Total Quality Management & Business Excellence

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ctqm20

A study on the relationship between the PDSA cycle of green purchasing and the performance of the SCOR model

Yeong-Dong Hwang [a], Yuan-Feng Wen [b] & Mu-Chen Chen [c]

[a] Department of Operations Management, Leader University, Tainan, Taiwan, Republic of China

[b] Department of Logistics Management, National Kaohsiung Marine University, Kaoshiung, Taiwan, Republic of China

[c] Institute of Traffic and Transportation, National Chiao Tung University, Taipei, Taiwan, Republic of China

Published online: 14 Dec 2010.

To cite this article: Yeong-Dong Hwang, Yuan-Feng Wen & Mu-Chen Chen (2010) A study on the relationship between the PDSA cycle of green purchasing and the performance of the SCOR model, Total Quality Management & Business Excellence, 21:12, 1261-1278, DOI: 10.1080/14783363.2010.529361

To link to this article: http://dx.doi.org/10.1080/14783363.2010.529361

Total Quality Management
Vol. 21, No. 12, December 2010, 1261–1278

A study on the relationship between the PDSA cycle of green purchasing and the performance of the SCOR model

Yeong-Dong Hwang[a*], Yuan-Feng Wen[b] and Mu-Chen Chen[c]

[a]*Department of Operations Management, Leader University, Tainan, Taiwan, Republic of China;* [b]*Department of Logistics Management, National Kaohsiung Marine University, Kaoshiung, Taiwan, Republic of China;* [c]*Institute of Traffic and Transportation, National Chiao Tung University, Taipei, Taiwan, Republic of China*

When environmental problems are the focus, conflicts between the general public and company stakeholders affect both regional and global cooperation prompting conflicts in many areas. As a consequence, various initiatives have been designed and adopted that improve environmental performance while maintaining sustainable development. Green purchasing is applied as a useful tool to mitigate the environmental impacts of consumption and to promote clean production technology. The supply chain operations reference (SCOR) model is proposed by a supply chain council as a standard supply chain performance evaluation model. This model has been widely embraced by many modern organisations. The SCOR model can be applied to analyse supply chain performance in a systematic way. It can also aid in communication among all members in the supply chain, and can assist in the development of a design for a better supply chain network. To further improve the performance of the green purchasing process, which is critical in numerous industries, this study explores the relationship between the plan-do-study-act (PDSA) cycle of green purchasing and the SCOR purchasing/sourcing process and its performance indices/metrics. In this study, those companies which produce Taiwanese green label products are taken as samples. The PDSA cycle of green purchasing and the SCOR model are used to construct a structural equation model (SEM). An SEM analysis is conducted to establish the relationship between the PDSA of green purchasing, the sourcing process, and its performance on the SCOR model. The results of this study provide some suggestions for companies conducting green purchasing.

Keywords: green purchasing; PDSA cycle; supply chain operations reference (SCOR) model; structural equation model (SEM)

Introduction

With globalisation development many enterprises face the challenge of global customers by actively constructing new types of business in order to compete with rivals in the marketplace. With the integration of a global economy, enterprises are no longer isolated individuals. Instead, they form a complete supply chain system by cooperating with each other in order to create a higher market value, including procurement, logistics and distribution for ensuring a consistently high degree of customer satisfaction in terms of quality, delivery and cost (Mehta, 2004). In recent years, it has become well-known that a green trend is sweeping across the world. Faced with an awakening environmental consciousness and the formulation of numerous environmental regulations, it is the traditional supply chain that must make the transition by becoming a green supply

*Corresponding author. Email: hyd1020@ms11.hinet.net

ISSN 1478-3363 print/ISSN 1478-3371 online

DOI: 10.1080/14783363.2010.529361
http://www.informaworld.com

chain in the future (Gifford, 1997; Walton, Handfield, & Melnyk, 1998). Green purchasing is an important issue and has drawn international attention because it can be used to mitigate the environmental impacts of consumption and promote clean production technology in the green supply chain system. Each company can choose the optimal appropriate green purchasing strategy and can obtain the competitive advantages of the whole green supply chain when facing a highly competitive global market.

The Supply Chain Council (SCC) was founded by Pittiglio Rabin Todd & McGrath, Advanced Manufacturing Research along with over 65 other enterprises in 1996. The supply chain operations reference (SCOR) model was proposed to help enterprises conduct analysis in a systematic way, to promote communication among members and to provide basic business rules for establishing supply chains. The SCOR is a cross-industry standard supply chain model and is an analysis tool of the supply chain obtained from the viewpoint of process, performance evaluation, and best practices.

Research combining green purchasing and the SCOR model is rare. This study explores relationships among the plan-do-study-act (PDSA) cycle of green purchasing, the sourcing process of the SCOR model and the performance of the SCOR model. Companies that produce green label products in Taiwan were selected as questionnaire respondents for conducting structural equation model (SEM) analysis, and to identify significant factors and the relationships of these factors.

Framework and hypotheses

In the following sections, a model consisting of 13 hypotheses is presented, including the PDSA cycle of green purchasing, the impact of the PDSA cycle of green purchasing on the sourcing process of the SCOR model, the impact of the sourcing process of the SCOR model on its performance of green purchasing and the impact of the PDSA cycle of green purchasing on the performance of the SCOR model.

The PDSA cycle of green purchasing

The PDSA cycle, including planning, doing, studying and acting phases, is a methodology for improvement based on the premise that improvement comes from the application of knowledge (Evans, 2005; Fredriksson, 2003), it is sometimes also called the Deming cycle or the Shewhart cycle. Gapp and Fisher (2008) addressed a platform for understanding the disadvantages of supply chain benchmarking by creating an internal knowledge and learning environment through the PDSA cycle, and then fostered innovation, organisational change and quality improvement. In the planning phase, the company establishes a green purchasing team and clearly identifies green purchasing strategies and environmental performance indices. In the doing phase, the team systematically collects data and modifies and evaluates tasks and activities that may significantly impact the environment. The studying phase is to effectively develop a performance evaluation system of green purchasing to measure actual performance. Appropriate corrective actions should be conducted for non-conformance with the goal. Finally, the acting phase is to develop a new measurement system to measure environmental performance, to control and maintain its performance, and to continuously implement the environmental strategies (Zhu, Sarkis, & Lai, 2008). The planning, doing and acting phases for green purchasing under the ISO 14000 structure are proposed by Chen (2005). Some relevant questions of supply chain, such as the source of delivery, delivery patterns and packaging patterns of delivery are illustrated. The PDSA cycle of green purchasing comprises the following four hypotheses:

H_1: The planning phase of green purchasing has a significant impact on its doing phase.
H_2: The doing phase of green purchasing has a significant impact on its studying phase.
H_3: The studying phase of green purchasing has a significant impact on its acting phase.
H_4: The acting phase of green purchasing has a significant impact on its planning phase.

The impact of PDSA cycle of green purchasing on sourcing process of the SCOR model

Under green purchasing, green suppliers, waste management, packaging problems, environmental regulations, resource reduction, resource reuse, and resource recycling are considered. In addition, support from top management, environmental targets revised, educational training and environmental evaluation are all advantageous when trying to achieve expected outcomes from the sourcing process (Carter, Ellram, & Ready, 1998; Min & Galle, 1997, 2001; Schlegelmilch, Bohlen, & Diamantopoulos, 1996).

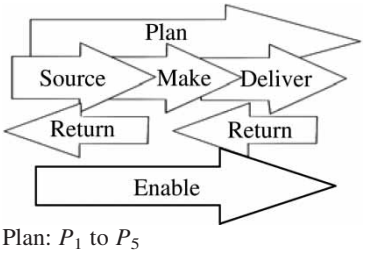
The SCOR model belongs to a supply chain performance evaluation model. It provides a consistent supply chain management framework, including business process performance, evaluation, and best practices. It can assist all participants of a supply chain, including manufacturers, first and second-tier suppliers, downstream retailers/distributors/logistics service providers, and customers, allowing effective communication via the SCOR model and improved the efficiency of supply chain management thereafter.

The SCOR model contains six levels. Its outlines and comments are shown in Table 1 (Xelocity, 2008; Supply-Chain Council, 2006). Level 1 is the top level that deals with process types and defines the supply chain as six key management processes: plan, source, make, deliver, return and enable. This level should clearly define the business objectives of the organisation. Level 2 shows the core process categories. Level 3 presents the process elements that are used to describe various activities and provides a greater insight into the operation of the supply chain. Although levels 4, 5 and 6 are not defined, they can be redefined and redrawn based on a companies' actual condition. Level 4 specifies supply chain management practices that will help achieve competitive advantage, and is known as task. Level 5 plans the activities for each task, and level 6 describes the rules of activities.

The SCOR sourcing type for level 2 and level 3 has three processes and 17 process elements, respectively. Level 2 shows a sourcing process that includes source stocked product, source make-to-order product and source engineer-to-order product. The sourcing process element of the first two processes for level 3 includes schedule product deliveries, product receiving, product verification, product transfer, and supplier payment authorisation. Beside the above-mentioned five items, the third process also includes identification of supply sources and a final suppliers' selection/negotiation. The PDSA cycle of green purchasing can not only mitigate environmental impacts, but also improve the operation of the sourcing process (Choi & Eboch, 1998; Choi & Hartley, 1996; Ofori, 2000).

H_5: The planning phase of green purchasing has a significant impact on sourcing process elements of the SCOR model.
H_6: The doing phase of green purchasing has a significant impact on sourcing process elements of the SCOR model.
H_7: The studying phase of green purchasing has a significant impact on sourcing process elements of the SCOR model.
H_8: The acting phase of green purchasing has a significant impact on sourcing process elements of the SCOR model.

Table 1. The outline and comment of the SCOR model.

Level	Description	Outline	Comments
1	Top level (process types)		Level 1 defines the scope and content for the SCOR model Here basis of competition performance targets are set
2	Configuration level (process categories)	Plan: P_1 to P_5 Source: S_1 to S_3 Make: M_1 to M_3 Deliver: D_1 to D_4 Return: SR_1 to SR_3; DR_1 to DR_3 Enable: EP, ES, EM, ED, ER	A company's supply chain can be configured-to-order at level 2 from core process categories Companies implement their operations strategy through the configuration they choose for their supply chain
3	Process element level (decompose processes)	Plan: $P_{1.1}$ to $P_{1.4}$; $P_{2.1}$ to $P_{2.4}$; $P_{3.1}$ to $P_{3.4}$; $P_{4.1}$ to $P_{4.4}$; $P_{5.1}$ to $P_{5.4}$ Source: $S_{1.1}$ to $S_{1.5}$; $S_{2.1}$ to $S_{2.5}$; $S_{3.1}$ to $S_{3.7}$ Make: $M_{1.1}$ to $M_{1.6}$; $M_{2.1}$ to $M_{2.6}$; $M_{3.1}$ to $M_{3.7}$ Deliver: $D_{1.1}$ to $D_{1.15}$; $D_{2.1}$ to $D_{2.15}$; $D_{3.1}$ to $D_{3.15}$; $D_{4.1}$ to $D_{4.7}$ Return: $SR_{1.1}$ to $SR_{1.5}$; $SR_{2.1}$ to $SR_{2.5}$; $SR_{3.1}$ to $SR_{3.5}$; $DR_{1.1}$ to $DR_{1.4}$; $DR_{2.1}$ to $DR_{2.4}$; $DR_{3.1}$ to $DR_{3.4}$ Enable: EP_1 to EP_9; ES_1 to ES_9; EM_1 to EM_8; ED_1 to ED_8; ER_1 to ER_8	Level 3 defines a company's ability to compete successfully in its chosen markets Companies fine tune their operations strategy at level 3
4	Implementation level (decompose process elements)	Plan: tasks (undefined) Source: tasks (undefined) Make: tasks (undefined) Deliver: tasks (undefined) Return: tasks (undefined) Enable: tasks (undefined)	Companies implement specific supply-chain management practices at this level Level 4 defines practices to achieve competitive advantage and to adapt to changing business conditions
5	Undefined (decompose tasks)	Plan: activities (undefined) Source: activities (undefined) Make: activities (undefined) Deliver: activities (undefined) Return: activities (undefined) Enable: activities (undefined)	The activities can be defined according to the companies' actual conditions
6	Undefined (analyze rule detailed for activities)	Plan: rules (undefined) Source: rules (undefined) Make: rules (undefined) Deliver: rules (undefined) Return: rules (undefined) Enable: rules (undefined)	The rules can be analyzed according to the companies' actual conditions

The impact of sourcing process of the SCOR model on its performance for green purchasing

The SCOR is a supply chain performance evaluation model, which can provide three levels of performance metrics. It has been successfully applied to many cases worldwide (Bolstorff, 2003a). At this time, the application of the SCOR model in green purchasing performance measurement is rare. The SCOR can be applied to develop action-oriented metrics that effectively measure the progress of supply chain projects (Bolstorff, 2004). The SCOR provides companies with a picture of how the processes from start to finish can be improved (Kevan, 2005) and supports cross-industry diagnostics since its standardised process definitions and metrics fit all types of business operations and environments (Bolstorff, 2002, 2003b). Lockamy and McCormack (2004) investigated the relationship between supply chain management planning practices and performance based on the planning, sourcing, making and delivering decision processes provided in the SCOR model. The concept based on the SCOR model evaluated different configurations of process chains with different sets of parameters describing realistic production and inventory processes (Roder & Tibken, 2006). Wang, Huang, and Dismukes (2004) evaluated the performance metrics of the SCOR model for suppliers by using an analytic hierarchy process and determined the strategies of the supply chain. The Taiwanese thin film transistor-liquid crystal display (TFT-LCD) industry was selected as a sample case study by Hwang, Lin, and Lyu (2008) and important performance metrics for the sourcing processes were explored.

H_9 : The sourcing process elements of the SCOR model of green purchasing has a significant impact on its performance.

The impact of the PDSA cycle of green purchasing on the performance of the SCOR model

In general, the major performance metrics of green purchasing include quality, delivery time, capacity of manufacturing systems, price, financial status, capability of R&D and packaging cost (Choi and Hartley, 1996; Hemsworth, Sanchez-Rodriguez, & Bidgood, 2008; Noci, 1997; Park, Hartley, & Wilson, 2001). Gapp and Fisher (2008) identified and reviewed benchmarking approaches in terms of both the internal and external elements of benchmarking with a focus on process, content and performance metric. Level 1 performance metrics of the SCOR model include perfect order fulfillment, upside supply chain flexibility, upside supply chain adaptability, downside supply chain adaptability, supply chain management cost, cost of goods sold, cash-to-cash cycle time, and return on supply chain fixed assets (Xelocity, 2008). The SCOR model also explicitly defines the performance metrics of level 2 and level 3 for companies to use. Under green purchasing, the overall performance of companies can be enhanced by evaluating the environmental performance of suppliers and relevant performances of the whole supply chain system (Hervani, Helms, & Sarkis, 2005; Mebratu, 2001; Rao & Holt, 2005; Vachon & Klassen, 2008; Zhu, Sarkis, & Geng, 2005; Zhu, Sarkis, & Lai, 2007a, 2007b). As a result, performance evaluation will be more definite if green purchasing can be used in conjunction with the performance metrics of the SCOR model.

H_{10}: The planning phase of green purchasing has a significant impact on level 1 performance of the SCOR model.

H_{11}: The doing phase of green purchasing has a significant impact on level 1 performance of the SCOR model.

H_{12}: The studying phase of green purchasing has a significant impact on level 1 performance of the SCOR model.

H_{13}: The acting phase of green purchasing has a significant impact on level 1 performance of the SCOR model.

Methodology

First, expert-opinion and related literature surveys are conducted (Chen, 2005; Choi & Hartley, 1996; Evans, 2005; Hwang et al., 2008; Ofori, 2000; Sarkis, 2003; Seuring & Muller, 2008; Vachon & Klassen, 2008; Zhu et al., 2007a, 2007b, 2008) are conducted to obtain an in-depth understanding of the relationship between the PDSA cycle of green purchasing, sourcing process and its effect on the performance of the SCOR model and further to design a questionnaire. A SEM framework is then constructed to verify the hypotheses.

Sample description

Because most manufacturers of green label products in Taiwan engage in production and purchasing based on the sourcing process of purchase-to-stock policy, the sourcing stocked product of the SCOR model is selected in this study. The sourcing stocked process comprises of five process elements, including schedule product deliveries ($S_{1.1}$), receive product ($S_{1.2}$), verify product ($S_{1.3}$), transfer product ($S_{1.4}$) and authorise supplier payment ($S_{1.5}$). Level 1 contains nine common performance metrics, but level 2 processes and level 3 process elements are with corresponding performance metrics respectively. The performance metrics and their definitions of the SCOR sourcing stocked product at levels 1, 2 and 3 are shown in Tables 2 and 3, respectively. In the SCOR sourcing stocked product, level 2 processes and level 3 process elements include nine and 27 performance metrics respectively. To construct the SEM, the questionnaire shown in

Table 2. The performance metric of SCOR sourcing stocked product at levels 1, 2 and 3.

Attribute	Metric (code)
Reliability	Perfect order fulfillment (R_1), % schedules generated with supplier's lead time ($R_{1.1}$), % schedules changed within suppliers' lead time ($R_{1.2}$), % orders/lines received complete ($R_{1.3}$), % orders/lines received on-time to demand requirement ($R_{1.4}$), % orders/line received damage free ($R_{1.5}$), % orders/lines received with correct shipping documents ($R_{1.6}$), % orders/lines received defect free ($R_{1.7}$), % product transferred on-time to demand requirement ($R_{1.8}$), % product transferred without transaction errors ($R_{1.9}$), % product transferred complete ($R_{1.10}$), % product transferred damage free ($R_{1.11}$), % of faultless invoices ($R_{1.12}$)
Responsiveness	Order fulfillment cycle time (RP_1), source cycle time ($RP_{1.1}$), schedule product deliveries cycle time ($RP_{1.1.1}$), receive product cycle time ($RP_{1.1.2}$), very product cycle time ($RP_{1.1.3}$), transfer product cycle time ($RP_{1.1.4}$), authorise supplier payment cycle time ($RP_{1.1.5}$)
Flexibility	Upside supply chain flexibility (F_1), upside supply chain adaptability (F_2), downside supply chain adaptability (F_3)
Cost	Supply chain management cost (C_1), cost of goods sold (C_2), product acquisition costs as % of source stocked product costs ($C_{2.1}$), schedule deliveries costs as a % of product acquisition costs in source stocked product costs ($C_{2.1.1}$), receiving cost as a % of product acquisition costs in source stocked product costs ($C_{2.1.2}$), verification costs as a % of product acquisition costs in source stocked product costs ($C_{2.1.3}$), transfer & product storage costs as a % of product acquisition costs in source stocked product costs ($C_{2.1.4}$), costs per invoice as a % of product acquisition costs in source stocked product costs ($C_{2.1.5}$)
Asset	Cash-to-cash cycle time (A_a), return on supply chain fixed assets (A_b)

Table 3. The performance metric definition of SCOR sourcing stocked product at level 1, 2 and 3.

Attribute	Metric code			Definition
	Level 1	Level 2	Level 3	
Reliability	R_1	R_1	$R_{1.1} \sim R_{1.12}$ (12 metrics)	The percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage. Components include all items and quantities on-time using customer's definition of on-time, and documentation - packing slips, bills of lading, invoices, etc.
Responsiveness	RP_1	$RP_{1.1}$	$RP_{1.1} \sim RP_{1.5}$ (5 metrics)	The average actual cycle time consistently achieved to fulfill customer orders. For each individual order, this cycle time starts from the order receipt and ends with customer acceptance of the order
Flexibility	F_1	F_1	F_1	The number of days required to achieve an unplanned sustainable 20% increase in quantities delivered
	F_2	F_2	F_2	The maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days
	F_3	F_3	F_3	The reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory or cost penalties
Cost	C_1	C_1	C_1	All direct and indirect expenses associated with operating SCOR business across the supply chain
	C_2	$C_{2.1}$	$C_{2.1.1} \sim C_{2.1.5}$ (5 metrics)	
Asset	A_a	A_a	A_a	The time it takes for an investment made to flow back into a company after it has spent for raw materials
	A_b	A_b	A_b	Measures the return an organization receives on its invested capital in supply chain fixed assets. This includes the fixed assets used in plan, source, make, deliver, and return

Appendix is designed as six unobserved/latent variables and 37 observed/manifest variables. These observed variables are abbreviated as P_1, P_2, P_3, P_4, D_1, D_2, D_3, D_4, D_5, D_6, D_7, S_1, S_2, S_3, S_4, S_5, S_6, A_1, A_2, A_3, A_4, A_5, A_6, $S_{1.1}$, $S_{1.2}$, $S_{1.3}$, $S_{1.4}$, $S_{1.5}$, R_1, $RP_{1.1}$, F_1, F_2, F_3, C_1, C_2, A_a and A_b. These variables are used to evaluate the relationship between green purchasing/sourcing process and its performance. Targeted purchasing staff from 325 green label manufacturers participated in the study. A total number of 218 questionnaires were returned, the response rate was 67%. A Likert scale was designed for the questionnaire using a scale of 1 to 5: 1 denoting very unimportant, 3 indicating neutral, and 5 representing very important.

SEM

The questionnaire was designed based on the PDSA cycle of green purchasing, sourcing stocked product and level 1 performance of the SCOR model. It can be used to determine

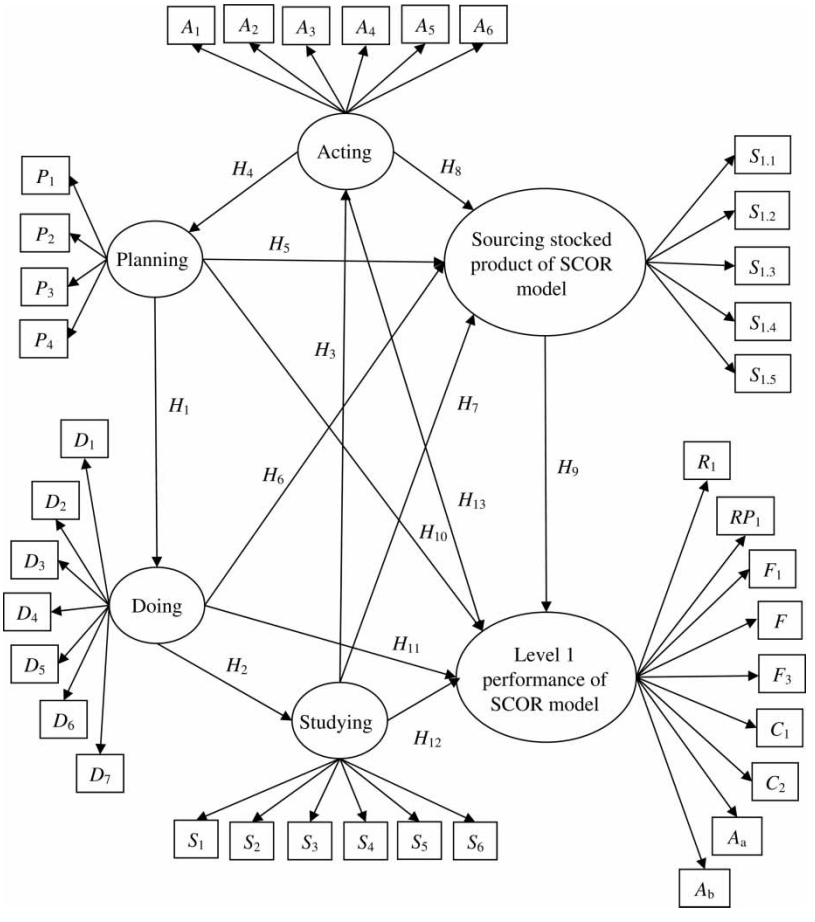


Figure 1. The architecture of structural equation model.

the SEM shown in Figure 1. The observed variables were obtained based on the questionnaire and the SCOR sourcing process. The questionnaire had a total of 37 items: 23 items belonging to the PDSA cycle of green purchasing, five items referred to sourcing stocked product of the SCOR model, and nine items related to level 1 performance of the SCOR model. The PDSA cycle of green purchasing comprises four phases of planning, doing, studying and acting, which include 4, 7, 6 and 6 items, respectively.

Results

The results obtained from the SEM analysis include a goodness-of-fit measurement and relationships. They are described below, respectively.

Goodness-of-fit measurement

Goodness-of-fit tests are used to determine whether the model is rejected or not. The Goodness-of-fit measurements are classified into three categories: an absolute fit measurement; an incremental fit measurement; and a parsimonious fit measurement. The absolute fit measurement includes chi-square (χ^2), goodness-of-fit index (GFI), adjusted goodness

of fit index (AGFI), root mean square residual (RMR) and root mean square error of approximation (RMSEA). The incremental fit measurement includes normed fit index (NFI), Trucker-Lewis index (TLI)/non-normed fit index and comparative fit index (CFI). The third category is either normed chi-square (NC) or Chi-square/degree of freedom. Among them, the values of GFI, AGFI, NFI, TLI and CFI over 0.9 were the optimal status; the result of goodness-of-fit measure can also be good if the values are larger than 0.8 (Joreskog, 1993; Kline, 1998; Maruyama, 1997). In addition, if the result of goodness-of-fit measure is good, then smaller values of p for χ^2, RMR, RMSEA and NC should be better (less than 0.05, 0.05, 0.1 and 2, respectively). At first all the observed variables are selected to construct the SEM. The result of goodness-of-fit measurement was not good. This is called the original model. In order to improve the goodness-of-fit measurement of the model, 16 insignificant observed variables, including P_3, P_4, D_2, D_7, S_4, S_5, S_6, A_3, A_4, A_5, A_6, $S_{1.3}$, F_1, F_2, F_3 and A_b, were deleted. This is called the revised model. Tables 4 and 5 show the analysis results for goodness-of-fit measurement and observed variables, respectively. The revised model has values of GFI, AGFI, NFI, TLI and CFI over 0.8 and the values of p for χ^2, RMR, RMSEA and NC are <0.001, 0.023, 0.051 and 1.512, respectively, and thus the goodness-of-fit measurement was good. Because the revised model obtained better results in the goodness-of-fit measurement than the original model, the revised model was used for the relationship study.

Results of relationship

Table 6 shows the analytic results of unobserved variables in the revised model. Among them, H_1, H_2, H_4, H_7, H_8, H_9, H_{10}, H_{11} and H_{12} are significant, which means paths of these unobserved variables exist. H_3, H_5, H_6, H_{12} and H_{13} are insignificant, which means that the mutual effects of these unobserved variables could be neglected. For the PDSA cycle of green purchasing, three hypothesis are significant, including H_1 (the phase of planning will have an impact on the phase of doing), H_2 (the phase of doing will have an impact on the phase of studying), and H_4 (the phase of acting will have an impact on the phase of planning). In respect of the relationship between the PDSA cycle of green purchasing and the sourcing stocked product of the SCOR model, the phases of studying and acting will have an impact on the sourcing stocked product of the SCOR model (H_7 & H_8). In respect of the PDSA cycle of green purchasing and level 1 performance of the SCOR model, the phases of planning and doing will have an impact on level 1 performance of the SCOR model (H_{10} & H_{11}). In addition, the sourcing

Table 4. The analysis results of goodness-of-fit measurement for the original and revised models.

Type	Index	The original model	The revised model
Absolute fit measure	χ^2 (p value)	960.345 (<0.001)	956.53 (<0.001)
	GFI	0.818	0.840
	AGFI	0.784	0.813
	RMR	0.039	0.023
	RMSEA	0.053	0.051
Incremental fit measure	NFI	0.616	0.810
	TLI	0.775	0.841
	CFI	0.800	0.880
Parsimonious fit measure	NC	1.619	1.512

Table 5. The analysis results of observed variables for the original and revised models.

Unobserved variable	Observed variable	The original model			The revised model		
		p value	Factor loading	Cronbach α	p value	Factor loading	Cronbach α
Planning	P_1	<0.001	0.991	0.403	Fixed parameter	0.952	0.952
	P_2	<0.001	0.947		<0.001	0.914	
	P_3	0.752	0.021				
	P_4	Fixed parameter	0.316				
Doing	D_1	<0.001	0.934	0.622	Fixed parameter	0.940	0.876
	D_2	Fixed parameter	0.373				
	D_3	<0.001	0.606		<0.001	0.641	
	D_4	<0.001	0.975		<0.001	0.960	
	D_5	<0.001	0.646		<0.001	0.716	
	D_6	<0.001	0.574		<0.001	0.604	
	D_7	0.697	0.026				
Studying	S_1	<0.001	0.936	0.573	Fixed parameter	0.941	0.798
	S_2	<0.001	0.574		<0.001	0.614	
	S_3	<0.001	0.900		<0.001	0.899	
	S_4	0.177	0.100				
	S_5	0.060	0.175				
	S_6	Fixed parameter	0.295				
Acting	A_1	<0.001	0.935	0.475	Fixed parameter	0.933	0.908
	A_2	<0.001	0.914		<0.001	0.870	
	A_3	0.894	0.009				
	A_4	Fixed parameter	0.325				
	A_5	0.429	0.053				
	A_6	0.629	0.032				
Sourcing stocked product of SCOR model	$S_{1.1}$	Fixed parameter	0.966	0.777	Fixed parameter	0.949	0.955
	$S_{1.2}$	<0.001	0.982		<0.001	0.995	
	$S_{1.3}$	0.394	0.362				
	$S_{1.4}$	<0.001	0.923		<0.001	0.963	
	$S_{1.5}$	<0.001	0.775		<0.001	0.796	
Level 1 performance of SCOR model	R_1	Fixed parameter	0.733	0.704	Fixed parameter	0.806	0.878
	RP_1	<0.001	0.814		<0.001	0.874	
	F_1	0.062	0.110				
	F_2	0.980	0.001				
	F_3	0.786	0.016				
	C_1	<0.001	0.708		<0.001	0.705	
	C_2	<0.001	0.924		<0.001	0.961	
	A_a	<0.001	0.907		<0.001	0.855	
	A_b	0.709	0.022				

Table 6. The analysis results of unobserved variables for the revised model.

Hypothesis	Path	Factor loading	p value	Impact
H_1	Planning → Doing	0.986	<0.001	Significant
H_2	Doing → Studying	0.403	0.024	Significant
H_3	Studying → Acting	0.225	0.242	Insignificant
H_4	Acting → Planning	1.046	<0.001	Significant
H_5	Planning → Sourcing	0.101	0.783	Insignificant
H_6	Doing → Sourcing	0.024	0.940	Insignificant
H_7	Studying → Sourcing	0.339	<0.001	Significant
H_8	Acting → Sourcing	0.902	<0.001	Significant
H_9	Sourcing → Performance	0.374	<0.001	Significant
H_{10}	Planning → Performance	0.739	<0.001	Significant
H_{11}	Doing → Performance	1.641	<0.001	Significant
H_{12}	Studying → Performance	0.01	0.330	Insignificant
H_{13}	Acting → Performance	0.045	0.114	Insignificant

stocked product of the SCOR model under green purchasing will have an impact on its level 1 performance (H_9).

Discussions

This study investigated the observed variables for the PDSA cycle of green purchasing, sourcing stocked product and level 1 performance of the SCOR model, and the last two variables belong to SCOR model. The significant observed variables obtained for the PDSA cycle of green purchasing and SCOR model through SEM analysis are discussed below.

PDSA cycle of green purchasing

In the planning phase, two observed variables shown in Table 5, including P_1 and P_2, are significant. Variable P_1 is used to describe the environmental objectives and targets in detail. The company has to clearly describe the practice and measurement of green purchasing in order to achieve the defined environmental objectives and targets and to ensure all purchase, practice, and procedures are set. Variable P_2 is to develop the knowledge in respect of green purchasing practices. The economic and environmental impacts of green purchasing are evaluated through appropriate evaluation tools, and some related factors conforming to the environment should also be found.

Variables D_1, D_3, D_4, D_5 and D_6 are significant in the doing phase. Variable D_1 is generated to meet the requirements of ISO 14000. Variable D_3 gathered and analysed related data for the environmental impact of green purchasing. Variable D_4 asked suppliers to provide reliable product environmental conditions and data for a life cycle assessment according to ISO 14040. Variable D_5 was used to select suppliers with ISO 14000 certification. To build up customer's confidence, the suppliers which have been validated to have green products by third parties are selected (Mendelson & Polonsky, 1995; Stanford & Hartman, 1996). Variable D_6 was used to consider logistics systems which are presented in three types including the source of delivery, delivery patterns and packaging patterns for delivery (Chen, 2005; Sarkis, 2003).

In the studying phase, S_1, S_2 and S_3 are significant. Variable S_1 describes that appropriate corrections should be conducted for non-conformance with predetermined objectives and targets in environmental performance. Variable S_2 supports ISO 14031

certification. This is an internal process and management tool designed for providing managers with reliable and verifiable information and to determine whether the organisation's environmental performance meet the standard or not (Kuhre, 1998). Variable S_3 was used to develop a new measurement system for measuring the environmental performance of green purchasing. Through monitoring a series of processes, non-compliance with objectives and targets of green purchasing can be fed back to managers, and then form a new environmental strategy (Chen, 2005; Hammer, 1997).

In the acting phase, A_1 and A_2 are significant. Variable A_1 represents the standardised processes and procedures for green purchasing. These processes and procedures can be standardised for conformance with objectives and targets. Variable A_2 increases purchasers' capability. This increases purchasers' knowledge of implementing green purchasing practices through training and to learn new methods for solving problems.

SCOR model

The results of the SEM analysis for sourcing stocked product and level 1 performance of the SCOR model are shown in Table 5, and are explained as follows. There are five significant performance metrics at level 1 which are perfect order fulfillment (R_1), order fulfillment cycle time (RP_1), supply chain management cost (C_1), cost of goods sold (C_2) and cash-to-cash cycle time (A_a). Many studies on green supply chain focused on reduced cycle times, improved quality through waste reduction, customer focus and cooperation (Choi & Eboch, 1998; Gapp & Fisher, 2008; Vachon & Klassen, 2008; Zhu et al., 2007a; Zhu & Sarkis, 2004). Past research suggests that companies should select good processes/strategies between environmental impact and costs to decrease the environmental impact of thegreen supply chain (Neto, Bloemhof-Ruwaard, Nunen, & Heck, 2008; Rao & Holt, 2005; Sarkis, 2003). Table 7 shows the performance metrics of the SCOR sourcing stocked product at levels 2 and 3 which are extended from level 1 performance metrics through the SEM analysis. Level 2 contains five significant performance metrics as well, including R_1, source cycle time ($RP_{1.1}$), C_1, C_2 and A_a. Level 3 comprises five process elements, including $S_{1.1}$, $S_{1.2}$, $S_{1.3}$, $S_{1.4}$ and $S_{1.5}$. The marks shown in Table 7 with Π represent the performance metrics defined by the SCOR sourcing stocked product at level 3, and marked areas denote significant metrics obtained.

In the $S_{1.1}$ process element, significant metrics include percentage schedules generated with suppliers' lead time ($R_{1.1}$), percentage of schedules changed with suppliers' lead time ($R_{1.2}$), schedule product deliveries cycle time ($RP_{1.1.1}$), C_1, schedule deliveries cost as 1% of product acquisition costs in sourcing stocked product ($C_{2.1.1}$) and A_a. $R_{1.1}$ which defines the ratio of total number of schedules to the number of schedules which are changed in the suppliers lead time in the measurement period. $R_{1.2}$ is 100% subtracted by $R_{1.1}$. $C_{2.1.1}$ representing the ratio of product acquisition cost to the total cost of scheduled deliveries in sourcing stocked product.

In the $S_{1.2}$ process element, the metrics include the percentage of order/lines received completely ($R_{1.3}$), percentage of orders/lines received on-time to demand requirement ($R_{1.4}$), percentage of orders/lines received damage free ($R_{1.5}$), percentage of orders/lines received with correct shipping documents ($R_{1.6}$), receive product cycle time ($RP_{1.1.2}$), C_1, receiving costs as a percentage of product acquisition costs in sourcing stocked product ($C_{2.1.2}$) and A_a. Among them, the attribute of $R_{1.3}$, $R_{1.4}$, $R_{1.5}$ and $R_{1.6}$ is reliability and $C_{2.1.2}$ is cost. The definition of $R_{1.3}$ is the ratio of the total number of orders/lines received to the total number of orders/lines received in the measurement period. $R_{1.4}$ is the ratio of the number of total orders/lines needed to meet demand to the number of orders/lines received

Table 7. The performance metric of SCOR source stocked product process at levels 2 and 3 through extending from level 1 performance metrics through the SEM analysis.

	Level 1	Level 2		Level 3				
				$S_{1.1}$	$S_{1.2}$	$S_{1.3}$	$S_{1.4}$	$S_{1.5}$
Reliability	R_1	R_1	$R_{1.1}$	✓				
			$R_{1.2}$	✓				
			$R_{1.3}$		✓			
			$R_{1.4}$		✓			
			$R_{1.5}$		✓			
			$R_{1.6}$		✓			
			$R_{1.7}$			✓		
			$R_{1.8}$				✓	
			$R_{1.9}$				✓	
			$R_{1.10}$				✓	
			$R_{1.11}$				✓	
			$R_{1.12}$					✓
Responsiveness	RP_1	$RP_{1.1}$	$RP_{1.1.1}$	✓				
			$RP_{1.1.2}$		✓			
			$RP_{1.1.3}$			✓		
			$RP_{1.1.4}$				✓	
			$RP_{1.1.5}$					✓
Flexibility	F_1	F_1	F_1	✓	✓	✓	✓	✓
	F_2	F_2	F_2	✓	✓	✓	✓	✓
	F_3	F_3	F_3	✓	✓	✓	✓	✓
Cost	C_1	C_1	C_1	✓	✓	✓	✓	✓
	C_2	$C_{2.1}$	$C_{2.1.1}$	✓				
			$C_{2.1.2}$		✓			
			$C_{2.1.3}$			✓		
			$C_{2.1.4}$				✓	
			$C_{2.1.5}$					✓
Asset	A_a	A_a	A_a	✓	✓	✓	✓	✓
	A_b	A_b	A_b	✓	✓	✓	✓	✓

on-time to the demand requirements. $R_{1.5}$ and $R_{1.6}$ respectively represent the ratio of orders/lines received without damage and with correct shipping documents to the total orders/lines processed. $C_{2.1.2}$ represents the ratio of the total cost of product acquisition to the receiving cost in sourcing stocked product. Because $S_{1.3}$ is not significant, the metrics can be neglected, including the percentage of orders lines received defect free ($R_{1.7}$), very product cycle time ($RP_{1.1.3}$), F_1, F_2, F_3, C_1, verification costs as a percentage of product acquisition costs in sourcing stocked product ($C_{2.1.3}$), A_a and A_b.

The key performance metrics of $S_{1.4}$ process element are percentage of product transferred to demand requirement ($R_{1.8}$), percentage of product transferred without transaction errors ($R_{1.9}$), percentage of product transferred complete ($R_{1.10}$), percentage of product transferred damage free ($R_{1.11}$), transfer product cycle time ($RP_{1.1.4}$), C_1, transfer and product storage costs as a percentage of product acquisition costs in sourcing stocked product ($C_{2.1.4}$) and A_a; $S_{1.5}$ process element include the percentage of faultless invoices ($R_{1.12}$), authorise supplier payment cycle time ($RP_{1.1.5}$), C_1, cost per type of invoice ($C_{2.1.5}$) and A_a. $R_{1.8}$, $R_{1.10}$ and $R_{1.11}$ are similar to $R_{1.4}$, $R_{1.3}$ and $R_{1.5}$, respectively. However, the first three metrics are used for transferring products and the rest are used for orders/lines received. $R_{1.9}$ represents the ratio of the total number of transactions processed to the number of transactions processed without error. $C_{2.1.4}$ and $C_{2.1.5}$ are similar,

and are used to represent the costs of product transferring and storage and the cost per type of invoice, respectively. $R_{1.12}$ represents the ratio of the total number of invoices processed to the number of invoices issued without error. In general, the reasons for invoice defects include a change in the customers' purchase order without their agreement, wrong customer information, wrong product information, wrong price, wrong quantity, terms or date, etc.

Conclusions and suggestions

The SEM was designed to find out the relationship between the PDSA of green purchasing and sourcing process and its performance on the SCOR model. There are 13 hypotheses proposed in this study. Since the p values (<0.001) for eight hypotheses are lower than the significance level (0.05) after analysis, the proposed null hypothesis are accepted. The results are summarised as follows:

(1) The planning phase of green purchasing will affect both the doing phase of green purchasing and level 1 performance of the SCOR model.
(2) The doing phase of green purchasing will affect both the studying phase of green purchasing and level 1 performance of the SCOR model.
(3) The studying phase of green purchasing will affect the sourcing stocked product of the SCOR model.
(4) The acting phase of green purchasing will affect both the planning phase of green purchasing and the sourcing stocked product of the SCOR model.
(5) The sourcing stocked product process of the SCOR model will affect level 1 performance of the SCOR model.

The number of observed variables for the PDSA cycle of green purchasing, sourcing stocked product of the SCOR model and level 1 performance of the SCOR model is 23, 5 and 9, respectively. After the SEM analysis, the number of significant variables screened is found to be 12, 4 and 5, respectively. The sourcing stocked product of the SCOR model at level 3 includes 52 performance metrics. By extending the results of level 1 performance, 27 critical performance metrics are screened out of the 52 defined performance metrics for level 3.

As shown in the case analysis, the results obtained are only suitable for companies with green label products in Taiwan. This method also provides an insight into the relationship between green purchasing for the improvement in the green supply chain performance in various industries. In addition, this study is conducted based on the SCOR version 7.0. The newly developed version 9.0 can be adopted for future study (Supply-Chain Council, 2008).

Acknowledgement

The authors wish to acknowledge funding support from the National Science Council of the Republic of China (Taiwan) (NSC 97-2221-E-426-007).

References

Bolstorff, P. (2002). How does SCOR measure up? *Supply Chain Technology News*, May, 22–25.
Bolstorff, P. (2003a). Measuring the impact of supply chain performance. *Logistics Today*, December, 6–11.
Bolstorff, P. (2003b). Measuring the impact of supply chain performance. *Logistics Today*, December, 6–11.
Bolstorff, P. (2004). Supply chain by the numbers. *Logistics Today*, *45*(7), 46, 48–50.

Carter, C.R., Ellram, L.M., & Ready, K.J. (1998). Environmental purchasing: Benchmarking our German counterparts. *International Journal of Purchasing and Materials Management*, *34*(4), 28–38.
Chen, C.C. (2005). Incorporating green purchasing into the frame of ISO 14000. *Journal of Cleaner Production*, *13,* 927–933.
Choi, T.Y., & Eboch, K. (1998). The TQM paradox: Relations among TQM practices, plant performance, and customer satisfaction. *Journal of Operations Management*, *17,* 59–75.
Choi, T.Y., & Hartley, J.L. (1996). An exploration of supplier selection practices across the supply chain. *Journal of Operations Management*, *14,* 333–343.
Evans, J.R. (2005). *Total quality management, organization and strategy* (4th ed.). Canada: Thomson & South–Western.
Fredriksson, M. (2003). TQM as a support for societal development–experiences from a Swedish community. *Total Quality Management & Business Excellence*, *14*(2), 225–233.
Gapp, R., & Fisher, R. (2008). Achieving organisational transformation: An action learning approach. *Total Quality Management & Business Excellence*, *19*(6), 609–625.
Gifford, D. (1997). The value of going green. *Harvard Business Review*, *75*(5), 11–12.
Hammer, B.A. (1997). A strategic approach to ISO 14000. *Corporate Environmental Strategy*, *4*(2), 47–52.
Hemsworth, D., Sanchez-Rodriguez, C., & Bidgood, B. (2008). A structural model of the impact of quality management practices and purchasing – related information systems on purchasing performance: A TQM perspective. *Total Quality Management & Business Excellence*, *19*(1–2), 149–162.
Hervani, A.A., Helms, M.M., & Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking*, *12*(4), 330–353.
Hwang, Y.D., Lin, Y.C., & Lyu, J.J. (2008). The performance evaluation of SCOR sourcing process – The case study of Taiwan's TFT–LCD industry. *International Journal of Production Economics*, *115*(2), 411–423.
Joreskog, K.G. (1993). *Testing structural equation models*. Newbury Park, CA: Sage.
Kevan, T (2005). Modeling the future. *Frontline Solutions*, *6*(1), 22–24.
Kline, R.B. (1998). *Principles and practice of structure of structural equation modeling*. New York: The Guilford Press.
Kuhre, W.L. (1998). *ISO 14031: Environmental performance evaluation*. Englewood Cliffs, NJ: Prentice–Hall.
Lockamy, A., & McCormack, K. (2004). Linking SCOR planning practices to supply chain performance: An exploratory study. *International Journal of Operations & Production Management*, *24*(11/12), 1192–1218.
Maruyama, G.M. (1997). *Basics of structural equation modeling*. Thousand Oaks, CA: Sage.
Mebratu, D. (2001). Environmental competitiveness 'Green' purchasing. *International Trade, 2*, 11–13.
Mehta, J. (2004). Supply chain management in a global economy. *Total Quality Management & Business Excellence*, *15*(5–6), 841–848.
Mendelson, N., & Polonsky, M.J. (1995). Using strategic alliances to develop credible green marketing. *Journal Consumer Marketing*, *12*(2), 4–18.
Min, H., & Galle, W.P. (1997). Green purchasing strategies: Trends and implications. *International Journal of Purchasing and Materials Management*, *33*(3), 10–17.
Min, H., & Galle, W.P. (2001). Green purchasing practices of US firms. *International Journal of Operations & Production Management*, *21*(9/10), 1222–1238.
Neto, J.Q.F., Bloemhof-Ruwaard, J.M., Nunen, J.A.E.E., & Heck, E. (2008). Designing and evaluating sustainable logistics networks. *International Journal of Production Economics*, *111*(2), 195–208.
Noci, G. (1997). Designing 'green' vendor rating systems for the assessment of a supplier's environmental performance. *European Journal of Purchasing & Supply Management*, *3*(2), 103–114.
Ofori, G. (2000). Greening the construction supply chain in Singapore. *European Journal of Purchasing & Supply Management*, *6*(3–4), 195–206.
Park, S., Hartley, J.L., & Wilson, D. (2001). Quality management practices and their relationship to buyer's supplier ratings: A study in the Korean automotive industry. *Journal of Operations Management*, *19,* 695–712.

Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations & Production Management*, *25*(9–10), 898–916.

Roder, A., & Tibken, B. (2006). A methodology for modeling inter–company supply chains and for evaluating a method of integrated product and process documentation. *European Journal of Operational Research*, *169,* 1010–1029.

Sarkis, J. (2003). A strategic decision framework for green supply chain management. *Journal of Cleaner Production*, *11,* 397–409.

Schlegelmilch, B.B., Bohlen, G.M., & Diamantopoulos, A. (1996). The link between green purchasing decisions and measures of environmental consciousness. *European Journal of Marketing*, *30*(5), 35–55.

Seuring, S., & Muller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16,* 1699–1710.

Supply-Chain Council. (2006). Supply chain operations reference model Version 7.0 overview. Retrieved from http://supply_chain.org

Supply-Chain Council. (2008). Supply chain operations reference model Version 9.0 overview. Retrieved from http://www.supply_chain.org/galleries/public_gallery/SCOR%209.0%20Overview%20Booklet.pdf

Vachon, S., & Klassen, R.D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economics*, *111*(2), 299–315.

Walton, S.V., Handfield, R.B., & Melnyk, S.A. (1998). The green supply chain: Integrating suppliers into environmental management processes. *International Journal Purchasing Material Management*, *34*(2), 2–11.

Wang, G., Huang, S.H., & Dismukes, J.P. (2004). Product–driven supply chain selection using integrated multi–criteria decision–making methodology. *International Journal of Production Economics*, *91,* 1–15.

Xelocity. (2008). ProcessWizard software. Retrieved from http://www.process_wizard.com

Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, *22,* 265–289.

Zhu, Q., Sarkis, J., & Geng, Y. (2005). Green supply chain management in China: Pressures, pratices and performance. *International Journal of Operations & Production Management*, *25*(5–6), 449–468.

Zhu, Q., Sarkis, J., & Lai, K.H. (2007a). Green supply chain management: Pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, *15,* 1041–1052.

Zhu, Q., Sarkis, J., & Lai, K.H. (2007b). Initiatives and outcomes of green supply chain management implementation. *Journal of Environmental Management*, *85,* 179–189.

Zhu, Q., Sarkis, J., & Lai, K.H. (2008). Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics*, *111*(2), 261–273.

Appendix

Questionnaire

1. Explanation for the planning phase of green purchasing

   (1) P_1: The company sets up the improvement team for green purchasing, and describe in detail the strategy of green purchasing in order to achieve stated environmental objectives and targets.
   (2) P_2: Develop knowledge of green purchasing practices in order to analyse economic and environmental impacts of green purchasing, and to evaluate the compliance with environmental policy, potentially significant environmental impacts, administrative matters, technological options, and cooperative partners.

(3) P_3: Top managers need to refine and review the environmental objectives and policies of green purchasing, and vigorously participate in the plan.
(4) P_4: Team members establish the improvement project of green purchasing via historical data collection and analysis, and identify environmental performance indices for measuring project.

2. Explanation for the doing phase of green purchasing

(1) D_1: It must be developed to meet requirements of ISO 14001 for documented procedures, as well as to monitor and measure the key operations and activities that bring significant impacts on the environment.
(2) D_2: Managers need to clearly assign tasks to relevant purchasing personnel based on specific targets and a documentation process.
(3) D_3: The company records operations and activities that impact the environment significantly, and systematically gathers and evaluates related data for further analysis.
(4) D_4: The company selects supplier with certification of ISO 14040 and asks them to conduct life cycle assessment and provide reliable environmental conditions and data for their products.
(5) D_5: The company selects supplier with certification of ISO 14001, and reduces costs and difficulties of the material/service supply process generating minimum environmental impacts.
(6) D_6: Managers consider the environmental impacts arising from delivery paths from the supply source/delivery point to the destination/the warehouse of the firm, including the source of delivery, delivery patterns and packaging patterns for delivery on logistics systems.
(7) D_7: The company selects suppliers with green label products or certification of ISO 14020 in order to reduce any environmental impact, and intends to take up social responsibility.

3. Explanation for the studying phase of green purchasing

(1) S_1: An effective performance evaluation system is required to develop for measuring the actual environmental performance of green purchasing; appropriate corrections should be conducted for non-conformance with predetermined objectives and targets.
(2) S_2: An internal process and management tool used to evaluate an organisation's environmental performance through ISO 14031, which is designed to provide reliable and verifiable information for management.
(3) S_3: It develops an indicator system to measure environmental performance of green purchasing and provides feedback to improve a series of processes.
(4) S_4: The company makes a qualitative review on the environmental aspects and impacts, legal requirements, and relevant data of organisation conformity arising from green purchasing, picking out and identifying problems, and conducts corrections to improve the performance.
(5) S_5: The company reduces waste of materials for designs and manufacturing according to ISO 14025 procedures, and develops new resources.
(6) S_6: The company conducts life cycle assessment as well as development and improvement for products according to ISO 14040 procedures, which can be references for managers' strategic planning in order to further enlarge the product market.

4. Explanation for the acting phase of green purchasing

(1) A_1: The company standardises the process and procedure for projects which conform to objective and targets of green purchasing.
(2) A_2: The company increases purchasers' knowledge in implementing green purchasing practices through training, and learns new methods for solving problems.
(3) A_3: It develops a new indicator system to measure environmental performance of green purchasing for controlling and maintaining a company's compliance with the requirement for continuous improvement in environmental performance.
(4) A_4: Top managers proactively participate in project implementation and assist/support related works.

(5) A_5: To conduct analysis to next cycle/planning phase in respect of the non-compliance with objectives and targets of green purchasing in order to formulate a new environmental strategy for continuous improvement in environmental performance.
(6) A_6: Relevant strategies of green purchasing must be helpful for internal and external coordination/communication and to be embedded in the organisational culture.

5. Explanation of the level 3 process elements of the SCOR model

(1) $S_{1.1}$: Scheduling and managing individual deliveries of products according to procurement contracts or purchase orders, including electronic data interchange, kaban system, synchronisation between sourcing and making process, consignment inventory management and vendor managed inventory.
(2) $S_{1.2}$: The process and associated activities of receiving products according to contract requirements, including suppliers' certification procedures, bar coding, deliveries balanced, suppliers' direct delivery and suppliers' agreements.
(3) $S_{1.3}$: The process and relevant activities which determine whether products meet requirements or not, including supplier certification programs, bar coding, deliveries balanced, supplier direct delivery and replacing defective material for supplier.
(4) $S_{1.4}$: To transfer accepted products to the appropriate stocking location within the supply chain, including all of the activities associated with repackaging, staging, transferring and stocking products.
(5) $S_{1.5}$: There is a payment process which is mutually recognised for suppliers' products and services, including invoice collection, invoice matching and the issuance of checks.

6. Explanation of the level 1 performance metrics of the SCOR model

(1) R_1: The product is delivered according to specification, location, and delivery time with no damage, and is accepted by customers.
(2) $RP_{1.1}$: Cumulative lead-time required for sourcing products from internal and external suppliers; for example, inside-plant planning, supplier lead time, receiving, handling, etc.
(3) F_1: The company can achieve an unplanned sustainable 20% increase in delivery quantity.
(4) F_2: The maximum sustainable percentage increase in delivery quantity can be achieved within 30 days.
(5) F_3: Sustainable reduction in order quantity within 30 days priors to delivery can be accepted with no inventory or cost penalties and with prioritisation of delivery.
(6) C_1: All direct and indirect expenses associated with operating business processes across the supply chain.
(7) C_2: The cost associated with buying raw materials and producing finished goods includes direct costs of labor and materials and indirect costs of overhead.
(8) A_a: The time it takes for an investment to flow back into the company after it has been spent for raw materials.
(9) A_b: The return an organisation receives on its invested capital in supply chain fixed assets.