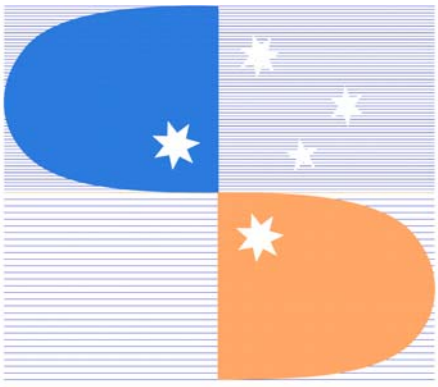

GREENING THE AUTOMOTIVE SUPPLY CHAIN: A RELATIONSHIP PERSPECTIVE

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ABSTRACT

Purpose: Organizations have increasingly looked outside of the firm and to the performance of their suppliers in order to achieve supply chain scale reductions in costs and improvements to quality and service. Of increasing prevalence in customer sourcing requirements has been the inclusion of environmental performance goals. These requirements represent the extension of an organisation's notion of its environmental responsibilities beyond the firm and upstream into the supply chain. Customer-Supplier relationships have been growing in their significance as an important influence in attaining performance improvement and competitive advantage in the supply chain. This paper presents the findings of a comprehensive study of customer-supplier relationships and their impact on the environmental performance of automotive component suppliers.

Methodology: Following a comprehensive review of literature, a conceptual model was developed and pre-tested with Toyota Motor Corporation and first tier automotive parts suppliers. A questionnaire was then mailed out to the Australian automotive industry. Returned questionnaires were analysed using exploratory factor and regression analyses.

Findings: Findings suggest that customers are able to influence their suppliers' strategic level of environmental commitment which in turn has a positive impact on the supplier's environmental performance. Transaction-specific investments and customer-initiated monitoring of the supplier's activities moderates this relationship by increasing the influence of the customer.

Originality/value: This research adds empirical support to the proposed development of a theory behind the relationship implications of a customer-driven program to green suppliers or the supply chain.

INTRODUCTION

The contribution of waste from the global manufacturing system to the natural environment presents a management issue that costs organizations, formal agencies and society. Manufacturing systems that are able to reduce pollution or waste at its source can avoid the costly re-management of wastes or investment in pollution control technology. Recent research has shown that improving environmental performance of the manufacturing system at a supply chain scale may provide a potential source of cost reduction through more efficient use of natural resources and reduced environmental risks (Klassen and Vachon, 2003; Zhu and Sarkis, 2004). It may also contribute to the higher order goal of working to achieve greater sustainability of production systems.

In the past five years environmental performance goals have appeared at an increasing rate in the sourcing requirements of customers for their suppliers (Sarkis, 2003). This relatively new expectation in business-to-business transactions represents the extension of an organisation's notion of its environmental responsibilities beyond the firm and upstream into the supply chain. The phenomenon is largely due to the increasing awareness of consumers and regulatory bodies of the cumulative environmental impacts that occur during a product's life cycle (Faruk et al, 2002). Organisations are also becoming more aware of the propensity for environmental pollution incidents within their supply network to cost them in penalties, cleanup and consumer backlash (Hoffman, 2001). The strategic benefits to a customer of including environmental performance requirements in supply requirements include reputational benefits, risk minimization and the flexibility to respond rapidly to increasingly stringent international environmental regulations (Melnyk et al, 2003). There remains a perception amongst both customers and suppliers however that these new requirements represent a cost burden that can't be practically met without compromise. This perception reflects an inexperience amongst supply chain stakeholders with the reciprocal benefits that improvements to environmental performance also provide for the manufacturing system and the organization overall.

Organizations have traditionally demonstrated almost no responsibility toward the environmental activities of suppliers (Atcheson, 1997; Hall, 2000). The existence of recent examples of natural environment goals being included in requirements for suppliers demonstrates a substantial shift in the appreciation by organizations of its importance – both financially and reputationally. Prominent examples have included Ford Motor Company's requirement for all suppliers to certify to the ISO14001 management standard and Starbucks' new guidelines on socially responsible supplier certification. This is matched by recent academic research which supports the potential of customer-supplier relationships to influence the environmental performance of supply chains. Conceptual underpinnings for this recent practical and academic activity however are relatively underdeveloped (Sarkis, 1999).

This paper will address this lack of theory development by considering green supply as an issue of performance management in the supply chain – where a customer has a minimum performance requirement or desires an improvement in performance from its suppliers. Supply chain level environmental performance goals may be influenced by the same factors which influence other supply chain level performance elements (ie quality, cost and lead time reductions). Greater knowledge of the customer-driven factors that have influence on a supplier's environmental performance may prove an important facilitator for improving the sustainability of product supply chains both locally and globally.

LITERATURE REVIEW

Component suppliers play a large role in the manufacture of the automobile. Some estimates place current levels of outsourcing in the automotive market at 70% of final assembly (Scannell et al,

2000). This represents a substantial shift from the traditional use of vertical integration by U.S. automotive assemblers to ensure supply of critical components. Much of this change was brought about during the 1980s and 1990s by the influence of Japanese supply management practice that favoured horizontal integration with suppliers through collaboration (Cousins and Stanwix, 2001; Kotabe et al, 2003). The global automotive industry provides a unique case for exploring the influence of supply relationships on performance indicators relevant to manufacturing because of the range of approaches to relationship management. It is also one of the few global industries that contains numerous examples of customers requiring suppliers to meet minimum standards of environmental performance.

Inter-firm relationships are critical to the successful coordination of supply chains and improvements in the performance of suppliers' production capabilities (Lamming, 1996; Handfield et al, 2000; Scannell et al, 2000). The supply relationship is an important channel for communicating customer requirements to suppliers and achieving longer term goals of production (Lamming, 1996; Handfield et al, 2000; Scannell et al, 2000). Managed supply chain relationships can often attain the types of performance improvement and superior competitive advantage that are not readily generated by open market transactions (Lamming, 1993; Burt and Doyle, 1993).

A primary concern of supply chain management is to find efficient modes through which customer firms can accurately communicate product and service goals to suppliers. Distance between exchange partners – physical, social and cultural – occurs increasingly as supply networks become more global (King et al, 2004). Distance creates problems generally with the ability of firms to communicate one another's supply requirements but particularly creates the conditions for high information asymmetry and possible opportunism.

In this research green supply is considered as a performance management issue of importance to the supply chain manager. Relevant literature through which to explore this premise include:

- *stakeholder management* – the influence of the requirements of legitimate stakeholders on firm performance;
- *supply relationships* – the form through which organizations are best able to communicate or collaborate with supply partners;
- *transaction costs* – the economics of an inter-organisational investment; and
- *supplier development* – practices which enable customers to encourage or extract desired performance gains from suppliers.

Customer-supplier interactions and environmental performance

Programs developed by business to 'green' supplier activities or include environmental performance requirements in supply guidelines are increasingly evident in practice. Such initiatives are broadly referred to as either green-supply or green-supply-chain in both the academic and practitioner literature. These have largely included activities with suppliers such as (1) programs to reduce or eliminate materials used in manufacturing processes or products, (2) programs focussed on the environmental compliance status and practices of supplier operations, (3) joint development of new materials, processes or other solutions to environmental issues (Sarkis, 1999).

A recent body of academic research generates support for the theory that the customer-supplier or supplier-supplier relationship may generate a range of positive environmental outcomes. Communicating goals of sustainability or environmental performance through the supply relationship has resulted in for example, collaborative waste reduction, environmentally sound innovation, cost-effective and environmentally beneficial solutions to production problems, and more rapid development

and uptake of environmental technologies. There is growing empirical support for the role of the supply relationship in environmental performance management that extends into the inter-firm setting.

In the antecedent work of Lamming and Hampson (1996), customer firms engaged in collaborative dialogue with suppliers were better able to understand the environmental impacts of their supply chains. Florida (1996) looked to customer-supplier relationships that were already characterized by improvement or learning activities:

> "… environmental improvements flow from ongoing joint efforts to improve productivity, eliminate defects and reduce costs, rather than from direct offers to transfer pollution prevention technology or organizational strategies designed expressly to eliminate toxins or prevent pollution." (Florida, 1996:81)

Hall (2000 and 2001) extended Florida's (1996) work by finding that a collaborative customer-supplier relationship often led to environmental performance improvements in both the customer and the supplier firm. Geffen and Rothenberg (2000) found the involvement of suppliers to be critical in the development and implementation of environmentally sound technologies in automotive paint production. Success in development and implementation was greatest where suppliers were physically involved in the customer's plant and the customer spent time in the supplier's plant. The level of frustration and failure rate for new technologies was significantly higher where customers did not get involved in supplier's activities and did not engage in dialogue with the supplier (Geffen and Rothenberg, 2000).

More recently, Klassen and Vachon (2003) investigated the role of supply-chain-level evaluation and collaboration activities on plant level environmental investment. They found that greater customer involvement and scrutiny of suppliers tended to: "… capture the attention of plant managers and encouraged greater environmental investment." (Klassen and Vachon, 2003: 347).

The commonality across this body of research has been support for the hypothesis that customers may be able to directly and indirectly improve a supplier's environmental performance.

Stakeholder management and environmental performance

Primary stakeholders – especially financially relevant stakeholders such as a major customer – may have a more significant influence on the firm's environmental performance than many authors have previously proposed. Only a relatively recent body of literature has begun to explore the role and influence of a financially relevant stakeholder on a firm's environmental performance. Freeman (1984) defined a stakeholder as – "any group or individual who can affect or is affected by the achievement of the organisation's objectives" (1984: 46). Mitchell *et al* (1997) referred to stakeholders as – "those entities to whom managers should pay attention" (1997: 854).

Friedman (1970) wrote that the business of being a business was to 'be' in business and concentrate solely on increasing its profits. Social or environmental responsibilities were a matter for government and business should not be in the practice of attempting to internalise such concerns unless there was a direct financial benefit for the firm. Firms taking this rather bleak view of their commitment to the natural environment are considered to have adopted a 'reactive' environmental strategy where environmental responsibility is externalized. The opposing view to that of the reactive stance toward environmental responsibilities (particularly in regard to generating pollution) offers that a more 'proactive' strategy toward the natural environment may also provide reciprocal benefits to the firm's financial and manufacturing performance (Porter, 1995; Hart, 1995; Florida, 1996).

These differences in the firm's environmental commitment are generally referred to as being either a proactive firm (market based) or a reactive firm (compliance based) as summarized by Aragon-Correa and Sharma (2003):

> "…. a reactive posture is a response to changes in environmental regulations and stakeholder pressures via defensive lobbying and investments in end-of-pipe pollution control measures … proactive postures involve anticipating future regulations and social trends and designing or altering operations, processes or products to prevent (rather than merely ameliorate) negative environmental impacts." (2003: 72)

The choice for an organization to adopt either a 'reactive' or 'proactive' stance toward its environmental responsibilities will reflect a complex interaction between its internal goals and the goals imposed externally by legitimate stakeholders (Banerjee, 2002; Aragon-Correa and Sharma, 2003). Legitimate stakeholders that bear influence on the organisation's level of environmental commitment include the government (as regulator), customers, suppliers and the community (Hoffman, 1999).

Firms that exhibit high levels of strategic pro-activity in support of the environment (Aragon-Correa, 1998) or have considered the environment within their supply strategy (Bowen *et al*, 2001a; 2001b) have been shown to have high levels of environmental performance. Aragon-Correa (1998) found a positive relationship between advanced levels of environmental performance in the firm and the firm's level of environmental proactivity and attitude to relevant stakeholders. The more proactive firm analysed all aspects of its context, attempted to reconcile the points of view of all stakeholders and were generally more inclusive of environment-related stakeholders (Aragon-Correa, 1998; Aragon-Correa and Sharma, 2003).

Buysse and Verbeke (2003) evaluated the relationship between the importance that firms attached to its stakeholders and the level of proactivity in the firm's environmental strategy. Firms with a strategy of basic pollution prevention (low proactivity) attached the highest importance to regulators and international agreements. Firms going beyond basic pollution prevention and incorporating environmental product design and innovative practices (high proactivity) – reviewed the needs of a broader range of stakeholders than just regulators.

The relationship that exists between the firm's commitment to protection or management of the natural environment and the influence of a financially relevant stakeholder (major customer) is explored through the following hypotheses:

H1: The supplier's level of environmental commitment is related to the environmental focus of its major customer.

H2: The supplier's level of environmental commitment is positively related to its environmental performance.

The a-priori expectation is that a major customer represents a legitimate stakeholder that may choose to communicate goals relevant to the natural environment to its suppliers. This is proposed to have an influence on the suppliers' own commitment to its natural environment goals. An increasing environmental commitment in the supplier is proposed to also have a positive relationship to increasing environmental performance.

Supply relationships

Customer-supplier relationships are important to the successful management of supply and in improving the performance of suppliers (Handfield *et al*, 2000; Scannell *et al*, 2000). Where the influence of one firm over another is required with an aim to improve or ensure a process, product or service, established and emergent theory offers varying explanations for the most important factors for

customers to consider when attempting to extract performance gains from suppliers. Much of this variation relates to the structure of the inter-firm relationship and the desired outcome of any improvement initiative (Cousins and Stanwix, 2001; Handfield and Bechtel, 2002; Dyer and Chu, 2003).

A supply relationship can be managed with the development of a culture of either collaboration or compliance. The establishment of a climate of trust provides a basis for achieving collaboration, while exercising the rights inherent in a customer's purchasing arrangement can serve as a mechanism for achieving compliance (Handfield and Nichols, 1999; Lamming, 1993). The literature available on supply relationships tends to agree on the view that successful programs of performance improvement are generated from relationships that a) retain mutual commitment to meeting performance requirements, and b) are governed and managed by some form of appropriate safeguard (contractually or relationally) (Williamson, 1975; Heide and Stump, 1995).

The traditional form for keeping suppliers in 'check' and minimizing opportunism in the automotive supply chain has been by either arms-length style transactions with suppliers (market), or complete bureaucratic involvement and ownership (hierarchy). More recent attention in the literature has been given to the comparative supply practices of Japanese automotive OEMs that use a more collaborative style of relationship with suppliers to attain performance gains and a competitive advantage. (Ring and Van de Ven, 1992; Dyer and Singh, 1998).

Both arms-length supply relationships and trust-based supply relationships have the same requirements of suppliers to reduce costs and meet specific quality and delivery targets. More rapid and sustainable improvements in a supplier's manufacturing performance however have been presented in recent literature for the trust-based or collaborative approach (Liker and Wu, 2000; Scannell *et al*, 2000).

The impact of the relationship conditions that exist between the customer and the supplier on the supplier's environmental performance is explored through the following hypothesis:

H3: The strength of the customer-supplier relationship will moderate the relationship between the supplier's environmental performance and the customer's environmental performance requirements.

The a-priori expectation is that supply relationship conditions that exhibit traits of high involvement will provide for a more effective deployment of a customer's environment-related performance requirements. Such conditions are proposed to moderate the effectiveness of any program of green supply between the customer and the supplier by increasing efficacy as collaboration and involvement increases.

Transaction Cost Theory

Transaction cost theory has received attention in the operations management literature in recent years for its use in framing choices for investment within supply relationships (Rindfleisch and Heide, 1997; Grover and Malhotra, 2003; Dyer and Wu, 2003). Transaction cost theory provides an efficient mechanism for describing the coordination costs and transaction risks of inter-organisational activities (Williamson, 1975). The major propositions of transaction cost theory are that a) bounded rationality and opportunism give rise to transaction costs, and b) higher transaction costs can be expected under conditions of high asset specificity and high uncertainty (Grover and Malhotra, 2003, Williamson, 1975; 1985).

Research on transaction costs has not yet resolved to provide a singular view on the most effective method for extracting performance improvements from the customer-supplier relationship. Arms-length relationships that do not involve asset specific investments keep transaction costs low and generate cost reductions through the adversarial climate that it creates amongst suppliers. Relational or trust-based contracting can involve high levels of asset specificity, but experience high transaction costs in the short term and higher risks of opportunism. Higher levels of asset specificity between the customer and supplier however have been found to lead to positive performance gains for both firms involved in the exchange. Dyer (1997) found high gains in mutual performance improvement in supply relationships that were characterized by (a) economies of scale and scope in transacting, (b) extensive information sharing, and (c) investments in co-specialised assets. Handfield and Bechtel (2002) also found high levels of supplier responsiveness to customer requirements in supplier firms where the customer had made asset-specific investments.

The impact of transaction-specific investments that exist between the customer and the supplier on the supplier's environmental performance is explored through the following hypothesis:

H4: The presence of relationship-specific investments will moderate the relationship between the supplier's environmental performance and the customer's environmental performance requirements.

The a-priori expectation is that supply relationship conditions that are characterized by relationship-specific investments will provide for a more effective deployment of a customer's environment-related performance requirements.

Supplier Development

Supplier development has been defined largely as any activity that a buyer would undertake to improve a supplier's performance and/or capabilities to meet the buyer's short-term or long-term supply needs (Handfield et al, 2000; Krause et al, 2000). This can often involve a long-term cooperative effort in order to upgrade a supplier's technical, quality or delivery capabilities and reduce costs (Scannell et al, 2000). Customers have at their disposal a range of measures used to encourage performance improvement in suppliers. Customers can rely on the competitive forces of the market as the basic method to extract performance gains. Other alternatives include assessment of a supplier's operations and performance, providing incentives to improve, or the customer working directly with it's suppliers by investing in training and equipment (Krause et al, 2000; Scannell et al, 2000; Handfield and Nichols, 1999; Handfield et al, 2000). Customers have increasingly used some or all of these supplier development strategies to improve the manufacturing performance of their suppliers (Krause et al, 2000).

Direct involvement activities where the customer involves itself in the supplier development effort, have been considered to play a far more critical role in achieving significant performance improvements (Krause et al, 2000). Direct involvement activity however represents asset-specific investments for the customer-supplier relationship and the customer must internalise the costs of any direct involvement (Williamson, 1975).

Collaboration or evaluation activities engaged by the customer for use with its supplier have recently been shown to have positive performance implications for the environmental performance of the suppliers involved (Rao, 2002; Klassen and Vachon, 2003).

The impact of supplier development activities deployed by the customer to monitor or improve a supplier's environmental performance or other aspect of manufacturing is explored through the following hypothesis:

H5: The supplier's environmental performance will be related to use by the customer of supplier assessment.

The a-priori expectation is that use by the customer of direct involvement activity in the form of supplier assessment routines will have a positive impact on the supplier's environmental performance where the customer includes goals of environmental performance in the supply requirements. Assessment routines are proposed to moderate the influence of the customer's environmental performance requirements at the relationship level.

CONCEPTUAL MODEL

An organisation's environmental performance reflects a complex interaction between the strategic and functional levels of the firm and between the firm's goals and the goals of its legitimate stakeholders (Aragon-Correa and Sharma, 2003). From the review of the literature it is proposed that a supplier's environmental performance may be influenced at two distinct levels. At an operational level, environmental performance will be driven by overall commitment to its environmental responsibilities and organizational awareness/knowledge of these responsibilities. At a strategic level environmental performance will be influenced by the environmental performance requirements of the stakeholder of interest – the major customer. This dual interaction will be further moderated by the nature of the supply relationship as explained by three critical factors – a) the level of transaction cost investment borne by the supplier, b) the supplier development approach employed by this customer and c) the strength of the supply relationship (measured by presence of collaboration or extensive contract).

An initial conceptual model suitable for testing is provided in Figure 1. The conceptual model articulates a theory for green supply. The model suggests that under conditions of an existing supply relationship there will be a primary relationship between a customer's environmental performance requirements for its suppliers and the environmental performance of the supplier. The model is developed and tested in two stages (qualitative followed by quantitative) using the Australian automotive industry as its case.

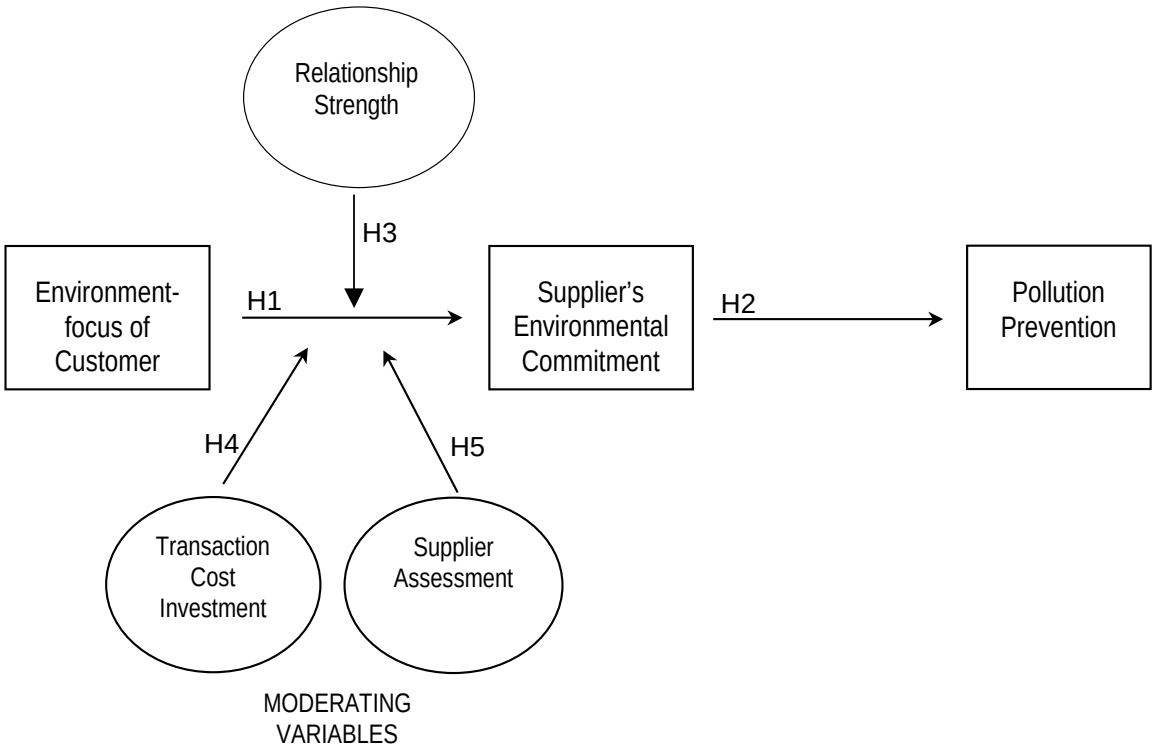

Figure 1: Conceptual model

Environmental Performance as 'Pollution Prevention'

Various authors have speculated on what constitutes 'environmental performance' for the firm (Banerjee, 2002; Curkovic, 2003). In-principle consensus settles on three main elements of environmental performance for an organization – a) management of pollution, b) maintaining compliance with internal and external regulatory requirements, and c) management of external stakeholder interests. Of these three the management of pollution or waste in-process and end-of-process has the most tangible connection to firm and manufacturing performance as supported a sizeable body of literature (King and Lenox, 2002).

The manufacturing system is responsible for the organisation's main production of hazardous and non-hazardous wastes, consumes the majority of natural resources and is responsible for the maintenance of equipment from which pollution is most likely to occur after an equipment breakdown or malfunction. The operations function is also where a majority of advances in efficiency and innovation are likely to occur (Florida, 1996; Kitazawa and Sarkis, 2000).

In measuring environmental performance self-reported values of the annual pollution output from firms submitted to public databases (for example the TRI) are considered by many authors as too uni-dimensional to be of much benefit to the field of operations management (Rothenberg, 1999; King and Lenox, 2002). Such gross measures do not discriminate between an end-of-pipe environmental strategy and a strategy of pollution prevention or source reduction (Russo and Fouts, 1997). King and Lenox (2002) found evidence that reducing the firm's waste solely by waste prevention (source reduction) had a positive impact on lowering emissions and improving the firm's profitability. Rothenberg (1999) also wrote that the critical benefits of pollution prevention to the firm were in that they reduced costs through material use reduction or through the avoidance of waste management costs.

In-process or operationally relevant measures of environmental performance are more likely to provide an understanding of the relationship between environmental performance, manufacturing performance and overall firm productivity (Klassen, 2000). For environmental performance to be an operationally relevant measure we have adopted Schramm's (1998) definition of 'pollution prevention' in the operations function as any activity that is intended to reduce (or minimise) a) the amount of resources consumed, b) the amount of waste and emissions generated or c) the hazards of the waste and emissions generated (mostly by appropriate substitution of input materials). In our model the concept 'Pollution Prevention' is measured as shown in Table 1.

Table 1: Concept 1 – pollution prevention

Concept	Scale items
Pollution prevention	PP1: Modifying processes to avoid use of materials hazardous to the environment. PP1: Reducing use of raw materials in manufacture. PP2: Reducing off-site disposal of solid waste. PP3: Increasing recycling rates.

Environmental Focus of the Customer

The customer's environmental performance requirements are measured in two parts – representing both the direct and indirect influence of the customer as stakeholder. Firstly, the customer's direct influence is measured as its articulated performance requirements which can range from simple expectations of its suppliers (compliance to the ISO14000 management standards) or more comprehensive expectations (for example specific waste reduction targets, avoidance of specified substances or use of environmentally sound technologies). Secondly, the customer's indirect influence is measured through the supplier's perception of the customer's own environmental commitment.

These elements of direct and indirect influence of a customer over its suppliers will be explored through the concept that the supplier's major customer has a measurable 'environmental focus'. It is hypothesized that as the customer's 'environmental focus' improves so too will the supplier's own commitment to its environmental responsibilities. For example a customer that emphasises the importance of cost over the importance of its environmental performance requirements may degrade the supplier's perception of the importance of its own environmental performance and thereafter affect its overall commitment to the natural environment. This proposed relationship is supported in the work of Theyel (2001) and in the more recent work of Klassen and Vachon (2003).

In attempting to capture the environmental focus of a customer measures are included that assess both the environmental performance requirements of the customer and the supplier's own perception of the customer's underlying commitment to these performance requirements. In our model the concept 'Environmental Focus of Customer' is measured as shown in Table 2.

Table 2: Concept 2 – environment focus of customer

Concept	Scale items
Environment-focus of customer	EFC1: Supplier certification to ISO14000. EFC2: Supplier to meet environmental performance requirements separate to ISO14000. EFC3: Customer has a clear policy statement on their environmental commitment.

	EFC4: Customer displays a level of environmental performance that we would like to follow.

Supplier's Environmental Commitment

The choice for an organization to adopt either a 'reactive' or 'proactive' stance toward its environmental responsibilities will reflect a complex interaction between it internal goals and the goals imposed externally by its legitimate stakeholders. Following previous work of Banerjee (2002), Aragon-Correa (1998) and Buysse and Verbeke (2003) the supplier's own commitment toward its environmental responsibilities is conceptualised. In our model this commitment is considered to reflect a commitment from the supplier somewhere between reactive (basic compliance and/or defensive) and proactive (beyond compliance). Measures have been adopted from those described in Banerjee's (2002) work. The wording of selected measures were modified and an additional added based upon the findings of Rothenberg (2003) who provides empirical support for the importance of worker training and participation in firm environmental performance.

In attempting to capture the supplier's own level of strategic commitment toward the natural environment measures are included that assess the supplier's strategic commitment at the level of values, policy, design and training. In our model the concept 'Supplier's Environmental Commitment' is measured as shown in Table 3.

Table 3: Concept 3 – Supplier's environmental commitment

Concept	Scale items
Supplier's environmental commitment	SEC1: Clear policy statement urging environmental awareness in every area of the business
	SEC2: Protecting the environment is a central corporate value in the firm
	SEC3: Effort made to ensure employees value the importance of environmental management
	SEC4: Environmental issues considered when developing new products

Supply Relationship Variables

The relationship conditions that exist between the customer and the supplier are expected to *moderate* the relationship between the customer's environmental focus and the supplier's commitment to its own environmental performance. The proposition is that supply relationship conditions that are high involvement or characterized by relationship-specific investments will provide for a more effective deployment of a customer's environment-related performance requirements. As described earlier, the relationship conditions that are considered important for this study are the presence or otherwise of transaction cost investments, whether or not the customer includes a regular monitoring or assessment routine designed to minimize behavioural uncertainty in the supplier, and strength of the supply relationship as measured by contractual involvement.

Recent work by Klassen and Vachon (2003) found that customer-led activities of evaluation and collaboration with suppliers had a positive impact on the supplier's level of environmental investment.

Other authors have found the increasing involvement of either a) relationship-specific investments, b) collaborative activity and/or c) some form of governance (contract) had positive implications for a customer's program to deliver performance specifications to a supplier (Dyer and Chu, 1998; Handfield and Bechtel, 2002).

Our measure attempts to capture the relationship conditions between the customer and the supplier relevant to transaction cost investment. Items were developed from the work of Handfield and Bechtel (2002). A direct form of supplier development is measured as whether or not supplier assessment activity takes place, following the work of Krause et al (2000) and Prahinski and Benton (2004). Strength of the relationship is measured as the extent of contractual involvement after Williamson (1985) and Heide and Stump (1995). The items used to measure the conditions of the customer-supplier relationship are shown in Table 4.

Table 4: Supply relationship conditions

Concept	Scale items
Transaction cost investment	**TCI1: We dedicate and reserve equipment and capacity specifically to maintain this relationship** **TCI2: We have purchased specialised equipment to meet the needs of this customer** TCI3: We share our production schedules with this customer
Supplier assessment	SA1: This Customer assesses our operations (eg questionnaire) from time to time
Strength of relationship	SR1: We have signed an extensive agreement with this customer specifying price, quality and lead-time

THE AUSTRALIAN AUTOMOTIVE INDUSTRY

Four major motor vehicle assemblers operate manufacturing and assembly hubs in Australia – Ford, Toyota, Holden and Mitsubishi. The Australian automotive industry produces large passenger motor vehicles, light commercial and sports utility vehicles (ABS, 2005). The industry has over 200 individual component manufacturers and around 500 smaller firms providing tooling services and other firms that provide specialist automobile services. The Australian industry supplies mainly to the international markets of South Korea, USA, North America, Japan and China. Australian-based industry makes up 65% of the inputs to domestic automotive production. The remaining 35% of inputs are mainly imported parts and components sourced from Japan and the USA. The sector produces around 5% of the global motor vehicle market.

Between 1998 and 2001 exports of Australian-made vehicles grew by an average 22% per year. In 2002-03 Australian vehicle exports were worth almost $3 billion and components and parts exports nearly $2 billion. In 2002-03 imports of vehicles were $14b and imports of components and parts were nearly $6b. Major import sources for both vehicles and components were Japan, the United States of America and Germany. Imports grow at an average rate of 10% each year (ABS, 2005). Australia has become a truly globalised production market through de-regulation of the industry, stable economy and its position and political/economic relationships with the growing automotive markets of the Asia-Pacific.

METHODOLOGY

Following a comprehensive literature review the study employed a two-stage approach to model testing with the ultimate intent of improving the internal validity and reliability of the primary research

instrument – questionnaire. In order to generate confidence in the relationships proposed in the conceptual model, clarify definition of poorly defined variables and potentially build new theory, both qualitative and quantitative research methods were used. Yin (1984), Eisenhardt (1989) and Wacker (1998) write of the synergistic benefits of combining qualitative and quantitative research methods especially in theory building research. The use of multiple research methods also provides for triangulation of results.

The two research stages are described as follows:

- Stage 1 – Exploratory case study, questionnaire development and pre-testing with Toyota Motor Corporation Australia (Toyota) and seven of its first tier automotive parts suppliers. Owing to the smaller scale of the Australian automotive sector a majority of these suppliers also supply components at the first and second tier level to other major assemblers (Ford, Holden, GM, Mitsubishi). The seven case study firms represented a range of supply relationship dynamics with Toyota and other assemblers.
- Stage 2 – Mail-out of the final questionnaire to the Australian automotive industry.

Questionnaire Development

New items and the choice of appropriate measurement scales were developed in accordance with DeVellis (2003). Scales used in the questionnaire were those described earlier in this paper. The chosen method of survey delivery and collection procedures – mailout – were selected as suggested by Dillman (1999). Multi-item scales were developed from either a) the analysis of interview and case data or b) the work of previous authors. A draft questionnaire was pre-tested by Toyota personnel, case study participants and university academics. The final instrument used a 5-point Likert scale consisting of: 1 = not at all; 3 = to some extent; 5 = to a very large extent.

Data Collection

The research sample was sourced from two known industry databases with up-to-date memberships. Database 1 contained all first and second tier component suppliers in the Australian automotive industry (200 contacts) obtained through the Federation of Automotive Products Manufacture. Database 2 contained all tooling firm suppliers in the Australian automotive industry (200 contacts) obtained through the Tooling Industry Forum of Australia. The instrument was distributed by both mail and email. Of the 400 surveys distributed, 56 usable surveys were returned for a response rate of 15%. The number of returned surveys (56) meets the minimum number or responses required for applying a factor and regression analysis (Hair et al, 1998).

Data Analysis

Returned questionnaires were analysed using linear regression and multiple regression analysis with SPSS Version 12. Data was checked for normality using normal probability plots and tests for kurtosis, skewness and kolmogorov-smirnov statistics pre-analysis and again after each stage of analysis. Items were grouped into draft constructs of similar concept and reduced with factor analysis using principal component analysis with a varimax rotation. Because of the small number of observations (N=56) factor loadings of less than 0.65 were excluded. Tests were done for Bartletts's sphericity and Keyser-Meyer-Olkin measure of sampling adequacy. Items within factors were assessed for collinearity and reliability (Cronbach's alpha > 0.7). Regression statistics were analysed for explanation of variance based on Adjusted R2 values and ANOVA test for significance. Moderator analysis was completed after Hair et al (1998) and Aguinis (2004).

RESULTS

Summary statistics from the exploratory factor analysis are provided in Table 5. Summary statistics from the regression analysis are provided in Tables 6A and 6B and summary statistics from the assessment of moderator/interaction effects are provided in Tables 7 and 8.

Table 5: Results of exploratory factor analysis

Construct (post-factor analysis)	Scale items (factor loading in brackets)	Cronbach's alpha
Pollution prevention	PP1* (0.80), PP2 (0.74),), PP3 (0.64), PP4 (0.86)	0.815
Environment-focus of customer	EFC1 (0.78), EFC2 (0.77), EFC3 (0.88), EFC4 (0.81)	0.823
Supplier's environmental commitment	SEC1 (0.85), SEC2 (0.90), SEC3 (0.89), SEC4 (0.70)	0.86
Transaction cost investment	**TCI1 (0.85), TCI2 (0.87), TCI3 (0.73)**	0.774

* These codes relate to the full descriptions of each item provided in the section on the Conceptual Model.

Testing of Hypothesis 1

The primary relationship which is proposed between the main construct Supplier's Environmental Commitment and Customer's Environmental Focus is articulated through Hypothesis 1. The results of the regression analysis for Hypothesis 1 are shown in Table 6A.

Table 6A: *Supplier's Environmental Commitment* as the dependent variable

Independent variable	Items	Beta	Sig. of Beta	Adjusted R^2	Sig.
Environment-focus of customer				0.140	0.027
	EFC1	0.318	0.103		
	EFC2	0.106	0.532		
	EFC3	0.171	0.478		
	EFC4	-0.111	0.603		

Testing of Hypothesis 1 indicated a significant relationship between the two constructs ($p<0.05$). At the item-specific level, the variable EFC1 contributed most of the variance in the relationship between the Supplier's Environmental Commitment and Environment Focus of Customer – supplier certification to ISO14000 – with the remaining three items explaining less of the variance though still enough to remain in the construct for future testing.

Testing of Hypothesis 2

The second primary relationship which is proposed between the main dependent measure Pollution Prevention and the Supplier's Environmental Commitment is articulated through Hypothesis 2. The results of the regression analysis for Hypothesis 2 are shown in Table 6B. An additional regression of the relationship between Pollution Prevention and the main construct Environment Focus of Customer was also run to provide an indication of whether the customer's sourcing requirements may also act as a direct influence on the supplier's environmental performance.

Table 6B: *Pollution Prevention* as the dependent variable

Independent variable	Items	Beta	Sig. of Beta	Adjusted R^2	Sig.
Supplier's environmental commitment				0.285	0.001
	SEC1	0.051	0.798		

	SEC2	0.158	0.512		
	SEC3	0.277	0.196		
	SEC4	0.195	0.211		
Environment-focus of customer				0.130	0.042
	EFC1	0.487	0.02		
	EFC2	-0.007	0.969		
	EFC3	-0.200	0.431		
	EFC4	0.216	0.337		

Testing of Hypothesis 2 indicated a significant relationship between the two major constructs ($p<0.001$). At the item-specific level, the variable SEC3 contributed most of the variance in the relationship between Pollution Prevention and Supplier's Environmental Commitment – *effort made to ensure employees value the importance of environmental management* – with the remaining three items explaining less of the variance though still enough to remain in the construct for future testing. A less significant relationship exists between Pollution Prevention and the construct Environment Focus of Customer ($p<0.05$) though again with the most influential item in the construct being EFC1 – *supplier certification to ISO14000.* On the basis of these results the primary relationship articulated by Hypothesis 2 is accepted.

Moderator Analysis

Table 7: Results of moderator analysis

Dependent variable (Y)	Independent variable (X)	Moderator variable (Z)	Adjusted R^2 (X+Z)	Adjusted R^2 (X+Z+X*Z)	Sig. of the change in R^2
Suppliers environmental commitment	Environment-focus of customer	Transaction cost investment	0.107	0.16	0.052
		SA1	0.096	0.22	0.031
		SR1	0.12	0.181	0.042

Supply relationship conditions are proposed to have a moderating effect on the primary relationship between Supplier's Environmental Commitment (dependent or Y variable) and the Environment Focus of Customer (independent or X variable). All three relationship measures were assessed as having a significant effect on the primary relationship between the dependent and independent variables. The relationship variable SA1 had the most significant effect, followed by SR1 and less significant but still of note, Transaction Cost Investment.

An additional analysis of the influence of the individual items that comprise the construct Transaction Cost Investment was also completed as shown in Table 8, tested as a simple two-construct linear regression with Supplier's Environmental Commitment as the dependent variable (SEC = a + b1TCI).

Table 8: *Transaction Cost Investment* as the independent variable (non-moderator)

Independent variable	Items	Beta	Sig. of Beta	Adjusted R^2	Sig.
Transaction cost investment				0.161	0.008
	TCI1	0.529	0.002		
	TCI2	-0.013	0.935		
	TCI3	-0.293	0.055		

In the additional analysis a significant influence is still shown to occur from the independent construct of Transaction Cost Investment. The only result of importance here however is the relative significance of the three items which comprise the independent construct. Greatest variance in the relationship is attributed to the item TCI1 – we dedicate and reserve equipment and capacity specifically to maintain this relationship. Thus this item is considered the most influential of the three in the moderating relationship and should be the only item retained in future analysis. The moderating effect of Transaction Cost Investment is expected to become more significant when the other two items TCI2 and TCI3 are not included in the analysis.

DISCUSSION

A primary relationship between the supplier's commitment to the natural environment and the customer's environmental performance requirements as articulated in H1 was confirmed. Significant variance in this relationship was attributed to the item EFC1 that asks whether the supplier is required to attain certification to the ISO14000 management standard. The remaining items were still moderately influential and may prove more significant when explored in isolation. The item EFC1 is considered the most direct measure currently available for communicating environmental performance requirements to suppliers in the global automotive industry as it is an accepted, visible and third-party auditable industry standard. At a basic level the ISO14000 management standards act as a market signal and provide a basic level of compliance in the supplier. A more innovative customer may desire a higher level of environmental performance amongst its supplier's that goes beyond the ISO14000 standard and as such the result of moderator analysis becomes important. As the moderating variables are included in the primary relationship, the significance of the customer's environmental performance requirements also increases. Influence increases as the customer is more likely to use a supplier assessment routine and the customer-supplier relationship becomes more involved and committed. In particular the transaction cost investment variable that related to the supplier having to dedicate equipment and capacity to the relationship was considerably more influential than the other two TCI variables.

The main moderating effect was attributed to the investment of transaction costs borne by the supplier as indicated by the item – supplier dedicates and reserves equipment and capacity specifically to maintain the relationship. These findings are supported by observations made during the earlier case study work such that suppliers were desirous of emulating or adopting their customer's environmental practices where the supply relationship was described by the supplier as being most critical to their firm's survival.

A primary relationship between our measure of environmental performance in the supplier and the supplier's strategic level of environmental commitment as articulated in H2 was confirmed. Of the relationships tested as part of our study this indicated the highest level of significance (p<0.001). Significant variance in this relationship was attributed to the item SEC3 that asks whether effort is being made to ensure that employees value the importance of environmental management in the organization. The remaining items were still moderately influential though not as important. The item SEC3 is considered the most direct measure of whether the organisation's strategy has been successfully articulated beyond the strategic level of the organization and into the functional level. A moderately

significant and less important relationship was found between the supplier's environmental performance and the customer's environmental performance requirements.

Moderator effects were assessed in the relationship between the supplier's environmental commitment (SEC variables) and the customer's environmental performance requirements (EFC variables). This relationship was hypothesized to indicate the main source of interaction effect from the supply relationship variables of transaction cost investment (TCI), supplier assessment (SA) and strength of the relationship (SR).

CONCLUSIONS AND FURTHER RESEARCH

The major finding of this research was that the customer's environmental performance requirements can have a positive influence on a supplier's strategic level of commitment toward the natural environment. The presence of relationship conditions that create greater involvement and commitment between the supplier and the customer or customer-initiated monitoring of the supplier's activities is proposed to increase this influence. Increasing levels of the supplier's strategic environmental commitment in turn has a positive impact on the supplier's environmental performance.

A more indirect relationship exists between the customer's environmental performance requirements and the supplier's environmental performance than originally proposed. The direct relationship or influence between the customer and the supplier on the key issue of the uptake or otherwise of a customer's environmental performance specifications occurs initially at the strategic level of the supply relationship which in turn effects a change in the supplier's own coordination of improvements to its environmental performance or general environmental management activity.

A practical application of these findings may be that customers consider the application of any program of green-supply in a hierarchical manner such that critical or strategic suppliers receive more intensive assistance or development with their environmental performance. Non-strategic suppliers particularly those that provide more commodity goods or are sourced on a market basis could be required to certify to a basic level of compliance such as an industry management standard (ISO14001). This provides the customer with a minimum assurance of risk management and environmental performance without the associated transactional investment. At a less tangible level our study suggests that customers should remain conscious of the old adage "Do as I say and not what I do" such that suppliers may become less responsive to the customer's environmental performance requirements where the customer does not demonstrate a level of commitment toward its environmental performance that exceeds its own requirements for the supplier.

The exploratory nature of this study has provided for the development of a more rigorous conceptual model that may be applied to further studies into the implications of supply greening. Of particular interest will be the use of the revised model and hypotheses to a larger sample size or different industry. Many additional questions still remain surrounding the relationship factors that might support, influence or degrade any customer or supplier-driven program of supply greening. This study has been able to provide some empirical support for a number of potential new theories in a large and under-developed field of research. Customer-driven programs of green-supply remain a potentially powerful tool for reducing the environmental impacts of product supply chains in addition to the influence that other non-financial stakeholders (government, community, employees) may have.

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