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Manufacturing Strategy: Does Institutions Matter?

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Abstract

Recent literature has proposed that institutions play a pivotal role in corporate and business strategies. We argue that this role holds for manufacturing strategy as well. We provide preliminary data analysis of a recent survey collected in Canada and in Brazil. We compare important variables of manufacturing strategy in these institutional contexts, such as the competitive priorities, environmental management, green supply management, and organizational learning.

Keywords:

Operations strategy; green supply management; sustainable operations; institutional context.

1. INTRODUCTION

Manufacturing is already a globalized economic activity, and global manufacturing will be increasingly geographically dispersed. Forecasts from the Organization for Economic Cooperation and Development (OECD) predict that the global share of the gross domestic product (GDP) from developed countries will drop from 60% in 2000 to 43% by 2030 (Radjou, Kaipa, 2010). This dispersion will require new capabilities and skills from operations managers. The field of operations management (OM) has a long tradition in studying international OM (e.g., Chakravarty et al., 1997, Roth et al., 1997). Most international OM literature, up to the year 2000, compared U.S. operations with their "overseas" counterparts (Prasad et al., 2001). When developing countries are the target of the research, generally there is a description only of the plants of the developing country (e.g., Fleury, 1999, Karhunen, 2008), or the relationship of the provider on a developing country with their clients from developed countries (e.g., Narayanan et al., 2011). However, we find few studies testing how the variables in strategic operations management vary across different countries (Ahmad, Schroeder, 2003, Cagliano et al., 2011). The scarcity of comparative OM research reveals an important gap both for research and practice. For example, an operations manager in AGCO, the global agricultural equipment manufacturer, can rely on published research relating environmental performance and financial performance to make decisions to his/her tractor plant in Brazil? Therefore, despite the relevant contribution of the OM literature to the international OM field, it still does not provide evidences of the consistency of operations strategy between countries.

This paper contributes to fill this gap by providing a country comparison of the levels and the relationships among important variables of operations strategy, such as the competitive priorities, environmental management, green supply management, and organizational learning.

Instead of comparing multiple countries, we conducted a careful choice of two countries that allowed us to control many important macroeconomic variables, such as GDP and production output structure.

In section 2, we develop the theory that links our variables and how we expect them to change between countries. We describe our research design and measurement procedures in section 3. The empirical findings and results are presented in section 4. Finally, in section 5 we present the limitations, managerial implications, future research possibilities, and conclude.

2. THEORY AND HYPOTHESES

Figure 1 shows our theoretical model. We draw our hypotheses from the resource-based view of the firm (Barney, 1991, Grant, 1991, 1996): the most basic plant resources, such as the knowledge exchange processes, form lower level capabilities, such as the green management process. The lower level capabilities build higher level capabilities (supply capabilities), such as green supply management (Gavronski et al., 2011). These plant resources and capabilities are then related to plant performance. We add to this framework the institution as a leg of the strategy (Peng et al., 2009). The institutional environment provided by a country should influence the relationships RBV suggests. Therefore, the relationships between plant resources and plant capabilities, and between plant resources and capabilities and plant performance, should be moderated by the country where the plant operates.

Insert Figure 1 about here

2.1. Plant Resources

The knowledge exchange processes are the most basic resources we investigate in this paper. We divide the knowledge exchange processes in internal and external (Paiva et al., 2008). External knowledge exchange is the level of acquisition of new information from outside sources (Cohen, Levinthal, 1990). Internal knowledge exchange is the level of communication and information exchange, therefore the diffusion of knowledge, inside the plant.

2.2. Manufacturing Capabilities

We define manufacturing capabilities as the set of physical, financial, human, technological, and organizational resources (Grant, 1991) coordinated by organizational routines (Nelson, Winter, 1982) and deployed inside a manufacturing plant to improve its manufacturing performance. Because this broad definition could include such disparate practices as lean manufacturing (Womack et al., 1990) and advanced manufacturing technologies (M. L. Swink, Nair, 2007), we focus on that particular set of manufacturing capabilities we term green process management.

Green Process Management (GPM) refers to a plant's internal environmental management practices (Zhu et al., 2008) geared towards improving the plant's environmental performance. GPM can include such activities as design for the environment (DfE), life cycle analysis (LCA), ISO 14001 (Sarkis, 2001), pollution prevention (reduction at the source), pollution control (end-of-pipe technologies), and environmental management systems (EMS) (Klassen, Whybark, 1999b).

GPM requires an intricate set of soft skills, such as motivating people to dispose of recyclable materials appropriately, and hard technologies, such as waste water treatment stations.

A successful GPM implementation requires both soft skills and hard technologies to work together, and cannot be measured separately. However, soft skills are more dependent of communication, team motivation, and leadership, while hard technologies, especially environmental technologies, are more dependent on external technology suppliers. Therefore, in developed countries, where machinery is cheaper and wages are higher, GPM will be dependent on external knowledge exchange and in developing countries, where machinery is costlier and wages are lower, GPM will be dependent on internal knowledge exchange. Moreover, we can expect that, in developed countries, internal knowledge exchange is detrimental to GPM. Team relationship strength, for instance, is negatively related to information search costs (Hansen et al., 2005). Internal knowledge exchange impedes the transfer of complex knowledge (Kathleen M. Eisenhardt, Santos, 2002). Some authors suggest that a lower level of internal knowledge exchange is, in fact, more effective for some manufacturing capabilities than higher levels of exchange (K. M. Eisenhardt, Galunic, 2000). Thus we propose the following hypothesis:

Hypothesis 1a. Internal knowledge exchange will be positively associated with green manufacturing capabilities in developing countries.

Hypothesis 1b. Internal knowledge exchange will be negatively associated with green manufacturing capabilities in developed countries.

Hypothesis 2a. External knowledge exchange will be negatively associated with green manufacturing capabilities in developing countries.

Hypothesis 2b. External knowledge exchange will be positively associated with green manufacturing capabilities in developed countries.

2.3. Supply Capabilities

We define supply management as the complex of mechanisms implemented at the corporate and plant level to assess or improve the performance of a supplier base. This study focuses on the specific practices that industrial buying agents engage in to ensure that suppliers behave appropriately. For most plants, only having good manufacturing capabilities is not enough – it is necessary improve suppliers' performance to have the own performance improved. For example, the car manufacturer Toyota started the pilot *kanban* (a lean manufacturing technique) deployment in the decade of 1950. By the decade of 1960, the deployment started in all Toyota's plants. In the decade of 1970, Toyota rolled his *kanban* methodology to suppliers (Ohno, 1988).

From all possible supply management initiatives, we focus only on green supply management, which is comprised of three distinct set of activities: environmental selection of suppliers, environmental monitoring of suppliers, and environmental collaboration with suppliers (Gavronski et al., 2011). Environmental selection of suppliers is the inclusion of environmental criteria for selecting potential suppliers. Environmental monitoring of suppliers are the activities conducted by plant employees to ensure current suppliers have adequate levels of environmental performance. Environmental collaboration with suppliers are conjoint activities between plant employees and managers and the current supplier base to improve the environmental performance of suppliers. Previous research has shown that green process management mediates the relationship between plant resources and green supply management (Gavronski et al., 2011). However, we have no reason to believe that these relationships would change from developed to developing countries. Therefore, we hypothesize:

H3a. When green process management in a plant increases, the effectiveness of its environmental supplier selection process also increases.

H3b. When green process management in a plant is at a high level, the environmental supplier monitoring is also high.

H3c. When green process management in a plant is high, environmental supplier collaboration is also high.

2.4. Manufacturing performance

Manufacturing performance is the ultimate goal of manufacturing strategy (Wheelwright, Hayes, 1985). Traditional manufacturing performance dimensions are cost, quality, delivery, and flexibility (Wheelwright, 1984). Newly identified dimensions include innovativeness, or new product development capabilities (M. Swink et al., 2006), environmental performance (Jiménez, Lorente, 2001), and social performance (Awaysheh, Klassen, 2010).

Manufacturing performance dimensions are linked to manufacturing practices (for a theoretical discussion, see Ketokivi, Schroeder, 2004). Plants that pursue cutting edge manufacturing practices extend their performance frontiers (Liu et al., 2011, Rosenzweig, Roth, 2004), achieving sustainable competitive advantages (Colotla et al., 2003). Extant literature in OM have linked manufacturing performance with internal and external knowledge exchange (Ahmad, Schroeder, 2001, Paiva et al., 2008), with green process management (Klassen, 2000, Klassen, Whybark, 1999b), and with green supply management (Rao, Holt, 2005, Zhu, Sarkis, 2004). Consistently with extant literature, we posit that manufacturing resources and capabilities are positively related with manufacturing performance. However, we argue that differences between developed countries and developing countries would change the slope of these relationships. Because developed countries have access to machinery at lower costs, and wages are higher, substantial returns will come from acquisition of technologies, instead of investing time of employees for the internal development of solutions. Therefore, for developed countries, external knowledge exchange will be more related to manufacturing performance than in developing countries, and internal knowledge exchange will be more related to manufacturing performance in developing countries than in developed countries. However, we do not expect a country effect on the relationship between manufacturing performance and green process management or between manufacturing performance and green supply management.

H4a. Manufacturing performance is positively related to internal knowledge exchange in developing countries.

H4b. Manufacturing performance is negatively related to internal knowledge exchange in developed countries.

H5a. Manufacturing performance is negatively related to external knowledge exchange in developing countries.

H5b. Manufacturing performance is positively related to external knowledge exchange in developed countries.

H6. Manufacturing performance is positively related to green process management both in developed and in developing countries.

H7. Manufacturing performance is positively related to green supply management both in developed and in developing countries.

3. METHODS

3.1. Research Setting and Data

For country comparison, we have chosen two countries. By choosing only two countries, comparing country effects would be easily performed, by including only a dummy variable. Because we would not be allowed to enter more control variables, common in country comparisons, such as GDP (Vachon, 2010), we have carefully chosen two countries comparable: Brazil and Canada. Both countries share many commonalities: land size is similar (8,459,417 sq km vs. 9,093,507 sq km), GDP is similar ($2.09 trillion vs. $1.57 trillion), and GDP composition by sector is also quite similar (agriculture: 5.8% vs. 2.2%, manufacturing: 26.8% vs. 26.3%, and services: 67.4% vs. 71.5%). Therefore, by comparing manufacturing plants in these two countries, all these macroeconomic variables are controlled. Despite these similarities, Brazil and Canada are very different. With a much larger population, Brazil has a much smaller GDP per capita than Canada ($10,800 vs. $39,400) and the inequality of income, measured by the Gini index, is also much higher (53.9 vs. 32.1)[1]. Canada, for example, is listed in the Annex B of Kyoto Protocol as one of the developed countries that should reduce greenhouse gas emissions, while Brazil is not. Therefore, Brazil qualifies as a developing country, while Canada is a developed country.

We conducted preliminary interviews with operation managers from a small sample culled from a larger number of industries in Canada and identified those industries

[1] Source for these data: CIA World Factbook 2011, https://www.cia.gov/library/publications/the-world-factbook/

technologically similar and subject to similar customer and government environmental requirements. From this preliminary study, we settled on four industries. We then made a stratified random sampling from the Scotts Industrial Database (SID) of manufacturing plants and Canada's National Pollutant Release Inventory (NPRI) database. We followed the expected proportion of the manufacturing plants by industry provided by the Statistics Canada agency. We contacted these companies by phone, checked their addresses, and respondent names. Before sending the questionnaires, we submitted the instrument to a PhD candidate with extensive experience in industry and two professors in the supply management field and solicited suggestions for improvement. We then sent 503 questionnaires, following the Total Design Method (TDM Dillman, 2000) and received 94 usable responses, an 18.7% response rate, which is close to the recommended level, i.e., 20%, on surveys of this nature (Malhotra, Grover, 1998). The survey questionnaires were addressed to the plant manager, operations manager, or equivalent decision maker, an approach used by other studies in environmental management and organizational learning and knowledge (Klassen, Vachon, 2003, Klassen, Whybark, 1999a). We then translated the questionnaire to Brazilian Portuguese, and submitted the questionnaire to three managers and one OM professor, for validation. We have contacted 277 plants, and received 46 questionnaires, a 16.6% response rate. Data collection in Brazil is still in progress. Therefore, our results are still preliminary.

3.2. Measurement Procedures

We report all scale items in the Appendix. We used measures for green supply management, green management practices, and knowledge exchange from previously published sources (Gavronski et al., 2011), to ensure validity and reliability. We utilized confirmatory factor analysis to assess the psychometric properties of the questionnaire's scales (CFA – see, e.g. Bollen, 1989). The final model fit for the multi-item scales are in the expected range (Kline, 2005). The reliability, measured by composite reliability, was also above the expected minimum of .7 for both internal and external knowledge exchange. After validating all scales, we converted the raw scores in summated scales by the arithmetic mean of the items of each construct.

For the measurement of manufacturing performance, we asked plant managers to compare their plant performance with competitors (Hill, 1989), also a customary practice in manufacturing strategy research (Liu et al., 2011).

Plant size was computed taking the natural logarithm of the number of full time employees in the plant.

Country was coded 1 for Brazil and 0 for Canada. For clarity purposes, the variable was termed *brazil*.

We tested the hypotheses of this paper using multivariate regression with ordinary least squares (OLS) estimation. We used Baron & Kenny's mediation and moderation tests (1986) to avoid misspecification of the model and inefficient estimation of the effects between organizational resources and green manufacturing capabilities, and from these capabilities to GSM capabilities. However, we are not providing mediation evidence, given that we took all measures at the same time.

Simulations show that the tests we used are the more conservative among those available, thus suggesting fewer Type I errors (MacKinnon et al., 2002). Baron and Kenny's test is a three-step procedure: first, regressing the mediator on the independent variables; second regressing the dependent variable on the independent variables; and third, regressing the dependent variable on both the mediator and on the independent variables.

Three conditions must hold. First, the independent variables and the mediator must be related in the first regression. Second, the independent and dependent variables must be related in the second regression. Third, the mediator and the dependent variable must be related in the third regression. The mediator is said to perfectly mediate the independent and depend variables if the relation between the latter is not significant when the mediator is controlled. If the coefficient of the independent variable is still significant in the third regression, but it is lower than in the second regression, then the coefficient has a direct and indirect effect on the dependent variable, and the mediator is said to partially mediate the effect.

4. ANALYSES AND RESULTS

4.1. Descriptive Statistics

Table 1 reports the means, standard deviations, and correlations of all variables used in this study. Our results showed little correlation between our independent variables, and we expect no concerns for multivariate models.

Insert Table 1 about here

Table 2 reports the means, standard deviations, and t-tests of all variables used in this study, by country. On average, Brazilian plants are larger in our sample than the Canadian plants, which differences will be controlled by including size in the estimation of the model.

Insert Table 2 about here

4.2. Green Process Management

We have modeled GPM practices as the dependent variable of the equation. Our models, then, take the form

$$GPM_i = \beta_0 + \beta_1 \times size + \beta_2 \times ike + \beta_3 \times eke + \beta_4 \times brazil + \beta_5 \times ike{:}brazil + \beta_6 \times eke{:}brazil + + \varepsilon_i, \quad (1)$$

Where *size* is plant size, *ike* is the internal knowledge exchange level, *eke* is the external knowledge exchange level, and *brazil* is the country variable. Table 3 speaks to the hypotheses 1a, 1b, 2a, and 2b. For model GPM 1, we have constrained β_2 to β_6 to zero. For model GPM 2, we have constrained β_4 to β_6 to zero. Models GPM 1 and GPM 2 are provided for comparison purposes only. Since model GPM 3 provides an interaction of continuous variables (*ike* and *eke*) with a categorical variable (*brazil*), the interpretation of the coefficients is as follows: β_2 is the slope of *ike* at *brazil*=0 (Canadian plants), while β_5 is the change of slope for *ike* at *brazil*=1 (Brazilian plants). Similarly, β_3 is the slope of *eke* at *brazil*=0 (Canadian plants), while β_6 is the change of slope for *eke* at *brazil*=1 (Brazilian plants). As we have predicted, internal knowledge exchange has a positive and significant relationship with GPM in Brazilian plants, while has a negative and significant relationship with GPM in Canadian plants. Therefore, we found support for hypotheses 1a and 1b. However, external knowledge exchange, contrary to our expectations, is positively related with green process management for both countries, thus providing support for hypothesis 2b, but not for 2a.

Insert Table 3 about here

4.3. Green Supply Management

We have modeled each set of practices of GSM (collaboration, monitoring, and selection) separately as the dependent variable of the equation. Our models, then, take the form

$$GSM_i = \beta_0 + \beta_1 \times size + \beta_2 \times ike + \beta_3 \times eke + \beta_4 \times gpm + \beta_5 \times brazil + \beta_6 \times ike{:}brazil + \\ + \beta_7 \times eke{:}brazil + \beta_8 \times gpm{:}brazil + \varepsilon_i, \qquad (2)$$

Where *size* is plant size, *ike* is the internal knowledge exchange level, *eke* is the external knowledge exchange level, *gpm* is the green process management level, and *brazil* is the country variable. Table 4 speaks to the hypotheses 3a, 3b, and 3c. For clarity purposes, we have omitted the models with only the control variable, but we have provided the ΔR^2 from this models to the models with plant resources (knowledge exchange), which we collectively termed Model 1. For Model 1, we have constrained β_4 to β_8 to zero. For Model 2, we have constrained β_5 to β_8 to zero. By freeing β_4, we are able to evaluate, in the change of β_2 and β_3 from Models 1 to Model 2, whether mediation is occurring. In our mediation tests (Baron, Kenny, 1986), if *gpm* mediates the relationship between *ike* and GSM and between *eke* and GSM, coefficients for *ike* and *eke* will drop from Model 1 to Model 2. Since Model 3 provides an interaction of continuous variables (*ike, eke,* and *gpm*) with a categorical variable (*brazil*), the interpretation of the coefficients is as follows: β_2 is the slope of *ike* at *brazil*=0 (Canadian plants), while β_6 is the change of slope for *ike* at *brazil*=1 (Brazilian plants). Similarly, β_3 is the slope of *eke* at *brazil*=0 (Canadian plants), while β_7 is the change of slope for *eke* at *brazil*=1 (Brazilian plants), and β_4 is the slope of *gpm* at *brazil*=0 (Canadian plants), while β_8 is the change of slope for *gpm* at *brazil*=1 (Brazilian plants). As we have predicted, green process management mediates, at least partially, the relationship between knowledge exchange (both internal and external) and green supply management, for the three dimensions of GSM (collaboration, monitoring, and selection). Also, GPM is positively related to collaboration, monitoring, and selection, thus providing support for hypotheses 3a, 3b, and 3c. The coefficients of the interaction terms are not significant, as we expected. Therefore, there is no country effect in the relationship between green process management and green supply management.

Insert Table 4 about here

4.4. Manufacturing Performance

We have modeled each dimension of manufacturing performance (cost, quality, delivery, flexibility, and new product development – NPD) separately as the dependent variable of the equation. Our models, then, take the form

$$Performance_i = \beta_0 + \beta_1 \times size + \beta_2 \times ike + \beta_3 \times eke + \beta_4 \times gpm + \beta_5 \times spc + \beta_6 \times spm + \beta_7 \times sps + \beta_8 \times brazil + \beta_9 \times ike{:}brazil + \beta_{10} \times eke{:}brazil + \beta_{11} \times gpm{:}brazil + \beta_{12} \times spc{:}brazil + \beta_{11} \times spm{:}brazil + \beta_{11} \times sps{:}brazil + \varepsilon_i, \quad (3)$$

Where *size* is plant size, *ike* is the internal knowledge exchange level, *eke* is the external knowledge exchange level, *gpm* is the green process management level, *spc* is the level of environmental supplier collaboration, *spm* is the level of environmental supplier monitoring, *sps* is the level of environmental supplier selection, and *brazil* is the country variable. Table 5 speaks to the hypotheses 4a, 4b, 5a, 5b, 6, and 7. For clarity purposes, we have omitted the models with only the control variable. For Model 1, we have constrained β_8 to β_{11} to zero. For Model 2, we have all coefficients unconstrained. Since Model 3 provides an interaction of continuous variables (*ike, eke, gpm, spc, spm,* and *sps*) with a categorical variable (*brazil*), the interpretation of the coefficients follows the same rules as the previous models. We only found support for hypothesis 4a in model Quality 2, where *ike* is positively related to quality performance for Brazilian plants. Contrary to our expectations, we found delivery and new product development performances to be positively related to internal knowledge exchange, both in Brazilian and in Canadian plants. Therefore, we found no support for hypothesis 4b. We found support for hypotheses 5a and 5b for quality and flexibility performances, which are negatively related to external knowledge exchange in Brazilian plants and positively related in Canadian plants. New product development performance, however, is positively related to external knowledge exchange for both countries, which contradicts hypothesis 5a and supports hypothesis 5b. Contrary to our expectations, green process management is not related to performance in all plants. Only quality performance in Brazilian plants is positively related to green process management. Therefore, we found no support for hypothesis 6. Finally, contrary to our expectations, environmental monitoring of suppliers is negatively related to quality performance in both countries, and the other estimates for green supply management are not significant. Therefore, we found no support for hypothesis 7.

Insert Table 5 about here
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5. DISCUSSION AND CONCLUSIONS

5.1. Research Implications

This paper provides a country comparison of the levels and the relationships among important variables of operations strategy, such as the competitive priorities, environmental management, green supply management, and organizational learning. To accomplish these objectives, we conducted a survey in a developing country and a developed country, namely Brazil and Canada, and compared results using multivariate hierarchical regression analysis.

Our research replicates and extends previous research (Gavronski et al., 2011). We found that for the Brazilian plants, where machinery is costlier and wages are lower, internal knowledge exchange plays a role in deploying manufacturing capabilities, such as green process management. Canadian plants, on the other hand, have access to machinery at lower costs, but wages are higher. In these plants, internal knowledge exchange is detrimental to the deployment of green process management. However, for both countries, external knowledge exchange is positively related to green process management. One possible explanation for this result is the dual characteristic of green process management: it depends on soft skills as well as hard technologies, and most plants do not have the required resources to develop everything internally. Given that most green technologies require special knowledge, such as advice and scanning of environmental laws and regulations, pollution control technologies, etc., external knowledge exchange is an important driver of green process management, both in developed and developing countries.

Manufacturing capabilities are positively related to supply capabilities. Our research provides empirical evidence of this relationship, using the case of green process management and green supply management. Given the anecdotal evidence that manufacturing capabilities are built before supply capabilities, our results also allow us to speculate that manufacturing capabilities mediate supply capabilities. We found as well evidence that this relationship is country invariant, therefore providing generalizability to the RBV-based claim that higher-order capabilities are built over lower-level capabilities (Teece et al., 1997).

Our research also shows that the relationship between resources, capabilities, and performance are more intricate than we previously expected. For example, while we did not found any evidence relating cost performance and plant resources and capabilities, we found resources and capabilities to be related to the other manufacturing performance dimensions. Internal knowledge exchange, for instance, is positively related to delivery and new product development performances, regardless of the country of operation. This result is contrary to our expectations, but consistent with results of research with data collected from either developed countries (Schroeder et al., 2002) or developing countries (Paiva et al., 2008). We found the expected relationships for both quality and flexibility performances, which are positively related to external knowledge exchange in Canadian plants and negatively related to external knowledge exchange in Brazilian plants. Again, one possible explanation is that Canadian plants rely more on machinery (therefore, external sources of knowledge) to improve and sustain quality and flexibility, while Brazilian plants rely more on internal resources, either because of the costs of machinery or the relatively lower costs of labor. Finally, we found no relationship between performance and green process management or green supply management. These results suggest that most basic resources, such as knowledge exchange (internal and external), are related to manufacturing performance, higher-level capabilities, such as the ones we tested, are linked to other dimensions of performance, such as marketing or financial, or linked to manufacturing performance indirectly, by means of other variables.

5.2. Managerial implications

We demonstrate that country of operation of the plant matters for manufacturing strategy formulation. When deploying a technology that can be achieved either by hard technology or by softer skills of employees, operations managers in developed countries will prefer the former, and should emphasize the external knowledge exchange in the plant, but operations managers in developing countries will prefer the latter, and should emphasize the internal knowledge exchange. When deploying a technology that requires the acquisition of machinery or very specialized knowledge, operations managers should emphasize the external knowledge exchange of the plant, regardless of the country of operation.

We also find that, depending on the competitive priorities operations managers want to prioritize in their plants, the country of operation can be important. For example, for achieving quality or flexibility performances, operations managers in developed countries should emphasize external knowledge exchange, but operations managers in developing countries can find that external knowledge exchange is detrimental to quality or flexibility. For new product development performance, both internal knowledge exchange and external knowledge exchange should be developed. These examples show that performance objectives can be either trade-offs or cumulative (Ferdows, De Meyer, 1990, Rosenzweig, Roth, 2004, Skinner, 1992), depending on the country of operation.

5.3. Limitations

Given the empirical nature of this research, it is important to highlight its limitations. First, we examined only a few industries and had only a modest response rate, thus the generalizability of our results is limited. Moreover, the data collection in Brazil is still in progress, so the results should be considered preliminary.

Second, we collected data from only one source inside the organization: the plant manager. This narrow range of respondents can cause problems with common method variance (Podsakoff et al., 2003). This specific group of respondents, however, is the most knowledgeable for the type of decision we are investigating. Third, we propose a model that demands robust mediation tests, particularly with panel data, and our evidence is taken from a cross-sectional survey. Therefore, these results should be considered preliminary. However, we did test our data with widely accepted mediation methods, and the results do not disconfirm our theory, a sign that further investigation should consider testing our model in other research designs. Finally, the largest models tested 14 independent variables, with sample sizes ranging from 122 to 132 cases. This is below the recommended 10:1 cases to variables ratio, but above the minimum 5:1 ratio (Hair et al., 1998).

5.4. Main contributions

A key contribution of this paper is to highlight the importance of taking country of operation into consideration in manufacturing strategy research and practice. While country effects have been accounted for in previous research (Ahmad, Schroeder, 2003, Cagliano et al., 2011, Vachon, 2010), the results were either country-level data (as opposed to our study, which analyzes plant-level data) or used country only as a control variable, not as a substantive independent variable.

5.5. Future Research

Peng and colleagues suggested that strategy sits on a tripod formed by resources and capabilities, industry, and institutional forces (Peng et al., 2009). While we accounted for resources and capabilities, and institutions, future research should consider the industry effect into manufacturing strategy, not only controlling by industry standard codes, but by industry variables, such as the bargain power of suppliers and clients, concentration of industry, relative size to competitors, etc.

While we used multiple regression to test our hypotheses, future research could deploy hierarchical linear models (e.g., Kull, Wacker, 2010) to test a wider range of countries and incorporate covariates at country-level, such as GDP, education, cost of labor, taxes, or industry-level covariates, such as the aforementioned variables, for more accurate estimates.

Last, given the cross-sectional nature of the data, future research should test the mediation hypothesis with a longitudinal design.

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APPENDIX

Description of variables

Environmental Collaboration with Suppliers

During the past two years, to what extent did your plant engage in the following environmental activities with your **existing primary suppliers** (i.e., the 15-20% most important suppliers)? (1=Not at all, 4=Moderately, 7=Great extent)

A1. Achieving environmental goals collectively *(dropped)*
A2. Developing a mutual understanding of responsibilities regarding environmental performance *(dropped)*
A3. Working together to reduce environmental impact of our activities
A4. Conducting joint planning to anticipate and resolve environmental-related problems
A5. Making joint decisions about ways to reduce overall environmental impact of our products

Environmental Monitoring of Suppliers

During the past two years, to what extent did your plant engage in the following environmental activities with your **existing primary suppliers** (i.e., the 15-20% most important suppliers)? (1=Not at all, 4=Moderately, 7=Great extent)

A6. Sending environmental questionnaires to existing primary suppliers in order to monitor their compliance
A7. Asking **existing** primary suppliers to commit to waste reduction goals
A8. Having environmental criteria in periodic evaluation of **existing** primary suppliers
A9. Having environmental specialists periodically auditing **existing** primary suppliers' plants *(dropped)*
A10. Requesting **existing** primary suppliers to provide evidence of all environmental licenses and permits *(dropped)*

Environmental Selection of Suppliers

During the past two years, to what extent did your plant engage in the following environmental activities with your **potential primary suppliers**? (1=Not at all, 4=Moderately, 7=Great extent)

A11. Requesting **potential** primary suppliers to provide evidence of all environmental licenses and permits
A12. Requiring that **potential** primary suppliers have an implemented environmental management system (e.g., ISO 14001)
A13. Requesting **potential** primary suppliers to sign a formal statement that all environmental regulations will be satisfied *(dropped)*
A14. Having environmental specialists audit **potential** primary suppliers' plants
A15. Asking **potential** primary suppliers to commit to waste reduction goals *(dropped)*

External knowledge exchange

Please indicate the extent to which each of the following **external sources** of learning provide valuable new ideas for your plant (1=none, 4=moderate, 7=extensive)
B1. Tracking new market trends in our industry
B2. Benchmarking best practices in our industry
B3. Trying out new technologies
B4. Taking new business opportunities
B5. Other plants from parent company *(dropped)*
B6. Supplier base
B7. Customers

Internal knowledge exchange

Please evaluate the **extent of communication** in your plant between the following groups (1=very low, 4=moderate, 7=very high)
B8. Between supervisors and their subordinates
B9. Among functional areas (e.g., marketing, engineering, manufacturing, and customer service)
B10. Between departments inside the plant (e.g., cutting, machining, and assembly)
B11. Between senior managers and supervisors

Green Process Management

Managers can choose to invest in many different areas, both inside and outside the plant. In the last two years, to what extent has **your plant** invested resources (money, time and/or people) in programs in the following areas? (1=not at all, 4=some extent, 7=great extent)

C1. ISO 14001 certification
C2. Pollution prevention
C3. Recycling of materials
C4. Waste reduction
C5. Workplace health and safety

TABLE 1

Means, Standard Deviations, and Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. gpm	—												
2. spc	.44 ***	—											
3. spm	.35 ***	.71 ***	—										
4. sps	.42 ***	.61 ***	.79 ***	—									
5. ike	.15	.04	-.02	.06	—								
6. eke	.36 ***	.40 ***	.18 +	.21 *	.45 ***	—							
7. cost	.26 **	.25 **	.26 **	.23 *	.14	.20 *	—						
8. qual	.27 **	.15	-.06	.10	.30 **	.37 ***	.24 *	—					
9. delv	.24 *	.14	.10	.14	.31 ***	.26 **	.38 ***	.28 **	—				
10. flex	.08	.12	.06	.11	.22 *	.27 **	.23 *	.32 ***	.55 ***	—			
11. nprd	.13	.20 *	.05	.04	.37 ***	.50 ***	.16 +	.43 ***	.38 ***	.38 ***	—		
12. size	.21 *	.27 **	.31 ***	.34 ***	-.06	.05	.10	.04	-.19 *	-.11	-.05	—	
13. brazil[a]	.01	.36 ***	.34 ***	.23 *	-.04	.23 *	.01	-.04	-.01	.08	.22 *	.30 **	—
Mean	4.14	2.47	1.99	2.03	5.21	4.79	4.27	5.50	5.15	5.16	4.54	5.25	0.34
SD	1.25	1.42	1.30	1.30	0.99	0.99	1.20	1.03	1.30	1.15	1.56	0.92	0.47
Range	1:7	1:7	1:7	1:7	1:7	1:7	1:7	1:7	1:7	1:7	1:7		0:1

Notes:

[a] 0=Canada 1=Brazil

+=p < .1 *=p < .05 **=p < .01 ***=p < .001

TABLE 2

Differences between means

Country	Canada		Brazil		
	Mean	s.d.	Mean	s.d.	t-test
gpm	4.16	1.35	4.16	1.03	-0.01
spc	2.21	1.41	2.97	1.42	-2.95 **
spm	1.73	1.13	2.46	1.39	-3.08 **
sps	1.90	1.31	2.33	1.39	-1.74 +
ike	5.23	0.96	5.18	1.05	0.28
eke	4.61	0.98	5.00	0.91	-2.36 *
size	5.01	0.88	5.60	0.79	-4.02 ***
cost	4.23	1.13	4.27	1.30	-0.16
qual	5.50	1.00	5.53	1.01	-0.18
delv	5.13	1.23	5.22	1.38	-0.38
flex	5.17	1.18	5.36	1.12	-0.93
nprd	4.46	1.54	4.98	1.47	-1.88 +
N	94		46		

Notes:

$^{+}$=p < .1 *=p < .05 **=p < .01 ***=p < .001

TABLE 3

Green Process Management

	GPM 1	GPM 2	GPM 3
(Intercept)	2.67 ***	1.58 +	2.17 *
size	.28 *	.24 *	.30 *
ike		-.14	-.35 *
eke		.43 ***	.49 ***
brazil[a]			-2.52 +
ike:brazil			.56 *
eke:brazil			-.15
R^2	.04	.13	.18
ΔR^2		.09	.05
F	5.72 *	6.48 ***	4.70 ***
df	1,133	3,130	6,127

Notes:

[a] 0=Canada 1=Brazil

$^{+}$=p < .1 *=p < .05 **=p < .01 ***=p < .001

TABLE 4

Green Supply Management

	Collaboration			Monitoring			Selection		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
(Intercept)	-.89	-1.62 +	-1.16	-.44	-1.01	-.29	-.81	-1.61 +	-2.07 +
size	.34 **	.27 *	.17	.39 **	.34 **	.25 *	.43 ***	.36 **	.35 **
ike	-.29 *	-.25 +	-.22	-.19	-.15	-.24	-.06	.00	.02
eke	.65 ***	.51 ***	.41 *	.29 *	.17	.17	.19	.01	.03
gpm		.37 ***	.42 ***		.29 **	.29 **		.41 ***	.48 ***
brazil[a]			.21			-.10			1.64
ike:brazil			-.01			.36			.10
eke:brazil			.17			-.27			-.15
gmp:brazil			-.10			.05			-.29
R^2	.21	.30	.33	.12	.20	.26	.10	.23	.25
ΔR^2	.15 [b]	.09	.03	.05 [b]	.07	.06	.01 [b]	.12	.02
F	11.32 ***	13.50 ***	7.57 ***	6.13 ***	7.64 ***	5.27 ***	4.98 **	9.33 ***	5.08 ***
df	3,129	4,125	8,121	3,130	4,126	8,122	3,131	4,127	8,123

Notes:

[a] 0=Canada 1=Brazil

[b] computed over the R^2 of the base model, only with the control variable

$^{+}$=p < .1 *=p < .05 **=p < .01 ***=p < .001

TABLE 5

Manufacturing Performance

	Cost 1	Cost 2	Quality 1	Quality 2	Delivery 1	Delivery 2	Flexibility 1	Flexibility 2	NPD 1	NPD 2
(Intercept)	1.77 *	1.98 $^{+}$	2.84 ***	3.38 ***	3.51 ***	3.96 ***	4.37 ***	4.55 ***	.74	.93
size	.07	.08	.06	.08	-.32 *	-.33 *	-.19	-.21 $^{+}$	-.13	-.21
ike	.14	.15	.17 $^{+}$	-.02	.34 **	.27	.13	.05	.31 *	.37 *
eke	.10	.08	.22 *	.41 **	.13	.13	.23 $^{+}$	.35 *	.66 ***	.63 ***
gpm	.13	.07	.14 $^{+}$	.00	.17	.21	-.04	-.13	-.05	-.12
spc	.03	.11	.09	.12	.00	-.01	.00	-.10	.06	.19
spm	.19	.26	-.32 **	-.40 **	.09	.11	-.04	.12	.03	-.07
sps	-.05	-.16	.13	.23 $^{+}$	.01	-.09	.14	.20	-.09	-.06
brazil[a]		-1.21		-.53		-.95		.56		1.14
ike:brazil		-.12		.51 *		.25		.36		-.13
eke:brazil		.17		-.71 **		-.05		-.67 *		-.16
gmp:brazil		.23		.40 *		-.08		.36		.39
spc:brazil		-.19		-.01		.08		.30		-.42
spm:brazil		-.29		.05		-.29		-.65 $^{+}$		.13
sps:brazil		.45		-.19		.39		.10		.03
R^2	.13	.17	.23	.32	.19	.21	.10	.18	.28	.33
ΔR^2		.04		.09		.02		.08		.05
F	2.40 *	1.52	4.82 ***	3.62 ***	4.03 ***	2.18 *	1.80 $^{+}$	1.67 $^{+}$	6.60 ***	3.86 ***
df	7,114	14,107	7,114	14,107	7,119	14,112	7,115	14,108	7,117	14,110

Notes:

[a] 0=Canada 1=Brazil

$^{+}$=p < .1 *=p < .05 **=p < .01 ***=p < .001

FIGURE 1

Country effects on operations strategy