DEVELOPMENT OF GREEN SUPPLY CHAIN PERFORMANCE INDICATORS FOR AN ARABICA COFFEE CHAIN

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Abstract
As the public has become more aware of environmental issues, so the green concept has been discussed widely by Thai industry, and in particular the agricultural sector. Green supply chain management can be defined as the integration of environmental thinking into supply-chain management disciplines. The aim of this research was then to develop green supply chain performance indicators for an Arabica coffee chain. The research followed three key steps, these being the study and screening of all relevant factors using an Analytic Hierarchy Process (AHP), the identification of all appropriate assessment indicators and the carrying out of an experiment using the designed assessment process. The first step began with a study of the relevant factors, based on theories and previous research works associated with green supply chains and Arabica coffee supply chains, covering four major groups of factors: green procurement, green manufacturing, green distribution and green logistics. Questionnaires and the AHP were used to screen for those factors actually affecting the performance of the green supply chain from the stockholders' perspectives, and such factors were then employed as indicators within the supply chain assessment process. During the second step, the screened factors were used to develop performance indicators, based on the applied balanced scorecard concept and covering four traditional key areas, these being the financial, customer, internal process, and learning and development perspectives, plus one additional area - the environmental perspective. The results of these steps were then used to design an assessment model. In the final step, the designed assessment model was utilized as part of an experiment covering two of the Arabica coffee chains, in order to compare their performance levels and establish guidelines for improvement, plus create a green supply chain performance assessment manual.

Keywords: Green Supply Chain, Performance Indicator, Balanced Scorecard, Arabica Coffee

Introduction

The Arabica coffee processing industry has been in place in northern Thailand for some time, and has made considerable progress, contributing to the rapid growth of the roasted and fresh coffee industry in the region. Nevertheless, coffee bean production in the area are still inadequate, meaning green coffee beans still have to be imported from neighboring countries in large quantities, and these are of a lower quality, and require additional roasting and distributing in order to satisfy domestic demand (Boonma and Korsamphan, 2010). Moreover, the connections between farmers, processing plant operators, shop owners and consumers are not yet clear, meaning enhanced supply chain management activities are needed in order to link information, finance, knowledge, products and services logistics operations, from the raw materials suppliers through to the consumers, plus to connect production units - whether of products or services - from the raw materials through to the end users, and so enhance the overall effectiveness and competitiveness of the industry. Recently, the government sector and concerned agencies have started to pay more attention to supply chain management issues, including the environmental impacts of the entire chain. The International Coffee Organization (ICO, 2009) has divided activities within the Arabica coffee production chain into 4 main stages, as follows: the agricultural stage, the coffee roasting stage, the additional processing stage, and the transportation and distribution, consumption and waste management stage.

Green supply chain management is a process which integrates environmental thinking into supply-chain management processes, and covers 4 key activities: green procurement, green manufacturing, green distribution and green logistics. The term "Green Procurement" refers to the purchasing of raw materials while taking into consideration the environment, while the term "Green Manufacturing" refers to the creation of a clean and environmentally friendly production process which does not create waste and pollution, and which results in energy and resource savings, plus which uses well-designed processes and appropriate technology. "Green Distribution"; meanwhile, refers to a product distribution process in which environmental impacts are minimized. Lastly, "Reverse logistics" or "Green logistics"

refers to the process of recalling products from end users in order to dispose of or recycle unused or processed materials, so as to reduce waste (Kanchanasuntorn, 2008; Choomrit, 2010).

The researchers of this paper carried out a review of previous research studies associated with supply chain management, and found a number of studies related to the assessment of organizational competency, the measurement of supply chain performance, and the assessment of the effectiveness of organizational management. However, we found little research on green supply chain management issues; most was related to the application of the green supply chain concept in large-scale industries, such as the electronics and automobile sectors. Furthermore, there was little research on the tools used to assess and measure green supply chain performance. Zhang and Zhiwei (2009) discussed the unsuitability of adapting traditional supply chain assessment systems to a green supply chain, due to the differences in factors influencing the green supply chain and also the impact of environmental issues. Also, Xue (2010) found that conventional measures focus on economic performance, such as customer satisfaction, service quality, and costs and benefits. If such factors were adopted for green supply chains, the environmental aspects might not be taken into consideration.

Therefore, the aim of this research was to develop green supply chain performance measurement indicators for an Arabica coffee chain. The study was based on the Balanced Scorecard (BSC) - a tool used to translate strategies into practice and which is known for its clear evaluation criteria, which cover both financial and non-financial areas- plus one additional area, the environmental perspective. (Kang and Juanmei, 2010; Yunning and Rong, 2010; Duarte, Cabrita, and Machad, 2011; Yao and Zhang, 2011). The results of this research may be used to assess the Arabica coffee supply chain and also provide information which may be used to develop its business strategy. The study was conducted among a number of stakeholders working at the Arabica coffee chain in Chiang Mai province, which is located in northern Thailand, and these stakeholders included roasting plant workers, distributors and coffee shop owners, but did not include farmers, processing plant workers or local collectors, as most of these stakeholders live in the highlands.

Green Supply Chain Performance Measurement

A review of previous research studies found that a variety of tools, concepts and principles have been applied to measure the performance of green supply chains. Xue (2010); for example, incorporated the green supply chain concept into the ISO14000 environmental management standards, and developed indicators for assessing green supply chain activities using Data Envelopment Analysis (DEA) - producing green supply chain management decision-making guidelines. Also, Zhang and Zhiwei (2009) proposed the use of the Fuzzy Analytic Hierarchy Process (FAHP) concept in the model development, and the model obtained from this research aimed to accurately measure performance. In addition, a research study conducted by Zongcheng and Ren (2009) took into account both financial and non-financial factors, and developed a green supply chain performance evaluation system comprised of 17 indicators covering 4 key areas, these being: financial conditions, customer service, operational processes and the degree of 'greenness', and which used Unascertained Means Cluster methodology (a combination of unascertained theory and clustering theory) to assess and improve green supply chain performance, as well as assessment reliability.

As well as the tools mentioned above, the BSC is another tool which has been applied extensively to measure green supply chain performance. For example, Duarte, Cabrita, and Machad (2011) conducted a study into the integration of the lean and green supply chain concepts. The lean concept focuses on performance improvements and waste reduction, while the green supply chain concept focuses on waste elimination and a reduction of adverse environmental impacts. Since this supply chain management performance measurement tool takes into account both financial and non-financial factors, the measurement applied can be divided into 4 categories: financials, customers, internal processes, and learning and development.

In addition to the traditional BSC approach, any evaluation of a green supply chain may also adopt the "applied BSC" model, which includes environmental aspects as a fifth category, and can be used with other tools such as the AHP and Benchmarking tools. Its use can be seen in the research conducted by Yao and Zhang (2011), who conducted an assessment of green supply chains by improving the traditional BSC to include environmental aspects, and this resulted in the use of a total of 19 indicators covering 5 categories. Similarly, Kang and Juanmei (2010) developed a green supply chain performance evaluation method, using both the BSC and Fuzzy Theory and taking into account all 5 categories (they added an environmental perspective to the traditional BSC). In this study, an indicator system and an evaluation protocol were developed using Fuzzy theory. Also, Yunning and Rong (2010) conducted a study into the assessment of green supply chain performance in the construction industry, improving the traditional BSC so as to develop an extensive indicator system that generated quantitative results. To do this, they added 2 more elements: supply chain operations

and environmental performance, to the traditional BSC, creating a total of 6 categories to be used alongside Principal Component Analysis - to minimize evaluation problems. Then, the AHP was used to weight the protocol, and the Genetic Algorithm (GA) tool employed for the final solution.

Research Methodology and Results

This research study was conducted using 3 main steps, these being: (1) study and screen those factors significant in the Arabica coffee green supply chain, using the AHP technique, (2) identify the key evaluation indicators, using the screened factors as performance indicators and developing an evaluation model, and (3) test the resulting model, in order to compare performance, and make recommendations for improvement. The details of the research activities and results are as follows:

1. Study and screening of factors significant to the Arabica coffee green supply chain using the AHP technique

This step involved a study into the Arabica coffee supply chain, including gathering key information to develop the most critical factors. A study of the primary factors was carried out covering 4 key phases: green procurement, green manufacturing, green distribution and green logistics, together with 34 secondary factors. The AHP was then used to identify those factors which actually impacted the Arabica coffee green supply chain, and this produced 28 factors of real significance. Details of the research methodology used and the results obtained can be found in Jamigranont and Chompu-inwai (2012). During the research, the key stakeholders stated that the most important activities impacting the performance of the green supply chain are those processes that produce quality products to meet consumer requirements, those which maximize effectiveness and those which minimize waste during the production process.

2. Identification of evaluation indicators for the Arabica coffee green supply chain

Those factors significant to the Arabica coffee green supply chain obtained above were then categorized based on the applied BSC tool using 5 categories, these being:

1) Financials (F) – An indication of whether the business will be able to continue, incorporating 4 sub-factors: raw materials procurement costs (F1), production costs (F2), distribution costs (F3), and waste management costs (F4).

2) Customers (C) – An important indicator for the organization in terms of recognizing customer satisfaction levels. The sub-factor stakeholders gave most importance to here was the number of returned products (C1).

3) Internal Processes (I) – Internal processes refers to the internal business processes which are importance to financial and customer aspects. In this study, the stakeholders placed importance on 13 factors: raw materials quality inspection (I1), supplier reliability (I2), proper raw material storage (I3), chemical substance control during production (I4), waste containment during production (I5), production resource control (I6), water source and water supply system control (I7), production effectiveness (I8), product quality (I9), proper product storage (I10), packaging for distribution (I11), suitability of vehicles employed for distribution (I12), and the suitability of fuel employed during distribution (I13).

4) Learning and Growth (L) -- involves employee learning and development within an organization, activities which both impact upon internal process performance. If employees acquire knowledge and enhance their competency levels through learning, it will result in better performance and eventually lead to higher product quality. In this study, the 5 factors stakeholders placed importance on within this category were employees responsible for production (L1), suitability of production areas and conditions (L2), facility maintenance planning (L3), transport route planning (L4), and transport vehicle maintenance (L5).

5) Environment (E) -- a perspective which supports environmental management within an organization. The 5 factors the stakeholders placed importance on here were: environmentally friendly processing or production carried by suppliers (E1), the selection of reliable transportation service companies – those with sound environmental policies in place (E2), wastewater treatment (E3), the appropriate management of non-conforming products (E4), and waste disposal management (E5).

After this, indicators were identified and a scoring assessment carried out. The scoring assessment was carried out based on Thai Agricultural Standards for Arabica coffee beans (National Bureau of Agriculture Commodity and Food Standards, 2009), the Thai Industrial Standard for Roasted Coffee (Thai Industrial Standards Institute, 1984), environmental management system standard ISO 14000, Good Manufacturing Practice (GMP), a review of previous research ((Udomvechayanunt, 2011; Wichaisri, 2011; Yao and Zhang, 2011; Yunning and Rong, 2010) and also interviews with business operators and coffee experts.

The scoring criteria were developed using Scoring Rubrics and based on Analytic Rubrics, both of which provided a clear definition or description for each level, as follows: 1 = Improvement required, 2 = Below average, 3 = Average, 4 = Good, and 5 = Excellent (Bunnag, 1988). Samples of indicators and descriptions, environmental objectives, assessment methods and scoring criteria used in this study, based on BSC categories are shown in Table 1.

3. Experiment using the design assessment process

The model developed to assess the green supply chain performance of the Arabica coffee chain was then used. The results show that the designed framework may be used to effectively evaluate a range of organizational types, in order to compare the performance of those with similar characteristics. From Figure 1, for instance, a comparison of Distributor B1 and Distributor B2, or of Coffee shop C1, Coffee shop C2 and Coffee shop C3 may be carried out. Nevertheless, the proposed indicators and evaluation methods may be more suitable for carrying out a comparison of coffee roasting plants than distributors and shops, as some indicators are inconsistent with the activities of such organizations.

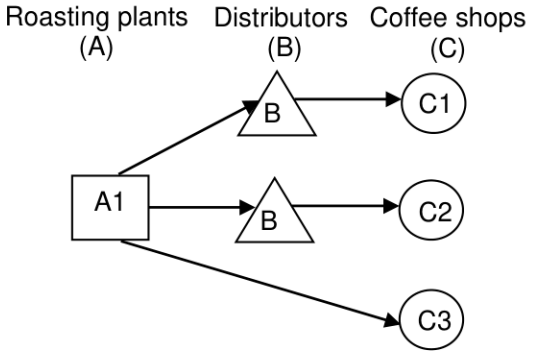

Figure 1: Example of Arabica coffee supply chains

After each indicator was used to assess the study organization's supply chain, a spider chart was developed in order to compare performance between operators, as shown in Figure 2, which shows the results of a comparison between Distributor B1 and Distributor B2, and where Distributor B2 shows the better overall performance. However, both distributors need to improve their financial processes. As for production costs, both distributors returned "below average" evaluation scores and should seek ways to reduce costs. In terms of internal processes, Distributor B1 needs to improve its production process waste containment activities and also the suitability of the vehicles its uses for distribution, while Distributor B2 needs to improve its production process waste containment activities. For the environmental aspects, Distributor B1 needs to focus more on the selection of reliable transportation service companies; those with appropriate environmental policies in place. Carry outing an evaluation both before and after improvements are strongly recommended.

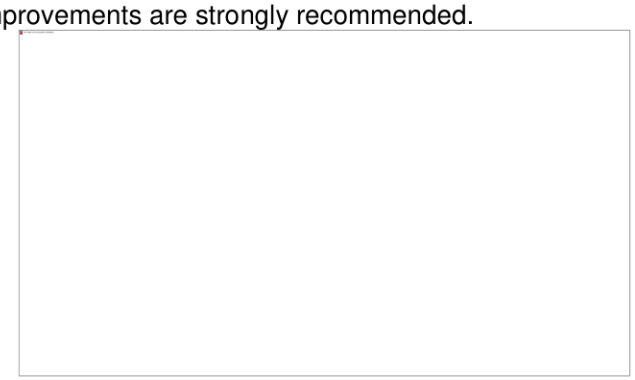

Figure 2: Performance comparison (for each indicator) between Distributor B1 and Distributor B2

Indicator and Description	Environmental Objectives	Assessment Method	Scoring Criteria
Financials			
F2 Production costs *(Unit: Percent)* refers to costs incurred when producing products, such as direct materials costs, direct labor costs and other indirect manufacturing costs such as rent, property insurance and electricity etc.	To realize lower productive resource utilization costs; the fewer resources are utilized, the less the production costs and environmental impacts will be.	$\frac{\text{Production cost}}{\text{Total operating costs}} \times 100$	1 > 90% 2 = 71 – 90% 3 = 51 – 70% 4 = 31 – 50% 5 < 31%
Customers			
C1 The number of returned products *(Unit: Percent)* refers to the number of products that do not meet customer requirements, or are damaged during transportation.	To decrease the number of non-conforming products; remove the need for product disposal processes to be in place	$\frac{\text{Number of products returned}}{\text{Total number of products delivered}} \times 100$	1 > 90% 2 = 71 – 90% 3 = 51 – 70% 4 = 31 – 50% 5 < 31%
Internal Processes			
I5 Waste containment during production *(Unit: Percent)* refers to the control of waste during production, such as dust, smoke and other waste items (shells, tissues, residues, etc.) prior to disposal within the environment.	To minimize waste prior to disposal within the environment	1 = No control of waste prior to disposal 2 = Waste quantity control in place, using a proper collection and disposal method 3 = Existence of waste management through the re-use of dust, shells, tissues and other residues - as fertilizers or planting materials 4 = Existence of waste quantity control through waste reduction, e.g. the installation of smoke/dust exhaust devices 5 = Existence of waste quantity control through innovations or new technologies to prevent wastes	Scoring 1 – 5 as specified
I9 Quality of produced coffee *(Unit: Percent)* refers to quality control during the production management process; to meet customer requirements in relation to moisture content, roasting, color, aroma and taste.	To minimize the number of non-conforming products - those not in accordance with customer specifications - and to minimize the need for an elimination process regarding such products	$\frac{\text{Total number of products} - \text{Number of non-conforming products}}{\text{Total number of products}} \times 100$	1 < 31% 2 = 31 – 50% 3 = 51 – 70% 4 = 71 – 90% 5 > 90%

Table 1: Samples of indicators and descriptions, environmental objectives, assessment methods and scoring criteria used in this study, based on BSC categories *(continued).*

Indicator and Description	Environmental Objectives	Assessment Method	Scoring Criteria
Learning and Growth			
L1 Employees responsible for production *(Unit: Percent),* refers to employee training on duties and responsibilities; enabling employees to give reasons why they need to comply with the regulations and cautions in place. The aim is to raise environmental awareness.	To decrease the number of non-conforming products made due to employees' lack of knowledge. To eliminate the production of non-conforming products by untrained employees during the production process. To raise environmental awareness	1 = Employees' lack of knowledge of production processes 2 = Existence of policies on employee training on production and the environment, but a lack of support from management 3 = Existence of employee training on production and the environment, with training carried out on a periodic basis in order to put knowledge into practice 4 = Existence of employee training on production and the environment, with regular training carried out to put knowledge into practice 5 = Existence of employee training on production and environment, with regular training carried out to put knowledge into practice, plus employees given regular knowledge tests.	Scoring 1 – 5 as specified
Environment			
E4 Proper management of non-conforming products *(Unit: Percent)* refers to the appropriate, environmentally-friendly management of non-conforming products	To be able to manage non-conforming products and prevent adverse environmental impacts	1 = No proper management of non-conforming products in place 2 = Plans for the management of non-conforming products in place, but not yet put into practice 3 = Existence of identification and sorting processes for non-conforming products 4 = Existence of identification, sorting and elimination processes for non-conforming products 5 = Existence of identification, sorting and recycling processes for non-conforming products; to create added value	Scoring 1 – 5 as specified

Table 1: Samples of indicators and descriptions, environmental objectives, assessment methods and scoring criteria used in this study, based on BSC categories *(continued).*

In addition, the designed model was also used to carry out a comparison of two Arabica coffee supply chains. Figure 1; for example, shows a comparison between two Arabica coffee supply chains, in which the first supply chain consists of a Roasting plant (A1), a Distributor (B1) and a Coffee shop (C1), and the second supply chain consists of a Roasting plant (A1) and a Coffee shop (C3) only, as there is direct product delivery from the plant to the shop. The designed evaluation framework was used by utilizing those indicators which applied to each business unit. In the second supply chain; for example, the roasting plant distributes products to the shop itself, so the indicators referring to the distributor (shown separately in the evaluation of the first chain) were used to assess the performance of the roasting plant. The results of this assessment are shown in Table 2.

Indicator	Assessment Results for the 1st Supply Chain							Assessment Results for the 2nd Supply Chain				
	A1		B1		C1		Score	A1		C3		Score
	%	Score	%	Score	%	Score		%	Score	%	Score	
F1	20	5					5	20	5			5
F2	90	1					1	90	1			1
F3			20	5			5	20	5			5
F4					0.1	5	5			0.17	5	5
C1	2	5					5	2	5			5
I1		4					4		4			4
I2	95	5					5	95	5			5
I3		5					5		5			5
I4		4					4		4			4
I5		2					2		2			2
I6		4					4		4			4
I7						3	3				4	4
I8	72	4					4	72	4			4
I9	95	5					5	95	5			5
I10				4			4		5			5
I11				3			3		3			3
I12				2			2		2			2
I13				4			4		4			4
L1		5					5		5			5
L2		3					3		3			3
L3		4					4		4			4
L4				3			3		4			4
L5				3			3		4			4
E1		3					3		3			3
E2			35	2			2		3			3
E3						2	2				2	2
E4		5					5		5			5
E5						2	2				2	2
Avg.							**3.64**					**3.82**

Table 2: Comparative performance of two Arabica coffee supply chains

According to the research results, the first and second supply chains had an average assessment score of 3.64 and 3.82 respectively, showing that the second supply chain has a slightly better performance in terms of the management of its green supply chain.

Conclusion and Discussion

In this study, the researchers developed indicators to assess the performance of the Arabica coffee green supply chain, using the BSC concept with its original 4 categories changed to 5 – an environment category being added, and through a use of both quantitative and qualitative evaluation techniques. The indicators developed here differ from those used in other industries, such as electronics (Wichaisri, 2011) and automobile sectors (Udomvechayanunt, 2011), due to the varying nature of each industry. Arabica coffee is an agricultural product within the food sector, and so most indicators used are associated with safety during production, such as chemical substance control, the suitability of production facilities, waste management/waste containment, the proper storage of raw

materials, and stock handling using a First in First out (FIFO) process. The quality control of raw materials and products in the Arabica coffee industry is conducted using, not only physical and chemical tests such as a moisture content analysis, but also using sensory and hygiene tests. In contrast, most indicators used for industries such as; for example, electronics and automobiles, focus on internal supply chain management processes, together with environmental management aspects such as lead times, machine readiness, downtime due to breakdowns, inventory management, product quality, and unused raw materials recycling (Udomvechayanunt, 2011; Wichaisri, 2011).

In addition, when evaluating the performance of an Arabica coffee green supply chain in the future, monitoring should be conducted regularly, including a periodic comparison of performance across business units or supply chains - such as monthly or annually, so as to provide enough information on green supply chain performance to the organization and its management team.

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