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The Relationship between Manufacturing Integration and Performance from an Activity-Oriented Perspective

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Abstract

Manufacturing integration with other functional areas and suppliers is a key aspect for achieving sustainable competitive advantage. The objective of this study is to analyze manufacturing integration from an activity-based perspective. We hypothesize that manufacturing integration with suppliers, marketing, and R&D is positively related to profit and sales growth when it occurs simultaneously in key internal activities. We surveyed 366 companies located in the southern region of Brazil, chosen from the SEBRAE(1) database. We used structural equations modeling to address validity and reliability issues. We evaluated common method variance (CMV) with the MTMM model and used path analysis to test the structural relations. We found that all manufacturing integration aspects are positively related to sales growth, but only manufacturing-R&D integration is positively related to profitability. Therefore, managers interested in improving the performance of their plants should favor the integration between manufacturing and R&D teams, at all hierarchical levels. We did not find any evidence, however, that direct interaction between manufacturing and marketing improves performance.

Key words: manufacturing integration; cross-functionality; performance; survey; MTMM.

Introduction

Both the literature and practice have called for more integration among different functional areas inside an organization (internal integration) and between organizations (external integration). Consequently, a growing number of studies attempt to analyze the dynamics of integration among manufacturing and different functional areas, hierarchical levels and organizations. Since those processes can enhance organizational performance (Swink & Song, 2007), companies need to increase their levels of internal and external integration.

The internal and external integration of manufacturing is a current topic in OM research, but previous research usually analyzed supply chain integration; manufacturing and marketing integration (Berry, Klompmaker, McLaughlin, & Hill, 1991; Boyer & Hult, 2005); and manufacturing integration along the new product development process (Koufteros, Edwin Cheng, & Lai, 2007; Swink, 1999; Ulrich & Ellison, 2005). Also, regarding supply chain integration, previous literature have explored the relationship between integration and performance (Devaraj, Krajewski, & Wei, 2007; Flynn, Huo, & Zhao, 2010; Narasimhan & Kim, 2002) and issues related to collaboration and commitment (Balakrishnan & Geunes, 2004; Cousins & Menguc, 2006; Zhao, Huo, Flynn, & Yeung, 2008).

Nevertheless, few articles analyzed these issues using an integrated approach considering internal and external integration at the same time. Rosenzweig, Roth and Dean (2003) identified that closer relationships between external actors (suppliers, distributors and customers) and internal actors strengthen capabilities and may lead to better performance. Swink, Narasimhan and Wang (2007) also showed that manufacturing integration throughout the value chain between internal and external actors positively influences business performance.

The objective of this study is to analyze manufacturing integration from an activity-based perspective. Differing from Rosenzweig, Roth and Dean (2003) and Swink *et al.* (2007), we specified the internal actors that interact with manufacturing and we assess three key activities for the integration among manufacturing and other organizational actors. The focus was on actors from three areas that usually develop direct activities with manufacturing: suppliers, R&D and marketing.

Theory and Hypotheses

Manufacturing integration

Internal Integration. From an internal perspective, integration between manufacturing and marketing has been studied throughout the past few decades (Abernathy, 1976; Crittenden, 1992; Hutt & Speh, 1984; Shapiro, 1977). Some classical articles like Shapiro (1977) and Crittenden (1992) emphasized the existing gap between manufacturing and marketing management. Piercy (2007, p. 202) stated that: "Despite a wide-ranging acceptance of such a proposition in theory, the practical nature of most relationships between marketing and operations departments has been demonstrated to be distant and hostile, with little of the co-operation and collaboration required actually being present".

Piercy (2009) also identified aspects such as conflicting reward systems, different backgrounds leading to different functional strategies, functional separation hindering integration, political power plays and competition for resources, and management and academic failures as the sources for manufacturing and marketing conflict. Malhotra and Sharma (2002) listed key-decision areas, which are dependent of inter-functional integration between manufacturing and marketing and range from strategic to tactical levels: strategic planning integration, strategic or visionary forecasting, new product/process development, tactical forecasting, demand management and operational integration.

According to Parente (1998), individual characteristics influence direct interactions between actors at the operational level, because short time adjustments are needed; while at the tactical level, individual characteristics are not at the center of the interaction. Individual and functional integrations are the focus at the strategic level. For Parente (1998) transaction and communication processes are relevant to all three hierarchical levels.

Despite the importance given to the interactions among marketing and other functions in market orientation literature (Kohli & Jaworski, 1990; Narver & Slater, 1990; Slater & Narver, 1994, 1995), there is not much empirical evidence on how these interactions are developed. Maltz and Kohli (2000) analyzed the relative effectiveness of the integrating mechanisms commonly used in reducing conflict between marketing and other functions, including manufacturing. Cross-functional teams appeared to be a useful mechanism for reducing conflict between marketing and manufacturing, while five other mechanisms (*i.e.*, multifunctional training, social orientation, spatial proximity, compensation variety and formalization) did not present clear effectiveness.

Considering the increasing dynamism of the marketplace, success will be determined by how companies are able to identify customers´ expectations and to transfer them to products and services (Zeithaml, 2000), and consequently requires a good interpretation of the market, as well as a good definition of what the company can produce (Varadarajan & Jayachandran, 1999). Therefore, the primary issues are how to coordinate and integrate decisions, how to operate effectively in order to deliver high quality at low cost, and how to fulfill consumers' expectations.

New product development (NPD) is one of the most fertile organizational processes to practice integration among different functional areas. Nevertheless, integration conflict is present throughout the process, as we can see in Table 1. Song, Montoya-weiss and Schmidt (1997) studied this process in Mexican high-tech firms, and stated that R&D, manufacturing, and marketing professionals believe that the strongest and most direct effects on cross-functional cooperation and NPD performance come from internal facilitators (*i.e.*, firms' evaluation criteria, reward structures, and management expectations). There is a similar point of view in Shapiro's classical article (1977), that compared the potential conflicts between marketing and manufacturing for aspects such as capacity planning, production scheduling, delivery, quality assurance, breadth of product line, cost control, NPD and services. Nevertheless, these articles take the traditional approach of manufacturing management centered on cutting costs as the only way to increase productivity, which was severely criticized by Skinner (1969) in his classical article on manufacturing strategy.

Table 1

Propensity for Conflict between Manufacturing and Other Functional Areas in the NPD Process

	Marketing	**R&D**	**Manufacturing**
Objectives	Create change through new products and new technology.	Create change through new products and new technology.	Achieve efficiency in production and cost minimization.
Results expected	Creating and maintaining new markets and satisfied customers.	Creating new products.	Efficient utilization of resources, cost minimization, and meeting objective quality standards.
Area preferences	Fast and fluid response to customer demands.	Elegance and perfection in product design.	Accurate sales forecasts and frozen design specifications.
	Broad product line to satisfy every customer.	Break-trough (patentable) revolutionary products.	Narrower product lines to gain economies of scale and minimize changeover problems.
	Rapid product delivery across a wide mix of products.		Just-in-time delivery systems that minimize inventory investment.

Source: Adapted from Song, X. M., Montoya-Weiss, M. M., & Schmidt, J. B. (1997). Antecedents and consequences of cross-functional cooperation: a comparison of R&D, manufacturing, and marketing perspectives. *Journal of Product Innovation Management, 14*(1), 35-47. doi: 10.1111/1540-5885.1410035

Current OM studies bring a wider approach regarding the role of manufacturing integration in the NPD processes. The benefits are not only related to cost but include gains and/or improvements in flexibility, time and quality as well (Koufteros *et al.*, 2007; Petersen, Handfield, & Ragatz, 2005; Swink, Talluri, & Pandejpong, 2006; Ulrich & Ellison, 2005). Swamidass and Newell (1987) made the pioneering research showing that manufacturing strategy influences performance.

There are some specific types of functional integration to consider for their influence on performance. Regarding manufacturing and marketing integration, Hausman, Montgomery and Roth (2002) showed that this is a result of area's morale. Complementarily, O'Leary-Kelly and Flores (2002) argued that manufacturing and marketing integration improves business performance. Similarly, other studies indicate that integration among functional areas influences operational or business performance (Droge, Jayaram, & Vickery, 2004; Swink, Narasimhan, & Wang, 2007): among others, manufacturing and supply chain integration (Flynn *et al.*, 2010; Narasimhan & Kim, 2002), supply chain and NDP integration (Primo & Amundson, 2002), and buyer and supplier integration (Dong, Carter, & Dresner, 2001). At the same time, integration is a result of different activities. Integration may occur during quality improvement efforts (Forker, 1997; Kaynak, 2003; Pannirselvam & Ferguson, 2001), activities that seek to enhance coordination (Frohlich & Westbrook, 2002; Monczka, Petersen, Handfield, & Ragatz, 1998), NPD processes (Koufteros, Vonderembse, & Doll, 2002; Koufteros, Vonderembse, & Jayaram, 2005; Tan, 2001) or capability strengthening (Rosenzweig, Roth, & Dean, 2003). The constructs proposed based on the literature review are listed below.

External Integration. Hayes (2002) argued that operations management has changed in many ways in the New Economy era. The author proposed that operations analysis should consider not only the operating unit, but also a group of independent parts where companies develop on-going relationships with suppliers, customers and **complementors**. These relationships seek to develop complementary products and to manage ever-changing processes and networks.

Integration also has been studied as an antecedent of value creation (Brandenburger & Stuart, 1996; Wang & Wei, 2007). Thus, Venkatraman and Subramanian (2001) claimed that the strategy is changing from a portfolio of capabilities to a portfolio of relationships in the **knowledge economy**. Accordingly, the current competitive environment is characterized by internal and external relationships, where companies seek integration into networks in order to achieve economies of scale, scope and expertise.

On the other hand, Ghemawat (2009) argued that competitiveness is not only based on the links among parts, but that the development of competencies in specific parts of the value chain is the key issue. For example, services added to manufacturing have been identified as one of the main sources of value and competitive advantage creation (Boyer & Hult, 2005; Wise & Baumgartner, 1999). Also the importance of NPD for performance is highlighted in different studies (Koufteros *et al.*, 2005; Swink & Nair, 2007). Swink *et al.* (2007) showed that there are some differences related to manufacturing integration with different actors over performance. Thus, manufacturing and supplier integration and internal integration positively influence quality performance but only marketing and supplier integration positively influences market performance.

Proposed hypotheses

We define integration as joint activities between two different functional areas or actors in the value chain. We assert that manufacturing decisions should be integrated with R&D, marketing, and supply, among other aspects. Activities deployed from these decisions will influence internal and external integration. Externally they involve integration with suppliers and internally they involve integration of a company's functional areas, including manufacturing, marketing and R&D.

Supply is a key activity for manufacturing performance. The shift from a competitive view of supply towards a more integrated approach is currently visible in various industries (Cousins &

Menguc, 2006). At the same time, integration with suppliers has been an antecedent of performance in different studies (Flynn *et al.*, 2010; Narasimhan & Kim, 2002). Therefore, we may address the first hypothesis:

H1. Integration between manufacturing and suppliers is positively related to business performance.

During the NPD process, manufacturing participation is seen as desirable in order to improve performance in cost, time, quality and flexibility of the project (Swink *et al.*, 2006). There is a need for a team integration involving manufacturing and R&D in order to improve manufacturability (Swink, 1999), and this integration also influences strategic issues related to make or buy decisions (Petersen *et al.*, 2005). Thus, the following hypothesis can be offered:

H2. Integration between manufacturing and R&D is positively related to business performance.

Manufacturing and marketing integration are one the critical aspects for management (Crittenden, 1992; Malhotra & Sharma, 2002; Shapiro, 1977). Empirical studies have shown that performance is better when these two areas are highly integrated (Hausman, Montgomery, & Roth, 2002; O'Leary-Kelly & Flores, 2002; Swink & Song, 2007). These references allow us to address the third hypothesis:

H3. Integration between manufacturing and marketing is positively related to business performance.

Manufacturing integration should be seen as wide range of activities from the strategic to the operational level (Parente, 1998). This integration, when involving activities from different stages of the value chain, is related to higher performance levels (Droge *et al.*, 2004; Rosenzweig *et al.*, 2003; Swink *et al.*, 2007). Therefore, it is expected that these activities are inter-related.

H4. Integration activities among manufacturing, suppliers, R&D, and marketing are positively related among themselves.

H4a. NPD integration activities are positively related to coordination integrated activities.

H4b. NPD integration activities are positively related to problem-solving integrated activities.

H4c. Coordination integration activities are positively related to problem-solving integrated activities.

Methods

Overview of the research process

The research was carried out in two stages. The first was an exploratory analysis, and the second a survey. With the objective of answering the research questions, we studied three companies from the machinery industry using an exploratory approach. Based on this information we developed the first version of the questionnaire.

Sample

We used a survey to collect the data for testing the hypotheses. Prior to the survey, we conducted preliminary case studies for fine-tuning the survey questionnaire. We mailed the questionnaires to a wide range of companies on two waves. The results were finalized after receiving the second wave of responses. The survey consisted of a five-scale questionnaire to evaluate manufacturing managers' opinions. The questionnaire items can be seen in the appendix of this article and were originally written in Brazilian Portuguese. They are provided in this paper translated into English.

The steps followed to conduct this research were: (a) framework validation with other researchers and with three companies; (b) first mailing of questionnaires to the chosen sample; and (c) second mailing to companies that did not respond to the first mailing.

The survey sample was composed of 366 companies located in the southern region of Brazil, belonging to food and machinery industries. These companies were chosen from SEBRAE's database. Because this database is not public, it was only accessed through contact with SEBRAE's management. All of the companies have more than 100 employees. Responses were received from CEOs, vice-presidents, manufacturing directors, and manufacturing managers. Table 2 represents the respondents' profiles.

Table 2

Respondents' Profiles

FUNCTION	Frequency	Percent	Cumulative percent
CEO	11	11.2	13.2
Vice-President	38	38.4	50.0
Industrial Director	10.1	10.1	60.2
Manufacturing Manager	30	30.3	90.8
Others	10	10.1	100.0
Total	10	10.1	100

The overall response rate was 27.2 % (99 companies). There was a response bias related to the industry's rate of response, as shown in Table 3, where the proportion of responses from the machinery industry was higher in the sample than the expected proportion in the population. This fact may be related to the more dynamic environment faced by the machinery industry (Instituto Brasileiro de Geografia e Estatística [IBGE], 1999, 2007; Viceconti, 1977), probably leading it to higher integration with universities, which can increase the response rate. Mentzer and Flint (1997, p. 211) stated that: "Non-response bias is concerned with whether there are important differences between (logistics) managers who responded and those who did not, whereas external validity looks at whether all (logistics) managers would respond the same as those who participated in the research". Thus the study presents a limitation regarding response bias but this aspect does not necessarily affect external validity.

Table 3

Response Rate for Each Industry

Industry	Number of Plants	Response Rate (%)
Food	163	31 (19.0%)
Machinery	203	68 (30.3%)
Total	366	99 (27.0%)

Measures

The overall orientation for the items used in this research is related to a capability building process (Leonard-Barton, 1998). In this case, a capability is created based on activities embedded in past situations and activities oriented for the future. In the first case, a usual example are the problem-solving activities (Leonard-Barton, 1998). On the other hand, companies during the new product development (NPD) process are making decisions related to their future activities. Linking these two activities, we included an item related to the present time: coordination with internal and external actors. Thus, we assert that coordination is central for companies in developing their daily activities.

Problem-solving Integration. We used an item related to problem solving in order to evaluate the intensity of integration among manufacturing and the other external (suppliers) and internal (R&D and marketing) actors (Forker, 1997; Kaynak, 2003; Pannirselvam & Ferguson, 2001).

Coordination Integration. We evaluated how often manufacturing seeks to improve coordination with external and internal actors (Dong *et al.*, 2001; Frohlich & Westbrook, 2002; Koufteros *et al.*, 2005; Monczka *et al.*, 1998; Vickery, Jayaram, Droge, & Calantone, 2003).

New Product Development (NPD) Integration. We used a measure related to new product/service development to evaluate the level of strategic integration between manufacturing and the other actors (Koufteros *et al.*, 2002; Koufteros *et al.*, 2005; Primo & Amundson, 2002; Tan, 2001).

Manufacturing and Supply Integration. We measured how often manufacturing engages in integration efforts in the three activities (problem-solving, coordination, and NPD) with suppliers (Droge *et al.*, 2004; Flynn *et al.*, 2010; Narasimhan & Kim, 2002; Rosenzweig *et al.*, 2003).

Manufacturing and Marketing Integration. We measured how often manufacturing engages in integration efforts in the three activities (problem-solving, coordination, and NPD) with marketing (Hausman *et al.*, 2002; O'Leary-Kelly & Flores, 2002; Swink & Song, 2007).

Manufacturing and R&D Integration. We measured how often manufacturing engages in integration efforts in the three activities (problem-solving, coordination, and NPD) with R&D (Koufteros *et al.*, 2005; Swink, 1999; Swink *et al.*, 2006).

Performance. We used scales related to financial performance (profitability) and market performance (sales growth) (Kaynak, 2003; Swamidass & Newell, 1987; Venkatraman & Ramanujam, 1987).

Control variables. We used two control variables. The first one identifies the two existing industries in the study (food and machinery). The second control variable is related to company size. These measures have been used as controls in related studies (*e.g.*, Wagner & Krause, 2009).

Table 4 summarizes the constructs and references.

Table 4

Constructs, References and Variables

CONSTRUCTS	REFERENCES	QUESTIONS
Problem-solving Integration.	Forker (1997); Kaynak (2003); Pannirselvam and Ferguson (2001)	Q2a, Q2b, Q2c
Coordination Integration	Dong, Carter and Dresner (2001); Frohlich and Westbrook (2002); Koufteros, Vonderembse and Jayaram (2005); Monczka, Petersen, Handfield and Ragatz (1998); Vickery, Jayaram, Droge and Calantone (2003)	Q3a, Q3b, Q3c

Continue

Table 4 (continued)

CONSTRUCTS	REFERENCES	QUESTIONS
NPD Integration	Koufteros *et al.* (2005); Koufteros, Vonderembse and Doll (2002); Primo and Amundson (2002); Tan (2001)	Q1a, Q1b, Q1c
Manufacturing and Supply Integration	Droge, Jayaram and Vickery (2004); Flynn *et al.* (2010); Narasimhan and Kim (2002); Rosenzweig *et al.* (2003)	Q1a, Q2a, Q3a
Manufacturing and Marketing Integration	Hausman *et al.* (2002); O'Leary-Kelly and Flores (2002); Swink and Song (2007)	Q1b, Q2b, Q3b
Manufacturing and R&D Integration	Koufteros *et al.* (2005); Swink (1999); Swink *et al.* (2007)	Q1c, Q2c, Q3c
Performance	Kaynak (2003); Swamidass and Newell (1987); Venkatraman and Ramanujam (1987)	BP1, BP2

Measurement analyses

The initial analyses of the measurements on the questionnaire showed cross-loading of the items. We then started searching for possible common method variance (CMV) sources. One source of CMV is the so-called **consistency motif** (Podsakoff & Organ, 1986). Consistency motif arises because respondents try to respond consistently to what they think the researchers want to know from them. One cause of consistency motif is having questionnaire items with approximate wording in different scales, which happened in our study (see Appendix). In these cases, the respondent attempts to respond to an item (for example, exchange of strategic information with suppliers, Q1a) consistently with an item with a similar wording (for example, cooperative activities for problem solving with suppliers, Q2a), as well as being consistent with the responses in the same scale (in our example, exchange of strategic information with other actors in the value chain).

To remedy this source of CMV, we conducted a correlated trait-correlated method (CTCM) analysis (Kline, 2005), a special case of the multitrait-multimethod (MTMM). MTMM is concerned with the confirmation or disconfirmation of constructs (Campbell & Fiske, 1959). Usually this method is used to evaluate different data sources. Nevertheless, Podsakoff, MacKenzie, Lee and Podsakoff (2003) states that this technique is a **statistical remedy** for common method variance (CMV) evaluation. One advantage according to them is that MTMM technique "does not require the direct measurement of the hypothesized method biases" (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 894).

CFA MTMM is performed by assigning items to their scales in the usual way (the **traits** side of the model), and assigning items which are the possible source of CMV (in our case, with similar wording) to a latent variable (the **method** side of the model). Hoyle (1995) shows that a MTMM model should have at least three trait factors and three method factors. One variable will load only one trait factor and one method factor simultaneously. We, accordingly, assigned each item to its respective **trait** construct (integration with suppliers, integration with R&D, and integration with marketing) and with its **method** construct (NPD integration, problem solving coordination, and coordination integration) – see Figure 1. The fit statistics of the model improved consistently from the traditional CFA model, allowing us to proceed to the full structural model.

Results

We have estimated the model using AMOS (Arbuckle & Wothke, 1999). Means, standard deviations, and correlations of all variables can be viewed in Table 5. Given the double nature of every observable variable (for example, Q1A, integration between manufacturing and supplier for NPD purposes is both part of manufacturing and supplier integration and NPD integration), it is expected that the correlations between the observed independent variables do not follow a pattern of correlation that is common to unidimensional, independent observed variables. The covariances, however, indicate no colinearity, ranging from .43 to .74. By specifying the observed items in the structural equations model as part of two constructs (see Figure 1), we were able to isolate the variance of each variable separately for each construct.

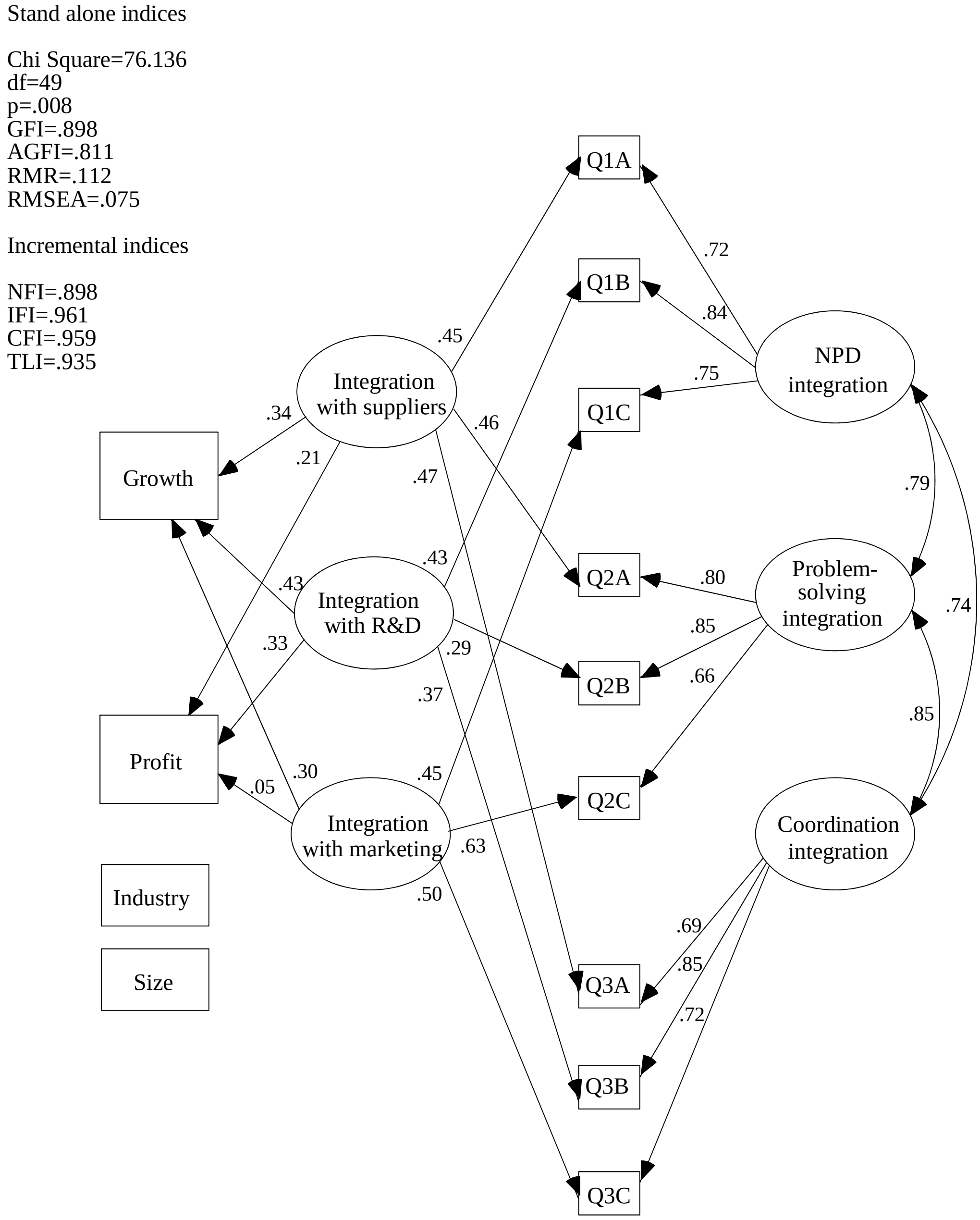

Figure 1. MTMM Model.

By accounting for the contribution of each observed variable to both the three stages of the value chain (suppliers, R&D, and marketing) and in the three coordination activities (problem-solving, coordination, and NPD), we were able to assess the relationship of the integration of each operations supply chain with plant performance. We conducted a two-step analysis of this data (Anderson & Gerbing, 1988). First, we evaluated the measurement model. The results were satisfactory (χ^2 = 8.42, df = 14, *p* = .87, GFI = .98, RMSEA = .00, NFI = .99), so we proceeded to analyze the path model.

Table 5

Means, Standard Deviations, and Correlations

Variables	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12
1. Q1A	3.71	0.94												
2. Q1B	3.92	1.03	0.61^{***}											
3. Q1C	3.67	0.97	0.52^{***}	0.66^{***}										
4. Q2A	3.84	0.91	0.72^{***}	0.53^{***}	0.52^{***}									
5. Q2B	4.10	0.85	0.52^{***}	0.66^{***}	0.50^{***}	0.69^{***}								
6. Q2C	3.77	0.93	0.43^{***}	0.43^{***}	0.69^{***}	0.58^{***}	0.54^{***}							
7. Q3A	3.69	0.88	0.64^{***}	0.44^{***}	0.38^{***}	0.69^{***}	0.52^{***}	0.43^{***}						
8. Q3B	4.06	0.81	0.51^{***}	0.67^{***}	0.48^{***}	0.57^{***}	0.72^{***}	0.47^{***}	0.61^{***}					
9. Q3C	3.66	0.91	0.52^{***}	0.43^{***}	0.62^{***}	0.59^{***}	0.51^{***}	0.74^{***}	0.56^{***}	0.60^{***}				
10. Profit	3.49	1.92	0.19^{+}	0.25^{*}	0.11	0.18^{+}	0.20^{*}	0.07	0.15	0.18^{+}	0.06			
11. Growth	4.07	0.90	0.28^{**}	0.34^{***}	0.26^{**}	0.31^{**}	0.27^{**}	0.23^{*}	0.18^{+}	0.28^{**}	0.27^{**}	0.29^{**}		
12. Size	2.44	0.99	0.39^{***}	0.33^{***}	0.29^{**}	0.42^{***}	0.35^{***}	0.19^{+}	0.30^{**}	0.29^{**}	0.23^{*}	0.24^{*}	0.27^{**}	
13. Industry [a]	0.31	0.47	0.10	-0.14	0.00	0.05	-0.26^{**}	0.10	-0.03	-0.24^{*}	0.04	-0.14	-0.18^{+}	-0.17^{+}

Note. n = 99; [a] Coded as food = 1, fabricated metal products = 0; $^{+}$ *p* < .10; * *p* < .05; ** *p* < 0.01; *** *p* < 0.001.

The fit of the path analysis was satisfactory, except for the chi-square statistics (χ^2 = 76.14, df = 49, *p* = .01, GFI = .90, RMSEA = .08, NFI = .90). As Kline (2005) points out, chi-square statistics are sensitive to sample size, size of correlations, and normality of data, among other factors, and should not be the only fit statistics used to assess the model.

Table 6 shows the coefficients (raw and standardized), as well as the standard errors of the ML estimation of the path analysis of the integration model. We found only partial support for hypothesis 1: the path that relates integration with suppliers and profit is not significant and the path that relates integration with suppliers and growth is only slightly significant. Regarding hypothesis 2, both the coefficients for integration with R&D and profit, and for integration with R&D and growth are positive, as expected, but only slightly significant. Finally, we could not find evidence of support for hypothesis 3, because the coefficients for the integration with marketing and profit and growth are non-significant. These results show that the manufacturing integration in the different stages of the value chain have different effects on performance. One possible explanation for these findings is that primarily manufacturing actually interacts directly with R&D, and even in the most successful plants, the interaction of manufacturing with suppliers and marketing is indirect. For example, it is possible that manufacturing needs flow to suppliers via the supply/purchasing or R&D departments, and market requirements, gathered by the company or plant marketing department, flow to the manufacturing department via R&D or the plant manager.

Table 6

Path Analysis Results for Integration Model

	Profit			**Growth**		
Integration with suppliers	β	Beta	s.e.	β	Beta	s.e.
Integration with R&D	0.97	0.21	0.70	0.74^{+}	0.34	0.41
Integration with marketing	2.11^{+}	0.33	1.20	1.26^{+}	0.42	0.74
Size	0.22	0.05	0.56	0.62	0.30	0.33
Industry	0.34	0.18	0.20	0.16	0.18	0.09
	-0.34	-0.08	0.44	-0.33	-0.17	0.20

Note. β ML estimate for the coefficients; Beta Standardized coefficients; s.e. Standard errors for estimates.
$^{+}$ $p < .10$.

Table 7 shows the estimates of the covariances, their standard errors, and the estimates of the correlations between the different hierarchical levels of manufacturing integration. We discovered support for hypothesis 4. When accounting only for the variance of the integration activities, NPD integration activities are positively and significantly related to coordination integration activities (hypothesis 4a) and to the problem-solving integration activities (hypothesis 4b). The coordination integration activities are positively and significantly related to the problem-solving integration activities as well (hypothesis 4c). Remembering that these correlations are estimated by taking into account the integration with the stages of the value chain and the performance and control variables, they show that the average plant seeks a balance in all three coordination activities: problem-solving, coordination, and NPD.

Table 7

Integration at Different Hierarchical Levels

Hierarchical Levels	Covariance	s.e.	Correlation
Strategic • • • • • Strategic	0.44^{***}	0.09	0.74

The effects we discovered are meaningful from a practical and theoretical standpoint. Managers interested in improving the performance of their plants should favor the integration between manufacturing and R&D teams, at all hierarchical levels. We did not find any evidence, however, that a direct interaction between manufacturing and marketing, a long-held belief in the literature, improves performance. This result has different possible causes. One is the limitation regarding the focus on only two industries. Another possible cause is that manufacturing integration is related primarily to operational performance, being a mediator for business performance: as exemplified by Kaynak (2003) and Swink *et al.* (2007). Future studies should assess how this interaction happens in manufacturing plants, and what are the most successful ways to: (a) keep manufacturing connected with downstream requirements as captured by marketing; and (b) to provide feedback upstream to the supplier base.

As with most research, our results have several limitations. First, untested or unmeasured exogenous variables may affect the relationships we studied: such as interaction with other stages of the value chain, such as customer service or supply/purchasing. Also, indirect paths from manufacturing interaction and other activities should be tested. Therefore, these relations should be assessed in future research. We also did not control for other variables that could affect the relationship between manufacturing integration and performance. Future research should look at other variables, such as team processes or context-related variables (competitive priorities imposed on the plant, for example), that may also help explain manufacturing integration-performance relationship.

Second, we used the MTMM model to isolate both CMV and the multidimensionality of the items we collected. Unfortunately, the MTMM literature does not provide clear guidance on calculating the evidence of reliability, such as composite reliability, how to provide identification for the model, nor how to proceed from the measurement model to the path analysis. However, we acted upon our best knowledge to provide what evidence was available, such as fit indices, to advance the knowledge and the OM literature on both substantive and methodological issues of gathering self-reported data on manufacturing integration. Additionally, only one person from each company answered the questions and this is a potential bias because most of them were related to a manufacturing function.

Also, some difference in understanding might arise from the sales growth variable. Respondents may have some difficulty in understanding that "more than -20%" interval includes all the negative results higher than this and **less than -20%** interval includes all the results between -20% and zero. Even so, the written version of the questionnaire suggests a trend of increasing sales (see Appendix). In this case, we follow Fowler (1995, p. 93), which states that "simple mechanisms of formatting the instrument properly can make the interviewers' job go more smoothly".

Finally, we collected data regarding manufacturing integration and performance from a single source – usually the plant manager. Despite the fact he/she is the most knowledgeable informant in the plant to provide such information, and the evidence of construct validity we provided, cautious interpretation should be made, as other researchers have pointed to a number of measurement problems associated with single-source measures. Future research should collect measures of manufacturing integration from multiple informants, and performance data from archival data could be merged with perceptual performance data to reduce CMV.

Despite these limitations, our study has a number of strengths. First, by using two industries in contexts with different dynamics, regulations, and manufacturing technologies, we could control for these factors in the analysis. Our findings are further strengthened by the use of MTMM method, since we could isolate and account for CMV and multidimensionality of data, at the same time that we could make the items simpler for the informants to respond to, thus enhancing our response rate and the reliability of the responses. Finally, this research provides one of the first tests of OM practices using the CTCM method.

In conclusion, our study provides preliminary evidence of the role that manufacturing integration with various value chain stages has in improving plant performance, both in profitability and sales growth. Our findings suggest that plant managers should foster manufacturing integration with other value chain activities, especially R&D, to boost performance.

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Note

[1] O Serviço Brasileiro de Apoio às Micro e Pequenas Empresas: The Brazilian governmental agency that supports micro and small businesses in entrepreneurial activities.

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APPENDIX

Variables

Internal and external integration

(Scale: 1=Never; 2=Rarely; 3=Sometimes; 4=Frequently; 5=Always)

Q1 – Indicate how often manufacturing exchanges strategic information related to new products or services with the following parts of the company’s value chain:
a) Suppliers
b) R&D
c) Marketing and Sales

Q2 – Indicate how often manufacturing develops cooperative activities for problem solving with the following parts of the company’s value chain:
a) Suppliers
b) R&D
c) Marketing and Sales

Q3 – Indicate how often manufacturing seeks to develop activities for improving the coordination/integration with the following parts of throughout the company’s value chain:
a) Suppliers
b) R&D
c) Marketing and Sales

BP1. What was the company’s profitability in the last year?

Negative	1
Equal to zero	2
Until 5%	3
5% to 10%	4
More than 10%	5

BP2. The sales improvement in the last three years was

More than -20%	Less than -20%	Stable	Less than + 20%	More than +20%
1	2	3	4	5

Control variables

SIZE: What is the appropriate number of personnel employed at the company and/or in your business unit, worldwide?

	Your Business Unit
Less than 100	1
Over 100 to 500	2
Over 500 to 1000	3
Over 1000 to 5000	4
Over 5000 to 10,000	5
N.A./Don’t know	6