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ANTECEDENTS AND OUTCOMES OF SUPPLIER ENVIRONMENTAL RESPONSIVENESS

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ABSTRACT

Nowadays we can see more and more manufacturing companies closely working with suppliers to improve their environmental footprint. To do so, prior research identified two actions that can be employed by a buyer to increase supplier's investments in pollution control and pollution prevention technologies. These are evaluation and collaboration. To advance current knowledge, we ask additional questions: i) what is the nature of the relationship between buyer actions and supplier investments?, (ii) when are these actions successful?, and (iii) how both buyer's and supplier's Triple Bottom Line (TBL) performance benefit from supplier's environmental investments. To answer the first question, we draw from Relational Exchange Theory and the offsetting argument and propose that buyer actions foster supplier asset specificity, which in turn stimulates supplier investments in environmental technologies. To answer the second question we draw from Self Enforcing Contract Theory and argue that buyer actions will be most effective when supported by supplier asset specificity. Results from a cross-sectional survey of 156 Canadian manufacturing plants showed that supplier asset specificity moderates the effect of evaluation on supplier investment in pollution prevention technologies and that it both mediates and moderates the effects of collaboration on supplier investment in both types of environmental technologies.

We made a very significant step toward answering the third research question – we developed a reliable and valid scale for measuring the TBL performance, since it is still not clear how to measure performance along its three components – environmental, social

and economic. During the scale development process we proposed to use a factor-analyzed Q-sort methodology, currently used in the Organizational Behavior research, to help identify problems with the scales that a traditional Q-sort methodology usually used in Operations Management literature fails to point out. Our initial list consisted of 55 items to measure TBL. As a result of reliability and validity tests, this list was later reduced to 47 items. We found that, empirically speaking, TBL performance consists of nine, rather than three, discriminant dimensions.

The theoretical, practical and methodological contributions of our research are discussed along with the suggestions for future research.

DEDICATION

This dissertation is dedicated to the people I love the most – my parents, husband and two kids – Ariel and Valerie.

Acknowledgments

I would like to thank my advisor, Dr. Markus Biehl, for his guidance and encouragement throughout the process of getting my degree. I really appreciate your patience with me. Without your tremendous support, I could not have reached my goal. Your comments have often forced me to look in directions I would have not considered and yet were very beneficial to my research.

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INTRODUCTION

The negative impact of manufacturing on the environment can be observed in many different ways. Directly, gaseous, liquid and solid wastes are generated as a by-product of production that may lead to the pollution of natural resources or health problems in plants, animals or humans. For example, airborne emissions are known to cause asthma and premature deaths, particularly in the older population (The Chief Medical Officer of Health, 2002). Indirectly, the use of the product or its disposal at the end of its useful life may cause an environmental impact. For example, when a product containing lead is used by children or disposed in the ground, it may cause lead-poisoning and damage children's brains and nervous systems, and cause behavioral and learning problems (Ace Coating, 2003). This is only one of the reasons for a growing number of national and international environmental programs (such as the ISO 14000 series, BS7750 in the UK, or the European Environmental Management and Audit System – EMAS – in the European Union) and by-laws that target manufacturers and help them manage or decrease their levels of pollutants (Foster *et al.*, 2000).

Many manufacturers (e.g., Xerox or DuPont) have started to counter the negative image arising from these consequences by improving and communicating their environmental performance. However, even if a manufacturer minimizes its own level of pollution, it may not necessarily be considered to be environmentally friendly. This is because in today's competitive and networked environment, where between 55% (Dyer and Singh, 1998) and 70% (Lewis, 1995) of a product's value created stems from outside suppliers, focusing on one's own operations is not sufficient anymore. Instead, a manufacturer must ensure that both its own operations *and* those of its suppliers are environmentally friendly (Barron, 1993).

The purpose of this dissertation is to develop a better understanding of (1) how buyer-supplier relationship mechanisms may affect investments in environmental technologies by the supplier, and (2) the potential benefits of such investments (and, in turn, relationship mechanisms) for both the buyer *and* the supplier. In the remainder of the dissertation, when we refer to a buyer, we mean a manufacturer. By a supplier we mean a manufacturer delivering products (parts or components) to the buyer.

Basics concerning the first part of our research question have been addressed before. Klassen and Vachon (2003) identified two main mechanisms organizations may use to influence their suppliers' environmental activities, as measured by environmental expenses. These are evaluative or collaborative activities. The former include periodic site visits to evaluate current environmental performance and may or may not include positive or negative feedback to suppliers (Klassen and Vachon, 2003; Vachon and Klassen, 2006; Vachon, 2007). Collaboration includes actions such as providing suppliers with regulatory, technical or managerial information, training programs or suggestions on how to change process or product designs (Bowen *et al.*, 2001; Klassen and Vachon, 2003; Vachon, 2007). Klassen and Vachon (2003) found that evaluative activities increase the level of suppliers' environmental investments, while collaboration between buyers and suppliers shift the investments from management systems toward pollution prevention. In contrast, Vachon (2007) found that collaboration had a negative impact on investments in management systems, and no other significant effects were observed. Although, these inconsistencies might be due to the sample frame differences, the question arises whether other variables might affect the relationship between buyer actions and supplier investments. Therefore, we want to answer the following questions in our research:

(1) What is the nature of the relationship between the buyer activities and supplier environmental investments? I.e., is there a direct path between the antecedents (buyers' activities) to the outcomes (suppliers' environmental investments), or are there any variables *mediating* this relationship?

(2) Under what conditions does the relationship between buyer activities and supplier environmental investments work? I.e. what are the variables affecting the effectiveness of buyer actions in increasing environmental investments by suppliers?

(3) Finally, to what extent do the buyer *and* the supplier benefit from the supplier's investments in environmental technologies?

In particular, we will investigate the mediating and moderating role of investments made by the supplier that are specific to the buyer, since asset specificity has been found to be a very important factor in operations management and other streams of management research (e.g., Joshi and Stum, 1999).

To answer the first question, we build on Relational Exchange Theory (Bradach and Eccles, 1989; Heide, 1994), which considers investments in transaction specific assets as a means of shaping the behavior of exchange partners. Based on this theory and the offsetting argument (Heide and John, 1988), we propose that transaction specific assets mediate the relationship between buyer's activities and supplier's environmental investments.

To answer the second question, we draw from Self Enforcing Contract Theory (Klein, 1980; Telser, 1980; Williamson, 1983), which is a variation of traditional Transaction Cost Analysis (TCA, Williamson, 1983; Williamson, 1991). Based on this theory we argue that in the presence of buyer-specific investments made by a supplier, to safeguard these investments, the latter will be more responsive towards buyer initiatives (i.e., evaluation and collaboration). Our first two conceptual models can be found in figures 1a and 1b.

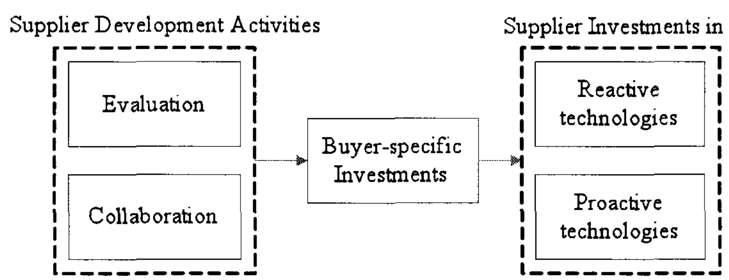
We make a very significant step toward answering our third research question. We are interested in seeing how supplier environmental investments affect both supplier and buyer performance (see figure 1c). Our goal is to measure performance along the Triple Bottom Line (TBL) framework, which includes environmental, economic, and financial performance (Elkington, 1994; Elkington, 1998). After screening the relevant literature, however, we found that there are several problems with this measurement system. First, the term TBL is sometimes used interchangeably with Corporate Social Responsibility (CSR) or Business Sustainability (or Sustainability). Second, the dimensions of the TBL are usually considered in isolation, as stand-alone dimensions (e.g., Klassen and McLaughlin, 1996; King and Lenox, 2002). Alternatively, studies establish relationships between a pair of the three dimensions (e.g., Pil and Rothenberg, 2003; Swink *et al.*, 2005) arguing causality, even though both really are outcome measures. Instead, to measure a company's performance, all three dimensions of TBL must be considered simultaneously and be driven by some activities, while allowing for correlations among the outcome dimensions.

The last problem we have identified relates to measurement issues. Although measures for economic performance have long been established and validated, the picture is different for social and environmental performance indicators. For the social dimension, authors typically use performance rankings that are based on incomplete information (e.g., the ethical rating using New Economics Foundation and Cooperative Bank's ratings or Fortune magazine's annual survey on corporate reputations, see e.g., Sharma and Vredenburg, 1998; Markley and Davis, 2007). In addition to being incomplete, these rankings usually reflect *activities* performed as part of a social aspect of company's strategy, rather than the actual *impact* of these activities (e.g., Holmes, 1977). For example, many rankings are based on statements such as "we invested in …", "we developed …", rather than "through our investment, our performance along … has been improved" or "development of … has enabled us to …". For the environmental dimension, the most reliable source of information is reports submitted by manufacturers to the US EPA's Toxics Release Inventory (TRI) or the Canadian National Pollution Release Inventory (NPRI). However, not all pollutants are reported to this database and only if they exceed a certain threshold. Moreover, only the amount of releases is reported, rather than their impact on human health or the environment.

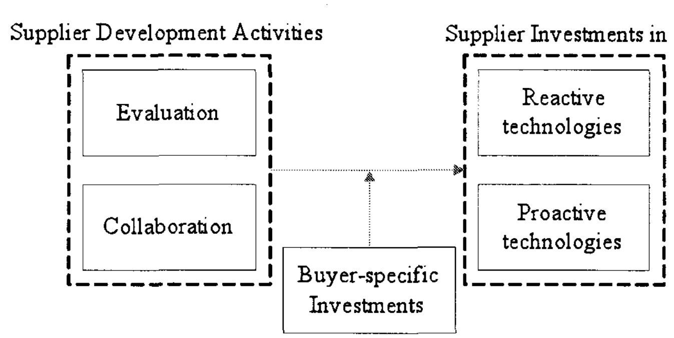
In the second part of this dissertation we therefore develop a reliable and valid scale to measure the TBL outcomes. To do so, we follow a rigorous scale development process (Churchill, 1979). We extend the Q-sort methodology currently used in the Operations Management literature to purify the measures (Stratman and Roth, 2002; Swafford *et al.*, 2006; Froehle and Roth, 2007; Menor and Roth, 2007) by adding a Q-sort technique based on factory analysis (Bish and Schriesheim 1974; Hinkin and Schriesheim 1989). Besides better pointing out to problematic items than usual Q-sort methods, the factor-analyzed method confirms the Likert scale structure of the items used to measure constructs.

Figure 1: Conceptual models

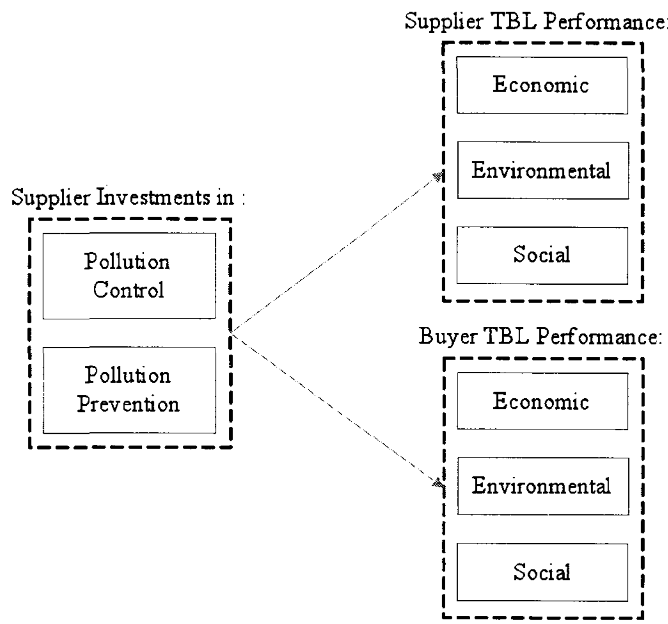
(a) Mediating role of buyer-specific investments



(b) Moderating role of buyer-specific investments



(c) TBL benefits for the supplier and the buyer



This dissertation follows a paper format and therefore is structured as follows. In chapter 2 we present the first paper, which is going to answer our first two research questions. Chapter 3 contains the second paper in which the Triple Bottom Line performance construct is developed and tested. The conclusions chapter draws both papers together again and closes the dissertation.

EFFECTS OF BUYER ACTIONS AND SUPPLIER ASSET SPECIFICITY ON SUPPLIER INVESTMENT IN ENVIRONMENTAL TECHNOLOGIES

1 Abstract

Increasingly, manufacturing firms are working with their suppliers to minimize the environmental footprint of the manufacturing firm's supply chain as a whole. Prior research has identified two buyer actions – evaluation and collaboration – as key to fostering supplier investment in pollution control and pollution prevention technologies. In this research, we seek to contribute to prior knowledge by asking two questions: (i) is the relationship between buyer actions and supplier environmental investments direct, and (ii) is this relationship affected by the level of buyer specific investments made by a supplier? Drawing from Relational Exchange Theory we argue that these buyer actions are successful because they foster supplier asset specificity, which in turn stimulates supplier investment in environmental technologies. Drawing from Self Enforcing Contract Theory we argue that these buyer actions will be most effective when supported by supplier asset specificity. Results from a cross-sectional survey of 156 Canadian manufacturing plants showed that supplier asset specificity moderates the effect of buyer evaluation on supplier investment in pollution prevention technologies and that it both mediates and moderates the effects of buyer collaboration on supplier investment in both pollution control and pollution prevention technologies. The theoretical and practical implications of the research are discussed along with a consideration of the research limitations.

2 Introduction

Across the industrial landscape, manufacturing firms are being exposed to a host of institutional forces ranging from formal laws and regulations to informal pressures from competitors, customers, and trade associations directing them to minimize their "footprint" on the natural environment (Bansal and Roth, 2000; Bansal and Clelland, 2004; Bansal, 2005). Firms responding positively to these institutional pressures are receiving government subsidies and customer patronage, among other benefits, that are not being made available to firms that are seeking to defy these pressures (Jennings and Zandbergen, 1995; Suchman, 1995). Thus, responding positively to institutional pressures to reduce their environmental footprint has become a source of strategic advantage for manufacturing firms.

Given, however, that manufacturing firms procure somewhere between 55% (Dyer and Singh, 1998) and 70% (Lewis, 1995) of the inputs for their final product, it is not sufficient for these firms to minimize the environmental footprint of only their own assembly operations; the environmental footprint of their suppliers has to be reduced as well in order to satisfy the institutional stakeholders. Firms such as General Electrics (Fisher, 2005; Immelt and Bolsinger, 2007), Nike (Holmes, 2006), Procter & Gamble (Maxwell *et al.*, 1997), GlaxoSmithKline (Beckley, 2004), and Cadbury (Truini, 2008) – to name some high profile pioneers that were recognized at the 2008 Carbon and Environmental Footprint Summit – have all spent much time and effort in recent years in initiatives to minimize the environmental impact of their supply chain as a whole. The focus of this research is on understanding better how buying firms are going about the process of building green supply chains.

In their path-breaking study in this area, Klassen and Vachon (2003) identified two types of actions that buyer firms employ in their attempt to seek a reduction in their partner's environmental footprint: evaluation and collaboration. Their results show that both actions have an influence on supplier behavior as it pertains to environmental investment. Buyer evaluation increases the level of supplier environmental investments while collaboration with the buyer increases a supplier's investments in pollution prevention technologies and reduces supplier investments in management systems. Surprisingly, however, the findings differed in Vachon's 2007 study. In this more recent paper collaboration was found to have a negative impact on investments in management systems, and no other significant effects were observed. Although the differences might be rooted in the difference in sample frames, it may be also the case that there is another, third variable, that affects the relationship between buyer actions and supplier investments. Given prior evidence from the operations management, organizational behavior and marketing literatures we hypothesize hat supplier asset specificity may in fact be this variable.

First, while these studies posit direct effects from buyer actions (i.e., evaluation and collaboration) to supplier investment decisions, they do not articulate a theoretical pathway that connects the antecedents to the outcomes. Thus, while we know from prior research that buyer actions have an impact on supplier environmental investment decisions, we have little knowledge as to the *nature* of this relationship. Thus, does supplier asset specificity connect the buyer actions to supplier investments?

Second, while the Klassen and Vachon (2003) and Vachon (2007) studies posit a direct and implicitly universal relationship between buyer actions and supplier environmental decisions, it seems likely that the effectiveness of these buyer actions may vary depending on other characteristics of the buyer-supplier relationship. For example, prior research has shown that despite the deployment of identical actions such as collaborative communication by the focal firm vis-à-vis their partners, partner response has varied depending on the extent of integration between the focal firm and the partner and on the extent of control deployed by the focal firm vis-à-vis the partner (Mohr *et al.*, 1996). Thus, based on our assessment of prior research, there is little theoretical and empirical knowledge in the sustainability area regarding *when* certain buyer actions are more impactful than others.

Based on the preceding, we identify two key research objectives:

1. To investigate whether supplier asset specificity connects between buyer actions and supplier environmental investments, and
2. To identify whether the level of supplier asset specificity affects the relationship between buyer actions and supplier investments.

We draw from Relational Exchange Theory (Dwyer *et al.*, 1987; Ring and Van de Ven, 1994) and Self Enforcing Contract Theory (Klein, 1980; Telser, 1980; Williamson, 1983) to motivate our answers to the above questions. As such, our research has implications for both bodies of knowledge. In turn, we expect that our research will be of interest to managers of buying firms because it identifies for them the actions they should deploy and the conditions they should monitor and cultivate in order to attain their desired outcomes, namely, reduction in the environmental footprint of their suppliers.

In the next section we articulate the theoretical bases for our conceptual models. The conceptual models are subsequently explicated along with the hypotheses embedded therein. Next, the methods used to test the models are outlined and the results are presented. We conclude with a discussion of the results in terms of its implications for theory and practice.

3 Theoretical Background

Williamson (1979) lists three main types of governance structures – market governance or classical contracting (when there are no specific investments involved), trilateral governance or neoclassical contracting (for occasional transactions with semi to specific investments involved), and transaction-specific governance or relational contracting (for recurring transactions with involvement of high-specific assets). In our research we are considering continuous, rather than occasional, buyer-supplier relationships. In addition, we want to test the effect of specific assets. Therefore, in our research the most suitable form of governance structure is relational contracting. There are two main theories that fit here. These are Self-Enforcing Contract Theory (SECT) and Relational Exchange Theory (RET). We will briefly introduce them next.

3.1 Self Enforcing Contract Theory

The focal concern within SECT is with the minimization of *opportunism* because of its potential to create *transaction costs* (Williamson, 1985, pp. 47-49). To do so, SECT focuses on creating relational safeguards (Poppo and Zenger, 2002). One such mechanism is the establishment of credible commitments between exchange partners. Credible commitments refer to economic hostages (investments) that parties to an exchange make in each other prior to commencement of the transaction. Thus, for example, when parties make specific asset investments with each other, these investments serve as economic hostages because, by definition, the investment is of little value outside of the focal partner relationship. As a result, the investing party is motivated to act in a manner that fosters relationship continuity, thereby ensuring that they obtain adequate returns for these investments. Thus, by aligning the economic incentives of the parties to the exchange, these self-enforcement mechanisms, rather than third parties, control the opportunistic tendencies of the exchange partners. As has been discussed both theoretically and demonstrated empirically in prior research, self-enforcement mechanisms reduce both the costs of drafting, negotiating and safeguarding contracts (ex ante transaction costs) as well as the costs of ensuring performance and facilitating adaptation to changed environmental conditions (ex post transaction costs, see Dyer and Singh, 1998 for an extensive review).

In the discussion below we draw upon this theoretical framework to illustrate the contingency condition under which buyer activities such as evaluation and collaboration will foster supplier investments in pollution control and pollution prevention technologies.

3.2 Relational Exchange Theory

Relational Exchange Theory is similar to SECT in two key respects: (i) it shares with SECT the focal concern regarding the minimization of transaction costs in the exchange relationship, and (ii) it also focuses on the development of endogenous safeguards against opportunism in exchange relationships. The key difference between the two perspectives is in the *nature* of the endogenous safeguards. Whereas SECT identifies *economic* safeguards, the focus within Relational Exchange Theory is on the development of *moral and social* safeguards against opportunism (Larson, 1992).

The core insight of Relational Exchange Theory is that relationships evolve through the development of trust between exchange partners, which, in turn, is determined by their performance in terms of expectation fulfillment over time, as the relationship progresses through a relationship life cycle. Thus, as expectations are fulfilled through performance, in time trust between the partners deepens. This in turn motivates them to increase their dependence on and expectation of each other, continuing this positive cycle (Dwyer *et al.*, 1987; Ring and Van de Ven, 1994). Whereas SECT sees safeguards as contingencies guarding against opportunism, in RET the safeguards are part of a linear, mediating process.

We draw from this theoretical framework in following section to discuss the process through which buyer activities such as evaluation and collaboration will foster supplier investments in pollution control and pollution prevention technologies.

4 Conceptual Model

4.1 Key Construct Definitions

Evaluation. Evaluation entails "monitoring and assessment" with an emphasis on activities such as "gathering and processing information in order to assess operating performance including legal compliance, and to mitigate any associated risks" (Klassen and Vachon, 2003, p. 340). Specifically, in the context of our research, evaluation refers to monitoring and assessing supplier performance and practices with respect to environmental indicators (Vachon and Klassen, 2006; Vachon, 2007; Vachon and Klassen, 2008).

Collaboration. Collaboration entails "tacit knowledge integration which occurs through information exchange in a rich communication setting." It typically manifests itself in domains such as product design, fundamental process modification and cooperation in the development of coordinated logistical systems (Klassen and Vachon, 2003, p. 339). In the context of our research, collaboration specifically refers to buyer initiatives to work with the supplier across functional domains and organizational levels in order to reduce the size of the latter's environmental footprint (Vachon and Klassen, 2006; Vachon, 2007; Vachon and Klassen, 2008).

Supplier Asset Specificity. Asset Specificity refers to specialized assets that "cannot be redeployed without sacrifice of productive value if contracts should be terminated or prematurely interrupted" (Williamson, 1985, p. 54). Parties to an exchange can make asset specific investments in each other across a range of domains including physical assets (e.g., customized machinery), operational procedures, human resource (e.g., training or the installation of one party's personnel in the other party's operations), and site specificity (e.g., when a supplier locates their operations in geographic proximity to the buyer's operations) (Williamson, 1991). Note that our focus in this research is on specific asset investments that are made by the supplier in their relationship with the buyer. As discussed in the transaction cost analysis framework, specific asset investments can produce cost savings and value generation, as a result of which parties are motivated to make these investments. While producing benefits, their specific character is also what creates risks in terms of imposing switching costs particularly on the party that has made this investment.

Environmental investments. Klassen and Whybark (1999a) define three types of environmental investments. These are Pollution Control (PC), Pollution Prevention (PP) and Management Systems (MS) technologies. PC technologies as "structural investments that capture, treat, or dispose of pollutants or harmful byproducts at the end of the manufacturing process." Thus, pollution control technologies are typically added on to at the end of existing manufacturing processes as means by which to reduce the environmental impact of these processes. In contrast to PC technologies that appear as augments to existing manufacturing processes, PP technologies are structural investments made in order to alter the manufacturing process itself with a view to reducing the environmental pollution that is created within the manufacturing process itself. As such, it involves addressing the pollution problem at its very source (Klassen and Whybark, 1999a). MS refer to the investments in infrastructure that improve the way that environmental issues in manufacturing are managed.

While agreement exists regarding pollution control focusing on the filtration or remediation of pollution, the literature offers differing conceptualizations with respect to PP and MS. Hart (1995, p. 992), for example, submits that PC and MS should be comprised in a category entitled pollution prevention, containing activities such as "better housekeeping, material substitution, recycling, or process innovation," as well as "extensive employee involvement." This definition is in-line with the EPA definition of pollution prevention (U.S. Environmental Protection Agency, 1990), as well as Statistics Canada definition (2004), although only in-process recycling is considered a pollution prevention investment.

While Klassen and Whybark's conceptualization of pollution technologies makes much sense in view of the Resource Based View of the firm (Barney, 1991), in this research we adopt the view of Hart (1995), EPA (1990), and Statistics Canada (2004) and argue that MS technologies serve as capabilities needed to support PP activities (and, to some degree, PC activities) and therefore should not be viewed separately. Thus, our definitions for PC and PP investments are as follows:

Pollution Control. These are predominantly structural investments in remediation as well as end-of-pipe equipment designed to filter or clean the pollution after its creation but before its been released into the natural environment.

Pollution Prevention. These are structural and infrastructural investments designed to reduce or eliminate the source of the pollution.

4.2 The Role of Supplier Asset Specificity

4.2.1 Buyer Actions and Supplier Investment in Environmental Technologies: The Mediating Role of Supplier Asset Specificity

For suppliers, the decision to invest in pollution control and pollution prevention technologies is typically a challenging one to make because it entails, in most managers' views, the extremely unattractive trade-off between incurring definite costs in the short-run in exchange for benefits that may or may not accrue over the long-run. In contrast to the much-cited *pollution prevention pays* literature (e.g., Porter and van der Linde, 1995), empirical evidence suggests that, in the short term, this investment decision may make its firm less attractive to buyers (Halme and Niskanen, 2001). In the long term, the resulting cost structure may limit the supplier firm's ability to compete on price (Feichtinger *et al.*, 2005). Thus, in addition to imposing immediate costs on the supplier firm, the decision to invest in environmental technologies may impose long-term costs on this firm in the form of both production costs and reduced business opportunities.

Why do supplier firms still invest in environmental technologies, despite these potential cost and risk disadvantages? Prior research has shown that two buyer actions, namely evaluation and collaboration, can foster supplier investment in environmental technologies (Klassen and Vachon, 2003). Due to the differences in several empirical studies' results (Klassen and Vachon, 2003; Vachon, 2007), we think that the underlying theoretical process that addresses the nature of the relationship between buyer actions and supplier investments and the boundary conditions for the effectiveness of this relationship, have not been fully developed or explored.

We argue that evaluation represents specific asset investments that are made by the buyer and specific to the supplier to which, in turn, the supplier invests in assets specific to that buyer. As to collaboration, by definition it assumes that both the buyer and the supplier make investments specific to the relationship.

To elaborate, first, for evaluation to be effective the buyer has to develop a performance scorecard against which supplier performance and practices are monitored and measured. The structure of the scorecard will be different for various suppliers, since they are assessed using different priorities (Saccomano, 2003). For some buyers the most important priority is cost, for others quality, etc. These preferences will be passed on to suppliers and reflected on the scorecard. More than that, different markets, products, manufacturing processes and environmental conditions will call for different metrics (Kaplan and Norton, 1992; Hoole, 2005). Similarly, the performance of one supplier against these indicators cannot necessarily be extrapolated to other suppliers. To a large extent, each supplier has to be evaluated individually (Goldberg and Yagan, 2007). Thus, development of the scorecard, monitoring of supplier performance, and measurement of its performance against the scorecard – require investments by the buyer in terms of personnel time and other resources that are, at least to a degree, specific to the supplier.

Drawing from Relational Exchange Theory we argue that, in the face of buyer specific investments, suppliers will reciprocate by making specific investments of their own toward the relationship. This notion of reciprocity in specific asset investments has been both extensively theorized (e.g., Dwyer *et al.*, 1987) and validated empirically across both case based (Larson, 1992) and survey based (e.g., Anderson and Weitz, 1992) research studies. To elaborate, Slobodow *et al.* (2008) explore the concept of dual accountability, which proposes that not only the supplier should be responsible for the relationship (and thus, being evaluated by a buyer); the buyer also has to be accountable for its part in the relationship. To achieve dual accountability, the authors propose to use a Two-Way Scorecard, which measures not only the supplier's, but also the buyer's performance, and thus requires buyer-specific investments to be made by a supplier (for the same reasons buyers have to make supplier-specific investments for evaluation process to be effective, see discussion above). Thus, we propose:

H1a: Evaluation will be positively related to supplier asset specificity

Collaboration, on the other hand, is not an arms-length governance structure like evaluation, but rather "a productive resource for value creation and realization" (Madhok and Tallman, 1998, p. 326). Many such partnerships, however, fail because the partners in this relationship underestimate the strategic value of transaction-specific assets, in which both partners should invest (Madhok and Tallman, 1998). Without these investments in place, "potential synergies from the alliance are likely to remain unrealized and the alliance is more likely to fail" (Madhok and Tallman, 1998, p. 336).

Indeed, although not in the environmental context, empirical evidence confirms that collaboration is associated with higher levels of supplier asset specificity. Dyer et al. (1997) confirmed that partnerships with suppliers (in contrast to arms-length supply arrangements) are marked by very high degrees of both collaboration and specific assets. Lietke and Boslau (2005) found that cooperation is associated with a higher degree of asset specificity in supply chains, leading to more fully integrated supply chain solutions. Artz's (1999) data on almost 400 manufacturing firms indicate that collaboration is significantly and positively correlated with both supplier and buyer investments in specific assets. Therefore, we propose that

H1b: Collaboration will be positively related to supplier asset specificity

According to the logic of Transaction Cost Economics, a supplier that made buyer-specific investments is highly dependent on its buyer and therefore this buyer can behave opportunistically toward a supplier (Heide and John, 1988). Opportunistic behavior can take a form of lying to the exchange partner, cheating, negotiating better (in terms of price, for example) terms of a contract (Williamson, 1985). While authors propose a variety of potential solutions to this problem (Dyer, 1997, Dwyer *et al.*, 1987, Heide and John, 1990; Joshi and Stum, 1999, Williamson, 1985, Anderson and Weitz, 1992), Heide and John (1988) recommend a mechanism they term 'offsetting investments'. The purpose of offsetting investments is to engage in bonding behavior and thus reduce the opportunistic behavior of the other partner. They aim to add additional value to the product or service through improving ordering, shipping and servicing procedures, or dedicating specific (human or physical) assets (on top of specific investments already made) to the relationship.

In line with this theory we argue that environmental investments made by a supplier serve as offsetting investments aimed at pleasing the buyer as the buyer has shown its interest in such activities either through its evaluations or collaboration with the supplier. As such, additional value is added to the relationship, further binding the buyer. Indirectly, the offsetting investment may also result in financial (Klassen and McLaughlin, 1996), environmental (Klassen and Whybark, 1999b) and manufacturing improvements which, in turn, benefit the buyer (Shin *et al.*, 2000). Both the direct and indirect value addition reduces the risk of opportunistic behavior. Based on the preceding theoretical rationale and empirical research, we submit that:

H2: Supplier asset specificity is positively related to investments in pollution control and pollution prevention

Combining hypotheses 1 and 2 we hypothesize that:

H3: Supplier asset specificity mediates the relationship between buyer actions and supplier environmental investments.

4.2.2 Buyer Actions and Supplier Technological Investments: The Moderating Role of Supplier Asset Specificity

While investments in specific assets by the supplier may be a response to buyer actions, it may also occur as a strategic activity in order to negotiate better terms of the contract in terms of price or volume (Rubin, 1990) or to secure efficiency gains. Thus, for example, suppliers that co-locate with their customers experience efficiency gains in the form of reduced transportation costs and improved inventory or quality control (Petersen *et al.*, 2003; Porter, 1998). In the discussion below, we focus on supplier asset investments not as a response to buyer actions but as a unilateral decision by the supplier.

Although prior research makes the case for a positive relationship between buyer actions (i.e., evaluation and collaboration) and supplier investments in environmental technologies (Klassen and Vachon, 2003), certain compelling theoretical arguments remain that make the opposite case, namely, that these buyer actions will undermine supplier technological investments. Thus, for example, based on Reactance Theory (Brehm, 1966), which contends that decision makers will resist the imposition of constraints on the decision process by external parties, the argument could be made that evaluation by the buyer will actually undermine the supplier's decision to make the requisite technological investments because making these investments will mean acceptance of the buyer's influence in the decision. By not making these investments the supplier asserts its independence from the buyer (Heide *et al.*, 2007).

Similarly, the literature on "learning races" (Hamel, 1991; Kale *et al.*, 2000) suggests that collaborative relationships are potentially doomed to fail if parties seek to collaborate only to extract knowledge from the other without providing the partner with equivalent knowledge in return. Instead, the aim of a learning race is to learn from the partner as quickly as possible and to exit the relationship afterwards. From the perspective of that literature, collaboration will undermine supplier technological investments because it gives suppliers the opportunity to learn about the buyer's operations. A supplier can generate value from this knowledge in their relationships with the buyer's competitors and as such, collaboration may actually facilitate the supplier's exit from the relationship. The high failure rate of alliances in business (Lewis, 1995; Park and Ungson, 2001) speaks at least in part to the validity of this perspective.

Given the existence of competing perspectives on the relationship between buyer actions and supplier technological investments and in light of the mixed results that are reported in prior empirical research (i.e., Klassen and Vachon, 2003; Vachon, 2007), it is important to further investigate the precise nature of this relationship. Rather than viewing them as competing hypotheses, we take the position in this research that each perspective is valid under certain boundary conditions. The particular boundary condition we explore in this research is supplier asset specificity.

Drawing from SECT (Williamson, 1983; Williamson, 1985) we argue that supplier asset specificity makes the supplier motivated to act in a manner that preserves and strengthens their relationship with the buyer, instead of resisting buyer's power or trying to extract knowledge from the buyer and leave the relationship. This argument is supported by the literature linking party dependence (expressed by high levels of specific assets) on its opportunism toward the partner. For example, it was found that dependence of a party enhances its commitment and trust to the relationship (Morgan and Hunt, 1994) as well as responsiveness to the partner's influence (Anderson and Narus, 1990) and requirements (Hallén *et al.*, 1991).

Note that the above argument also aligns with the contingent resource based view of the firm. This view argues that strategic value is maximized when endogenous design variables are aligned with exogenous context variables (see Aragon-Correa and Sharma, 2003). In the context of environmental investments, an increase in uncertainty regarding the supplier's exogenous environment, as induced by the buyer's evaluative or collaborative activities, will improve the supplier's preposition towards developing a proactive environmental strategy (Aragon-Correa and Sharma, 2003) consisting of investments in both pollution control and pollution prevention technologies (Klassen and Whybark, 1999a). As a result, the positive effects of both evaluation and collaboration on investments in pollution prevention and control systems will be enhanced in the presence of high levels of asset specificity, whereas low levels of asset specificity could lead to supplier reactance. Consequently, we hypothesize that:

H4: Supplier asset specificity will moderate the positive effect of

(a) evaluation on pollution control such that this effect will be enhanced when supplier asset specificity is high;

(b) evaluation on pollution prevention such that this effect will be enhanced when supplier asset specificity is high;

(c) collaboration on pollution control such that this effect will be enhanced when supplier asset specificity is high;

(d) collaboration on pollution prevention such that this effect will be enhanced when supplier asset specificity is high.

5 Methodology

In this section, we discuss the survey instrument, sampling procedure and the measurement model used to test our conceptual models.

5.1 The Survey

In designing the survey instrument we used existing and previously validated scales for some items. Other items we based on the existing literature but changed their wording to suit our mode of survey execution. The items and corresponding references are listed in Appendix A. We used several plant- and product-specific characteristics that may affect the environmental performance of the suppliers as control variables. These are plant size, age of the plant and equipment (Klassen, 2001; Klassen and Vachon, 2003), product type, and the product's importance to the buyer (Heide and John, 1988). The latter two were measured on 5-point Likert scales ranging from 'commodity to speciality' and 'peripheral to critical', respectively. Following Cua et al. (2001) we used the natural logarithmic transformation of the number of employees to reflect the plant size.

To measure investments in environmental technologies, Klassen and Vachon (2003) and Vachon (2007) used a relative scale – managers were asked to allocate 100 points to five project categories, which corresponded to investments in pollution control, pollution prevention and management systems. In the pilot study we asked managers the same question, but managers found this item very hard to respond to over the phone (which was our method of survey execution). We therefore decided to use absolute measures. Based on the five project categories used by Klassen and Vachon (2003) and Vachon (2007) we constructed items, probing for a list of investments in line with PC and PP, as defined above. Managers were then asked to rate on the scale from 1 to 5 the extent of their plant's investments in each one of these technologies (see Appendix A).

We designed the measures for evaluation and collaboration activities based on Klassen and Vachon (2003). As the original measures were not environmentally oriented, however, we adjusted the wording of these items and added additional items to reflect environmental evaluative and collaborative activities.

In this study, our unit of analysis is the supplier plant. In a pilot study we asked managers about the development activities targeted at them by their buyers as well as activities undertaken by themselves targeting their suppliers. By buyers, we mean other manufacturing plants, rather than end consumers (i.e., we focus on B2B relationships). We found that most plants thought that they needed to significantly pressure their suppliers. In addition, Vachon and Klassen (2008) found that collaboration with suppliers yielded broad benefits while collaboration with customers resulted in mixed outcomes. We therefore decided to investigate how *suppliers* perceive supplier development activities of their buyers and what investments *suppliers* make as a result. The choice of the supplier's plant as the unit of analysis is not unusual in operations management research (Van der Vaart and Van Donk, 2008). We asked every plant to focus on its major buyer and report which supplier development practices were present in the relationship with this buyer and which investments in different environmental technologies this supplier had made.

5.2 The Sample

Klassen and Whybark (1999a) noted that industries that have been subjected to non-changing environmental regulations for a long time are not suitable for the study of environmental issues, since these plants tend to have very standardized environmental programs and little variation can be observed. Chemical, pharmaceutical, rubber and plastics manufacturing firms were thus ideal for this study because they have to deal with ever changing regulations and scrutiny. Electrical and electronics manufacturers had to adapt to the Waste Electrical and Electronic Equipment (WEEE) and the Restriction of Hazardous Substances (RoHS) directives recently introduced by the European Union (Shah and Sullivan, 2002). Many Canadian plants manufacture for European OEMs or markets and, thus, their products must conform to European standards. This makes Canadian plants from these industries appropriate candidates for our study.

The data collection was executed during the Winter of 2006. We obtained a list of 1320 Canadian manufacturing plants from Dun and Bradstreet (www.dnb.ca). An initial screening of the plants was carried out to verify contact information and confirm their eligibility for the survey. Non-manufacturing suppliers, i.e. firms that did not produce components for other manufacturers, plants with short-term operations, and small plants with revenues of less than $1 Million CDN were discarded from the sampling frame. The financial limit was introduced to exclude firms with a dubious viability (Ecotec, 2000) that would not support long-term management activities. Over 28% of the plants (n=373) were not reachable due to various reasons. After the initial screening, we were left with 628 usable plants.

The data collection was carried out through a phone survey. We chose this alternative due to the targeted plant sizes – the majority of our sample consisted of plants with less than 100 employees. Other advantages of a phone survey include that it can help to obtain answers to all questions because it is more difficult for respondents to skip questions (Dillman, 1978) and the ability to provide clarification on questions.

To survey French-speaking plants (located mainly in Quebec) our questionnaire had been translated to French and then translated back to English to assure proper translation.

We completed seven rounds of calls. If the respondent still had not answered our survey after the seventh attempt, it was checked as a non-respondent. 156 respondents fully completed our survey, for the response rate of 25%. Non-response bias analysis was performed using a χ^2-test. No significant differences in the number of employees among respondents and non-respondents (*p-value* = .826) or number of plants by 2-digits SIC codes (*p-value* = .724) were found. In addition, we compared 40 earliest responses (from the earliest rounds of calls) with 40 latest responses (from the latest rounds of calls) by calculating t-tests for each of items used in this research (Lambert and Harrington, 1990). No significant differences were found between the two groups. Descriptive statistics of the sample can be found in Table 1.

Table 1: Sample Profile

Primary Industry (2-digits SIC)	
Chemicals And Allied Products (28)	30.9%
Rubber And Miscellaneous Plastics Products (30)	27.6%
Electronic And Other Electrical Equipment And Components (36)	41.4%
Total	*100.0%*
Number of Employees	
Less than 100 (small)	70.3%
100 – 499 (medium)	25.8%
500 and above (large)	3.9%
Total	*100.0%*
Revenue	
Less than 5,000,000 CAD	24.4%
5,000,000 – 50,000,000 CAD	24.4%
Over 50,000,000 CAD	5.1%
Missing values	46.2%
Total	*100.0%*
Title of interviewed person	
Plant, Operations or Manufacturing Manager (including Director, VP, etc.)	39.0%
EHS, Safety, or Environmental Manager	3.8%
President, General Manager	28.8%
Other[1]	28.4%
Total	*100.0%*

[1] Includes positions such as Procurement & Planning Manager, Sales Manager, Quality Assurance Manager, Technical Director, VP of Finance, VP of Sales.

5.3 The Measurement Model

To be able to use standard empirical methods for our analyses, we tested our data for normality. No violations for skewness and kurtosis values were found (Curran *et al.*, 1996). To control for possible differences among industries, all items (including independent, dependent, and control variables) were standardized by industry (Cua *et al.*, 2001).

We used confirmatory factor analysis (CFA) to assess our measurement model. Before starting our analysis we checked for missing data. Our data contain 8% missing data. Since it is less than 10% (Tsikriktsis, 2005) and the pattern of missing data based on the Little's test (Little and Rubin, 1987) is MCAR (Chi-square = 6.933, *df* = 4, *p-value* =

.139), we utilized the Full Information Maximum Likelihood (FIML) approach to missing values (Arbuckle, 2005) in our CFA.

Due to our sample size (n=156), we tested two separate measurement models – one for independent variables and asset specificity, and the other for our dependent variables only. The error terms associated with each measurement item were allowed to freely correlate with each other (Bollen, 1989; Stratman and Roth, 2002). Table 2 provides the results for our measurement models. All constructs have at least two items, which is consistent with the recommendations of Bollen (1989). We assessed the fit of our measurement models by the Bentler-Bonett Non-Normed Fit Index (NNFI; Bentler and Bonett, 1980), and the Comparative Fit Index (CFI; Bentler, 1990), as well as chi-square statistics and Root Mean Square Error Approximation (RMSEA). Our results indicate that our measurement models show acceptable fit to the data.

Table 2: CFA Results: Assessment of Reliability and Construct Validity of the Measurement Model

Construct	Items	Standardized loadings [1]	Standard Error	Composite reliability [2]	Variance extracted [3]	Model Fit [4]
Evaluation	Eval1	.77	.08	.92	.62	
	Eval2	.70	.08			
	Eval3	.67	.09			
	Eval4	.79	.07			
	Eval5	.79	.07			
	Eval6	.86	.06			
	Eval7	.90				χ^2= 256.74
Collaboration	Coll1	.56	.08	.89	.50	χ^2/ df = 1.77
	Coll2	.74	.11			*p-value* < .000
	Coll3	.71	.08			
	Coll4	.76	.10			CFI = .94
	Coll5	.74	.09			NNFI = .92
	Coll6	.60	.09			RMSEA = .07
	Coll7	.72	.07			
	Coll8	.76				
Buyer-specific Investments	Asset1	.79	.17	.84	.58	
	Asset2	.80	.50			
	Asset3	.76	.16			
	Asset4	.68				
Pollution Control	PC1	.74	.17	.80	.51	
	PC2	.66	.17			
	PC3	.62	.16			χ^2= 71.15
	PC4	.83				
Pollution Prevention	PP1	.63	.11	.84	.41	χ^2/ df = 1.55
	PP2	.53	.11			*p-value* = .01
	PP3	.71	.11			
	PP5	.56	.12			CFI = .96
	PP6	.57	.13			NNFI = .93
	PP7	.54	.13			RMSEA = .06
	PP8	.75	.11			
	PP9	.78				

[1] All loadings are significant at *p-value* < .001; Acceptable values are: [2] Composite reliability > .70 (Nunally, 1978); [3] Average variance extracted > .40 (Hatcher, 1994); [4] NNFI ≥ .9 (Gefen, 2000), χ^2/df < 3 (Hair *et al.*, 2006), RMSEA ≤ .10 (Hair *et al.*, 2006).

We assessed unidimensionality by checking whether the measures are significantly associated with their latent constructs and by evaluating the overall fit of the

CFA model (Hair *et al.*, 2006). Since the analyses returned satisfactory fit indices and have significant item loadings, we can conclude that all our constructs are unidimensional. To assess the reliability of our measures we applied two commonly used metrics: composite reliability and average variance extracted. Composite reliability is similar to Cronbach's alpha (Cronbach, 1951), which measures the degree of internal consistency of the indicators measuring a specific factor. Average variance extracted measures the amount of variance that is captured by an underlying factor in relation to the amount of variance due to measurement error (Fornell and Larcker, 1981; Hatcher, 1994). All constructs exhibited satisfactory reliability measures.

Content validity of our constructs was supported by the literature reviewed for this study as well as in-depth interviews with 13 operations, health, safety & environment, or marketing managers from the automotive, chemical, and electric and electronic products industries. We conducted these interviews following the suggestions of Eisenhardt (1989), Miles and Huberman (1994), and Yin (2003).

Construct validity assesses the "extent to which a set of *measured variables* actually represent the theoretical *latent construct* they are designed to measure" (Hair *et al.*, 2006, p. 707). Construct validity consists of two main parts – an item should load significantly on the construct it is designed to measure (convergent validity) and not be significantly associated with any other construct (discriminant validity) (Campbell and Fiske, 1959). Evidence of convergent validity can be found by observing items' loadings on their constructs. These loadings should be greater than twice the standard error (Gerbing and Anderson, 1988), all our constructs met this condition (see Table 2). We validated discriminant validity between the constructs by comparing chi-square differences between each two pairs of nested models. All pairs met the standard criteria.

In summary, all our constructs are reliable and valid and therefore, we can proceed with the analysis of the theoretical model. After ensuring the reliability and validity of our constructs, we created summated scales of our constructs (by averaging the items) in order to test our hypotheses. In Table 3, we present the correlation matrix and the descriptive statistics for our constructs.

Table 3: Pearson Correlation Matrix

Construct	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Pollution Control	3.03	1.11	1								
2. Pollution Prevention	3.18	.85	.56**	1							
3. Evaluation	1.75	.96	.19*	.35**	1						
4. Collaboration	2.02	.98	.27**	.37**	.61**	1					
5. Buyer-specific investments	3.12	1.16	.36**	.48**	.39*	.56**	1				
6. Product Type	4.11	1.33	.13	.26*	-.20†	-.16	.14	1			
7. Product Importance	4.16	1.10	.09	.10	.05	.18†	. 12	.18			
8. Plant Size	3.85	1.20	-.06	-.09	.38**	.21*	.13	-.24*	.05	1	
9. Plant Age	18.90	15.47	.05	-.16	.08	.10	-.01	-.02	-.01	.25*	1
10. Equipment Age	9.60	6.35	-.14	-.21	-.11	-.14	-.05	.01	-.01	.01	.42**

n = 156; † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

6 Results

6.1 Mediation Model

We used Ordinary Least Square regression method to test our hypotheses. For mediation, following the recommendations of Baron and Kenney (1986), we performed the OLS analyses in three stages. In the first stage, our mediator was regressed on independent variables; in the second stage dependent variables were regressed on the independent variables; and, in the last stage dependent variables were regressed on both independent variables and a mediator. We relied on Variance Inflation Factors (VIF) to check for potential multicollinearity. All values were less than 2 (the recommended cut-off value is 10 (Hair *et al.*, 2006)). The numbers presented in Table 4 reflect standardized regression coefficients.

Table 4: Mediation Model

	Stage 1	**Stage 2**				**Stage 3**	
	Model1	Model2		Model3[3]		Model4[4]	
Dependent Variables	Asset	PC	PP	PC	PP	PC	PP
Control Variables							
Product Type[1]		-.12	.16	$-.21^{\dagger}$	$-.27^{*}$	-.22	$-.29^{**}$
Product Importance		.05	$.20^{\dagger}$	.04	$.17^{\dagger}$	.02	.15
Number of Employees[2]		$.34^{**}$	.13	$.34^{**}$	.14	$.29^{**}$	.05
Plant Age (years)		.04	.15	.07	.16	.07	.17
Equipment Age (years)		-.18	-.20	-.06	-.11	-.08	-.14
Main Effects							
Evaluation (Eval)	.10			.02	.13	-.01	.08
Collaboration (Coll)	$.42^{**}$			$.34^{*}$	$.36^{**}$	.22	.16
Mediator							
Buyer-specific Investments (Asset)						$.27^{*}$	$.46^{**}$
Statistic							
R^2	$.24^{**}$	$.17^{*}$	$.13^{\dagger}$	$.28^{**}$	$.32^{**}$	$.34^{**}$	$.69^{**}$
Adj. R^2	.23	.11	.07	.21	.25	.26	.41
R^2 *change*				$.10^{**}$	$.18^{**}$	$.05^{**}$	$.16^{**}$

n = 156; $^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; [1] 5-point Likert scale (Commodity -> Specialty); [2] Natural logarithmic transformation of number of employees; ; [3] The R-square change is based on the difference between Model 3 and Model 2; [4] The R-square change is based on the difference between Model 4 and Model 3.

As shown in Table 4, the effect of Evaluation on Buyer-specific investments is not significant, rejecting H1a. However, the effect of collaboration on supplier asset specificity in the first model is significant, supporting H1b. Also the effect of collaboration on pollution control and prevention in the third model is significant (*p* <

.05). Note, however, that the significant effect of collaboration on pollution control and prevention once supplier asset specificity is introduced in the forth model becomes non-significant, leaving only the direct effect of asset specificity on pollution control and prevention to be significant ($p < .05$). These results support H2. On the other hand, we do not observe any significant effect of evaluation on neither buyer–specific investments nor pollution prevention and control.

Overall, combined with the significant R-square change, our results partially support the mediating role of buyer-specific investments (H3). They suggest that supplier asset specificity fully mediates the effect of collaboration on pollution control and pollution prevention. The results provide no support, however, for our argument that supplier asset specificity will mediate the effect of evaluation on either pollution control or prevention.

6.2 Moderation Model

To test moderation, we performed the OLS analyses in five steps, each time adding a group of explanatory variables. The numbers presented in Table 5 reflect standardized regression coefficients. Before conducting our analyses, to avoid multicollinearity, we centered our data by subtracting mean from the observed values of our variables (Baron and Kenney, 1986). All Variance Inflation Factor (VIF) values were less than 2.5 (the recommended cut-off value is 10 (Hair *et al.*, 2006)).

Table 5: Moderation model

	Models									
	Model1		Model2		Model3		Model4		Model5[3]	
Dependent Variables	PC	PP	PC	PP	PC	PP	PC	PP	PC	PP
Control Variables										
Product Type[1]	-.12	.16	$-.21^{\dagger}$	$-.27^{*}$	$-.22^{*}$	-29^{**}	-.18	$-.25^{*}$	$-.22^{*}$	$-.29^{**}$
Product Importance	.05	$.20^{\dagger}$	.04	$.17^{\dagger}$	.02	$.15^{\dagger}$	.04	$.16^{\dagger}$	.05	$.16^{\dagger}$
Number of employees[2]	$.34^{**}$	.13	$.34^{**}$	.14	$.29^{**}$	.05	$.31^{**}$	.07	$.31^{**}$	.06
Plant Age (years)	.04	.15	.07	.16	.07	.17	.10	$.20^{\dagger}$	.09	$.18^{\dagger}$
Equipment Age (years)	-.18	-.20	-.06	-.11	-.08	-.14	-.10	-.16	-.08	-.14
Main Effects										
Evaluation (Eval)			.02	.13	-.01	.08	-.09	.01	.03	.07
Collaboration (Coll)			$.34^{*}$	$.36^{**}$	.23	.16	.23	.17	.19	.13
Moderator										
Buyer-specific Investments (Asset)					$.27^{*}$	$.46^{**}$	$.25^{*}$	$.46^{**}$	$.25^{*}$	$.49^{**}$
Interaction Effects										
Eval X Asset							.18	$.18^{\dagger}$		
Coll X Asset									$.25^{*}$	$.18^{*}$
Statistic										
R^2	$.17^{*}$	$.13^{\dagger}$	$.28^{**}$	$.32^{**}$	$.33^{**}$	$.47^{**}$	$.36^{**}$	$.49^{**}$	$.40^{**}$	$.50^{**}$
Adj. R^2			.21	.25	.26	.41	.27	.43	.31	.44
R^2 *change*			$.10^{**}$	$.18^{**}$	$.05^{*}$	$.16^{**}$	.01	$.02^{\dagger}$	$.04^{*}$	$.03^{*}$

$n = 156$; $^{\dagger} p < 0.1$; $^{*} p < 0.05$; $^{**} p < 0.01$; [1] 5-point Likert scale (Commodity -> Specialty); [2] Natural logarithmic transformation of number of employees; [3] The R-square change is based on the difference between Models 3 and 5.

The positive and significant coefficient of Eval*Asset in model 4 ($p < .1$), suggests that supplier asset specificity moderates the positive effect of evaluation on pollution prevention, thus providing support to H4b. No support was found for hypothesis H4a, suggesting that supplier asset specificity moderates the positive effect of evaluation on pollution control. The positive and significant coefficients of Coll*Asset in model 5 ($p<.05$), suggest that supplier asset specificity moderates the positive effect of collaboration on pollution control and pollution prevention, thus providing support to H4c and H4d.

Lastly, as for the control variables, our results suggest that the number of employees or the size of the plant positively affects the investments on pollution control whereas product complexity has a negative impact on both pollution prevention and control. On the other hand, we did not observe any significant effect of neither the age of the equipment nor plant age on pollution prevention and control.

7 Discussion

Prior research has identified two buyer actions – evaluation and collaboration – as being key drivers of a supplier's decision to invest in environmental technologies (Klassen and Vachon, 2003). First, since our items for both buyer actions (evaluation and collaboration) and environmental investments (PC and PP) are significantly different from those used in prior research (Klassen and Vachon, 2003; Vachon, 2007), our results should not be compared to each other. In addition, given inconsistent results regarding the impact of evaluation and collaboration on environmental investments reported in the literature, the aim of this research is to expand prior insight by testing both the mediating and moderating role of buyer-specific investments on the relationship between buyer actions and supplier environmental investments.

We drew from Relational Exchange Theory to argue the mediating role of buyer-specific assents between buyer actions and supplier investments. As demonstrated by our results, however, only the results for one buyer action – collaboration – are significant, with evaluation fostering neither supplier asset specificity nor supplier investments. Recall our argument that evaluation is a type of specific asset investment by the buyer in the supplier, which in turn triggers reciprocal investments by the supplier. Note that this argument assumes that suppliers perceive evaluation as a type of specific asset investment by the buyer in the supplier made with the intent to enhance supplier performance. Our results suggest that this is not the case. Another explanation for the non-significant result is that two contrary forces may be at work, cancelling each other and resulting in a very small and non-significant effect. Thus, in addition to the positive force noted above, buyer evaluation may also unleash a negative force in the form of supplier reactance (Brehm, 1966) to perceived constraints on their freedom, which manifests in the form of supplier non-responsiveness to buyer preferences. Future research should disentangle these forces in the form of specific mediators, thereby providing a more detailed and comprehensive understanding of the mechanisms by which buyer evaluation affects supplier decisions to invest specific assets in the buyer.

In terms of identifying the boundary conditions for the effects of buyer actions on supplier investments, we posited supplier asset specificity as the moderating factor that would enhance the effects of buyer actions. In line with the results for mediation, results of our moderation model show that, while the impact of *collaboration* on supplier investment in pollution control and pollution prevention is indeed enhanced, supplier asset specificity has no impact on the effectiveness of *evaluation* on supplier investment in pollution control technologies and only limited effectiveness on supplier investment in pollution prevention technologies. This pattern of results for evaluation provides additional credence for the Reactance Theory argument and further suggests that, even if it is in the supplier's self-interest to conform to manufacturer preferences, such "rational" behavior is ruled out once reactance has been activated within the supplier against the buyer's attempt to constrain their decision making freedom.

7.1 Theoretical Implications

Our conceptual model integrates insights from Relational Exchange Theory and Self Enforcing Contract Theory (SECT). As such, our empirical results offer implications for both theories. In our view, integration of both theories results in a more nuanced and comprehensive understanding of the role that supplier asset specificity plays in the relationship between buyer actions and supplier investments. Thus, whereas Relational Exchange Theory suggests only a mediating role for supplier asset specificity, results from our research show that, in addition to being a mediator, it also moderates the relationship between buyer actions and supplier investments. The implication of this finding for Relational Exchange Theory is the following. The theory has a strong process orientation, outlining as it does the various stages of relationship development and evolution. A necessary complement to this process focus in our view is a consideration of the structure within which this process unfolds. Indeed, as prior research has noted, outputs from earlier stages of a process become structural characteristics that affect future stages of the process. Thus, we encourage the continued development of Relational Exchange Theory in a manner that consciously incorporates the dynamic interactions between structural and process characteristics.

On the other hand, SECT suggests only a moderating role for supplier asset specificity. Our research results show that, in addition to being a moderator, it also mediates the antecedent-outcome relationship. SECT has a strong structural focus. It identifies structural characteristics that need to be in place for transactions to be executed without governance recourse to third parties. The theory, however, is more or less silent on the sociology of the relationship with which these transactions occur. By acknowledging the social context within which transactions unfold, SECT will be able to identify key process characteristics such as trust and relational norms that make the crafting of formal structural self enforcing mechanisms unnecessary and/or process characteristics that will enable their installation (e.g., Heide and John, 1992). Thus, we encourage the development of SECT along the lines of incorporating the social context of relationships to complement its understanding how transactions should be structured to yield optimal efficiency.

To summarize, to better understand the relationship between a buyer and a supplier, it is equally important to take into account both structural characteristics of the relationship and relevant to the relationship social context. If only one of these two factors is considered, the understanding of the interaction between a buyer and a supplier will not be complete.

7.2 Managerial Implications

Across the industrial landscape, manufacturing firms are under pressure from civil society groups to reduce their environmental footprint. The best-in-class manufacturing firms have responded to these calls by not only reducing their own environmental footprint but also that of the supply chain that they depend upon for essential input components. As the practice of working with suppliers to reduce the environmental footprint of the supply chain spreads across firms and industries it has become increasingly important for manufacturing firms to identify the drivers and enabling conditions that trigger supplier investment in environmental technologies.

In our research we asked the question how, und under what conditions, buyers can effectively influence suppliers to invest in environmental technologies, namely pollution prevention (PP) and pollution control (PC). Our research results are very clear: the key driver of supplier investment in both types of technologies (PC and PP) is buyer collaboration. Thus, to be better able to help build green supply chains, we recommend that managers of manufacturing firms initiate collaborative arrangements with their suppliers in the form of joint activities in domains such as product design, process design and training across all organizational levels. The experience of firms such as Wal-Mart, Home Depot, and Loblaws (Harris, 2007), all of whom have collaborated with their suppliers extensively and were able to improve the performance of the whole supply chain, provides a wealth of case-based data to validate this recommendation (see also Sharma and Vredenburg, 1998).

Note that, for the supplier, invetstments in PP differ substantially from investments in PC. While pollution control filters or cleans pollution after they have been created (but before being released), pollution prevention strives to change product and process designs such that the generation of pollutants is minimized in the first place. The literature indicates that investments in PP result in a broader set of benefits than investments in PC. For example, King and Lenox (2002) found that investments in pollution prevention alone were responsible for increases in profitability; Sharma and Vredenburg (1998) found that proactive companies perceived a number of competitive benefits, compared to their reactive competitors, etc. These insights mirrors those from the quality management literature which shows that, unlike quality control, quality by design is associated with a range of performance benefits (e.g., Yeung *et al.*, 2003).

On the other hand, Klassen and Whybark (1999a) found that proactively oriented companies had a balanced portfolio of investments in both PC and PP technologies. The reason might be in the PP technologies themselves. In our set of case studies performed prior to this research, we asked managers to report any problems associated with the adoption of Pollution Prevention technologies. One of the managers from a company producing electronic components reported that a product that did not contain lead was not as reliable as the one containing lead. That means, that sometimes it is not feasible to invest in PP technologies only, because (1) they might not bring immediate benefits (Halme and Niskanen, 2001), when the company is to comply with regulations, and (2) the PP technology might be not developed well enough in order to be comparable to the market alternative (Klassen and Whybark, 1999a). However, investments in PP technologies are still preferred, since they can offer more benefits, which include competitive advantage in the market (Hart, 1995; Sharma and Vredenburg, 1998).

Note that supplier investment in environmental technologies may require substantial capital outlays with extended payback periods (Halme and Niskanen, 2001). As a result, suppliers may not be naturally inclined to make these investments. Our results indicated that when the choice was to be made between environmental investments and buyer-specific assets, suppliers favored investments in specific assets (see Model 3 in Table 5, Chapter 2), because these helped to improve the relationship with a buyer and thus perceived as the most beneficial. Prior literature (e.g., Pagell *et al.*, 2004), however, indicates that investments in environmental technologies should not be viewed as a cost, but rather as an opportunity because they create capabilities for a company (Hart, 1995) which, in turn, help improve market position and performance (Sharma and Vredenburg, 1998). We thus recommend increasing awareness of the suppliers of the potential benefits from investing in environmental technologies. If all members of the supply chain view environmental investments as opportunity, significant improvement of the whole supply chain might be achieved (Pagell *et al.*, 2004).

7.3 Limitations and Future Research

Recall that our data was collected from single respondents (per organization) using a cross-sectional survey based design. The use of a single respondent design makes our findings vulnerable to two key threats: (i) poor quality data and (ii) same source bias. To ensure that our data was of high quality we qualified our respondents both prior to establishing their willingness to participate in the survey and during the survey itself. Data from both stages led to the conclusion that the respondents were highly knowledgeable regarding the issues raised in the survey, thereby giving us the confidence that lack of quality in the data is not a threat to our research findings.

Same source bias refers to a condition where the correlation between the independent and dependent variables is high not because it is reflective of reality but because data on both variable sets is collected from the same data source. The common source bias is further exacerbated when data on both variable sets is collected using the same research method (e.g., the same survey). To investigate the possibility of these biases in our data we examined our correlation matrix to identify significant correlations that could not be explained theoretically or logically. None of the significant correlations was surprising from either perspective. Also, we conducted the Harman's one-factor test (Podzakoff and Organ, 1986) and found that the first factor accounted for only 29.4% of the variance, thereby providing no evidence for the hypothesis that the common source-common method design used in our study resulted in bias.

While we make implicit claims of causality in our research model, note that the cross-sectional nature of our study does not allow us to validate these claims. Future research should adopt a longitudinal design whereby data is collected at one point in time on the independent variables and at a subsequent point in time on the dependent variables. Thus, for example, researchers could identify a sample of recently initiated buyer-supplier relationships and track these relationships over time with measurements of the model variables taken along the way. Such a design would permit a rigorous test of the causal claims that are implied in our research model.

Future research should try to integrate Relational Exchange Theory and Self-Enforcing Contract Theory in a single mediation-moderating model to advance our understanding of the interaction between the two. In addition, besides asset-specificity, other important factors, such as power-dynamics between a buyer and a supplier, might be considered in explaining why, how and when buyer actions trigger supplier investments in environmental technologies.

Additionally, as noted in Table 1, our sample comprised mostly small firms across only three SIC codes. Both these sample characteristics should be noted before generalizing our findings across industries and across the size of supplier firms. Indeed, to enhance the external validity of our research, future research should investigate our models across a wider cross-section of SIC codes and supplier firm sizes. Finally, despite the precautions taken to ensure that same source bias did not contaminate our results, it remains the case that a future design that collects data from multiple data sources will provide a stronger test of our research model.

Whereas evaluation and collaboration are characterized as independent activities that are undertaken by the buyer, in reality these buyer activities may be inter-twinned as buyers engage in both actions simultaneously. Future research should theorize and empirically investigate the direct effects of the interaction between collaboration and evaluation on supplier investment in pollution control and pollution prevention technologies. Further, future research should also investigate the mediating/moderating role played by asset specificity in this relationship. Whereas our focus has been on buyer actions as key drivers of supplier decisions to invest in environmental technologies, other factors such as the role of the institutional environment (Zhu and Sarkis, 2007), power-dynamics within the relationship (Gulati and Sytch, 2007), and the influence strategies that buyers use to convince suppliers to make these decisions (McFarland *et al.*, 2008), all may have a bearing on whether or not suppliers decide to undertake these investments. Future research should expand the focus of our model by systematically incorporating each of these factors as additional drivers of supplier investment in environmental technologies, thereby generating a more comprehensive understanding of this phenomenon.

The Triple Bottom Line Construct: Scale Development and Validation

1 Abstract

The "Triple Bottom Line" (TBL) reporting framework suggests that companies report not only their economic, but also environmental and social performance. More than 10 years after the conception of the TBL concept, however, it is still not clear how to empirically measure performance along the three components as up-to-date, valid and reliable scales do not exist for two of the three dimensions. The objective of the current paper is to address this shortcoming.

We develop constructs using the two-stage approach recommended by Menor and Roth (2007), with an alteration to the first phase. During the first phase, we test three different versions of the Q-sort methodology and compare them to each other, thus extending the methodological toolkit available in the operations management literature. The extended Q-sort methodology helps us to identify problems with constructs that a traditional Q-sort methodology usually used in Operations Management literature fails to point out.

Based on a review of the literature and guidelines of practitioners' organizations, we indentified a list of 55 items to measure TBL. As a result of reliability and validity tests, this list was later reduced to 47 items. We found that, empirically speaking, TBL performance consists of nine rather than three dimensions. All environmental items loaded on one dimension; social items loaded on two distinct dimensions – employee relationships and external social performance, while economic performance consisted of

financial, market, flexibility, quality, reliability and cost performance. The last four dimensions are defined as manufacturing capabilities and should be kept as separate constructs.

Besides the methodological contributions, the resulting constructs can be used by researchers within and beyond the operations management field as well as rating agencies that currently tend to use less reliable and complete measures.

2 What is Happening to the Triple Bottom Line?

Three types of unresolved issues currently exist within the business sustainability literature: definitional, causational and measurement problems. We will briefly address these problems in the following paragraphs.

The concept of the *Triple Bottom Line* (TBL) was first introduced by Elkington in 1994 and later expanded in his book "Cannibals with Forks: The Triple Bottom Line of 21st Century Business" (1998). The TBL is a framework for measuring and reporting corporate performance along three prongs of the fork - economic prosperity, environmental quality, and social improvement. Economic prosperity is the economic impact of the organization on the environment in which it operates, and therefore cannot be viewed as the traditional internal profit of the organization alone. Environmental quality measures the environmental footprint of the organization. It should be based on comprehensive life cycle assessments of its products to determine their possible effects on the natural environment. Social improvement is about fair practices of the organization towards its employees, customers, suppliers, communities and other stakeholders. According to Eklington, all three dimensions must be considered simultaneously since each management decision either directly or indirectly affects all of them. For example, Pullman *et al.* (2009) found that environmental and social sustainability practices had a direct effect on environmental and quality performance and indirect (through quality) effect on cost performance. Indeed, most large corporations have displayed an increasing interest in reporting along the dimensions of the TBL, as exemplified by companies such as Canon, British Airways, Fuji Xerox, Shell, Sony and many others (Omniserve, 2008). Even if firms decide to continue using a sole focus on financials, external rating agencies (e.g., KDL or the Dow Jones Sustainability indices) take the liberty to do it for them.

The term TBL is often used synonymously with *Corporate Social Responsibility* (CSR), *Corporate Social Performance* (CSP) and *Sustainability* (or *Sustainable Development* or *Business Sustainability*), and there is neither a clear differentiation between these three very ubiquitous terms (Hart, 2005; Silberhorn and Warren, 2007), nor an agreed-upon way of measuring the outcomes. Typically, *sustainability* is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development, 1987, p. 8). Daly (1990) lists several principles that should be followed in order to achieve sustainable development. For renewable resources (1) "harvest rates should equal regeneration rates", and (2) "waste emission rates should equal the natural assimilative capacities of the ecosystems into which the wastes are emitted" (p. 2). For non-renewable resources "any investment in the exploitation of a nonrenewable resource must be paired with a compensating investment in a renewable substitute" (p. 4).

Clearly, plants use renewable and non-renewable resources as inputs and generate waste. Therefore, they affect the ecosystem in which they operate, an assertion that is equally valid with respect to social systems.

In contrast, no uniform definition of the CSR exists (Aupperle *et al.*, 1985). Synthesizing the meaning of the most common descriptions of this term (see Dahlsrud (2008) for the list of select definitions), a common and recurring theme is the organization's responsibility towards the wellbeing of the society in which it operates. Thus, *CSR* refers to the policies and activities a company engages in, as evaluated through the eyes of the company's stakeholders, with CSP being the outcome measure of CSR.

The following points become clear from the above discussion. First, the terms sustainability and CSR are closely related to one another. Clearly, ensuring future generations' viability goes hand in hand with corporations behaving ethically and responsibly. Second, although sometimes treated differently in the literature, sustainability and CSR share the trait of being action-oriented. This stands in stark contrast to the TBL concept, which is not concerned with actions but with performance (although it frequently is not treated as such in the literature, e.g., (Stanwick and Stanwick, 1998; Orlitzky *et al.*, 2003)). That is, as the TBL covers the performance dimensions targeted by the sustainability and CSR concepts, it is suitable for measuring the impacts of such actions on the organization's financial, environmental and social performance dimensions. Even though, currently, most organizations measure activities as proxies of their environmental or social performance (e.g., "we donated …"; "we engaged in …"), ultimately performance measures will have to address the real impacts of all activities on the long list of stakeholders and beneficiaries (e.g., "through our donation, we enabled …"; "through supporting this initiative with our expertise, the recipient benefited …").

The second difficulty relates to the first one and concerns causality. Although individual dimensions of the TBL (economic, environmental, and social) are considered in many research papers (e.g., Abbott and Monsen, 1979; Klassen and McLaughlin, 1996; King and Lenox, 2002, they are typically used in terms of a single dimension (e.g., plant performance is measured only in environmental terms, not taking into account the financial or social impact of plant's activities). Alternatively, many papers, instead of assessing the three dimensions of the TBL as outcome measures, attempt to prove the existence of causal effects between a pair of them (e.g., Pil and Rothenberg, 2003, Orlitzky *et al.*, 2003, Stanwick and Stanwick, 1998). Given the conceptual argument above – that is has to be actions that simultaneously affect the three categories of outcome measures – however, such attempts make little sense beyond the fact that, for various reasons, the outcome measures may be correlated with each other. For example, the literature has shown that pollution prevention activities benefit the environment (Klassen and Whybark, 1999b) and the firm's financial performance (Klassen and McLaughlin, 1996), suggesting that non-exclusive relationship between the two dimensions may exist.

Lastly, measurement issues prevail. Although measurements for the economic dimension have long been established and validated both in academia and practice, the same does not hold for the environmental and social dimensions. Due to the lack of reliable data, performance along the latter two dimensions is often estimated using either rankings based on incomplete information (e.g., the ethical rating using New Economics Foundation and Cooperative Bank's ratings or Fortune magazine's annual survey on corporate reputations) or other publicly available sources (such as environmental awards) that serve as proxies for actual performance. To date, data for social performance barely exists. Instead, firms speak of activities as part of their social reporting, rather than the impact of these activities (e.g., Holmes, 1977). As for environmental reporting, the most reliable measures to date include pollution reports submitted by manufacturers to the US EPA's Toxics Release Inventory (TRI) or the Canadian National Pollution Release Inventory (NPRI). Still, not all pollutants are included in these frameworks, and plants have to report pollution only once they exceed a certain size and certain pollution thresholds and belong to certain industries. In addition, not all pollutants are similarly detrimental to the natural environment of human health – something else not reflected in the existing pollution databases.

In conclusion, our position is that the TBL constructs constitute solely a set of outcome measures. Correlations appear to exist between items of the three dimensions. Those, however, should not be interpreted as causal relationships, as activities (such as CSR or sustainable activities, or green manufacturing / supply chain activities) are necessary to drive changes in the TBL outcomes. Given the need to use the TBL as a set of outcome measures to measure the effects of sustainable development and CSR activities, a valid and reliable way of measuring it is needed but not readily available.

3 Purpose and Structure of this Paper

Given the importance of proper outcome measurement for both organizations and researchers, this paper seeks to develop a valid and reliable multi-dimensional construct for TBL measurement. To do so, we follow a rigorous, two-stage scale development process (Churchill, 1979; Menor and Roth, 2007) as outlined by Menor and Roth (2007). In the first step, however, we extend the Q-sorting technique currently used in the Operations Management literature (Stratman and Roth, 2002; Swafford *et al.*, 2006; Froehle and Roth, 2007; Menor and Roth, 2007). A drawback of the current approach is that it does not confirm the Likert scale structure of the items used to measure constructs (Stephenson, 1953). We therefore propose an extra step to purify the items before going into large scale data collection. In this step the scales are factor analyzed, thus confirming their structure during the first stage of the construct development process (Bish and Schriesheim, 1974; Hinkin and Schriesheim, 1989).

Along these lines, in section 4 we define the TBL construct and discuss measures available to measure it. In section 5 we present the scale development process and the psychometric properties of our scales. Conclusions, limitations and directions for future research follow next.

4 Conceptual Development

4.1 Measuring the Dimensions of the Triple Bottom Line

4.1.1 Data Sources and Proposed Dimensions

Since CSR, Sustainability, CSP and the TBL are used interchangeably in the literature we based our review of the existing scales covering all four terms. We included empirical studies that propose dimensions of CSR/CSP/Sustainability/TBL (e.g., Carroll, 1979), directly investigate one or more dimensions (e.g., Abbott and Monsen, 1979; Bragdon and Marlin, 1972), or use publicly available sources (e.g., Markley and Davis, 2007). We also reviewed rating systems, such as that of the Global Reporting Initiative and the Dow Jones Sustainability index.

There is no uniform agreement as to how many and which dimensions should be considered when measuring activities or the performance of companies. The range varies from three (e.g., Elkington, 1998) to more than seven dimensions (e.g., Abbott and Monsen, 1979). However, if we adopt the TBL framework, each one of the dimensions of different studies or practitioners' organizations can be classified into one of the three dimensions of the TBL framework. Moreover, both academics and practitioners have come to think of performance measurement as occurring in three dimensions. Thus, we will structure our literature review around the Economic, Environmental, and Social dimensions as defined by the TBL framework. The exact number of factors will be later determined by various statistical methods.

Carroll (1979) defined four components that should be considered when defining CSR, including economic, legal, ethical, and discretionary responsibilities. *Economic* responsibility is defined as "a responsibility to produce goods and services that society wants and to sell them at a profit" (Carroll, 1979, p. 500). This dimension is similar to the Economic one of the TBL. An organization cannot fulfill its economic responsibility without considering the legal implications – "laws and regulations" – of its business, linking to the organization's *legal* responsibilities. *Ethical* responsibilities go beyond the legal ones. There are some activities that are not forbidden by law but nevertheless considered unethical, and therefore it is expected that organizations adhere to whatever is the tightest constraint —ethical or legal. Although there is no one-by-one congruence of the above two dimensions (legal and ethical) to the dimensions of the TBL, the components of both dimensions neatly fit into the Social and Environmental dimensions. *Discretionary* responsibilities are less clearly defined. They go beyond the legal and ethical requirements, and thus they remain at the discretion of a company. In the CSR literature, they are often referred to as philanthropic activities. Examples of discretionary responsibilities might be "providing day-care centres for working mothers" or "training hardcore unemployed" (p. 500). These activities can be a part of all three TBL dimensions, but typically fit into the social dimension.

Based on the review of five studies, Aupperle *et al.* (1985) identified a list of 117 statements to measure Carroll's CSP construct. After performing different reliability and validity checks, this list was reduced to 59 items. This study focused on the CSR activities, rather than CSR performance (CSP). As a result, the scales, although suitable for providing some guidance, cannot be used to directly measure TBL.

Based on the analysis of corporate reports of *Fortune 500* companies, Abbott and Monsen (1979) developed a measurement system for corporate social disclosure. This system consists of seven main dimensions: Environment, Equal Opportunity, Personnel, Community Involvement, Products, Location of Disclosures and Other/Additional Information. Each dimension is measured through several indicators. Equal Opportunity, Personnel, and Community Involvement can be classified as part of the Social dimension of the TBL. The Product dimension includes safety and quality. Safety resulting from the use of the product can be classified as social (safety of employees or communities) dimension, while quality may form a part of either economic (manufacturing) or social performance.

Beyond these two major studies, certain publicly available sources are frequently used in empirical studies as proxies for different performance measures (e.g., Markley and Davis, 2007). These sources include Innovest (http://www.innovestgroup.com) and KLD (http://www.kld.com). Innovest tracks companies' performance along 120 factors of sustainability and finance. It rates more than 2000 publicly traded companies listed on the major stock exchanges. Its ratings focus on the following areas: Strategic Governance, Human Capital, Stakeholder Capital, and Environment. Strategic Governance includes criteria such as Product Safety, Intellectual Capital / Product Development, and thus can be classified as part of the Social Dimension, along with

Human and Stakeholder Capital's areas. Clearly, the Environmental area corresponds to the Environmental dimension of the TBL.

Similarly, the KLD indices focus on *environmental, social and governance* factors (KLD Research & Analytics, 2009b). Again, social and governance factors form the Social dimension of the TBL, while environmental corresponds to the environmental dimension. A drawback of the Innovest and KLD indices is that both are based on information gleaned from corporate reports, government sources, media, and industry associations. Therefore, the ranked companies tend to be larger industry players. Moreover, the ratings tend to be based on what firms have done, rather than what they have achieved.

There are also practitioners' organizations that rate companies using a variety of indicators. The Dow Jones Sustainability Index (DJSI) (www.sustainability-index.com) and the Global Reporting Initiative (GRI) (www.globalreporting.org) use the three main dimensions set out by the TBL construct. The DJSI assesses companies using publicly available information only; whereas GRI, although providing guidelines for assessing performance, does not list any specific indicators to be used.

Again, we will structure our further review of the literature around three dimensions of the TBL. By using various statistical methods later on, the exact number of factors that should form the TBL will be determined. The items of these sources were collected and reviewed as the basis for developing a comprehensive set of items for each one of the three dimensions. The measurement of the three dimensions is discussed in detail in the following subsections.

4.1.2 The Economic Dimension of the TBL

The economic responsibility of a company, as defined by a Carroll's construct of corporate performance, is "to produce goods and services that society wants and to sell them at a profit" (Carroll, 1979, p. 500). That means that while products and services should have attributes attractive to buyers and final consumers (e.g., high quality, low cost, etc.), a company should be able to generate profits and enjoy a reasonable market position. Economic performance is typically measured using a variety of dimensions, including market share, financial and manufacturing performance (reflecting some of its capabilities). That is, it appears that economic performance in itself may be a three-dimensional construct. Definitions of the three dimensions can be found in Table 6. We reviewed the comprehensive collection of economic measures used in the literature by studying the work of Roth, Schroeder, Huang, and Kristal (2007). For each one of the sub-dimensions comprehensive lists of items exist, as shown in Table 7[1].

[1] Although we tried to compile a complete list, due to space limitations not all references are mentioned in our study. For a full list of references please refer to Roth, A. V., R. G. Schroeder, et al. (2008). Handbook of Metrics for Research in Operations Management: Multi-item Measurement Scales and Objective Items. Thousand Oaks, California, Sage Publications..

Table 6: Operational definitions of the Economic Dimension of TBL

Construct	Definition
Manufacturing Performance	Realized manufacturing capabilities of the plant, including cost, quality, flexibility, and delivery.[1]
Financial Performance	Performance of the plant in monetary terms.
Market Performance	Degree of the plant's presence in the market place.

[1] The four capabilities are treated as separate constructs.

Table 7: Items used to measure manufacturing dimension of economic performance

Economic Performance Dimension	Measure	References
Manufacturing Capabilities	Cost (overall, as a percentage of sales)	Cleveland *et al.*, 1989; Flynn *et al.*, 1995; Bozarth and Edwards, 1997; Klassen and Whybark, 1999b; Cua *et al.*, 2001; Schroeder *et al.*, 2002
	Quality (overall, conformance, performance)	Cleveland *et al.*, 1989; Bozarth and Edwards, 1997; Klassen and Whybark, 1999b; Carter and Dresner, 2001; Cua *et al.*, 2001; Schroeder *et al.*, 2002
	Delivery (speed, reliability, on time, cycle time)	Flynn *et al.*, 1995; Bozarth and Edwards, 1997; Klassen and Whybark, 1999b; Cua *et al.*, 2001; Schroeder *et al.*, 2002
	Product range	Bozarth and Edwards, 1997
	Design capability	Bozarth and Edwards, 1997
	Dependability	Cleveland *et al.*, 1989
	Flexibility (overall, to change volume, length of fixed production schedule)	Cleveland *et al.*, 1989; Flynn *et al.*, 1995; Klassen and Whybark, 1999b; Cua *et al.*, 2001; Schroeder *et al.*, 2002
	Inventory turnover	Flynn *et al.*, 1995
Market Performance	Market share (overall, growth in)	Cleveland *et al.*, 1989; Roth, 1993; Roth and Jackson III, 1995; Vickery *et al.*, 1995; Burgess *et al.*, 1997; Burnes and New, 1997; Li *et al.*, 2002; Kaynak, 2003; Christensen *et al.*, 2005; Swink *et al.*, 2005

	Sales growth	Cleveland *et al.*, 1989; Vickery *et al.*, 1995; Kaynak, 2003; Christensen *et al.*, 2005; Swink *et al.*, 2005
	Competitive position	Hausman *et al.*, 2002
Financial Performance	Annual profit	Global Reporting Initiative, 2007
	Average assets	McGuire *et al.*, 1988
	Profit as % of sales	Adam *et al.*, 1997; Carr and Pearson, 1999; Chen *et al.*, 2004
	ROA (pre-tax, after tax)	Global Reporting Initiative, 2007
	ROI (overall, growth in)	Vickery *et al.*, 1995; Global Reporting Initiative, 1997b; Carr and Pearson, 1999; Droge *et al.*, 2003; Kaynak, 2003; Vickery *et al.*, 2003; Chen *et al.*, 2004; Cao and Dowlatshahi, 2005; Markley and Davis, 2007
	ROS (overall, growth in)	Vickery *et al.*, 1995; Vickery *et al.*, 2003; Cao and Dowlatshahi, 2005
	Liquidity	Cao and Dowlatshahi, 2005
	Cash flow	Cao and Dowlatshahi, 2005
	Profitability	Roth, 1993; Roth and Jackson III, 1995; Hausman *et al.*, 2002; Droge *et al.*, 2003; Rosenzweig and Roth, 2004; Cao and Dowlatshahi, 2005; Swink *et al.*, 2005
	Income (net, per employee)	Roth, 1993; Carr and Pearson, 1999; Chen *et al.*, 2004
	Present value	Carr and Pearson, 1999
	Profit growth	Droge *et al.*, 2003; Kaynak, 2003
	Operating profit	Li *et al.*, 2002
	Operating income growth	McGuire *et al.*, 1988
	Price/earnings ratio	Roth, 1993
	ROE	Bragdon and Marlin, 1972; Bowman and Haire, 1975; Roth, 1993
	Stock performance	Klassen and McLaughlin, 1996
	Tobin's q	King and Lenox, 2002; Markley and Davis, 2007
	Financial implications due to climate change, financial assistance form the government	Global Reporting Initiative, 2007

The GRI guidelines go beyond the costs and revenues of the focal firm. In the Economic indicators section they also include financial implications as well as risks and opportunities associated with climate change. Note that this indicator relates to the Environmental dimension, since greenhouse emissions affecting climate change might be costly to avoid or, instead, create revenues in carbon markets, if reduced. Other non-traditional indicators listed under the economic dimension include benefit plans, wage levels, and procedures for local hiring. These three items might better be classified as part of Social performance since they are concerned with stakeholders internal to the firm (i.e., employees). Government financial assistance and spending on locally-based suppliers, although very important to company's investors, do not actually directly reflect performance on any of the three dimensions. The GRI defines and suggests a way of compiling each indicator. For the sake of flexibility, however, the development of the exact measures is often left to the user. Due to the fact that most of the GRI items that go beyond the collection of traditional economic items are directly or indirectly covered in the environmental or social dimensions, we refrained from adding them to the already long list of economic performance measures shown in Table 7.

4.1.3 The Environmental dimension of the TBL

The environmental dimension of the TBL performance reflects an organization's ecological footprint. A review of the literature has shown that most empirical studies use environmental performance measures based on either publicly available data or ratings provided by consultancies. The constructs used are summarized in Table 8 and discussed further in the remainder of this subsection.

Table 8: Items used to measure environmental performance

Measure	References
Compliance	Global Reporting Initiative, 2007
Emissions, effluences, and waste (incl. Toxics Release Inventory (TRI))	Global Reporting Initiative, 1997a; Klassen and Whybark, 1999a; The New Economic Foundation, 2009
Inputs (incl. materials, energy, water)	Global Reporting Initiative, 2007
Overall environmental impact (incl. climate change, biodiversity)	Global Reporting Initiative, 1997a; Innovest, 2009; KLD Research & Analytics, 2009a
Pollution Control*	Bragdon and Marlin, 1972; Abbott and Monsen, 1979
Pollution Prevention*	KLD Research & Analytics, 2009a
Products and services	Abbott and Monsen, 1979; Global Reporting Initiative, 1997a; KLD Research & Analytics, 2009a
Recycling*	Abbott and Monsen, 1979; KLD Research & Analytics, 2009a; The New Economic Foundation, 2009
Repair of environment*	Abbott and Monsen, 1979

* Activity-, rather than performance-based, measures

Several observations follow from this table. First, many of the dimensions used to assess environmental performance actually measure *activities* performed by a company rather than *performance*. For example, the pollution control index provides information on how much pollution control equipment has been installed by a company, rather than (reductions in) pollution levels. The same argument is true for the Pollution Prevention, Repair of environment and Recycling indicators. If these indicators are to be used, they need to be modified to reflect outcomes, rather than activities.

Second, the "overall environmental impact" indicators used by KLD, Innovest, and GRI are very broad measures and therefore should be divided into tangible sub-dimensions. Third, the "compliance" indicator of the GRI measures the amount of fines for non-compliance with environmental laws and regulations. As such, although providing a rough proxy for environmental performance, it does not indicate the environmental or health impact caused by the firm. As better measures exist, we excluded the Compliance indicator and other proxies from out list of constructs to measure environmental dimension of TBL, leaving us with only three measures for environmental performance. These are "Emissions, effluences, and waste", "Inputs", and "Products and Services".

To measure emissions, effluence and waste, Klassen and Whybark (1999a) used the Toxic Release Inventory (TRI) database. To date, the TRI, its Canadian equivalent, the National Pollution Release Inventory (NPRI) and other, similar national databases provide probably the best and certainly the most complete picture of manufacturing-based pollution entering the natural environment. In North America, if manufacturing plants in most industries deposit or release more than a specified threshold of pollutants in a given year, they are legally required to report these pollutants to this database. At the same time, these databases have some limitations. In particular, impacts generated through production inputs, such as energy use or the use of materials and substances, are not reflected. Also, not all manufacturing plants and only specific pollutants (above the specified threshold) are covered. Pollution is reported based on substances and mass, rather than environmental impact (Toffel and Marshall, 2008). The same is true for the

Co-operative Commission, since it measures carbon-dioxide emissions only. In contrast, the GRI asks participants to report *all* emissions, effluents, and waste, regardless of the amount generated. We therefore decided to follow the GRI guidelines to measure this sub-dimension. We re-named it to "Environmental Impact", reflecting the fact that not the amount of pollution, but its impact, is of the essence.

"Inputs", according to the Global Reporting Initiative framework, include materials used during the manufacturing process, as well as water and energy consumption. Energy consumption is related to the energy sources used during the manufacturing process – renewable versus non-renewable. We think that proportion of remanufactured or recycled input materials should be a part of this sub-dimension as well.

The "products and services" sub-dimension includes the safety and quality of a product (Abbott and Monsen, 1979), the overall environmental impact of products and services, the percentage of products and packaging reclaimed (Global Reporting Initiative, 2007), and whether chemicals are used in the product (KLD Research & Analytics, 2009). As product quality is related to economic performance, it is not replicated at this point. Instead of the percentage of products and packaging reclaimed by category, we included the proportion of reused and remanufactured components in the product design, because we think that this item will be easier to report by Operations/Manufacturing managers.

Thus, the complete environmental dimension tentatively includes three sub-categories, as listed in Table 9. The exact number of dimensions will be later determined through statistical analyses.

Table 9: Operational Definitions of the Environmental Constructs

Construct	Definition
Environmental Impact	Any change to the environment (air, water, land), whether adverse or beneficial, wholly or partly resulting from the plant's manufacturing processes.
Products and Packaging	Environmental effects of a product at every stage of its existence, from production to packaging, to usage, to its final disposal.
Inputs	Inputs into the manufacturing process affecting environmental performance of the plant.

4.1.4 The Social dimension of the TBL

The social dimension refers to the organization's impact on social systems (Elkington, 1998). It is the most problematic of three dimensions of the TBL, since it is the most ill-defined and badly measured. Table 10 summarizes various measures used in the literature to assess social performance.

Table 10: Items used to measure social performance

<table>
<tr><th colspan="2">Dimension/Measure</th><th>References</th></tr>
<tr><td colspan="2">Corporate Citizenship/Philanthropy, corporate reputation</td><td>SAM Indexes GmbH., 2006; Fortune magazine, 2009</td></tr>
<tr><td rowspan="4">Employee relations</td><td>equal opportunity/ diversity/staff profile</td><td>Abbott and Monsen, 1979; Co-operative Commission, 2009; KLD Research & Analytics, 2009a</td></tr>
<tr><td>personnel</td><td>Abbott and Monsen, 1979</td></tr>
<tr><td>labour practice/relations/ labour practices & decent work/human rights</td><td>SAM Indexes GmbH., 2006; Global Reporting Initiative, 2007; Innovest, 2009; KLD Research & Analytics, 2009a</td></tr>
<tr><td>human capital development/ talent attraction and retention</td><td>SAM Indexes GmbH., 2006; Innovest, 2009</td></tr>
</table>

	employees' health and safety/staff injury and absentee rates	Abbott and Monsen, 1979; Co-operative Commission, 2009; Innovest, 2009
	participation of employees and members in training and education	Abbott and Monsen, 1979; Co-operative Commission, 2009
	employee satisfactions ratings	Fortune magazine, 2009
	help for displaced employees to locate work	Abbott and Monsen, 1979
Number of lines in the corporate report devoted to corporate responsibility		Bowman and Haire, 1975
Product responsibility		Global Reporting Initiative, 1997a; KLD Research & Analytics, 2009a
Stakeholder relations	stakeholder relationships/ stakeholder capital	Bowman and Haire, 1975; Carter and Dresner, 2001
	community involvement/society/ relationship with local community/investment in community and co-operative initiatives	Abbott and Monsen, 1979; Global Reporting Initiative, 2007; Co-operative Commission, 2009; Innovest, 2009; KLD Research & Analytics, 2009a
	public health	Abbott and Monsen, 1979
	partnerships/supply chain relationships	Innovest, 2009
	customer satisfaction/customer ratings	Co-operative Commission, 2009; Fortune magazine, 2009

The Dow Jones Sustainability Index (SAM Indexes GmbH., 2006) measures corporate citizenship or philanthropy by assessing voluntary social contributions made by a company based on answers provided by the firms to a set of questionnaires. The Fortune magazine provides a list of companies to executives, directors, and securities analysts and asks them to pick up to ten of the companies they admire most. These firms are then ranked along nine criteria, ranging from investment value to social responsibility (Fortune magazine, 2009). The resulting overall ranking provides investors, practitioners and researchers with a corporate reputation index. The items in these two systems (Dow Jones Sustainability Index and Fortune Magazine Corporate Reputation Index), however, check for social or philanthropic *activities* undertaken by companies, rather than actual social *performance*.

In the academic literature, Bowman and Haire (1975) used an even rougher proxy for social performance – the number of lines in the corporate report devoted to corporate responsibility. The validity of this measure is undocumented, and no convincing argument has been put forth that makes a case for the equivalence between the number of lines and social performance.

The GRI and KLD Index (Global Reporting Initiative, 2007; KLD Research & Analytics, 2009a) use product responsibility measures that include customer health and safety, product labeling, marketing strategies and fines associated with non-compliance with laws and regulations. The KLD framework also includes the quality of a product, benefits to the economically disadvantaged arising from the use of the product, and R&D/Innovation. Some of these indicators, such as product labeling and marketing strategies, again reflect *activities* rather than *performance*. Others, such as quality, innovation and benefits to economically disadvantaged (in terms of low product's cost, for example) overlap with the manufacturing capabilities part of economic performance.

The remaining indicators of social performance can be grouped into two general categories – employee and external stakeholder relations (see Table 11). Employee relations covers the management's relationship with employees, health and safety performance, the treatment of disadvantaged and minority groups, help for displaced employees, etc. The external stakeholder relationships category evaluates the firm's relationships with communities and other stakeholders, the promotion of health and safety within external communities, and other factors. Outcomes of philanthropic activities (the fourth category in Carroll's model of Social responsibility (Carroll, 1979)), can easily be classified into these two dimensions. For example, voluntarily supporting displaced employees in finding new work can be captured in the employee relationship dimension of TBL; investing in communities affects communities' well-being, thus affecting the stakeholder relationships dimension. As with the environmental construct, the exact number of dimensions will be determined later through statistical analyses.

Table 11: Operational definitions of the Social constructs

Construct	Definition
Employee Relationships	Relationships with employees and practices aimed at improving these relationships.
External Social Performance	Relationships with outside stakeholders and practices aimed at improving these relationships.

4.1.5 Interactions between the three Dimensions

By this point the discussion of the three dimensions of the TBL it has become apparent that the dimensions are significantly related to each other. For example, pollution released by a plant (environmental performance) has a negative impact on the neighbourhood (social performance) and may be subject to government fines (financial performance). Reducing pollution (environmental performance) may be costly (financial performance) but improve employee and neighbourhood relations (social performance).

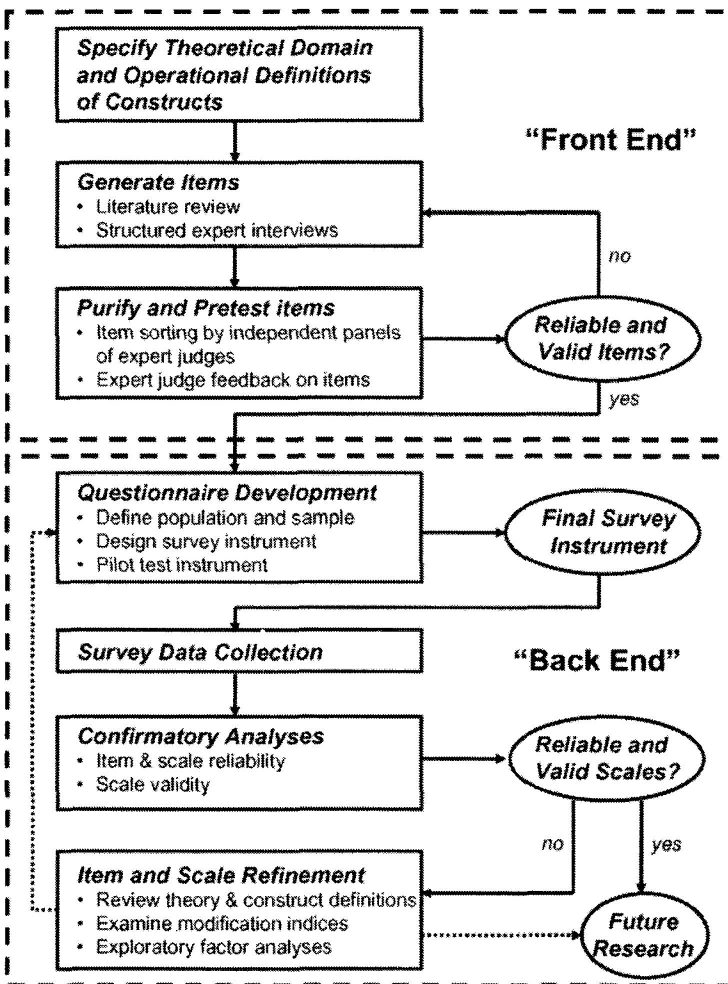
Many studies have related different dimensions of the TBL to each other, thus suggesting explicit causal links between a set of the three performance dimensions. For example, it was found that improved environmental performance enhances manufacturing performance (e.g., Pil and Rothenberg, 2003), that there is a positive association between corporate social performance and corporate financial performance (Orlitzky *et al.*, 2003), or that corporate social performance is affected by profitability and the firm's emissions (Stanwick and Stanwick, 1998), etc. In these studies, one or two performance dimensions are used as input (causal) variables, another one as an outcome variable. Although it is important to understand how different dimensions of TBL are connected with each other (i.e., it is clear that correlations exist), our position is that when trying to evaluate effectiveness of a company's strategy, all *three* dimensions of TBL – properly defined – must be considered at once and solely as outcome measures, driven by actions, while allowing for correlations between different dimensions.

5 Analysis of the TBL Dimensions

5.1 Phase 1: An Upgraded Q-Sort Process

A general scale development process starts with the specification of the domain of the constructs of interest, followed by the item generation, and finally the purification of the items and constructs (Churchill, 1979). Menor and Roth (2007) proposed using the following approach for scale development and validation (see Figure 2):

Figure 2: Two-stage approach for new measurement development



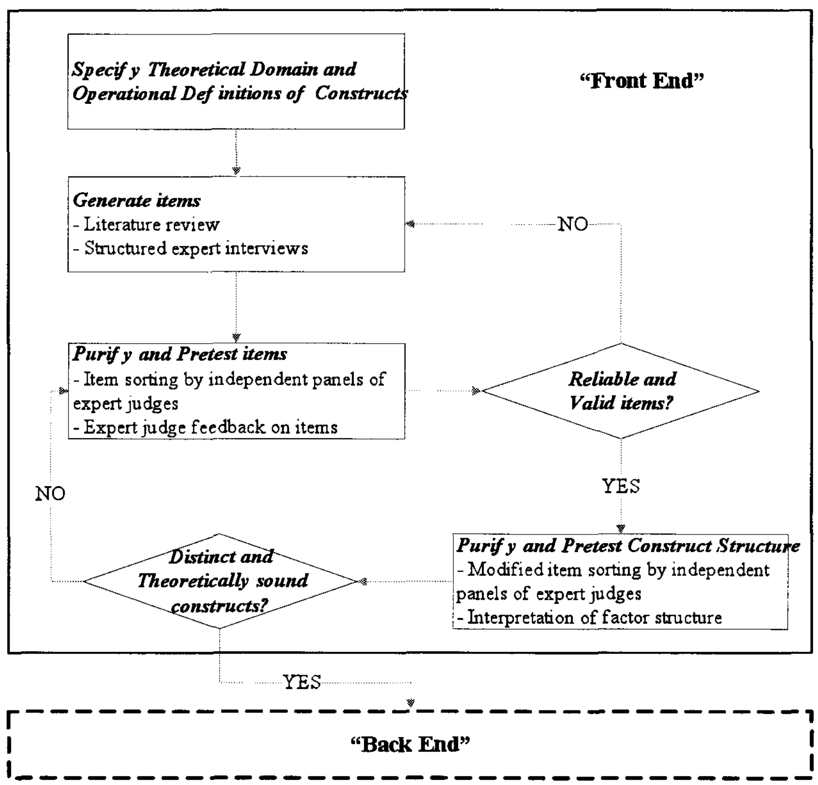
Source: (Menor and Roth, 2007)

In the "Front End" of this process, the items are generated by conducting a literature review and interviews with industry experts. Once the initial list of items is finalized, these items are subject to an item-purification process. Usually, at this stage different Q-sorting techniques are used. The Q-sort technique was first developed by Stephenson (1953) and it is defined as "a method of sorting objects into theoretical categories for statistical purposes" (Nunally, 1978 in Schriesheim *et al.*, 1993). In the Operations Management (OM) literature the main type of Q-sort exercise employed is a manual factor sorting technique (see Hinkin and Schriesheim, 1989) in which expert judges are asked to classify a randomized list of items into a set of constructs that was pre-defined by the researchers (e.g., Stratman and Roth, 2002; Swafford *et al.*, 2006; Froehle and Roth, 2007; Menor and Roth, 2007). Different reliability measures are calculated and, depending on the results, some items or definitions are improved.

This Q-sorting technique is a simple, inexpensive, and reliable method that can provide a very valuable initial input into the structure of the scales. Although the output of the Q-sorting might not be the finalized scale, disagreements between judges provide researchers with suggestions for modifications of items' wording, the deletion or addition of constructs, or modifications of definitions. The main disadvantage of this method is its reliance on a small sample size. In addition, it is very subjective and its reliability measures are calculated without any significance levels attached to them (Schriesheim *et al.*, 1993).

To overcome these shortcomings of the Q-sorting technique, several researchers proposed to use a more sophisticated, factor-analyzed method. This method was first introduced by Tucker (1966) and then, independently, by Bish and Schriesheim (1974). This method has been used since in Organizational Behavior research and proven to be a valuable instrument for both new scales development and for validation of existing scales (e.g., Bish and Schriesheim, 1974; Hinkin and Schriesheim, 1989). According to this approach, each item is rated on a Likert scale on the extent to which it is consistent with each one of the proposed construct definitions. The results are then statistically analyzed using factor analysis to determine the content of each construct, the distinctiveness of the constructs, and the adequacy of the definitions used in the study. The disadvantage of this method is its reliance on the initial definitions developed by researchers and the accuracy of interpretations of the results (Schriesheim *et al.*, 1993). Therefore, it is suggested to employ the simple Q-sorting technique prior to the modified version. We, thus, propose to extend the "Front End" of Menor and Roth's scale development process by adding one additional step as follows:

Figure 3: Modified "Front-End" stage of new measurement development, based on Menor and Roth (2007)



In the following subsections we explain in detail how each stage of the proposed scale development process was employed in the current research.

5.2 Step 1 – Specify Theoretical Domain and Operational Definitions of Constructs Generate Items

Our first step was to specify the theoretical domain for each one of three dimensions of TBL – economic, environmental, and social. To do so, we reviewed literature and summarized items used for measure each one of the three dimensions (as explained in section 4.1). Since the financial and manufacturing dimensions within the economic performance construct are well developed with established scales (e.g., Roth, 1993; Vickery *et al.*, 1995; Russo and Fouts, 1997; Klassen and Whybark, 1999b; Schroeder *et al.*, 2002), we did not include them in our initial scale development efforts. They were included later during the confirmatory factor analysis stage. Based on the literature review of environmental and social performance measures, we started our Q-Sorting analyses with an initial set of 40 items. After every round of the Q-sorting exercise some items and definitions of the categories were modified.

5.3 Step 2 – Purify and Pretest Items (Q-sort 1 and 2)

We Q-sorted forty items and six constructs (see Table 12 for the list of definitions and the Appendix B for the list of items). Our respondents were ten Operations Management and Information Systems professors and PhD students. The respondents were asked to classify every item into one category, or suggest another category that could contain this item, but was not present in our definitions. For each pair of judges (in total 45 pairs) we calculated the inter-judge agreement percentage, Cohen's Kappa (Cohen, 1960), and the Perreault and Leigh reliability index (Perreault and Leigh, 1989). The statistics of this q-sort round can be found in Table 13.

Table 12: List of definitions used in Q-sort 1

Construct	Definition
Environmental Impact (EI)	Any change to the environment (air, water, land), whether adverse or beneficial, wholly or partly resulting from the plant's manufacturing processes.
Products and Packaging (PP)	Environmental effects of a product at every stage of its existence, from production to packaging, to usage, to its final disposal.
Inputs (IN)	Inputs into the manufacturing process affecting environmental performance of the plant.
Employee Relationships (ER)	Relationships with employees and practices aimed at improving these relationships.
External Social Performance (ES)	Relationships with outside stakeholders and practices aimed at improving these relationships.
Market Performance (M)	Degree of the plant's presence in the market place.

Table 13: Summary statistics for the first round of Q-sort

Statistics	Interjudge agreement %	Cohen's kappa	Perreault and Leigh reliability
Average	0.77	0.72	0.78
Min	0.51	0.42	0.60
Max	0.96	0.95	0.94
Standard Deviation	0.10	0.12	0.08

After modifying the wording of some items and adding one more construct ("Leadership" for market performance (the items can be found in the Appendix)), as was proposed by our respondents from the first round, we administered a second version of the Q-sort to eight PhD students from different departments of the Business school. The results of this second Q-sort round are presented in Table 14.

Table 14: Summary statistics for the second round of Q-sort

Pair	Interjudge agreement %	Cohen's kappa	Perreault and Leigh reliability
Average	0.82	0.78	0.88
Min	0.66	0.60	0.78
Max	0.95	0.94	0.97
Standard Deviation	0.08	0.10	0.06

Our respondents proposed to delete the "Leadership" dimension of market performance (associated with 3 items), since Leadership can be interpreted as good environmental performance or it can be a part of market performance. In addition, they proposed to combine two dimensions of environmental performance ("Environmental Impact" and "Inputs") into one construct called "Manufacturing Process". One item ("Energy consumption during the life of a product" for Product and Packaging) was deleted, because of its high dependence on the nature of the product.

5.4 Step 3 – Purify and Pretest Construct structure (Q-sort 3 and 4)

To perform a factor analysis, we needed a large sample size. We administered the modified Q-sort version to 115 MBA students. We felt that, because of their various backgrounds and work experiences (with an average of 7 years), MBA students would provide us with very valuable and relevant information on the structure of our scales (see Hausman *et al.*, 2002; Froehle and Roth, 2004). The questionnaires were distributed to the students during the break of their classes and collected about 15 minutes later. The respondents were asked to rate the extent to which each item was consistent with each one of 5 categories presented at the top of each page. That is, for each item 5 ratings were required (one for each construct). The scale ranged from 1 (not at all consistent) to 7 (completely consistent). The list of the definitions and the structure of the questionnaire can be found in tables 15 and 16, respectively.

Table 15: List of definitions used in Q-sort 3

Construct	Definition
Manufacturing Process (MP)	Environmental impact of the *manufacturing process* (excluding product and packaging impact) – from inputs and raw materials used in production, to the process of manufacturing itself, to the discharge or disposal of any by-products.
Products and Packaging (PP)	Environmental impact of a *product* at every stage of its existence – from product's design, to materials used in production of the product, to *packaging*, to usage, and finally, to its final disposal.
Employee Relationships (ER)	Impact on employees and practices aimed at improving relationships with employees.
External Social Performance (ER)	Impact on *outside* stakeholders and practices aimed at improving relationships with outside stakeholders.
Market Performance (M)	Degree of the plant's presence in the market place (e.g., market share).

Table 16: Example of the questionnaire used in the first construct structure purification process (Q-sort 3)

#	Indicator	MP	PP	ER	ES	M
1	Environmental impact through air emissions					
2	Rate of work-related injuries					
…	…					
36	Other potential customers are looking to do business with our firm					

To illustrate, the first item, "Environmental impact through air emissions," should have been rated by each respondent on five dimensions – Manufacturing Process (MP), Products and Packaging (PP), Employee Relationships (ER), External Social performance (ES), and Market performance (M) – using a scale from 1 to 7. If a respondent thought that this item belonged to the MP construct, this dimension would have gotten a higher score than other dimensions (e.g. 6 or 7 for MP, compared to 1 or 2 for other dimensions).

To analyse the responses using factor analysis, the first step is to organize the responses into a data matrix. This data matrix can be structured in one of two ways. In the first one, the means for each item in each category are calculated (across N respondents) and then a data matrix is constructed with K rows (number of constructs) and M columns (number of items). See Table 17 for an example of this structure. Each number in this table is constructed by averaging responses of 115 judges (MBA students).

Table 17: Averaged data matrix structure

Construct	Items				
	1	**2**	**...**	**35**	**36**
MP	6.17	2.40	...	2.43	2.47
PP	2.94	2.16	...	2.39	2.67
ER	1.64	5.90	...	2.24	2.44
ES	3.53	3.33	...	2.82	3.15
M	2.15	2.17	...	5.33	5.33

Using the second approach, an "extended data matrix" is formed, in which there are M columns and N x K rows. In this data matrix, no averages are calculated and all the data are used. In our research, each set of five consecutive rows (as the number of constructs) of this matrix belong to the same respondent. Each row, within a set of five, corresponds to a different construct. In total there are 5x115, or 575 rows. Columns represent the 36 items used in the analysis (see Table 18).

Table 18: Extended data matrix structure

Respondent	Construct	Items				
		1	**2**	**...**	**35**	**36**
1	MP	7	2	...	2	1
1	PP	4	2	...	1	1
1	ER	6	7	...	1	2
1	ES	4	3	...	1	3
1	M	4	1	...	7	7
2	MP	6	1	...	1	2
2	PP	6	1	...	2	1
...	...	...	...	...	...	...
115	ES	2	4	...	3	2
115	M	1	1	...	7	6

Osgood *et al.* (1961) compared the results of analyzing both types of matrix structures and found the results to be similar. Technically, however, the first, simpler, matrix structure comes with a distinct disadvantage. Factor analysis is based on the sample size of M (the number of factors), which usually is a small number (Schriesheim *et al.*, 1993). For example, in our research we have only five factors (or rows in the matrix), which are not enough to produce reliable factor analysis results. We therefore proceeded using the extended data matrix.

Using SPSS 15.0, we factor analyzed the matrix structure using the Maximum-likelihood extraction method followed by a Varimax rotation. Loadings smaller than .3 were suppressed due to practical insignificance (Hair *et al.*, 2006). Both the eigenvalues and the scree-plot (see figure 4) approaches suggested six constructs. When we started analysing the loadings, we noticed that items belonging to the fifth and the sixth factors cross-loaded on the first factor. The first factor was formed from the items belonging to the "Inputs" construct, the fifth from "Environmental Impact" items and the sixth from "Products and Packaging" items (recall definitions in table 9). In the five-factor solution "Inputs" and "Products and Packaging" formed one construct, while "Environmental Impact" items cross-loaded on that factor. Four-factor solution produced no cross-loadings with all environmental items loading on the same factor. We renamed the collapsed environmental construct "Environmental Performance" (see table 19).

Figure 4: Scree plot for the MBA students factor analysis

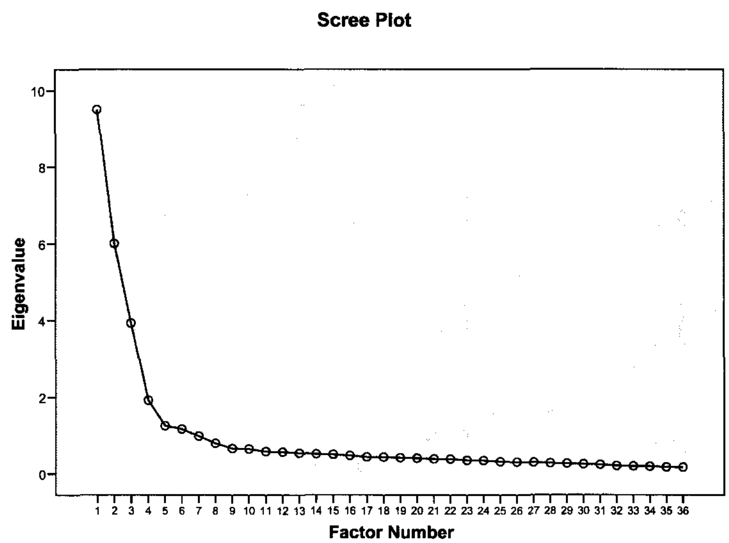


Table 19: Rotated Factor Analysis solution for MBA students

Items	Component			
	MP/PP	ER	M	ES
MP1	.76			
MP2	.82			
MP3	.78			
MP4	.68			
MP5	.72			
MP6	.77			
MP7	.71			
MP8	.78			
MP9	.74			
MP10	.69			
MP11	.78			
MP12	.75			
PP1	.70			
PP2	.71			
PP3	.59			
PP4	.70			
ER1		.68		
ER2		.65		
ER3		.68		
ER4		.77		
ER5		.78		
ER6		.79		
ER7		.82		
ER8		.80		
ER9		.80		
M1			.57	
M2			.66	
M3			.77	
M4			.77	
M5			.76	
M6			.81	
ES1				.71
ES2				.71
ES3				.66
ES4				.52
ES5				.60
Eigenvalues	9.75	6.2	4.0	1.9

Extraction Method: Maximum Likelihood Analysis. Rotation Method: Varimax with Kaiser Normalization.

To validate our results, we administered another round of surveys, but this time to industry experts. To collect the data, we followed the Dillman's (1978) total design method. First, a cover letter along with the questionnaire was sent to the whole sample. As an incentive, our respondents were offered $5 Starbucks gift cards. Two weeks later, a reminder in the form of the postcard was sent to companies who had not responded yet. If after three more weeks the response had not been received, a second envelope with a questionnaire was sent again. We received 37 competed surveys, for a response rate of 21.8%. Our respondents were from three primary industries – Chemicals and Allied Products, Rubber and Miscellaneous Plastics Products, and Electronic and Other Electrical Equipment and Components; the size of the companies ranged from small (less than 100 employees, 21 companies), to medium (less than 500 employees, 14 companies) to large (more than 500 employees, 2 companies). The typical title of our respondents was President.

These data were analyzed using One-way ANOVA (Hinkin and Tracey, 1999). The advantage of one-way ANOVA is its capability to deal with smaller sample sizes than factor analysis. In addition, as opposed to factor analysis, it will report both the loadings (as in factor analysis) and the significance of differences between loadings of the same item on different constructs. Comparing the loadings using one-way ANOVAs resulted in 36 F-statistics (for each one of the items) with *p-values* less than 0.001. A post-hoc analysis using Bonferroni tests revealed significant differences between the loadings.

Table 20 presents the average loadings of each item on each one of four dimensions as well as the F-statistics associated with the one-way ANOVAs. Significant differences between the loadings of the same item on different constructs are listed in parentheses. For example, one-way ANOVA analysis for the first item (MP1) resulted in F-statistic of 53.2, which corresponds to a *p-value* of smaller than 0.001 and suggests that at least one of the average loadings is different from others. Post-hoc analysis for the same item revealed that the highest average loading belongs to the EP construct. More than that, paired differences between the loading on EP constructs and ER, ES, and M constructs (e.g., three pairs of differences: EP vs. ER, EP vs. ES, and EP vs. M) are all significant at *p-value* < .001, suggesting that MP1 belongs to the EP construct. The same analysis was repeated for all items.

The results of our analysis of the industry experts' responses confirmed those of the third (previous) round of Q-sort (see Table 20), thus providing evidence that the scales and constructs were now reliable and ready for use in a large scale survey.

Table 20: ANOVA results

Items	Average loadings on construct:				F-stat
	EP	ER	ES	M	
MP1	5.97 (ER, ES, M)	1.35 (EP, ES)	3.14 (EP, ER, M)	1.84 (EP, ES)	53.2
MP2	5.95 (ER, ES, M)	1.51 (EP, ES)	2.92 (EP, ER)	2.22 (EP)	41.38
MP3	5.65 (ER, ES, M)	1.19 (EP, ES)	2.73 (EP, ER)	1.81 (EP)	44.43
MP4	5.59 (ER, ES, M)	1.57 (EP, ES)	3.38 (EP, ER, M*)	2.00 (EP, ES*)	31.66
MP5	5.68 (ER, ES, M)	1.68 (EP, ES)	3.35 (EP, ER, M*)	1.97 (EP, ES*)	31.22
MP6	5.24 (ER, ES, M)	1.46 (EP, ES*)	2.68 (EP, ER*)	2.22 (EP)	30.14
MP7	6.08 (ER, ES, M)	2.49 (EP)	3.24 (EP)	2.35 (EP)	25.19
MP8	6.46 (ER, ES, M)	1.886 (EP)	2.73 (EP)	2.16 (EP)	45.97
MP9	5.24 (ER, ES, M)	1.70 (EP)	2.05 (EP)	2.22 (EP)	28.29
MP10	5.22 (ER, ES, M)	1.49 (EP, ES†)	2.51 (EP, ER†)	1.68 (EP)	33.37
MP11	5.62 (ER, ES, M)	1.73 (EP)	2.41 (EP)	1.86 (EP)	36.46
MP12	5.22 (ER, ES, M)	1.57 (EP, ES*)	2.89 (EP, ER*)	2.05 (EP)	23.52
PP1	5.84 (ER, ES, M)	1.49 (EP, ES†)	2.46 (EP, ER†)	2.32 (EP)	46.50
PP2	5.54 (ER, ES, M)	1.62 (EP)	2.51 (EP)	2.51 (EP)	25.91
PP3	6.62 (ER, ES, M)	1.35 (EP, ES)	2.46 (EP, ER)	1.97 (EP)	99.06
PP4	6.19 (ER, ES, M)	1.43 (EP, ES*)	2.38 (EP, ER*)	1.73 (EP)	77.98
ER1	1.89 (ER, ES)	6.41 (EP, ES, M)	3.51 (EP, ER, M*)	2.14 (ER, ES*)	45.06
ER2	1.97 (ER, ES†)	5.54 (EP, ES, M)	3.16 (EP†, ER, M)	1.65 (ES, M)	29.41
ER3	1.89 (ER, ES*)	5.59 (EP, ES, M)	3.27 (EP*, ER, M)	1.78 (ER, ES)	30.26
ER4	1.30 (ER, ES)	4.97 (EP, ES*, M)	3.73 (EP, ER*, M)	1.76 (ER, ES)	28.76
ER5	1.35 (ER, ES)	5.35 (EP, ES, M)	3.89 (EP, ER, M)	1.89 (ER, ES)	33.21
ER6	1.54 (ER, ES*)	6.19 (EP, ES, M)	2.81 (EP*, ER)	2.19 (ER)	42.44
ER7	1.86 (ER)	6.11 (EP, ES, M)	2.65 (ER, M†)	1.59 (ER, ES†)	54.96
ER8	1.14 (ER, ES)	5.30 (EP, ES, M)	3.03 (EP, ER, M)	1.49 (ER, ES)	41.74
ER9	1.41 (ER, ES)	5.51 (EP, ES, M)	3.35 (EP, ER, M)	1.57 (ER, ES)	38.58
ES1	2.19 (ES)	2.16 (ES)	5.84 (EP, ER, M)	2.62 (ES)	31.68
ES2	2.24 (ES)	2.08 (ES)	5.30 (EP, ER, M)	2.78 (ES)	21.12
ES3	1.81 (ER*, ES)	3.11 (EP*, ES, M*)	5.43 (EP, ER, M)	1.76 (ER*, ES)	26.34
ES4	2.46 (ES)	2.92 (ES)	5.03 (EP, ER, M)	2.05 (ES)	12.25
ES5	2.24 (ES)	1.68 (ES)	4.86 (EP, ER, M)	2.22 (ES)	17.51
M1	2.32 (M)	1.97 (M)	3.14 (M)	5.46 (EP, ER, ES)	19.60
M2	2.70 (M)	2.11 (M)	3.38 (M)	5.59 (EP, ER, ES)	16.30
M3	2.95 (ER†, M)	1.70 (EP†, M)	2.68 (M)	4.89 (EP, ER, ES)	13.85
M4	2.38 (M)	1.76 (M)	2.35 (M)	5.27 (EP, ER, ES)	21.70
M5	2.30 (M)	2.22 (M)	2.32 (M)	5.32 (EP, ER, ES)	17.76
M6	2.84 (M)	1.89 (M)	2.78 (M)	5.46 (EP, ER, ES)	19.38

Significant differences are listed in parentheses

† *p-value*< .1; * p-value < .05; all other differences and F-stats are significant at *p-value*< .01

5.5 Phase 2: Confirmation of Scales

5.5.1 Sample

We collected data for the "Back End" step of the scale development process as a part of a larger data collection effort. Our 36 items represented only one part in the 5-parts questionnaire. The respondents were asked to rate the performance of their organizations in relation to their main competitors. The data was collected during the summer of 2008.

Contact information of 1800 Canadian manufacturing companies was purchased from Dun and Bradstreet (www.dnb.ca). The manufacturers belonged to the three primary industries polled during the last Q-sort round (see Table 16). The choice of the industries was made to suit our larger data collection effort within this research program. After an initial screening to confirm contact information and eligibility to participate in the larger scale development effort, 1094 usable contacts remained. Data collection was carried out via phone, rather than a mail, in order to increase the response rate. Our survey consisted of 5 parts and was 8 pages long. We suspected that, due to the length of the questionnaire, mail survey would have resulted in a very low response rate. For French-speaking plants the questionnaire was translated to French and then back to English to assure proper translation.

We completed 9 rounds of calls. If the respondent still had not answered the survey after 9 rounds, it was marked as a non-respondent. 136 companies fully completed our questionnaire for a response rate of 12.4%. Non-response bias was assessed using a series of χ^2- and t-tests. No significant differences were observed between the early and late respondents (first 35 vs. last 35 respondents). We also compared 2-digits NAICS codes and the number of employees between respondents and non-respondents. No significant differences were found (*p-values* ranged from 0.119 for the number of employees to 0.721 for the 2-digit NAICS code comparisons).

To test the differences between the three industries used in the survey, we ran one-way ANOVA tests on all items relevant to our scale-development process (36 items in total). No significant differences were found. Descriptive statistics of the sample can be found in Table 21.

Table 21: Sample Profile

Primary Industry (2-digits SIC)	
Chemicals And Allied Products (28)	16.9%
Rubber And Miscellaneous Plastics Products (30)	47.1%
Electronic And Other Electrical Equipment And Components (36)	36%
Total	100.0%
Number of Employees	
Less than 100 (small)	77.9%
100 – 499 (medium)	15.5%
500 and above (large)	6.6%
Total	100.0%
Revenue	
Less than 5,000,000 CAD	15.4%
5,000,000 – 50,000,000 CAD	22.1%
Over 50,000,000 CAD	20.5%
Missing values	42.0%
Total	100.0%
Title of interviewed person	
President, General Manager	83.1%
Other[1]	16.1%
Total	100.0%

[1] Includes positions such as Sales Manager, Technical Director, VP of Finance, VP of Sales.

5.5.2 Validity and Reliability

Psychometric Properties. To be able to use parametric methods, we tested our data for normality (Curran *et al.*, 1996). No significant violations of skewness or kurtosis were found. Due to the small sample size (n=136) we ran three separate CFA models, as detailed in Table 22. The TBL construct is reflective, rather than formative, because (1) variations in the individual dimensions' constructs lead to variations in the items used to measure them (Bollen, 1989), and (2) the items used to measure our constructs are interchangeable (Nunally, 1978). This means that if we delete some items, the nature of the construct won't change, although we have to be careful not to harm the domain space of the construct (Little *et al.*, 1999). Reflective indicators are expected to be correlated with each other. Therefore the error terms associated with our items were allowed to freely correlate with each other (Bollen, 1989).

Table 22: CFA Results: Assessment of Reliability and Construct Validity of the Measurement Model

Measurement Model	Construct	Items	Standardized Loadings [1]	Standard Error	Composite Reliability [2]	Average Variance Extracted [3]	Model Fit [4]
1	Employee Relationships	ER1	.70	.15	.86	.41	χ^2= 103.327
		ER2	.69	.16			χ^2/ df = 1.542
		ER3	.75	.13			*p-value* = .003
		ER4	.53	.16			
		ER5	.58	.16			CFI = .957
		ER6	.56	.17			NNFI = .932
		ER7	.61	.16			RMSEA = .063
		ER8	.54	.16			
		ER9	.77				

	External Social Performance	ES1	.61	.19	.84	.53	
		ES2	.70	.19			
		ES3	.78	.20			
		ES4	.88	.23			
		ES5	.63				
	Environmental Performance	PP1	.77	.10	.93	.49	
		PP2	.74	.11			
		PP3	.62	.11			
		PP4	.79	.10			
		MP1	.64	.10			
		MP2	.63	.10			
		MP3	.60	.10			
		MP4	.72	.09			
		MP6	.72	.11			χ^2= 254.40
		MP7	.61	.11			χ^2/ df = 1.32
2		MP8	.62	.11			*p-value* = .002
		MP9	.70	.11			
		MP10	.75	.13			CFI = .961
		MP11	.75	.13			NNFI = .949
		MP12	.80				RMSEA = .049
	Cost	MF1	.89	.13	.89	.81	
		MF2	.91				
	Delivery	MF4	.92	.13	.89	.74	
		MF5	.93	.14			
		MF6	.71				
	Flexibility	MF8	.92	.23	.82	.70	
		MF9	.74				
	Market Performance	M1	.82	.28	.86	.52	
		M2	.83	.28			
		M4	.77	.31			
		M5	.71	.24			χ^2= 79.08
		M6	.57	.21			χ^2/ df = 1.72
3		M7	.56				*p-value* = .002
	Financial Performance	F1	.71	.08	.91	.64	
		F2	.79	.07			
		F3	.80	.07			CFI = .966
		F4	.60	.09			NNFI = .942
		F5	.92	.06			RMSEA = .073
		F6	.95				

[1] All loadings are significant at *p-value* < .001; Acceptable values are: [2] Composite reliability > .70 (Nunally, 1978); [3] Average variance extracted > .40 (Hatcher, 1994); [4] NNFI ≥ .9 (Gefen, 2000), χ^2/df < 3 (Hair *et al.*, 2006), RMSEA ≤ .10 (Hair *et al.*, 2006).

Content validity. The measurement items are said to have content validity if they cover the domain of the construct being measured (Nunally, 1978). In order to confirm content validity, usually an extensive literature review is done. In addition, our "Front-end" process of scale development, which consisted of several rounds of the traditional Q-sort and two rounds of the modified Q-sort (to pre-test the scale structure) contributed to the constructs' content validity.

Unidimensionality. A construct is considered unidimensional if the items belonging to this scale are really measuring only a single construct (Hatcher, 1994). To assess unidimensionality in our measurement models we relied on a set of widely used indices: Bentler and Bonett'sNormed Index (NFI, Bentler and Bonett, 1980); Bentler's Comparative Fit Index (CFI, Bentler, 1990); Parsimony Normed Fit Index (PNFI; Hatcher, 1994); a chi-square (χ^2) test; χ^2/df; and the Root Mean Square Error of Approximation (RMSEA; Hair *et al.*, 2006).

The first attempt to fit the models resulted in non-satisfactory results for the second and the third models. After deleting items MP5 and M3, we rerun the models. The results are presented in table 17. Although the *p-values* associated with our measurement models are significant, all other model fit statistics fall within an acceptable range. The *p-value* statistic is based on the value of χ^2, which is very sensitive to sample size (Joreskog and Sorbom, 1993), and therefore "large samples are critical to the obtaining of precise parameter estimates" (Byrne, 2001, p. 81). This does not hold for most empirical research using structural equations models. As a result, other measures, such as the ratio of χ^2 to the degrees of freedom are usually used to access the goodness-of-fit of the covariance structure (Joreskog and Sorbom, 1993). Since the final fit indices all fall within acceptable ranges, we can conclude that our scales are unidimansional.

Reliability. We relied on two commonly used metrics to measure reliability: composite reliability and average variance extracted. Composite reliability is similar to Cronbach's alpha (Cronbach, 1951), which measures the degree of internal consistency of items measuring a specific construct; however, it does not use the assumption of equal importance of all items (Hatcher, 1994). Average variance extracted measures the amount of variance explained by the indicators in relation to the variance due to measurement error (Fornell and Larcker, 1981; Hatcher, 1994). All constructs exhibited satisfactory reliability measures.

Construct validity assesses the degree to which indicators measuring a specific construct actually represent "the theoretical latent construct they are designed to measure" (Hair *et al.*, 2006, p. 707). Construct validity consists of two main parts: convergent and discriminant validity. Convergent validity refers to the fact that every item should be statistically associated with the construct it is supposed to measure (Campbell and Fiske, 1959). Convergent validity may be observed by looking at the loading of each item on its construct. These loadings should be significant and in the predicted direction (Krause *et al.*, 2000). In addition, the magnitude of the loading should be greater than twice its standard error (Gerbing and Anderson, 1988). All our items met the standard criteria (see Table 22).

Discriminant validity refers to the fact that every item should not be statistically associated with the constructs it is not designed to measure (Campbell and Fiske, 1959). Evidence of the discriminant validity can be observed by investigating pairs of nested models. In the first model two constructs are allowed to freely correlate (thus representing two distinct constructs), while in the second model the correlation is set to 1 (the items are forced to represent the same construct). The differences in χ^2 between these two models should be significant (Joreskog, 1971). All our constructs met this criterion.

After confirming reliability and validity of our measures, we parceled the items belonging to a construct by computing their averages. The correlations and the summary statistics of all constructs are presented in Table 23.

Table 23: Pearson Correlation Matrix

Construct	Mean	S.D.	1	2	3	4	5	6	7	8
1. Employee relationships	3.35	.94	1							
2. External Social Performance	2.43	1.01	.59**	1						
3. Environmental Performance	2.59	1.06	.69**	.71**	1					
4. Cost	2.97	1.06	-.01	.01	-.07	1				
5. Delivery	3.65	.83	.33**	.24**	.38**	.01	1			
6. Flexibility	3.79	.91	.22*	.19*	.32**	-.00	.41**	1		
7. Quality	3.84	.80	.31**	.30*	.31**	.03	.50**	.30**	1	
8. Market Performance	3.30	.94	.39**	.45**	.41**	-.03	.30**	.26**	.37**	1
9. Financial Performance	2.96	.96	.09	.20*	.20*	-.07	.19*	.09	.23**	.45**

n = 136; $^{*}p < 0.05$; $^{**}p < 0.01$

6 Conclusions, Limitations and Future Research

By reviewing the literature and applying a rigorous scale development process, we developed a valid and reliable scale for measuring the Triple Bottom Line performance of manufacturing plants. Although there is an increasing interest in the business and academic community in measuring TBL performance, to date, to the best of our knowledge, a valid, reliable and comprehensive scale does not exist. By using the scales proposed in this paper, future research may investigate interesting questions, such as how adoption of different supply chain practices affects the overall TBL performance of plants, rather than individual aspects of performance (environmental, social, or economic).

We also proposed to use a factor-analyzed Q-sort technique in addition to the manual sorting Q-sort. Although the latter provides initial evidence of content validity, it fails to confirm the structure of the construct. As it follows from our results, when we factor-analyzed our Q-sort results, 2 constructs ('Manufacturing Process' and "Products and Packaging') that in the manual sorting technique were confirmed to be two separate constructs, ended up forming a single construct ('Environmental Performance') in the factor-analyzed Q-sort. This fact was later confirmed by the confirmatory factor analysis.

Thus, this paper makes the following contributions to the literature and practice. First, we developed a comprehensive, reliable and valid scale for measuring the Triple Bottom Line performance of manufacturers (small adjustments will make the scale suitable for service firms as well). Second, we suggested extending the scale development method proposed by Menor and Roth (2007) by including a step in which a factor-analyzed Q-sort method (Tucker, 1966; Bish and Schriesheim, 1974) is used. We demonstrated the importance of this additional step.

Our research is not without limitations. First, due to a relatively small sample size we used 3 different measurement models in CFA, a fact that might jeopardize the discriminant validity of our scales. However, testing the nested models for discriminant validity might suggest a reasonable evidence of discriminant validity in the overall model

(Stratman and Roth, 2002). Second, our manufacturing performance scales were measured with only 2 items per construct. Since manufacturing performance is a well developed scale, future research may use more items per scale (see Roth *et al.*, 2008 for appropriate items). In addition, although most items pertain to any type of firm, our scales (mostly the environmental performance construct) were developed with manufacturing firms in mind. Therefore, in the future research, out TBL performance should be adjusted and tested for the service sector. More than that, we included only three industries in our sample frame. Although we think that these industries are a very good representation of the manufacturing sector, in the future research our scales might be retested using a sample of other industries. Lastly, while we took care to only include performance items in our constructs, particularly the social dimension may need additional development. Many corporate reports focus on philanthropic activities. Measures should be developed that are capable of assessing the social impact of these activities (Husted and Allen, 2007).

CONCLUSIONS

Our research sought to address three main questions:

(1) What is the nature of the relationship between buyer actions and supplier environmental investments?

(2) How the relationship between buyer actions and supplier environmental investments changes in the presence of buyer specific assets?

(3) To what extent do the buyer *and* the supplier benefit from supplier's investments in environmental technologies?

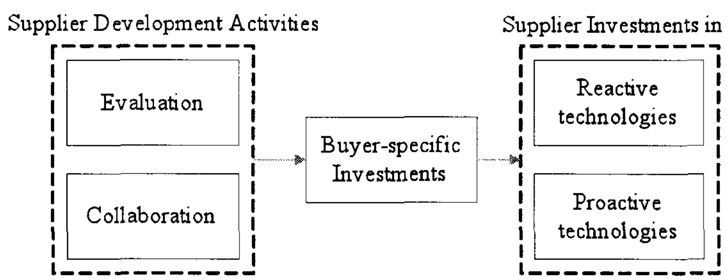
In this research, we answered the first two questions and made a significant step toward answering the third question. In this chapter we discuss our findings and also point out further research that needs to be carried out to fully investigate our last research question.

1 Prior Research on effect of buyer initiatives on supplier environmental investments

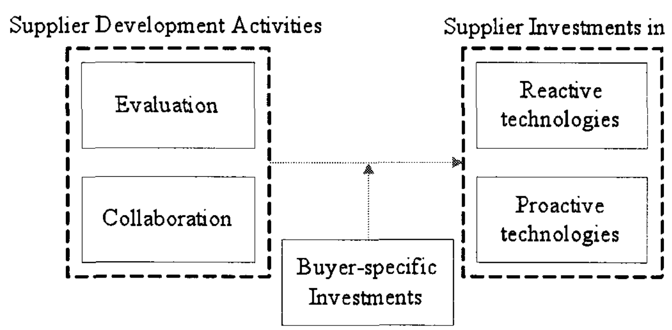
Prior research investigating the relationship between buyer initiatives and supplier environmental investments (Klassen and Vachon, 2003) found that evaluative activities correlated with higher investments in environmental (a mix of Pollution Prevention, Pollution Control, and Management Systems) technologies, while collaborative activities were able to shift the investments toward Pollution Prevention technologies. In contrast, Vachon (2007) found that collaboration had a negative impact on investments in Management Systems. Given these mixed results, we though that buyer specific investments made by a supplier might affect the relationship between buyer actions and supplier environmental technologies. We found theoretical evidence in the literature indicating that buyer-specific investments made by a supplier could serve as either a mediator or a moderator (see Figure 5). In the next section we will discuss our main results related to the moderation/mediation effect of buyer-specific investments.

Figure 5: Mediating/moderating role of buyer-specific investments

(d) Mediating role of buyer-specific investments



(e) Moderating role of buyer-specific investments



2 Theoretical Pathways

2.1 What is the nature of the relationship between buyer actions and supplier environmental investments?

Building on Relational Exchange Theory we proposed that supplier asset specificity mediates the impact of buyer actions on supplier investments. We based our hypotheses on two arguments:

(1) To evaluate or collaborate with suppliers, buyers have to make some investments, such as developing a scorecard, monitoring and assessing supplier's performance, sharing knowledge, etc. These investments are mostly supplier-specific and can usually not be transferred into the relationship with another supplier. Relational Exchange Theory suggests that these supplier-specific investments by a buyer trigger reciprocal buyer-specific investments by a supplier.

(2) Once the buyer-specific investments are in place, a supplier will be responsive toward buyer's preferences. If a buyer is interested in supplier's investments in Pollution Control or Prevention technologies, a supplier will conform to these preferences to preserve the relationship and to make this relationship valuable to the buyer.

Our results demonstrated that a mediating role of asset specificity held for collaboration, but not for evaluation. Note that the above two arguments assume that a supplier perceives buyers' investments in the relationship as supplier-specific with the intent of improving supplier's performance. If, on the other hand, a supplier does not perceive evaluation activities as buyer-specific investments, then the arguments of the Relational Exchange Theory won't hold and a supplier might remain unresponsive or even resist (Brehm, 1966) to buyer's evaluation activities. This is exactly what we observed in our research.

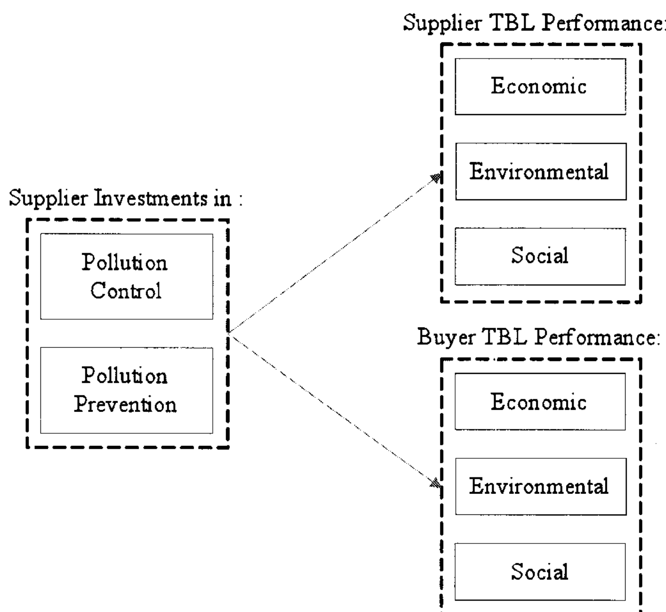
2.2 How the relationship between buyer actions and supplier environmental investments changes in the presence of buyer specific assets?

Self Enforcing Contract Theory suggests not a direct pathway from buyer activities to supplier investments via specific investments, but rather a moderating role of the latter. We argued that, in the presence of buyer-specific investments made by a supplier, the latter will be more responsive toward buyer activities, such as evaluation and collaboration, to preserve and strengthen the relationship. Similar to the mediation results, our results indicated that a moderation effect held for collaboration, with only limited results for evaluation. In particular, supplier investments in environmental technologies in reaction to collaboration were enhanced in the presence of supplier asset specificity. Supplier investments in pollution control technologies as a reaction to evaluation, however, were only slightly enhanced in the presence of supplier asset specificity. These results added further credibility to the argument of the supplier reactance as a result of evaluative activities.

2.3 To what extent do the buyer and the supplier benefit from supplier's investments in environmental technologies?

Our third research question (see Figure 6) was focused on assessing the benefits for both a supplier and a buyer from supplier environmental investments. Although we do not answer this question yet, we made a significant step towards exploring it – we developed a valid and reliable scale for measuring Triple Bottom Line performance of companies.

Figure 6: TBL benefits for the supplier and the buyer

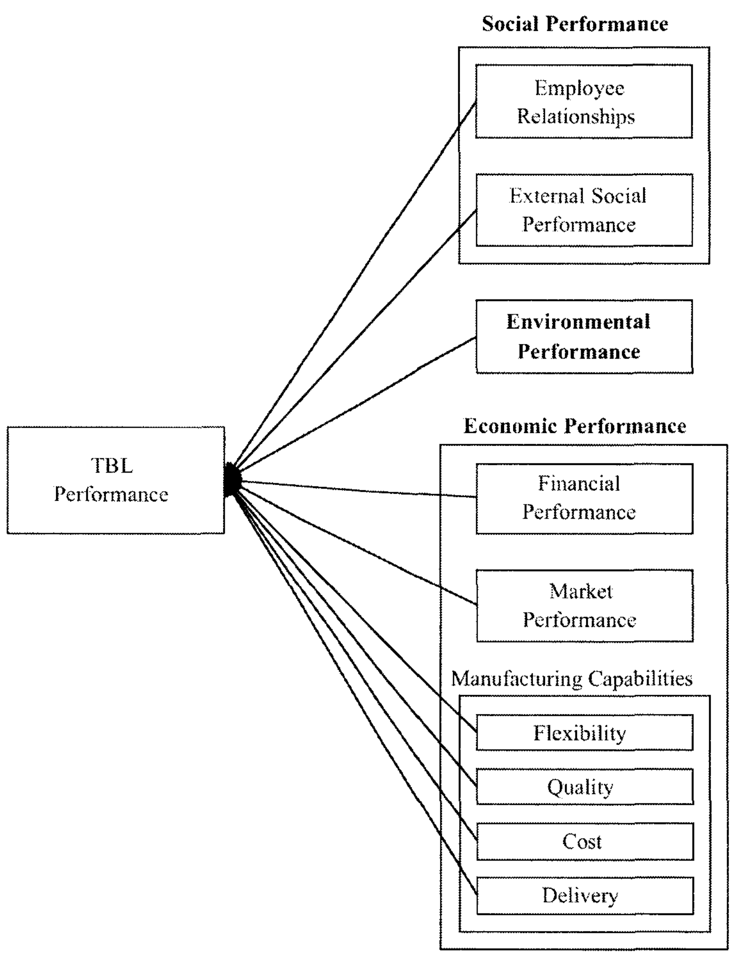


There are several problems with the Triple Bottom Line measurement that exist in the current literature. First, it is often used interchangeably with other important concepts – Corporate Social Responsibility (CSR) and (Business) Sustainability. Second, dimensions of TBL are sometimes used as stand alone dimensions (e.g., Klassen and McLaughlin, 1996) or research explores relationship between a pair of dimensions (e.g., Pil and Rothenberg, 2003). And third, so far a valid, reliable and comprehensive scale for measuring TBL performance has not existed.

In the second part of this dissertation we therefore (1) clearly discussed and differentiated the various concepts used in the literature, including TBL, Corporate Social Responsibility and Corporate Social Performance, as well as Sustainability, and (2) developed a valid and reliable tool for empirically measuring TBL performance. We did so by following a rigorous scale development process (Churchill 1979) as outlined by Menor and Roth (2007). More than that, we extended the traditional content validity clarification stage by using a factor-analysed Q-sorting technique in addition to the manual one traditionally used in Operations Management research (e.g., Menor and Roth, 2007). Factor-analysed Q-sort not only offers benefits of initially confirming content validity, but it also intially cofirms the structure of the constructs. As we explained step-by-step how to use this Q-sorting technique, we showed that the manual sorting failed to identify certain problems with our constructs. At the same time, the factor-analyzed technique clearly indicated that problems existed. At a later stage, confirmatory factor analysis confirmed the changes made as a result of the factor-analyzed Q-sort outcomes.

Our final TBL scales indicated that more than three dimensions exist within the TBL concept (see Figure 7). The social dimension consists of two distinct parts – internal social performance (employee relationships) and external social performance (relationships with other stakeholders). Environmental performance measures the environmental impact of a plant's products and manufacturing processes, but formed only a single dimension. Economic performance includes financial, market and manufacturing performance, with manufacturing performance consisting of a set of distinct manufacturing capabilities, including cost, quality, reliability and flexibility (e.g., Rosenzweig *et al.*, 2003).

Figure 7: Final TBL dimensions



3 Contributions to Research

3.1 Relational Exchange Theory (RET) and Self Enforcing Contract Theory (SECT)

Despite their similarity to each other, both Relational Exchange Theory and Self Enforcing Contract Theory propose only one specific role asset specificity might play in the relationship between buyer initiatives and supplier environmental investments – either mediating or moderating. Why is this the case?

Relational Exchange Theory has a process orientation, meaning that outputs from earlier processes become structural characteristics affecting future stages of the process, proposing a mediating role of specific assets. RET does not take into account the structure within which the process unfolds. On the other hand, Self Enforcing Contract Theory has a strong structural focus. It identifies structural characteristics that should be in place in order for relationship to exist without third-parties involvement, proposing a moderating role of specific assets. SECT, however, ignores the sociology of the relationship, such as social context.

Our results, however, showed that buyer-specific assets both moderate and mediate the relationship between buyer initiatives and supplier investments in environmental programs. For research, that means that both structural characteristics of the relationship and the social context in which the relationship exists are relevant and must be taken into consideration to unfold the true relationship between independent and dependent variables.

3.2 Triple Bottom Line Performance

Using a rigorous scale development process, we developed a valid and reliable scale for measuring Triple Bottom Line performance of plants. To clarify the structure of the construct, we proposed to use a factor-analyzed Q-sorting technique in addition to the manual Q-sort. This step is important, because the manual sorting technique may fail to identify problems with a scale, while the results from a factor-analyzed Q-sort are more reliable and more likely to uncover structural problems.

Thus, we make the following contributions to research. First, methodologically, we suggest extending the scale development process to include a factor-analyzed Q-sorting technique. Second, having gone through a rigorous scale development process, we have developed a TBL scale that can be used in future research to assess the effect of different managerial decisions on company's social, economic and environmental performance.

4 Managerial Implications of our Research

4.1 Importance of environmental investments and role of collaboration and specific assets

Our research helps managers in several ways. First, environmental investments can be quite substantial, with uncertain outcomes. Many suppliers are therefore not naturally inclined to make such investments. Indeed, our data indicated that, given the choice between Pollution Control, Pollution Prevention, or specific-assets, suppliers favored investments in specific-assets (see model 3 in table 5), because the expected outcome –

an improvement in the relationship with the buyer – was perceived as most beneficial. In the presence of buyer-specific assets, however, suppliers invested in environmental technologies to safeguard prior investments and enhance relationship with a buyer. As Pagell and Yang (Pagell *et al.*, 2004) found, however, "investments in EM [Environmental Management] improve plant performance and should be viewed as an opportunity, not a cost" (p. 34). How do environmental investments improve performance? As the Natural Resource View of the firm suggests, environmental management creates capabilities for a company (Hart, 1995) which, in turn, create competitive capabilities (Sharma and Vredenburg, 1998) and help to improve performance. Thus, if all members of the supply chain will see environmental investments as an opportunity, rather than a cost, significant improvement of the whole supply chain might be achieved (Pagell *et al.*, 2004).

To help suppliers understand the strategic importance of making investments in environmental programs, we recommend that managers of manufacturing companies collaborate with their suppliers (and customers) on environmental matters. It is collaboration that helps reduce uncertainty and, in extension, the unwillingness to invest in potentially costly environmental programs (Klassen and Vachon, 2003), help identify and evaluate options to overcome environmental challenges (Bonifant *et al.*, 1995), and help make product and process adaptations (Klassen and Vachon, 2003).

As our results show, collaboration influenced suppliers' investments in both Pollution Control and Pollution Prevention technologies. However, although investments in PC help in achieving immediate compliance with regulations and in some cases can serve as a substitute to an undeveloped PP technology (Klassen and Whybark, 1999a), in the long run investments in PP are more beneficial, since they provide a source of competitive advantage (Hart, 1995; Sharma and Vredenburg, 1998).

4.2 Performance Measurement

To date, performance reports issued by firms are incomplete, at best. Until the 1980s firms reported exclusively their financial performance. In the mid-nineties, many started adding information about their environmental efforts. In recent years, CSR reports have also become part of corporate reports. CSR reports mainly address philanthropic activities, expressed in terms of what the firm has done, rather than what has been achieved. This leaves us with merely an impression, rather than a real picture, of CSP. To our knowledge, our TBL scale is the most complete empirically validated tool for measuring TBL performance. As such, it enables managers to report something closer to the actual performance of companies along the three dimensions. This way, managers, investors and general public may obtain a more complete and reliable picture about the company's performance.

5 Limitations and Future Research

Collecting our data we requested responses from a single manager for each company. As previously discussed in the literature, this may create two problems: poor data quality and single source bias. To ensure data quality we conducted a qualitative study consisting of several cases prior to the development of the instruments. We also qualified all respondents prior to the data collection, based on their knowledge of the subject.

Same source bias might be a problem only in the first part of our research focusing on the role of specific assets in the relationship between buyer initiatives and supplier environmental investments. We examined the correlation matrix to identify significant correlations that cannot be theoretically explained and performed the Harman's one-factor test. Neither test provided evidence for the common source bias problem.

In the TBL scale development part of the paper we used three separate CFA models to validate our scales. This might jeopardize discriminant validity of the constructs. We tested pairs of nested models, however, and did not find any evidence of lack of discriminant validity.

Various avenues for further research exist. To advance further our claim regarding the co-existence of Relational Exchange Theory and Self Enforcing Contract Theory, in future research these two might be investigated in a single mediation-moderation model to develop a better understanding of how these two theories interact with one another. In addition, besides asset specificity, there might be factors affecting the relationship between buyer initiatives and supplier environmental investments, such as power-dynamics within the relationship, the role of institutional environment, etc. These should be introduced to the model in a systematic manner to advance our knowledge of the theoretical pathways within a buyer-supplier relationship.

Our hypotheses in the first paper propose causal relationships between variables. We employ a cross-sectional data collection, however, that does not allow us to validate such relationships. In future research a longitudinal design should be employed to allow testing the claims of causality. In addition, this research should be extended to include different SIC codes and various firm sizes. Data, if possible, should be collected using multiple respondents per firm to allow for cross-validation.

More items to measure economic performance of TBL might be included in future research, depending on the goal of the research in question. In addition, our scales could be modified by adding industry-specific indicators.

Appendix A – List of items used in the theoretical model

Construct	Items
Evaluation	(based on: Vachon and Klassen, 2006)
	Scale: 1=strongly disagree to 5=strongly agree
	The buyer …
	Eval1: Monitors our environmental performance.
	Eval2: Rewards improvements in our environmental responsiveness.
	Eval3: May discontinue business with us if we are not environmentally responsive.
	Eval4: Punishes us for lack of improvement.
	Eval5: Contractually requires environmental improvements.
	Eval6: Defines our environmental performance targets.
	Eval7: Defines our environmental responsibilities.
Collaboration	(based on: Klassen and Vachon, 2003; Vachon and Klassen, 2006)
	Scale: 1=strongly disagree to 5=strongly agree
	To make us more environmentally friendly, this buyer has:
	Coll1: Provided equipment.
	Coll2: Provided information.
	Coll3: Provided training to our plant
	This buyer works with us on the following activities to make us more environmentally friendly:
	Coll4: Product design.
	Coll5: Production process.
	Coll6: Developing alternative sources of raw materials.
	Coll7: Works with operations personnel.
	Coll8: Works with senior management.
Pollution	(based on: Klassen and Whybark, 1999a; Klassen and Whybark, 1999b; Klassen and Vachon,

Control	2003)
	Scale: 1=not at all to 5=to a great extent
	In this plant we have installed:
	PC1: Abatement equipment for airborne emissions.
	PC2: Equipment or developed procedures to treat, recycle or reuse aqueous effluents.
	PC3: Equipment or procedures to treat, recycle or reuse solid waste
	PC4: Collection systems.
Pollution Prevention	(based on: Klassen and Whybark, 1999a; Klassen and Whybark, 1999b; Klassen and Vachon, 2003)
	Scale: 1=not at all to 5=to a great extent
	In this plant we have installed:
	PP1: Production equipment upgrades
	In this plant we have invested in:
	PP2: Personnel training.
	PP3: Work-flow re-engineering.
	PP4: Recycling programs. [dropped]
	PP5: Material substitutions to our product.
	PP6: Design changes to our product.
	PP7: Packaging changes to our product.
	PP8: Changes to the manufacturing process.
Buyer-specific investments	(Heide and John, 1990)
	Scale: 1=strongly disagree to 5=strongly agree
	In this plant we have made the following investments that are specific to this buyer:
	Asset1: Tools and equipment.
	Asset2: Production system modifications.
	Asset3: Design changes for components.

Asset4: Adjustments to our physical plant.

Appendix B – List of items used to measure TBL dimensions

Please rate the extent to which you have achieved the following outcomes on the following scale: 1 = not at all; 5 = to a great extent

Compared to our main competitors, over the past 2 years, we have:

1. Environmental Performance

MP1: Reduced air emissions[3]

MP2: Reduced discharge of effluents[3]

MP3: Reduced solid waste disposed of into the landfill[3]

MP4: Reduced number of significant spills[3]

MP5: Reduced volume of significant spills[3, 5]

MP6: Increased the proportion of recycled input materials during the manufacturing process[2]

MP7: Reduced use of toxic substances during the manufacturing process[2]

MP8: Reduced environmental impact of our manufacturing process[3]

MP9: Increased the proportion of remanufactured input components during the manufacturing process[2]

MP10: Reduced the use of fresh water during the manufacturing process[2]

MP11: Reduced the use of non-renewable energy sources (such as coal, natural gas, fuel) during the manufacturing process[2]

MP12: Increased the use of renewable energy sources (such as biofuel, ethanol, hydrogen) during the manufacturing process[2]

PP1: Increased proportion of recyclable materials in the product design[4]

PP2: Improved product's impact on the environment during its useful life[4]

PP3: Improved environmental impact of our packaging[4]

PP4: Increased the proportion of reused components in the product design[4]

PP5: Reduced energy consumption during the life of a product[4, 6]

2. Social Performance

2.1 Employee Relationships

ER1: Reduced the rate of work-related injuries

ER2: Reduced the severity of work related injuries

ER3: Increased help to displaced employees to locate new work

ER4: Increased advancement of women within the plant

ER5: Increased the proportion of minority employed

ER6: Improved relationship with our employees

ER7: Increased awareness of employees regarding work health and safety

ER8: Increased the proportion of women employed

ER9: Increased advancement of minorities within the plant

2.2 External Social Performance

ES1: Improved relationship with our external stakeholders

ES2: Improved relationship with local authorities

ES3: Increased community involvement

ES4: Increased general public awareness regarding health risks resulting from plant's operations

ES5: Improved relationship with national authorities

3. Economic Performance

3.1 Market Performance

M1: Increased volume of business with our major customer

M2: Improved competitive advantage in the marketplace

Please rate how much you agree with the following statements (1=not at all; 5=to a great extent)

M3: Our main customer is now buying components from our firm that it has not previously bought[5]

M4: Our main customer is buying more of the same component from our firm that it has in the past

M5: Our firm has taken away market share from the competition in our industry

M6: Other potential customers are looking to do business with our firm

M7: Market share[7]

L1: Our plant is regarded by the industry as a leader in environmental responsiveness[8]

L2: Our industry looks to our plant for best practices on environmentally responsive manufacturing[8]

L3: Our manufacturing practices are believed to be among the best in the industry in terms of environmental responsiveness[8]

Please rate the extent to which the following performance indicators have changed during the past two years. Use the following scale: 1 = decreased significantly to 5 = increased significantly

3.2 Financial Performance

F1: Plant's annual profit level before taxes.

F2: Profits as percentage of sales

F3: Net income before taxes

F4: Net present value of the plant

F5: Return on assets

F6: Return on investments

3.3 Manufacturing Capabilities

MF1: Unit production costs

MF2: total production costs

MF3: perceived product quality

MF4: order fulfillment speed

MF5: delivery speed

MF6: manufacturing throughput time

MF7: delivery flexibility[5]

MF8: flexibility to change the output volume

MF9: flexibility to change the product mix

MF10: product repairability[5]

This appendix includes items used in the CFA. In all rounds of Q-sort (regular and factor-analyzed) only the indicators were used, omitting the words increased/decreased. For example, the first item "Increased the proportion of recycled input materials during the manufacturing process", was worded "Proportion of recycled input materials during the manufacturing process" in the Q-sort rounds.

[2] Items belonging to the Inputs dimension of Environmental Performance. This dimension was combined with Environmental Impact during Q-sort 2.

[3] Items belonging to the Environmental Impact dimension of Environmental Performance. This dimension was combined with Inputs during Q-sort 2.

[4] Items belonging to the Products and Packaging dimension of Environmental Performance. This dimension was combined with Manufacturing Performance during Q-sort 3 (the first factor-analyzed Q-sort).

[5] Dropped during CFA.

[6] Dropped during Q-sort 2.

[7] Added in the main survey (CFA).

[8] These items belonging to Market Performance were combined in the Leadership dimension during Q-sort 1 and then deleted during Q-sort 2.

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