753	LOP_08	3.410	0.767	0.735		
	COC_03	4.210	0.725	0.741		Short-term Financial (STF)	STF_01	2.950	0.718	0.910					
COC_04	4.250	0.726	0.829	STF_02			2.960	0.713	0.882						
COC_05	4.150	0.782	0.771	STF_03			3.000	0.763	0.928						
COC_06	4.120	0.670	0.761	STF_04			2.950	0.693	0.866						
Environmental cost (ENV)	ENV_01	3.960	0.749	0.918		Short-term Growth (STG)	STG_01	3.050	0.802	0.954					
	ENV_02	3.980	0.779	0.943			STG_02	3.030	0.792	0.907					
	ENV_03	3.890	0.838	0.803			STG_03	3.040	0.738	0.907					
	ENV_04	4.060	0.698	0.787			STG_04	3.140	0.784	0.790					
Business Wastage (BUS)	BUS_01	4.170	0.718	0.874	0.939	0.912	0.795	Customer Satisfaction (CS)	CS_01	3.850	0.847	0.930			
	BUS_02	4.210	0.700	0.802					CS_02	3.830	0.915	0.900			
	BUS_03	4.150	0.770	0.903											

Table 14: Assessment of reflective measurement models

Structural model

A structural model was used to assess the hypothesized relationships among the constructs, the coefficient of determination (R^2), the path coefficient, and their corresponding significance scores (Hair et al., 2016). To assess the statistical significance between latent variables, traditional parametric tests were inappropriate in PLS (Chin, 1998). Therefore, bootstrapping as a non-parametric test was applied to test the hypotheses relationship between constructs. In this study, 5,000 bootstrap samples were established by resampling with replacement from the original samples. T-statistics are calculated for all coefficients, based on their stability across the subsamples, indicating which links were statistically significant. Table 2 shows the path coefficients, t values and p values for this study.

	Path Coefficients	t Values	p Values	Significance?
SResSCM Def -> SResSCM practices	0.172	0.644	0.520	No
SResSCM practices -> SC Performance	0.491	4.162	0.000	Yes
SResSCM practices -> SResSCM Impact	0.386	2.947	0.005	Yes

Table 15: Significance testing results of the structural model path coefficients

Results and discussions

The hypotheses evaluation yielded mixed results. While some of the hypotheses were supported, others were not. Table 3 presents hypothesis test results for this study. The results show sustainable supply chain management and supply chain resilience management are interlinked in the understanding of Thai practitioners. However, it can be seen that their definitions of same do not relate to practices or

procedures applied in organizations. Furthermore, sustainable and resilient supply chain management has a positive effect on supply chain performance improvement and provides positive impact on short-term and long-term organizational performance. Therefore, SResSCM practices, which were provided in this study, will guide Thai manufacturers to develop their organization to be more sustainable and resilient. Short-term impact and long-term impact were combined after the EFA process so we infer that SResSCM practices have a positive impact on both short-term and long-term organizational performance. Figure 2 summarizes the relationship between SResSCM practices, SC performance and organizational performance from this study.

Research hypotheses	Description	Result
H ₁	Sustainable supply chain management has a positive relationship on supply chain resilience management	Supported
H ₂	Sustainable supply chain management definition has a positive effect on sustainable and resilient supply chain management practices	Not supported
H ₃	Supply chain resilience management definition has a positive effect on sustainable and resilient supply chain management practices	Not supported
H ₄	Sustainable and resilient supply chain management practices positively affect supply chain performance	Supported
H ₅	Sustainable and resilient supply chain management practices have a positive impact on short-term organizational performance	Supported
H ₆	Sustainable and resilient supply chain management practices have a positive impact on long-term organizational performance	Supported

Table 16: Hypothesis test results

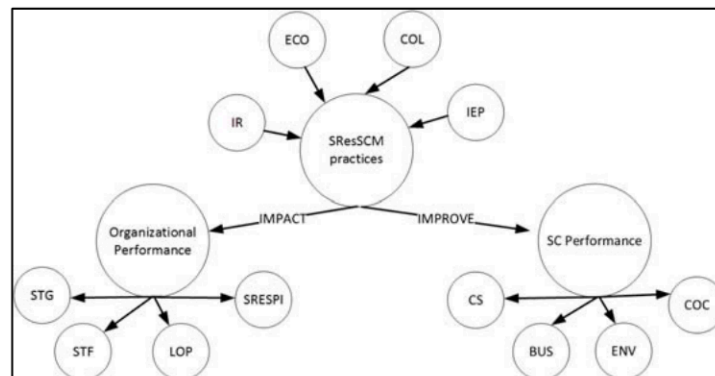


Figure 13: Relationship between SResSCM, SC performance and organizational performance

Conclusions, implications, limitations and future research

The main objective of this paper was to summarize survey results from the Thai manufacturing sector regarding SResSCM. It can be demonstrated from this study there is a relationship between SSCM and SRES. But the results showed that there is no relationship from both SSCM and SRES definitions to SResSCM practices. Furthermore, this study also supports the relation between SResSCM practices to supply chain performance, short-term organization performance and long-term organizational performance.

In respect of managerial implications, the results indicate that SResSCM practices have already been applied in some organizations’ strategies; however it was found that there were different levels of implementation, i.e. “considering” implementation, “partial” implementation and “full” implementation of

these practices. This study also provides an important framework for supporting decision-making related to sustainability and resiliency in SCM. In this way, supply chain managers can adjust organizational behaviour to achieve better levels on measurement scales for SResSCM practices in order to: 1) reduce risks and impacts while improving organizational sustainability efficiency; 2) improve the supply chain ability to cope with unexpected disturbances; and 3) prepare for the impact of the implementation of SResSCM practices on organizational performance. Supply chain managers can use this knowledge to respond to disruptive events more effectively and with increased confidence.

However, like all research studies this study has some limitations. This study has a low sample size (i.e. 113) requiring the use of PLS to calculate the structural equation model. Future research should use increases sample size to achieve possibly more robust results from covariance based SEM than PLS. Also, this study was a snapshot of a particular point in time. Future research should use a longitudinal analysis in studying SResSCM practices as a means of providing a clear picture concerning its long-term effects. A good example would be to perform a comparison on the outcomes of SResSCM before and after the adoption of SResSCM practices.

References

- Ahi, P. & Searcy, C. (2015), "An analysis of metrics used to measure performance in green and sustainable supply chains." *Journal of Cleaner Production*, Vol. 86, No.0: pp. 360-377.
- Anderson, J. C. & Gerbing, D. W. (1991), "Predicting the performance of measures in a confirmatory factor analysis with a pretest assessment of their substantive validities." *Journal of Applied Psychology*, Vol. 76, No.5: pp. 732.
- Carter, C. R. & Rogers, D. S. (2008), "A framework of sustainable supply chain management: moving toward new theory." *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No.5: pp. 360-387.
- Chin, W. W. (1998), "The partial least squares approach to structural equation modeling." *Modern methods for business research*, Vol. 295, No.2: pp. 295-336.
- Cohen, J. (1988), "Statistical power analysis for the behavioral sciences." *Lawrence Earlbaum Associates*, Vol. 2, No.
- Douglas, S. P. & Craig, C. S. (2007), "Collaborative and iterative translation: An alternative approach to back translation." *Journal of International Marketing*, Vol. 15, No.1: pp. 30-43.
- Faul, F., Erdfelder, E., Lang, A.-G. & Buchner, A. (2007), "G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences." *Behavior Research Methods*, Vol. 39, No.2: pp. 175-191.
- Fornell, C. & Larcker, D. F. (1981), "Evaluating structural equation models with unobservable variables and measurement error." *Journal of marketing research*, No.39-50.
- Gerbing, D. W. & Anderson, J. C. (1988), "An updated paradigm for scale development incorporating unidimensionality and its assessment." *Journal of marketing research*, No.186-192.
- Govindan, K., Azevedo, S. G., Carvalho, H. & Cruz-Machado, V. (2014), "Impact of supply chain management practices on sustainability." *Journal of Cleaner Production*, Vol. 85, No.0: pp. 212-225.
- Green, K. W., Whitten, D. & Inman, R. A. (2008), "The impact of logistics performance on organizational performance in a supply chain context." *Supply Chain Management: An International Journal*, Vol. 13, No.4: pp. 317-327.
- Green, K. W., Zelbst, P. J., Meacham, J. & Bhadauria, V. S. (2012), "Green supply chain management practices: impact on performance." *Supply Chain Management-an International Journal*, Vol. 17, No.3: pp. 290-305.
- Hair, J. F., Black, W. C., Babin, B. J. & Anderson, R. E. (2010), "*Multivariate Data Analysis: A Global Perspective*," New Jersey, Pearson Education Inc.
- Hair, J. F., Hult, G. T. M., Ringle, C. & Sarstedt, M. (2016), "*A primer on partial least squares structural equation modeling (PLS-SEM)*," Sage Publications.
- Harman, H. H. (1976), "*Modern factor analysis*," University of Chicago Press.
- Joradon, W., Colicchia, C. & Grant, D. B. (2015), Performance measurement and its impact on sustainable and resilient supply chain management practices in the Thai electronic industry.

Proceedings of the 20th Annual Logistics Research Network (LRN) Conference. University of Derby.

- Joradon, W., Colicchia, C. & Grant, D. B. (2016), Sustainable and resilient supply chain management : scale development. *Proceedings of the 21st logistics research network annual conference 2016.* the University of Hull, UK, Chartered Institute of Logistics and Transport.
- Nunnally, J. (1978), C.(1978). Psychometric theory. New York: McGraw-Hill.
- Pallant, J. (2016), "*SPSS survival manual,*" (Sixth edition edn.), McGraw-Hill Education (UK).
- Pettit, T. J., Fiksel, J. & Croxton, K. L. (2010), "Ensuring Supply Chain Resilience: Development of a Conceptual Framework." *Journal of Business Logistics*, Vol. 31, No.1: pp. 1-21.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y. & Podsakoff, N. P. (2003), "Common method biases in behavioral research: a critical review of the literature and recommended remedies." *Journal of applied psychology*, Vol. 88, No.5: pp. 879.