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Green Supply Management and Supplier Development: Effects on Supplier Environmental Actions

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Abstract
This paper examines the relationship between the buying firm's environmental requirements and the suppliers' environmental actions. The mediating role of the supplier development plans is also investigated in analysing this relationship. The analysis is done based on a structural model using quantitative survey data collected in UK during summer 2010.

Keywords: environmental requirements, environmental actions, supplier development.

1. Introduction

Sustainable operations management tries to initiate, develop, and support a wide range of activities fulfilled by companies to meet the increasing environmental requirements. Environmental considerations and activities focused on by operations management include green logistics/transport policies (Holt and Ghobadian 2009), manager awareness of environmental issues and their significance (Lee 2008), public disclosure of environmental records such as corporate environmental reports and toxic release inventory data (Sroufe 2003, Carter 2005, Zhu and Geng 2006, Zhu et al. 2010), advanced technologies including environmental solutions (Lee 2008), adopted energy efficiency measures for lighting and heating (Holt and Ghobadian 2009), use of environment friendly material in production (Rao 2006), environmentally friendly product packaging (Sroufe 2003, Zhu and Geng 2006, Walker and Brammer 2009, Zhu et al. 2010), actively manage the disposal of packaging wastes, papers, cartridges, and so on (Holt and Ghobadian 2009), design of products for

recycling or reuse (Walker and Brammer 2009, Carter 2005), role of human resources to deal with emerging environmental issues (Lee 2008), optimisation of process to reduce solid waste (Sroufe 2003, Rao 2006, Zhu et al. 2010), use of energy efficient systems in operation in warehouses (Holt and Ghobadian 2009), hazardous material, toxic pollution and hazardous emissions management (Sroufe 2003, Zhu and Geng 2006, Zhu et al. 2010), considering environmental matters in transport decisions (Holt and Ghobadian 2009), availability of information and know-how relating to emerging environmental issues (Lee 2008), use of life-cycle analysis/reverse logistics programme (Sroufe 2003, Carter 2005, Zhu and Geng 2006, Walker and Brammer 2009, Zhu et al. 2010), and ISO 14000 certification (Sroufe 2003, Vachon and Klassen 2006, Zhu and Geng 2006, Lee 2008, Holt and Ghobadian 2009, Zhu et al. 2010).

The literature has not studied in detail the role of buyers in environmental actions carried out by suppliers, whether that role is in form of expectations and requirements or in form of support and development.

Buyers may expect several environmental requirements to be fulfilled by suppliers. Min and Galle (1997) introduce 'potential liability for disposal of hazardous materials', 'cost for disposal of hazardous materials', 'cost of environmentally friendly goods', 'cost of environmentally friendly packages', 'advances in providing environmentally friendly packages', and 'advances in developing environmentally friendly goods', as environmental criteria for supplier selection. Lee (2008) discusses that supply chain environment-friendliness depends on both buyer and supplier. Eltayeb et al. (2010) indicate the positive effect of regulations, buyer pressures, social responsibility, and expected business benefits on green procurement in supply chain.

To achieve environmental targets, supplier development programmes can also be leveraged (Carter 2005). Consequently, supplier development programmes can be led by the environmental requirements.

Given the increasing attention to the environmental issues, there is still lack of comprehensive frameworks for integration of environmental initiatives into decision-making processes across supply chain (Sroufe 2003). Theyel (2006) also underlines that more research is needed on the ways companies manage their environmental activities with their suppliers and customers.

Considering the existing gaps in the literature, the main objective of this paper is to structurally analyse the relationship between the buyer's environmental requirements and supplier's environmental action and the possible mediating role of supplier development in this relationship. Accordingly, an initial framework of this research can be developed as illustrated in **Figure 1**.

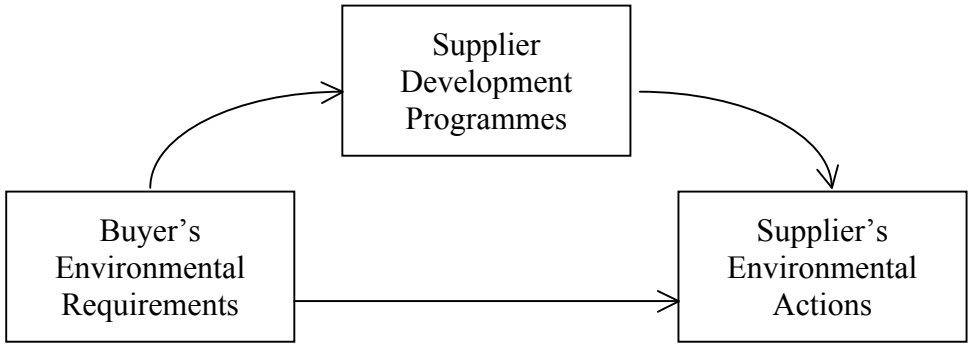


Figure 1. The research framework: linking the supplier's environmental actions with the buyer's requirements and Supplier Development Programmes.

Environmental actions in companies may vary depending on the industry, ownership, purchasing material or services, and customer requirements. By and large, they can be summarised into the following areas (Sroufe 2003, Rao 2006, Vachon and Klassen 2006, Zhu and Geng 2006, Holt and Ghobadian 2009, Walker and Brammer 2009, Zhu et al. 2010):

(i) Energy efficiency in manufacturing/service operations; in warehouses; and for lighting and heating.

(ii) Logistics/transport, where environmental matters are generally considered in transport decisions; vehicles transport routes are planned in order to reduce environmental impact; and investment is made in more environment-friendly vehicles,

(iii) Material management to control hazardous material, toxic pollution and hazardous emissions; to use environment friendly material in production processes and product packaging; to optimise processes in order to reduce solid waste; to handle the disposal of packaging wastes, papers, cartridges, etc.; and ultimately to carry out life-cycle assessment.

Accordingly, the initial research framework shown in **Figure 1** can be expanded to a structural model as presented in Figure 2. Details of the research constructs, and their validity and reliability will be discussed in next section.

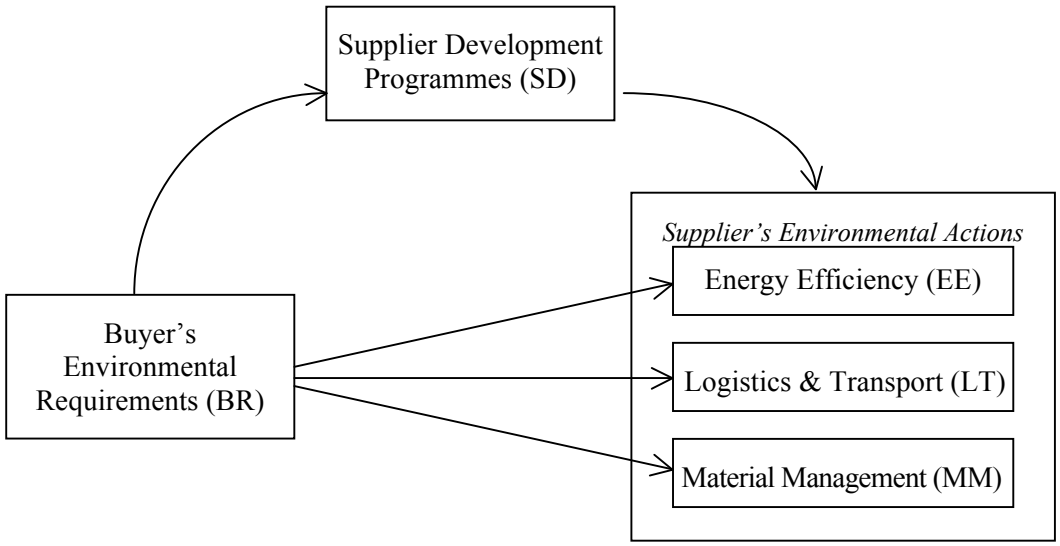


Figure 2. Research structural model.

2. Methods

The following sub-sections provide details of the research methods. Figure 3 illustrates an overview of the different steps and related activities involved in the study.

2.1 Latent Variable (LV) Approach. The research constructs in many research fields are not directly apparent or measurable. In that case, the construct is called 'latent variable' and the method to analyse it is named latent variable approach (Bagozzi 1984). The latent variable approach is appropriate for this research, as the environmental requirements, environmental activities, and performance constructs in this study can be represented by a number of measured variables each. The literature of sustainability has highlighted the multidimensionality of environmental activities and requirements. Besides, academicians and practitioners who participated in the pilot study of this research supported the idea of latent variable approach in this research.

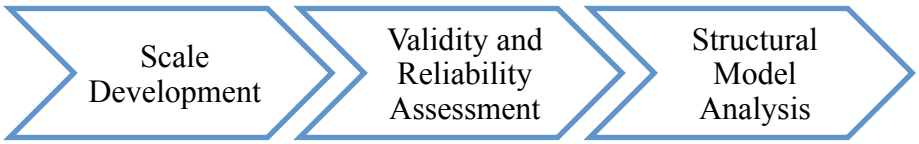
2.2 Construct and Scale Development. Similar to the measurement instrument development procedures tried out in the literature repeatedly, this research pursued the following steps:

Step 1: Identification of the constructs and definition of their measured variables. In this step, an extensive literature review identified the measured variables for the buyer's environmental requirements, supplier's environmental actions, and supplier development constructs. Accordingly, this research identified an initial list of measured variables for each construct. In total, 21 measured variables were generated for the research constructs. Constructs and their associated variables are listed in the Appendix).

Step 2: Content validity analysis and scale purification through pilot study. After identification of the constructs and their measured variables, the validation process tries to

ensure that a construct, which is not observable, is reflected or manipulated by its measured variables (Hair et al. 2006). In step 2, expert judges, including practitioners and academicians, participated in a pilot study to assess the constructs content validity. The definitions of the constructs and their measured variables, identified earlier in step 1, were presented to four experienced practitioners and three academics, who were all knowledgeable of sustainability research and practice. They could recommend changes in the construct definition and their variables. The output constructs and measured variables then entered to the large-scale study (structural equation analysis).

2.3 Large-Scale Study. Empirical data for assessment of the proposed structural model was targeted at a sample frame of 1329 suppliers of the public sector in the UK. Therefore, the unit of study was the individual firm/company. The sample frame was suitable as it reflected a wide range of manufacturers and service providers to public sector. UK Public sector has a key role in promoting sustainable development within the country and internationally (Walker and Brammer 2009). It has addressed sustainability through a wide range of procurement initiatives. Local authorities have been demanding higher environmental performance to be achieved by suppliers. Instructing suppliers to reduce their energy or fuel consumption, phasing out hazardous materials in procured products and services, and requiring a minimum recycled content for purchasing items are some examples of green procurement move in public sector. Therefore, the sample frame in this study represented a considerable set of environmental efforts pursued by an extensive range of businesses.



Develop constructs and measured variables Assess content validity of constructs using 4 experienced practitioners and 3 academics	Assess reliability using Cronbach's α and average variance extracted (AVE) Assess convergent and discriminant validities, and unidimensionality	Test structural model using PLS; assess the confirmation of the hypothesised relationships

Figure 3. Overview of the research methods in the study.

The target respondents in the firms were senior or middle managers in the areas of sustainability, environmental issues, operations, production, customer relationship, purchasing, or strategic management. The questionnaire was provided in electronic format and respondents were asked to complete it online (through the hyperlink sent to them via email). After three rounds of attempts, in total some 267 usable questionnaires were collected. This indicates the response rate of 20%, which is comparable to other similar studies.

The questions tried to quantify the measured variables using the five-point Likert scale. Then the answers were coded as '1' to '5'. Concerning the missing values, returned questionnaires with multiple missing values were dropped (eighteen cases). However, those with one, two or three non-responded questions were kept. Missing values were given the value of '-1'. Later the data analysis software package, Smart PLS, handled them using the case-wise replacement technique before it started the estimation process.

Concerning the non-response bias in responses, the extrapolation method recommended by Armstrong and Overton (1977) was followed. The first wave of responses was compared with those responses received after follow-ups (which were considered as non- responses). A

random sample of 30 responses was taken from each group, and possible difference between them was tested by the t-test for difference between the two samples for each single measured variable. The results indicated no significant difference at α=0.05 level.

Based on this set of approved data, Convergent validity, discriminant validity, unidimensionality, and reliability of the constructs and the structural model were tested first.

Any measured variable with a factor loading below 0.7 were removed (three measured variables were dropped at this stage – see the italic items in the Appendix). This rigorous test ensured that only very strongest measured variables remained in the scales. As a result, all measured variables had factor loading of 0.7 or more, and the levels of average variance extracted (AVE) of the final constructs were higher than the 0.50 level recommended by Fornell and Larcker (1981). The reliability of the constructs was assessed by the levels of Cronbach's α which was compared to the standard threshold of 0.70 recommended by Nunnally (1978) and the more rigorous 0.80 threshold recommended by Straub and Carlsson (1989). Discriminant validity was examined using the method of Fornell and Larcker (1981), by comparison of the AVE and squared correlations for pairs of constructs, where AVE was expected to be much high.

Further, the unidimensionality was assessed by estimation of the cross loadings among the measured variable. For all pairs of constructs, all measured variables for each pair of constructs were expected to be loaded clearly and strongly on their expected construct, without exception and with a good margin of difference between loadings.

Overall, a set of valid, reliable constructs was expected to be subsequently used to test to the structural model in the large-scale study. Details of the validity and reliability tests and the outcomes of the structural model analysis are explained in the next section.

3. Findings

The first step in the analysis of our structural model was to test for validity and reliability. Table 1 provides the AVE, reliability and intercorrelations for each of the constructs in the model. Convergent validity is demonstrated by the high levels of AVE, ranging from 0.774 and 0.920, well above the suggested level of 0.50 in the literature (Fornell and Larcker, 1981). Comparison of the intercorrelations between constructs and the square-root of AVE confirms discriminant validity (Fornell and Larcker, 1981); in every case the square-root of AVE is higher than intercorrelations with other variables by a sizeable margin. Composite reliability and Cronbach's α values for the research constructs in Table 1 indicate high reliability in the model; Cronbach's α varies from 0.923 to 0.957, while composite reliability varies from 0.945 to 0.972, well above the 0.70 and 0.80 cut-offs recommended in the literature (Nunnally, 1978; Straub and Carlsson, 1989). Finally, Table 2 indicates the factor loadings and cross-loadings of all measured variables and constructs. As we can see, all loadings exceed 0.70 (the lowest being 0.790), and are significant at the 0.1% level, which confirms convergent validity (Anderson and Gerbing, 1988). Moreover, the cross-loadings shown in Table 2 verify the discriminant validity and unidimensionality of constructs (Chin, 1998). Overall, the results demonstrate a strong, valid and reliable set of constructs in the research model.

Constructs	Composite Reliability	Cronbach's α	AVE	*Intercorrelations*				
				BR	SD	EE	LT	MM
BR	0.970	0.957	0.887	*0.942*				
SD	0.945	0.927	0.774	0.050	*0.880*			
EE	0.950	0.923	0.863	0.236	0.091	*0.929*		
LT	0.972	0.956	0.920	0.148	0.140	0.019	*0.959*	
MM	0.965	0.957	0.823	0.168	0.054	0.148	0.027	*0.907*

Table 1. Reliabilities, intercorrelations and AVE (square-root of AVE in italic on diagonal).

Constructs / Variables	BR	BS	EE	LT	MM	Loading *t*-value
BR1	0.949	0.038	0.209	0.151	0.174	320.270
BR2	0.933	0.000	0.225	0.146	0.165	134.388
BR3	0.935	0.079	0.225	0.129	0.161	233.346
BR4	0.950	0.074	0.229	0.131	0.131	285.685
SD1	0.082	0.877	0.112	0.106	0.083	66.710
SD2	0.017	0.909	0.021	0.132	0.046	83.576
SD3	0.017	0.875	0.021	0.114	0.053	54.582
SD4	0.061	0.924	0.097	0.141	0.040	143.379
SD5	0.029	0.808	0.117	0.119	0.017	31.364
EE1	0.133	0.106	0.895	0.038	0.131	69.012
EE2	0.256	0.062	0.951	0.011	0.142	243.562
EE3	0.238	0.095	0.941	0.013	0.139	195.806
LT1	0.121	0.149	0.001	0.962	0.027	288.535
LT2	0.132	0.157	0.011	0.965	0.012	297.660
LT3	0.174	0.095	0.044	0.950	0.039	137.094
MM1	0.161	0.096	0.164	0.046	0.929	138.628
MM2	0.124	0.080	0.091	0.020	0.930	154.226
MM3	0.177	0.028	0.167	0.000	0.881	90.172
MM4	0.153	0.046	0.141	0.010	0.932	178.205
MM5	0.157	0.083	0.117	0.018	0.933	186.952
MM6	0.134	0.010	0.117	0.056	0.833	43.680

Table 2. Loadings (in gray) and cross-loadings in the final structural model.

In the second step of the structural analysis, estimations of all paths and the calculation of corresponding t-values were done via the calculation of the PLS algorithm and the application of bootstrapping respectively in the Smart-PLS 2.0 software package (Ringle et al., 2005). Figure 4 illustrates the full path model with the final path estimations and t-values.

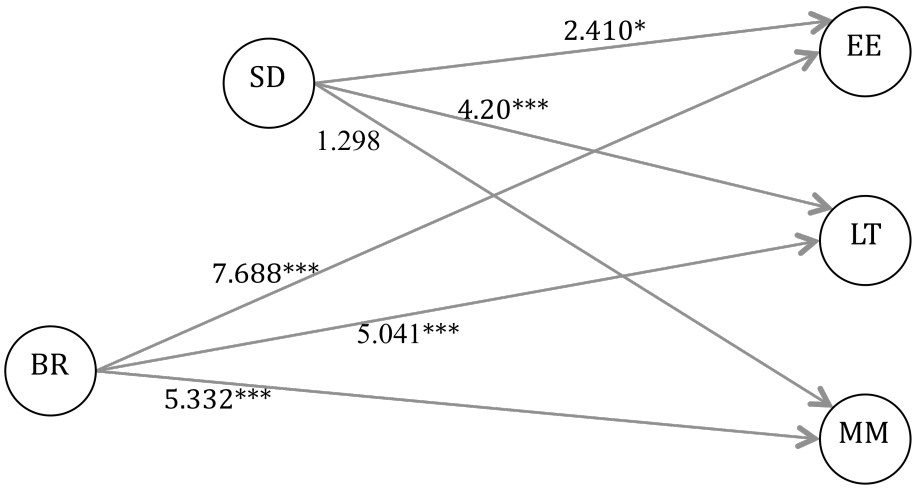


Figure 4. Path estimates in the final structural model (*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$)

Four paths were found to be significant at the 0.1% level of significance (SD→LT, BR→EE, BR→LT, BR→MM, one path was significant at the 5% level (SD→EE), and one path was not significant (SD→MM).

The mediating effect of supplier development on the relationship between the buyer's requirements and the supplier's environmental actions can be inferred by observing the path leading from the buyer's requirements to the supplier's environmental actions. The mediation effect can be confirmed if the direct effect of the buyer's requirements on the supplier's environmental actions is significant in the absence of the supplier development, but becomes insignificant once supplier development is introduced. As **Figure 5** shows, we observe that, supplier development has a slight impact on relationships between the buyer's requirements and the supplier's environmental actions, however, it does not significantly act as a mediator for those relationships.

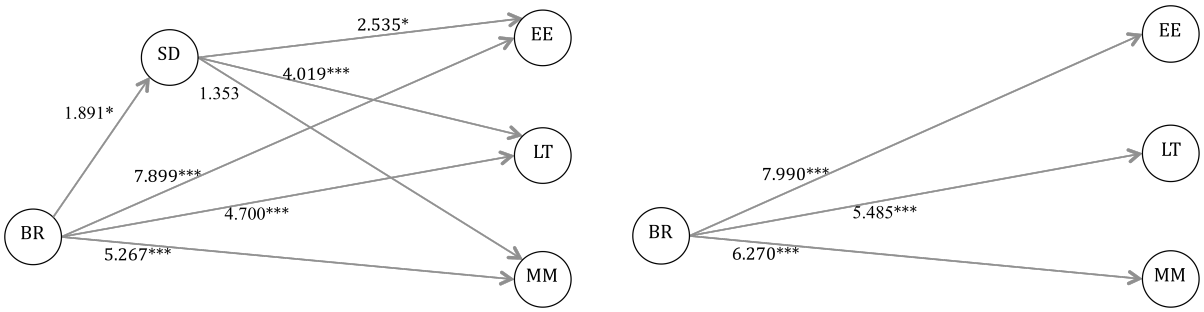


Figure 5. Path estimates in the structural models with and without the supplier development model (*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$)

4. Discussion of Results and Concluding Remarks

Academics as well as practitioners have underlined the importance of environmental actions across the supply chain. This research assessed three major relationships among the requirements of the buying company (from it suppliers), environmental actions in the supplying company, supports provided by the buyer in form of supplier development programmes to support the supplier's environmental actions. The impacts of the buyer's requirements on the supplier's environmental actions have been found significant. Supplier development also has significant effects on the supplier's environmental actions in logistics/transport and energy efficiency areas. It, however, does not mediate the relationships between the buyer's requirements and the supplier's environmental actions.

Managers in buying or supplying companies should be aware that their environmental decisions and activities affect other parties in supply chain. This paper indicated details of the impacts buying company's environmental requirements and supports may have on supplier's environmental actions. Hence, buyers should work with suppliers to secure the mutually beneficial results of environmental decisions and activities. This can be viewed as an opportunity for the buying company to further govern and orchestrate the supply chain. In managing environmental actions, suppliers should also take the buyer's environmental expectations and supports into account. This helps them to enhance their marketing and

financial performance. Suppliers can then leverage those achievements in managing environmental activities in the rest of supply chain. Overall, management of environmental activities across the supply chain needs attention to long-term, strategic benefits of all parties. Both buyer and supplier can provide significant advantages to each other, while they improve their own performance.

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Appendix: Research constructs and measured variables (in the questionnaire format).

Buyer's Requirements (BR)

BR1. Our main buyer(s) urges us to take environmental actions.

BR2. Our company is evaluated and selected by our main buyer(s) based on environmental criteria.

BR3. Our main buyer(s) send its/their auditors to appraise our environmental performance and compliance.

BR4. Our main buyer(s) asks us to commit to waste reduction goals (e.g. to use recyclable pallet system).

BR5 Our main buyer(s) expects us to take back our packaging or pallet systems we use to supply goods. (This measured variable is dropped in validity test)*

Supplier Development (SD)

SD1. Our main buyer(s) exchanges information with us to improve environmental performance.

SD2. Our main buyer(s) holds environmental awareness seminars for its/their suppliers (i.e. educating suppliers through written material, workshops or seminars).

SD3. Our main buyer(s) guides/helps us to establish our own environmental programmes.

SD4. Our main buyer(s) bring its/their suppliers (including us) together to share their environmental know-how and problems.

SD5. Our main buyer(s) arranges funds to help us for our environment programmes.

Leadership and Resource Management (RM)

RM1. Our firm has financial reserves to invest in advanced technologies, including environmental solutions.

RM2. We disclose our environmental records (for example corporate environmental reports, and Toxic Release Inventory data)

RM3. Our manager is aware of the importance of environmental issues. (This measured variable is dropped in validity test)*

RM4. Our firm has human resources to deal with emerging environmental issues in its industry.

RM5. Our firm has information and know-how relating to emerging environmental issues in its industry.

Energy Efficiency (EE)

EE1. We have energy efficient systems in our manufacturing/service operations.

EE2. Energy efficiency measures are adopted for lighting and heating.

EE3. We have energy efficient systems in operations in our warehouses.

Logistics/Transport (LT)

LT1. We consider environmental matters generally in our transport decisions.

LT2. We plan the routes of our vehicles in order to reduce environmental impact.

LT3. We have invested in vehicles that are designed to have reduced environmental impacts.

Material Management (MM)

MM1. We manage our hazardous material, toxic pollution and hazardous emissions.

MM2. We use environment friendly material in production.

MM3 We use environment friendly product packaging (i.e. use of recycled materials for packaging and waste minimisation of packaging materials.

MM4. We optimise our processes to reduce solid waste.

MM5. We actively manage the disposal of packaging wastes, papers, cartridges, etc.

MM6. We use life-cycle analysis/reverse logistics programme: A system is in place for the recovery of products or packaging from the consumer, or supply chain members.