THE EFFECT OF GREENING THE SUPPLIER AND INNOVATION ON ENVIRONMENTAL PERFORMANCE AND COMPETITIVE ADVANTAGE

UNINE VAN DEN BERG*
JEAN-PIERRE LABUSCHAGNE*
HUGO VAN DEN BERG**
vdberu@unisa.ac.za
**Department of Environmental Sciences*
University of South Africa (UNISA)
***Department of Transport and Supply Chain Management*
University of Johannesburg

ABSTRACT

Companies in South Africa should realise the important influence of greening their suppliers and innovation to achieve environmental goals and competitive advantages. A questionnaire survey was conducted with 75 companies from 11 industries in Johannesburg. A confirmatory analysis was done followed by structural equation modelling to evaluate the theoretical causal relationships. Correlations between greening the supplier, innovation, environmental performance and competitive advantages were done. The research found that a green innovative process had a significant effect on environmental performance. Green product innovation further had a significant relation to environmental performance and competitive advantage. Green product innovation therefore creates a competitive advantage for a company and simultaneously addresses environmental aspects. The primary result of the study indicated that all the constructs positively related to each other, meaning that greening suppliers by means of green innovation leads to an enhanced environmental performance and competitive advantages.

INTRODUCTION

Companies and managers should regard environmental awareness skills as critical when recruiting employees. Companies however perceive it as the least important logistics and supply chain-related skill (Luke & Heyns, 2013). The Supply Chain Intelligence Report 2009 indicated that 40% of the surveyed companies were not implementing environmental sustainable business strategies and were even unwilling to do so (SAPA, 2009). However, the remaining 60% of companies that utilised Green

Supply Chain Management (GSCM) strategies, indicated that they had an advantage over their competitor and that they showed an increase in profitability and savings during purchasing and production (SAPA, 2009). Companies may still perceive the change from a traditional supply chain to a more environmentally sustainable green supply chain as costly and an additional burden. However, with increased global environmental concern, a demand for greener products, manufacturing processes and pressure from governments, legislation, public and customers, it is imperative that companies start greening their supply chain (Seman, Zakuan, Jusoh, Arif, Saman, 2012). Companies, their suppliers and stakeholders need to respond to the changing business environment and implement the latest trends and strategies to survive. The buzz word currently is environment and the pressures it brings about for a company and its supply chain.

LITERATURE REVIEW

The aim of a any supply chain is to reduce the overall operating costs. The difference between a Green Supply Chain (GSC) and a traditional supply chain is that the GSC is using best practices to minimise waste and emissions along the value chain (Kumar, Teichman & Timpernagel, 2012). Seuring (2013) defines green or sustainable supply chain management as the management of material, information, capital flow, the collaboration amongst companies and the incorporation of environmental, social and economic goals. A GSC consists mainly of suppliers, manufacturers, distributors, retailers and end-users (Li, 2011; Zhu, Sarkis & Lai, 2013). GSCM includes how companies source their raw materials or parts, reduce their packaging or waste, provide more environmentally friendly products and measure the environmental performances of their suppliers. The adoption of such a supply chain is influenced by internal and external barriers (Walker, Di Sisto & McBain, 2008).

Internal barriers are the costs that a company incurs for implementing GSCM and external barriers are legislation and poor supplier commitment. Internal drivers are organisational factors such as the commitment of top and middle management, employees and investors. External drivers include legislation and regulations,

customers, competitors, society and suppliers. A company is driven more by external drivers than internal drivers (Walker, *et al*., 2008). With the adopting of GSCM, business operations can cope with barriers, only if continuous green innovation is implemented (Seman, *et al*., 2012).

Green innovation

Constant innovation is needed to deal with the pressures and drivers in GSCM. For a company to experience growth, green innovation is needed to create new markets. Green innovation, according to Seman, *et al.*, (2012) is a new approach, idea, product, process or service that contributes to differentiation amongst competitors and reduces adverse environmental impacts. Fields of innovations may include efficiency in energy and materials and technologies in energy, water, waste and transport. Market forecasts indicate that these fields will grow above average in the following 10 years and therefore provides potential and opportunities (Walz & Eichhammer, 2012).

For a company to take advantage of green innovation it needs to work closely with all stakeholders especially their suppliers to establish partnerships, appraisal systems and service level agreements. Knowledge needs to be shared and guidance must be provided. There needs to be attitude changes from both parties in terms of time, money and resource investments (Chiou, Chan, Lettice & Chung, 2011). Green innovation is the best way to minimise environmental pollution, improve the environmental performance of a company and to adhere to legislation and regulations but the company needs to be a leader and not a follower (Seman, *et al*., 2012). Green innovation may provide a platform for companies and their suppliers to collaborate.

The commitment of the supplier is important as they need to produce and provide material that is environmentally acceptable. The collaboration between suppliers and buyers or manufacturers leads to green product innovation and development. The study of Lee & Kim (2011) as cited by Seman, *et al.*, (2012) examined the role of suppliers by increasing their ability to utilise green innovation. It was indicated that greening the supplier positively influences green innovation. Rao (2002) in (Seman, *et al*., 2012)

determined that greening the supplier leads to greener suppliers and hence to more green innovation. For a company to utilise green innovation it needs to know where in the supply chain it can occur. Green innovation can be categorised into green product, green process, green management and green technology (Tseng, Wang, Chiu, Geng & Lin (2013). This study will however only focus on the first three.

Green product innovation

Green innovation enhances the product value, which offsets the cost of environmental investments and improves the corporate image of a company. Customers feel good if they buy greener products and will therefore support companies that offer these products (Pharbhoo, 2013). In 1994 a Customer was willing to pay approximately 13% more for green products (Zhu, *et al.,* 2013) Product innovation pertains to the evaluation of a green product's economical, technical and commercial feasibility. Green or eco-design means that a product can assist companies to improve their environmental performance as in the process the functionality of the products is reviewed and impacts on the environment can be mitigated (Tseng, Huang & Chiu, 2012). A study by Kurapatskie & Darnall (2013) revealed that companies who develop new products and processes enjoy more benefits than companies, who just modify existing products and processes.

Green process innovation

It is estimates that 75% of a company's carbon footprint is produced by its supply chain (Kroes, 2011). The term 'cradle to grave' needs to change to 'cradle to cradle' as it will ensure the recovery and re-use of the company's end-life products and a better environment (Kumar, *et al*., 2012). The Lean manufacturing approach should be followed to eliminate waste and create improved performances (Caniëls, Gehrsitz & Semeijn, 2013). This can be achieved by reducing material in the production process, minimising energy and resource consumption, using more efficient machinery, recycle, reduce, reuse and implementing cleaner technologies. Early supplier involvement (ESI) and in-house auditors to appraise the supplier's environmental performance may all lead

to green process innovation (Tseng, *et al*., 2012). Innovation do however need management support.

Green management innovation

The leader in the company is the visionary and needs to motivate employees to be part of the green innovation process. Managers need to direct their actions and should distribute human resources and financial assets more towards environmental sustainable strategies (Tseng, *et al*., 2012). Management must realise that external pressures do not lead to effective green innovations and the benefits associated. Management innovation is considered as one of the most important and sustainable ways to attain a competitive advantage (Tseng, *et al*., 2013). The competitiveness of a company is dependent on the internal environmental leadership, culture and capability of the management. Management innovation consists of environmental awareness seminars, training on reduction of natural and non-renewable energy resource consumption. Suppliers should be Environmental Management System (EMS) ISO 14000 certified and encouraged to reduce emissions and waste. The support and environmental capabilities of a company's leader are the most effective way to develop green innovation strategies (Chen, Chang & Wu, 2012).

Relationship between green innovation and environmental performance

Green innovation pertaining to GSC has a positive effect on the natural environment. This is achieved by the reduction of waste and use of non-toxic, non- hazardous materials (Eltayeb, Zailani & Ramayah, 2011). The literature tends to support the notion that green innovation has positive environmental outcomes. There is however a problem with the definition of green innovation and environmentally friendly as both are relative and do not have an absolute value. Schiederig, Tietze & Herstatt (2012) stated that to their understanding the two definitions are more related to a new standard of the companies own level. Only one study was found where the correlation between green innovation and the direct or quantified impact on the environmental performance was clearly deliberated and explicitly researched. The study found that green process and green product are positively associated with environmental performance (Chiou, Chan,

Lettice & Chung, 2011). Through product design innovations, reuse and recycling of products, adhering to international standards, the sustainable sourcing of raw material, minimising emissions or waste and the evaluation of suppliers on environmental criteria, a company can generate benefits to the environment (Large & Thomsen, 2011). But does it lead to a competitive advantage for a company.

Relationship between green innovation and competitive advantage

Due to the continuous changes in technology and the short life cycle of products, companies need to improve their green innovations to enhance their competitiveness (Tseng, *et al*., 2013). The focal point of all companies is to save money and to reap maximum profits. Costs can be reduced by conducting product Life Cycle Assessments, pollution prevention or elimination strategies, product quality enhancements and reverse logistics (Walker, *et al*., 2008). Such measures increase profitability and leads to a competitive advantage. Not many companies are dramatically changing their practices to be more environmentally sustainable, despite external drivers (Kumar, *et al*., 2012). The impacts of green innovations directly affect the internal performance of a company and are positively associated with a company's competitive advantage. Innovation is therefore needed to stay competitive (Chen, Lai & Wen, 2006; Eltayeb, *et al*., 2011).

Relationship between environmental performance and competitive advantage

Existing literature is not clear whether GSCM are economically or not and if a company will enjoy competitor advantages. Some companies may even be affected negatively as costs increases and business process are slowed down (Caniëls, *et al*., 2013). A study conducted by (Zhu, *et al*., 2013) empirically tested a theoretical model on the different types of pressures that encourages companies to implement GSCM. Their empirical results suggested that GSCM practises do not notably affect the economic performance of a company, but the improved environmental and operation performances do create better economic performances in the long term. It was found that green supply chain management does not influence economic performance directly, but it can enhance it indirectly. The study by Fujii, Iwata, Kaneko & Managi (2013) established that

environmental performance is notably related to economic performance in Japanese manufacturing companies. They suggested that environmentally friendly products and pollution abatement expenditure must be viewed as an investment in green innovation and technology for costs to decrease. Collaboration between stakeholders and suppliers can assist to realise environmental and economic goals.

Relationship between greening the supplier and environmental performance and between greening the supplier and competitive advantage

Companies do value and view ecological aspects as a high priority, but do not associate its importance with their own contributions when choosing their suppliers and the environmental sustainability of these suppliers. Empirical research identified that suppliers are not the driving force that makes supply chains more sustainable, it is a heighten awareness of the need to integrate the environment into the supply chain (Large, Kramer, & Hartmann, 2013; Walker, *et al*., 2008). This awareness should be created by the focal company, as the public are holding them responsible for degrading environmental impacts. Companies that do not choose and monitor their supplier with scrutiny, may be at risk (Caniëls, *et al*., 2013). A company's environmental corporate image may be deterred by the mismanagement and poor environmental performances of a supplier. Companies need to provide suppliers with clear environmental requirements and design specification to ensure that environmental goals are reached (Li, 2011). Two business strategies for the export of fresh fruit between Brittan and South Africa were explored. The collaborative, shared value approach supply chain was found to be more successful than a prescriptive, paternalistic pushing strategy (Muller, Vermeulen & Glasbergen, 2012).

Collaboration between suppliers and companies whereby they share logistical data and create universal standards and practises, can lead to each other's corporate sustainability. It is important to invite suppliers to early product design meetings so as to ensure early supplier involvement (ESI) and to incorporate management strategies for example just in time (JIT) (Zhu, *et al*., 2013). By sharing this data all the role players can

predict environmental impacts and how to mitigate these impacts more effectively (Kroes, 2011). Companies do however need to assist their suppliers in meeting regulations and requirements. The negative aspect of enforcing certification is that suppliers may see these requirements only as the 'ceiling' and not the 'floor' (Caniëls, *et al*., 2013). Suppliers on their side, need to act now to be a first mover, as early adopters out performs companies that only realises the benefits of GSCM later (Zhu, Sarkis & Lai, 2012). Innovation brings about operational, environmental and economic benefits for first movers.

According to the available literature, greening the supplier and green innovation has a positive influence on a company's competitive advantage and environmental performance Tseng, *et al.,* (2013). This study will explore if the same could be said for companies in the Johannesburg area. A further motivation for the study is that GSCM is still a novel research area in South Africa and has decreased its publication output since 1990. This study will explore the relationships between greening the supplier, green innovations (product, process and management) and the influence on the environmental performance and competitive advantage. A similar study was conducted for Taiwan and the questionnaire was adapted from this study.

RESEARCH STRATEGY

Research Method

The design made use of questionnaire survey data from various companies in the Johannesburg region in order to perform confirmatory factor analysis followed by structural equation modelling. The purpose of which is to evaluate the theoretical causal relationships between the various latent constructs within the questionnaire. The hypothesis were derived from the literature review and the study conducted by Chiou, *et al*., (2011). The hypotheses can be found in Table 2 along with the results of the structural framework.

Structural equation modelling can be decomposed into measurement- and structural models. The measurement model is used to evaluate both the relationship between the observed and unobserved variables as well as the reliability and validity of the model, confirmatory factor analysis is used in this model (Chiou, *et al*., 2011). The structural model is then used to test the pre-defined hypotheses of relationships between the unobserved or latent construct variables. The unobserved or latent constructs are grouped into " Greening the Supplier"; "Green Innovation" {comprised of "Green product innovation", "Green Process Innovation", "Green Managerial Innovation"}; "Environmental Performance" and Competitive Advantage". "Greening the Supplier" and "Green Innovation are used as exogenous variables in the different models whilst the remaining variables are treated as endogenous. IBM SPSS AMOS 21.0 was used to conduct the analysis.

Sample Size and data collection

Questionnaires were distributed to local and national companies within the Johannesburg area. The Fast Moving Consumers Goods (FMCG) industry had the most respondents. Purposeful sampling was used in choosing the organisations and questionnaires were distributed to managerial-level staff. The items on the questionnaires were adopted from the study by Chiou, *et al*., (2011).

The sample size for this study equals 75 observations in total, with no missing values. Sample size requirements for structural modelling usually exceed 100 observations (Kline, 1998). Additional recommendations make use of a variable to observation ratio requirement, suggesting at least 10 observations per estimated parameter. From the recommendations the amount of observations can be seen as insufficient for the purpose of structural equation modelling. The hypothesized model was therefore simplified to 13 separate models, each modelling the latent constructs in a simple linear regression format – one exogenous latent construct in relation to one endogenous latent construct. The loadings for the various latent constructs were also fixed to 1 in order to limit the amount of estimation required.

Reliability Analysis

Reliability analysis measures consistency, repeatability and the precision or lack of distortions of the indicators (Chiou, *et al.*, 2011). Cronbach Alpha was used as a measure of internal consistency and indicates how reliable the different sub-items or indicator variables within a specific group, measure the latent structure that they have been assigned to. Values above 0.7 indicate strong internal consistency, values between 0.5 - 0.7 moderate internal consistency and values below 0.5 relatively weak internal consistency. The corrected item-total correlation (ITC) values indicate each item's contribution to the Cronbach's alpha value of the latent construct.

Values below 0.4 where evaluated and those significantly lower were removed. Two items in the questionnaire showed very low correlation and were removed from the analysis. The remaining items below 0.4 where considered in light of the change of the Cronbach's Alpha value if they were deleted. These values {C21, C18} were retained because of the relatively low increase in Cronbach's alpha, if removed. A summary of the reliability analysis between the different latent constructs and the indicator variables were also done and can be found in Table 1.

[Place Table 1 here]

Results and Analysis

The structural framework is shown in Figure 1. The theoretically causal relationships have been adopted from (Chiou, *et al.*, 2011). The objective of structural equation modelling is to relate different latent constructs to each other whilst indicating the direction of the relationship and presenting these relationships within one comprehensive model. The framework is complex and requires a large number of observations and due to the amount of latent structures that need to be estimated. The framework model was therefore broken down to 13 different simple models in order to maximize the degrees of freedom. These models do however still measure the same hypothesized linear directional relationships as indicated in the framework model.

[Place Figure 1 here]

The results of the structural modelling are indicated in Table 2. All of the path coefficients are significant when using an alpha value of 0.05. Showing that each of the tested hypotheses of positive association are supported. The largest coefficients are shared between Green Process Innovation, Green Product Innovation and Green Managerial Innovation. The top four positive hypotheses are H2b: with 6.672, H2a: with 4.288, H3c: with 3.888 followed closely by H2c: with 3.781.
[Place table 2 here]

Model fit

Evaluating the model fit by use of a number of different indices is recommended. The Root mean square residual (RMR) <0.08; Incremental fit index (IFI) ≥0.95 for acceptance; Tucker–Lewis index (TLI) ≥0.95 and Comparative fit index (CFI) ≥0.95 indices were used to indicate the degree of model fit, along with requirements for good model fit (Hooper, Coughlan, & Mullen, 2008). The CFI index is mentioned to be good with small samples, as is the current study and therefore shows higher model fit coefficients. The significant models are Green Managerial Innovation on environmental performance; Green Managerial Innovation on Green product innovation and Green Managerial Innovation on Green process innovation.

DISCUSSION

All fifteen hypotheses tested positive and are supported. This indicates that there is a significant relation between greening the supplier, green innovation, environmental performance and competitive advantages. Focal companies should invest in greening their supplier by providing them with technical assistance, training and involving them in product designing meetings. Collaboration and information sharing amongst focal companies and suppliers, leads to innovation. Green innovation considers the environment and a company's performance by increasing their market share and competitive advantage. Other associations that were deemed important will similarly be discussed.

The most significant association is between green process innovations an environmental performance (H2b). A green innovative process minimises resource utilisation, waste, energy use and pollution, whereby the environment benefits. The relation between Green product innovation and environmental performance (H2a) has the second highest relation significance, followed by Green product and competitive advantage (H3a). A green innovative product would be designed with the environment in mind, which will enhance the company's environmental performance. The green innovative product will provide the company with a better corporate image and a first mover advantage over their competitors. Customers support companies that are environmentally responsible as they themselves, are also making a difference. A company is then increasing its market share by having green innovative products.

Greening the supplier and green managerial innovation are also highly associated with environmental performance (H2c and H5). These relationships confirm that greening the supplier and innovative management interventions do lead to increased environmental performance. Greening the supplier and innovation (H1a-c) (product, process and managerial) had a lower association and confirms the literature that innovation is not created at the supplier, but by the focal company.

The association between environmental performance and competitive advantages is the weakest (H4). The literature review indicated that environmental performance does not really affect the economic performance of a company and that it is not considered an important skill. The improved environmental operation and specifically green innovative products do create better economic advantages in the long term. Environmental performance does not influence economic performance directly, but improves it indirectly.

CONCLUSIONS

The researchers are aware of the fact, that respondents could have overly accentuated their contribution, as they anticipated that the research may expect a high degree of agreement. The dependence on one middle manager respondent from a company to

evaluate green practises maybe be subjective and biased as they might not have an overall view of the company's entire supply chain. The small number of participants further leads to the notion that the study is not conclusive but more exploratory in nature and therefore the results cannot be generalised. Further research could be conducted by interviewing top management of companies and to compare similar industries in relation to their environmental performance and competitive advantage.

The research found that a green innovative process had a significant effect on environmental performance. Green product innovation further had a high relation to environmental performance and competitive advantage. Green product innovation therefore creates a competitive advantage for a company and simultaneously addresses environmental aspects. The primary result of the study indicated that all the constructs positively related to each other, meaning that greening your suppliers by means of green innovation leads to an enhanced environmental performance and competitive advantages. Companies therefore need to assist in greening their suppliers through green innovation strategies, as it will lead to improved environmental performance and competitive advantages for both.

REFERENCES

Caniëls, M.C.J., Gehrsitz, M.H. Semeijn, J. 2013. Participation of suppliers in greening supply chains: An empirical analysis of German automotive suppliers. *Journal of Purchasing and supply management,* http://dx.doi.org/10.1016/j.pursup.2013.02.005.

Chen, Y.S., Lai, S.B., Wen, C.T. 2006. The influence of green innovation performance on corporate advantage in Taiwan. *Journal of Business Ethics*, 67: 331-339.

Chen, Y., Chang, C. & Wu, F. 2012. Origins of green innovations: The differences between proactive and reactive green innovations. *Management Decisions*, 50 (3): 368-398.

Chiou, T., Chan, H. K., Lettice, F. & Chung, S.H. 2011. The influence of greening the supplier and green innovation on environmental performance and competitive advantage in Taiwan. *Transportation Research Part E*, 47: 822-836.

Eltayeb, T.K., Zailani, S. Ramayah, T. 2011. Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resources, Conservation and Recycling*, 55: 495-506

Fujii, H. Iwata, K., Kaneko, S., & Managi, S. 2013. Corporate environmental and economic performance of Japanese manufacturing firms: Empirical study for sustainable development. *Business Strategy and the Environment*, 22: 187-201.

Hooper, D., Coughlan, J. & Mullen, M. R. 2008. Structural equation modelling: Guidelines for determining model fit." *The Electronic Journal of Business Research Methods,* 6 (1): 53 – 60.

Kline, R. B., 1998. Principles and practice of structural equation modelling. New York: Guilford Press.

Kroes, R. 2011. A supply chain green with envy (and cash). *Supplychaindigital.* Available from:http://www.supplychaindigital.com/procurement/a-supply-chain-green-with-envy-and… (Accessed 9 September 2011).

Kumar, S., Teichman, S., Timpernagel, T. 2012. A green supply chain is a requirement for profitability. *International Journal of Production Research*, 50: 1278-1296.

Kurapatskie, B. & Darnall, N. 2013. Which corporate sustainability activities are associated with greater financial payoffs? *Business Strategy and Environment*, 22: 49-61.

Large, R.O., Kramer, N. & Hartmann, R.K. 2013. Procurement of logistics services and sustainable development in Europe: Fields of activity and empirical results. *Journal of Purchasing & Supply Management,* http://dx.doi.org/10.1016/j.pursup.2013.05.002

Large, R.O., Thomsen C.G. 2011. Drivers if green supply chain management performance: Evidence from Germany. *Journal of Purchasing & Supply Management*, 17: 176-184.

Li, Y., 2011. Research on the performance measurement of green supply chain management in China. *Journal of Sustainable development*, 4(3): 101-108.

Luke, R. & Heyns, G. 2013. Skills shortages and requirements in the logistics industry in South Africa. 9th Annual State of Logistics Survey for South Africa: 76-82.

Muller, C., Vermeulen, W.J.V. & Glasbergen, P. 2012. Pushing or sharing as value-driven strategies for societal change in global supply chains: Two case studies in the British-South African fresh fruit supply chain. *Business Strategy and the Environment*, 21: 127-140.

Parbhoo, P. 2013. Sustainability and the green economy. Latest research and insights. Presentation at Green Supply Chain Morning Seminar on 13 August 2013 in Sandton. Conducted by Promech.

SAPA, 2009. South African firms 'not green enough'. [Retrieved September 20, 2011, from www.southafrica.info/news/business/207879].

Schiederig, T., Tietze, F., Herstatt, C. 2012. Green innovation in technology and innovation management – an exploratory literature review, *R&D Management*, 42, 2.

Seman, N.A.A., Zakuan, N., Jusoh, A., Arif, M.S.M., Saman, M.Z.M. 2012. The relationship of green supply chain management and green innovation concept. *Procedia – Social and Behavioural Sciences*, 57: 453-457

Seuring, S., 2013. A review of modelling approaches for sustainable supply chain management. *Decision Support Systems*, 54: 1513-1520

Tseng, M. Huang, F. Chiu, S.F.A. 2012. Performance drivers of green innovation under complete information, *Procedia – Social and Behavioural Sciences*, 40: 234-250.

Tseng, M., Wang, R., Chiu, S.F.A. Geng, Y. and Lin, Y.H. 2013. Improving performance of green innovation practises under uncertainty. *Journal of Cleaner Production,* 40: 71-82.

Walker, H., Di Sisto, L. & McBain, D. 2008. Drivers and barriers to environmental supply chain management practices: lessons from the public and private sectors. *Journal of Purchasing & Supply Management*, 14: 69-85.

Walz, R. and Eichhammer, W. 2012. Benchmarking green innovation. *Miner Econ*, 24: 79-101.

Zhu, Q. Sarkis, J. Lai, K. 2012. Green supply chain management innovation diffusion and its relationship to organizational improvement: An ecological modernization perspective. *Journal of Engineering and Technology Management*, 29: 168-185.

Zhu, Q., Sarkis, J., Lai, K. 2013. Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices*. Journal of Purchasing & Supply Management*, http://dx.doi.org/101016/j.pursup.2012.12.0001.

Tables

Table 1: Reliability coefficients

Latent construct	Indicator variable	Code	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Greening the supplier	Has your company ever taken the following actions with your suppliers or subcontractors				
	Selecting suppliers or subcontractors based on environmental criteria	B12	.429	.693	0.721
	Required suppliers or subcontractors to obtain a third-party certification of Environmental Management Systems (EMS) such as ISO 14000	B13	.480	.673	
	Provided environmental awareness seminars or training for your suppliers	B14	.420	.699	
	Provided environmental technical advice to suppliers and sub-contractors	B15	.590	.626	
	Send-in-house auditors to appraise the environmental performance of suppliers	B17	.485	.671	
Green product innovation	Has your company ever taken the following actions?				
	Using less non-polluting/toxic materials	C18	.394	.439	0.556
	Designed and improved environmentally friendly packaging for products	C19	.439	.365	
	Used-eco labelling	C21	.322	.599	
Green process innovation	Has your company ever taken the following actions during the production process?				
	Lowered consumption of natural resources (e.g. Water, electricity, gas or petrol)	D22	.419		0.581
	Used cleaner or renewable technologies to make savings	D23	.419		
Environmental performance	Has your company performed better compared to your main competitors in the following areas?				
	Reduction of hazardous waste, emissions, etc.?	E25	.657	.788	0.824
	Consumed less resources such as energy, water, gas petrol, etc.	E26	.749	.692	

	Compliance to environmental regulations	E27	.645	.792	
Competitive advantage	Customer satisfaction in relation to product design and development	E28	.707	.690	0.795
	Product design and innovation skills	E29	.624	.736	
	Production cost	E30	.616	.745	
	Quality of product and service	E31	.509	.791	

Table 2: Hypotheses and Structural framework coefficients

Hypotheses	P-value	Path coefficient	Std error
H1a: Greening the supplier is positively associated with green product innovation.	<0.001	0.917	0.142
H1b: Greening the supplier is positively associated with green process innovation.	<0.001	0.785	0.146
H1c: Greening the supplier is positively associated with green managerial innovation.	<0.001	1.381	0.22
H2a: Green product innovation is positively associated with environmental performance.	<0.001	4.288	1.286
H2b: Green process innovation is positively associated with environmental performance.	0.048	6.672	3.371
H2c: Green managerial innovation is positively associated with environmental performance.	0.036	3.781	1.805
H3a: Green product innovation is positively associated with competitive advantage.	0.006	3.888	1.406
H3b: Green process innovation is positively associated with competitive advantage.	<0.001	2.336	0.563
H3c: Green managerial innovation is positively associated with competitive advantage	<0.001	1.171	0.207
H4: Environmental performance is positively associated with competitive advantage	<0.001	0.747	0.082
H5: Greening the supplier is positively associated with environmental performance	<0.001	2.987	0.555
H6: Greening the supplier is positively associated with competitive advantage	<0.001	1.715	0.272
H7a: Green product innovation is positively associated with green process innovation	<0.001	0.884	0.191
H7b: Green managerial innovation is positively associated with green process innovation.	<0.001	0.828	0.219
H7c: Green managerial innovation is positively associated with green product innovation.	<0.001	0.797	0.165

Figures

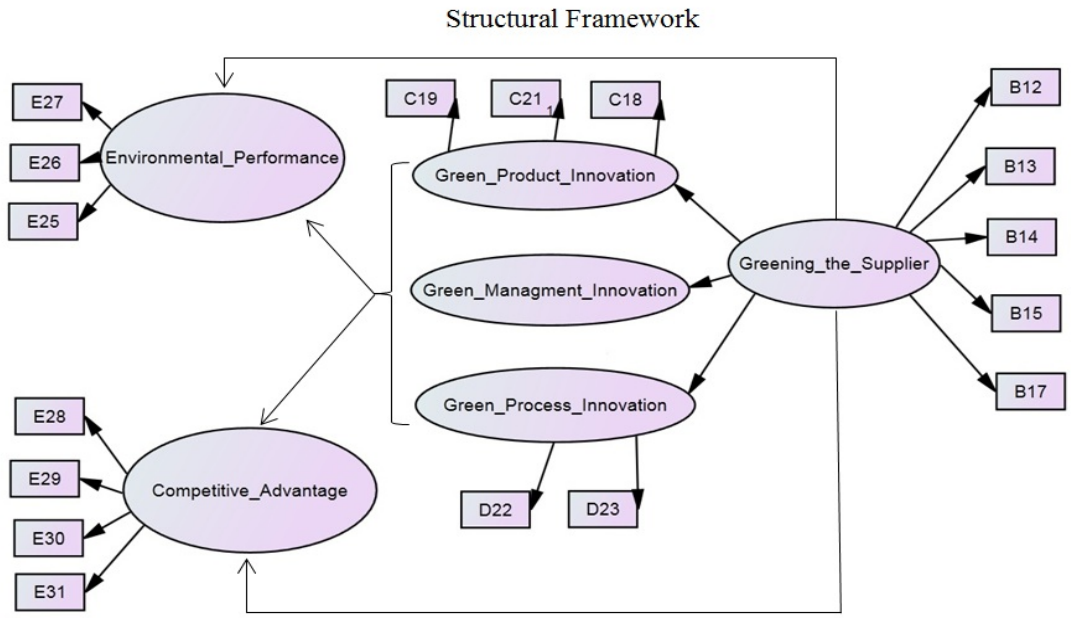

Figure 1: Structural Framework (Authors own & Chiou, *et al*., 2011)