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Organizational knowledge and the manufacturing strategy process: A resource-based view analysis

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Abstract

The current competitive environment is characterized by new sources of information, new technologies, new management practices, new competitors, and shorter product life cycles, which highlights the importance of organizational knowledge in manufacturing companies. We integrate some of those knowledge-based approaches seeking to understand how aspects related to cross-functional orientation, new technologies, and increasing access to information affect manufacturing strategy. In this paper, ‘‘know-what’’ (where to find the needed information) and ‘‘know-how’’ (how to run operations smoothly) are considered key components of organizational knowledge in the process of manufacturing strategy formulation. Assuming that knowledge accumulation may lead to competitive advantage, we propose a model of manufacturing strategy process from a resource-based view perspective. We used a survey to collect field data from 104 companies. The results indicate that cross-functional activities integrate manufacturing knowledge and contribute to the creation of valuable and rare product characteristics.

Keywords: Organizational knowledge; Resource-based view; Manufacturing strategy process

1. Introduction

Modern manufacturing strategy has evolved from two broad schools of thought. Early literature links strategic planning concepts and the trade-off approach (Skinner, 1969; Wheelwright, 1984), and highlights the ‘‘manufacturing task’’ or how manufacturing should align decisions with the company’s business strategy. Those proposals highlighted the ‘‘manufacturing task’’ or how manufacturing should link their decisions to the company’s business strategy. Currently, anecdotal references have stated that a rigid process of strategic planning is not enough under the dynamic environmental conditions.

More recent literature on manufacturing strategy pertaining to the cumulative capability model posits that the competitive criteria are related to each other. (Ferdows and De Meyer, 1990; Roth, 1996a; Boyer and Lewis, 2002; Rosenzweig and Roth, 2004). Manufacturing tasks, in this view, should follow a sequence of improvement in order to build manufacturing capabilities more effectively (Schmenner and Swink, 1998). Nevertheless, Flynn and Flynn (2004) did not find evidence supportive for the Ferdows and De Meyer’s (1990) sandcone model.

Thus, the current competitive landscape has created the need for new research on manufacturing strategy formulation. St. John et al. (2001) argue that

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a resource-based view is a theory fitted to the current competitive trends and provides a frame for manufacturing strategy research. Furthermore, Amundson (1998, p. 10) states that the resource-based view provides research in manufacturing strategy ''a more fine-grained understanding of how competitive advantage is provided through the resources generated by operations''.

Marucheck et al.'s (1990) exploratory study showed that manufacturing strategy formulation is not a static process. Rather, it is an iterative process that involves the formulation, gathering, and creation of organizational knowledge. In the last decades, new studies using the capability-based approach view manufacturing as a strategic resource (see for example Hayes and Upton, 1998). This article follows this stream of research in manufacturing strategy by empirically analyzing the process of manufacturing strategy using a resource-based perspective.

Like in past studies (Voss, 1992; Fine and Hax, 1985; Giffi et al., 1990; Marucheck et al., 1990), we identify the core elements, such as cross-functional orientation, new technologies, and increasing access to information, which are related to the formulation process of manufacturing strategy; however, we follow an empirical approach, testing a theoretical model based on the resource-based view of the firm. Also, in contrast to traditional view of trade-offs, this study focuses on the resources related to the process of manufacturing strategy. In this process organizational knowledge is considered a key resource.

This article is structured as follows: Section 2 provides the theoretical background of manufacturing strategy, organizational knowledge, and the resource-based view; Section 3 describes and explains the proposed theoretical model; Section 4 presents the general theoretical premises; Section 5 discusses the research methodology; Section 6 presents the empirical results; finally, Section 7 discusses the results.

2. Theoretical background

In considering the role of the manufacturing function in capability creation and sustainability, different researchers in manufacturing strategy have stressed that manufacturing plays a central role in this new competitive environment (Wheelwright, 1984; Hayes et al., 1988; Hill, 1989; Giffi et al., 1990; Schroeder et al., 2002). Skinner (1969) and Wheelwright (1978) were pioneers in showing that a manufacturing management that only tries to reduce costs is not sufficient to compete. We integrate some of these theoretical approaches seeking to understand how aspects related to cross-functional orientation, new technologies, and increasing access to information affect the process of manufacturing strategy formulation. These issues are presented in the next sections that explore the linkages between manufacturing strategy, organizational knowledge and the resource-based view.

2.1. Organizational knowledge as a resource

In general, the distinction between information and knowledge is not clearly specified in the literature (Bell, 1999). Various authors identify information as the basic input for organizational knowledge (Kogut and Zander, 1992; Garvin, 1998; Davenport and Prusak, 1998). Nonaka and Takeuchi (1995, p. 58) state that ''information is a flow of messages, while knowledge is created by that very flow of information, anchored in the beliefs and commitment of its holder. This understanding emphasizes that knowledge is essentially related to human action''.

Other research links the role of information and knowledge creation. Davenport and Prusak (1998) claim that knowledge provides a framework for evaluating and incorporating new experiences and information. These authors consider that organizational knowledge is, at the same time, both tacit (originated and applied in the mind of knower) and explicit (embedded in documents, norms and repositories). Also, Bell (1999) argues that information is a context-based arrangement of items while knowledge is the judgment of the significance of events and items. Two basic differences between information and knowledge found in the literature are that: (1) knowledge is connected to existing values and beliefs, and (2) it is close to action. Therefore, even though the literature is not conclusive on the difference between information and knowledge, it does provide some distinctive characteristics between them.

Organizational knowledge influences the ways that companies deal with dynamic environmental changes (Grant, 1996). According to Leonard-Barton (1994), factories will increasingly become ''learning laboratories'' in order to adapt to external turbulences. A growing body of literature suggests that in dynamic environments, increased organizational knowledge reduces risks and uncertainties (Liebeskind, 1996). This learning process starts with information assimilation, which is related to the company's pre-existing knowledge. Considering information as an input to knowledge, companies' learning follows a cumulative process orientation based on information integrated with past experiences and knowledge (Cohen and

Levinthal, 1990; Garvin, 1998). ''Knowing what'' allows the firm to accumulate the information necessary for building its ''know-how'' (Kogut and Zander, 1992). Combining the concepts of ''know-what'' (where to find the needed information) and ''know-how'' (how to run operations smoothly), Roth et al. (1994, p. 27) created the metaphor of a ''knowledge factory'' to describe ''an accelerated learning organization driven by dynamic processes that create superior knowledge and translate that knowledge into competitive capabilities and core competencies''. Currently, several articles have highlighted the role of knowledge in operations management. Hult et al. (2006) and Modi and Mabert (2007) analyzed the knowledge elements and their relations with supply chain performance. Also, Dyer and Nobeoka (2000) and Germain et al. (2001) explored the knowledge sharing process in operations management.

External and internal perspectives compose the approaches along the strategy formulation process (Andrews, 1971). Liedtka and Rosenblum (1996) reinterpreted Andrews' framework based on organizational competence and company's values related to a continuous development and learning. They proposed a dynamic view for improving the internal perspectives of the strategic process. An internal perspective emerges from the knowledge-based strategy approach, which encourages more interdependence among managers' choices (Grant, 1997). An external perspective focuses on market positions, allowing companies to see new forms of competitive advantage (Leonard-Barton, 1994). Davenport et al. (1998) offer a theoretical model with three dimensions: one external (competitive intelligence) and two internal (structured internal knowledge and informal internal knowledge).

In this research, two facets of organizational knowledge compose the process of manufacturing strategy. The first facet involves a dynamic view of internal knowledge development (Liedtka and Rosenblum, 1996), leading companies to continuously fit their capabilities to environmental changes (Teece et al., 1997). The second relates to organizational knowledge derived from sources external to the company, which we will call external organizational knowledge. Managers can better analyze external environment based on relevant information, which in turn allows them to anticipate and promptly respond to environmental changes (Badri et al., 2000). The manufacturing strategy formulation process is therefore a result of resources alignment, including information, knowledge and company's functions.

Following the resource-based view, we recognize that the strategy formulation process itself can be viewed as a competitive capability and that its imperfect transferability is fundamental in sustaining the competitive advantage created from that capability (Grant, 1991; Barney, 1991).

2.2. Cross-functional orientation

A cross-functional approach is critical to the knowledge creation process within firms. We define cross-functional orientation as the ability of manufacturing to interact with other functional areas in order to improve a company's strategies and processes. Skinner (1969) was a pioneer in demonstrating/identifying the importance of a cross-functional perspective in the manufacturing strategy formulation process. Hayes and Wheelwright (1985), Hill (1989), and Hayes et al. (1988) argued as well that competitiveness is related to effective cross-functional participation in the strategic process. Cross-functionality has been seen as the basis for the creation of competencies that enable firms to capture and exploit competitive advantages (Grant, 1996). Despite this, research has shown a general lack of integration between manufacturing and other functional areas (Crittenden, 1992). The lack of a proactive stance of manufacturing in the strategic process has been a recurrent theme in the literature (Malhotra and Sharma, 2002).

Ward et al. (1994) and Hausman et al. (2002) reinforce the importance of a cross-functional approach for manufacturing. In both studies, cross-functional decision-making is found to be one of the central issues in knowledge creation (e.g., the process of cross-functional knowledge integration during the strategy formulation process).

Nonaka and Konno (1998) define the concept of *Ba* – a susceptible environment for knowledge creation – in terms of networks, teams, and open organizational designs. Literature on knowledge management asserts that sharing information among all functional areas of a company enhances organizational knowledge, and that organizational knowledge is continuously created or improved through cross-functional interaction (Brown, 1998; Quinn et al., 1996; Grant, 1996; Davenport et al., 1998). Dyer and Nobeoka (2000) and Germain et al. (2001) analyze the process of knowledge integration and the results show that operations performance is improved trough knowledge integration.

2.3. Resource-based view theory

The strategic process may be analyzed under a resource-based view approach with knowledge being a resource for capability creation. Peteraf (1993) states that Andrews' approach to strategy formulation ''begins

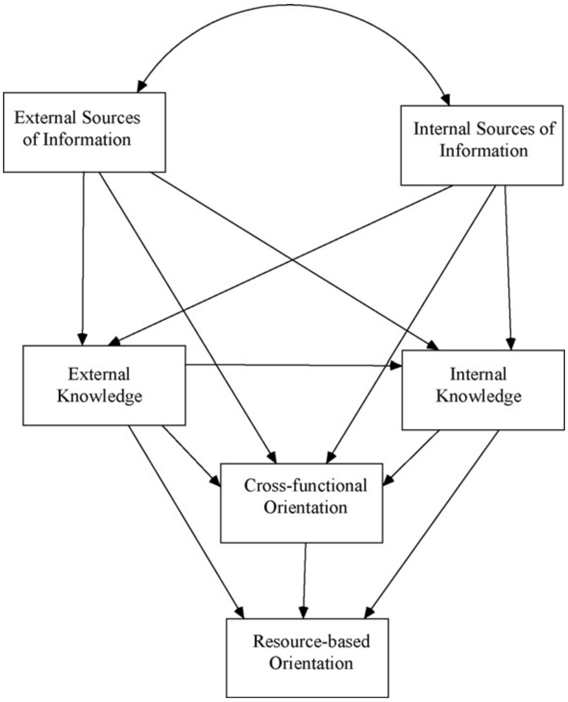

Fig. 1. Organizational knowledge and the process of manufacturing strategy formulation from a resource-based approach.

with an appraisal of organizational competencies and resources'' (p. 179). The emerging knowledge-based view theory discusses the role of the knowledge for the existence and nature of the firms (Grant, 2002). Those streams include the resource/capabilities analysis of the firm, the epistemological view of knowledge and organizational learning. Based on the resource-based view of the firm, we may consider the managers' choice based on their previous experience and knowledge as important resources in the manufacturing strategy process. Thus, in the proposed model (Fig. 1), we argue that companies formulate their manufacturing strategies from different inputs and internal arrangements, which compose their resources.

According to Collis and Montgomery (1995), the resource-based view is built on the combination of internal and external perspectives related to traditional approaches to strategy. They stress that the strength of the resource-based view is the ability to explain, in clear managerial and practical terms, competitiveness, profitability and core competencies. Peteraf (1993) states ''. . .that firms are fundamentally heterogeneous, in terms of their resources and internal capabilities, has long been at the heart of the field of strategic management'' (p. 179). Thus, manufacturing strategy should allow the firm to develop its competencies by exploring its internal resources (Coates and McDermott, 2002; Schroeder et al., 2002).

A central aspect for the formulation of manufacturing strategy is Wernerfelt's assumption (Wernerfelt, 1984): ''What a firm wants is to create a situation where its own resource position directly or indirectly makes it more difficult for others to catch up'' (p. 173). This competitive position is achieved when the resources create products/services that are valuable, rare and imperfectly imitable (Barney, 1991). Roth (1996b) also relates manufacturing strategy to the resource-based view. Table 1 shows the constructs proposed here and their theoretical domains.

2.4. *The process of manufacturing strategy formulation*

Among the first references on the process of corporate strategy formulation were those of Chandler and Andrews. Chandler (1962) defined the central stream of the formulation process as a rational process (Rumelt et al., 1994). Andrews (1971), extending this approach, defined the classic strategy formulation process in terms of an analysis of external (threats and opportunities) and internal (strengths and weaknesses) aspects of the firm. Porter (1980, 1986) follows these views in his traditional industry analysis evaluating industry attractiveness and industry barriers, among other concepts.

In his seminal article on manufacturing strategy, Wheelwright (1978) defended the fit between business strategy and manufacturing strategy in order to reinforce competitiveness. Other studies on manufacturing strategy, such as Skinner (1969), Wheelwright (1978, 1984), and Hill (1989), follow a hierarchical view of the formulation process, linking corporate and business strategies, competitive criteria (cost, quality, flexibility, and delivery), and product and process decisions. This hierarchical orientation assumed basically a structured view of the process and was clearly influenced by traditional strategic planning, which has also influenced some formulation tools proposed by researchers including Fine and Hax (1985), Platts and Gregory (1992), Slack (1994), and Menda and Dilts (1997). Other studies analyzed the process of manufacturing strategy formulation from a less structured perspective, considering that the challenges faced by managers are more complex than a mere dichotomy between ''weakness'' and ''strength'' (Cheng and Musaphir, 1996). Rather, the strategy formulation process is seen as a sequence of decisions, or consistencies in decision behavior. In this category we include studies such as those of Swamidass and

Table 1
Constructs and their theoretical domains

Construct	Domain	Theoretical references
External organizational knowledge	Extent to which manufacturing knows the threats and opportunities in the marketplace	Andrews (1971), Cohen and Levinthal (1990), Liedtka and Rosenblum (1996), Leonard-Barton (1994), Roth (1996b), Grant (1997), Davenport et al. (1998), Badri et al. (2000), Dyer and Nobeoka (2000), Germain et al. (2001) and Grant (2002)
Internal organizational knowledge	Extent to which manufacturing knows how to explore the firm's internal resources	Andrews (1971), Giffi et al. (1990), Nonaka (1995), Nonaka and Takeuchi (1995), Roth (1996b), Grant (1997), Davenport et al. (1998), Teece et al. (1997), Dyer and Nobeoka (2000), Germain et al. (2001) and Grant (2002)
Cross-functional orientation	Extent to which manufacturing participates in the strategic process	Skinner (1969), Hayes and Wheelwright (1985), Grant (1991), Crittenden (1992), Ward et al. (1994), Grant (1996), Nonaka and Konno (1998), Boyer and McDermott (1999), Narasimhan and Wang (2000), Ward and Duray (2000), Verma et al. (2001), Germain et al. (2001), Hausman et al. (2002), Papke-Shields et al. (2002) and Malhotra and Sharma (2002)
Information Sources	Variety of information sources used by manufacturing	Kogut and Zander (1992), Garvin (1998), Von Hippel (1994), Mata et al. (1995), Davenport and Prusak (1998), Kathuria et al. (1999) and Kotha and Swamidass (2000)
Resource-based view	Extent to which manufacturing creates unimitable value in the products from the existing internal resources	Wernerfelt (1984), Barney (1991), Collis and Montgomery (1995), Schroeder et al., 2002, Coates and McDermott (2002)

Newell (1987), Anderson et al. (1991), Voss (1992), and Papke-Shields et al. (2002). The view of competence creation in production and operation systems (Cleveland et al., 1989; Vickery, 1991; Miller and Roth, 1994; Vickery et al., 1993) is another approach identifiable in manufacturing strategy formulation studies. In this view, the result of the process of manufacturing strategy is capability creation or reinforcement (Zahra and Das, 1993; Hayes and Pisano, 1994; Tracey et al., 1999).

With the increasing dynamism of the current competitive environment, anecdotal reports and academic literature presently claim that flexible business strategies are needed. Hamel (1997, p. 73), using a logic related to the Kuhnian view of radical changes in scientific development, states, "we reached the end of incrementalism in the quest to create new wealth". According to Hamel, the new competitive environment is characterized by new products and services, and sometimes even new markets built by new competitors using nonlinear strategies. In this new environment, Collis and Montgomery (1995, p. 118), note "managers (*presently*) complain that the strategic planning is too static and too slow", because "the markets move faster and faster".

In this research, we view manufacturing strategy formulation as a process comprising both structured and unstructured strategy formulation (Adam and Swamidass, 1992). In this way, tacit (more present in the unstructured part of the process) and explicit knowledge (more present in the structured part of the process) are components of the process. Consistent with the resource-based theory of the firm, we believe that companies may either combine both types of processes or use only a specific type in their manufacturing strategy formulation. Consequently, differing results are obtained regardless of the orientation during this process.

We hold that existing knowledge in manufacturing (or "manufacturing knowledge") plays a central role in the manufacturing strategy formulation process. The integration of manufacturing knowledge leads to faster learning cycles (Roth, 1996b) and a cross-functional orientation is one source of this knowledge.

3. Theoretical model

In the proposed model (Fig. 1), multiple information sources comprise the inputs to the process. Information is considered the main input to internal and external organizational knowledge. Organizational knowledge and cross-functional orientation are at the center of this process and lead to the creation of firm's competencies. As these competencies are the output of the process and they are created by the firm's resources, the proposed model links the manufacturing strategy to the resource-based view perspective. Instead of the traditional idea of manufacturing task or the capability sequence model, the theoretical model proposes that the manufacturing strategy formulation process is oriented to the creation of products/services that are valuable, rare and imperfectly imitable. This manufacturing strategy focus was named as resource-based orientation. The formulated strategy then results from a continuous process in which manufacturing organizational knowledge is used to create and sustain the company's competencies.

The current competitive environment influences the overall process of manufacturing strategy formulation in several ways. New information sources (such as Electronic Data Exchange, EDI), advanced techniques in manufacturing management (such as Total Quality Management or Just-In-Time), and new ways to support competitiveness (such as alliances) all increase the complexity of the manufacturing strategy formulation process. Companies thus face the possibilities of new types of inputs and new technologies, which can yield new types of outputs.

The proposed model views inputs as either internal or external information sources. The manufacturing function uses these inputs as the starting point in the process of manufacturing strategy formulation. The first step in the process is the development of manufacturing organizational knowledge. This knowledge derives from two main sources: the external and the internal environment. External knowledge also influences internal knowledge through a wide range of information-including suppliers, competitors' actions and benchmarking.

As companies increase their internal organizational knowledge, cross-functional orientation also increases and consequently allows the company to be more responsive to environmental changes. The cross-functional integration allows the enhancement of organizational knowledge, which is the core resource for internal competencies creation and sustainability. Cross-functionality reinforces firms' internal strengths and helps to overcome internal weaknesses. Finally, creating products characteristics valuable for customers and not easy to find are the central aspects of the resource-based orientation. Fig. 1 presents the constructs' relationships that will be detailed in the next sections.

4. General theoretical premises

4.1. Organizational knowledge and information

Stalk et al. (1992), point out the important role of internal competencies in the process of corporate strategy formulation. For them, these competencies should lead the firm to "see the competitive environment clearly and thus to anticipate and respond to customers' evolving needs and wants" (p. 63). When operations and marketing are entangled, Roth and Jackson (1995, p. 1725) called this capability as *marketing acuity* and pointed out that the "managers of service organizations must be aware of their competitors' levels of service quality as well their own". Ability to understand the competitive environment is the basic premise for external knowledge. On the other hand, knowing how to explore and evaluate internal resources is a fundamental aspect of the strategic process. This has been at the heart of studies on the manufacturing strategy formulation process (see Skinner, 1969; Fine and Hax, 1985; Hill, 1989).

Information sources, both internal and external, provide the inputs to build manufacturing organizational knowledge. This knowledge arises from the integration of information, technology and human assets and allows the manufacturing system to better analyze the external and internal environments and to reinforce or build capabilities.

The ability to access information from various sources influences the quality of the manufacturing decision process. But companies have different sources from which to obtain information. For example, managers can access internal information from TQM and JIT or other improvement programs, which are related to organizational learning and knowledge building from several internal information sources (Garvin, 1998; Roth and Jackson, 1995; Womack et al., 1992; Nonaka and Konno, 1998; Taylor, 1998). In addition, they can access external information.

Alliances are a possible way to get information. Companies may develop different types of alliances in the supply chain (McCutcheon and Ian, 2000; McCarter and Northcraft, 2007). Bensao and Venkatraman (1995), Helper and Sako (1995), and Carr and Pearson (1999) also highlighted the role of buyer–supplier relationships for information access. Customers are a fundamental source of external information, especially when learning processes (Garvin, 1998) or innovation practices (Brown, 1998) are the focus. New information technologies lay the foundation for firms to build knowledge out of information (Von Hippel, 1994; Mata et al., 1995; Nonaka and Konno, 1998; Kathuria et al., 1999).

The following hypotheses relating information and manufacturing knowledge can be advanced.

Hypothesis 1. Internal information sources are positively related to internal manufacturing knowledge (γ_{11}).

Hypothesis 2. Internal information sources are positively related to external manufacturing knowledge (γ_{21}).

Hypothesis 3. External information sources are positively related to internal manufacturing knowledge (γ_{12}).

Hypothesis 4. External information sources are positively related to external manufacturing knowledge (γ_{22}).

Hypothesis 5. External and internal information sources are positively related to each other. ($\varnothing_{21}$)

4.2. *Manufacturing organizational knowledge and cross-functional orientation*

Roth (1996b) shows that knowledge integration among different areas is the support for "economies of knowledge". Germain et al. (2001) state that a knowledge-based "world-class manufacturer" apparently embraces an organic flow of information across the functions creating a readily accessible knowledge for the different functional areas. Dyer and Nobeoka (2000) shows the role of the information from the Toyota's suppliers in the company's cross-functional activities related to quality improvement.

Additionally, Ward et al. (1994) argued that a more proactive role of the manufacturing is related to the interaction with other functional areas during the strategic process. Therefore, cross-functional integration requires broad-based functional knowledge integration (Nonaka and Takeuchi, 1995; Nonaka and Konno, 1998; Dyer and Nobeoka, 2000; Germain et al., 2001).

Thus, a close relationship between cross-functionality (a central issue for manufacturing strategy authors) and organizational knowledge creation would enable firms to create faster cycles of knowledge creation and application. The following hypotheses can be advanced:

Hypothesis 6. Internal information sources are positively related to manufacturing cross-functional orientation (γ_{31}).

Hypothesis 7. External information sources are positively related to manufacturing cross-functional orientation (γ_{32}).

Hypothesis 8. External manufacturing knowledge is positively related to internal manufacturing knowledge (β_{12}).

Hypothesis 9. Internal manufacturing knowledge is positively related to manufacturing cross-functional orientation (β_{31}).

Hypothesis 10. External manufacturing knowledge is positively related to manufacturing cross-functional orientation (β_{32}).

4.3. *Manufacturing cross-functional orientation and resource-based theory*

According to Daft (1983), resources may be understood as the overall assets, capabilities, organizational processes, attributes, information and knowledge that a company controls in order to improve its efficiency and effectiveness.

The metaphor of "knowledge factory" is related to an accelerated learning organization and processes able to translate that knowledge into competitive capabilities and core competencies (Roth et al., 1994). These processes require a cross-functional orientation since they are built on knowledge integration (Germain et al., 2001) and they link manufacturing resources to capability creation (Schroeder et al., 2002). This competence should be valuable to customers, as it is based on a rare resource, imperfectly imitable and without substitutes easily found (Barney, 1991).

Thus, the following hypotheses are advanced.

Hypothesis 11. Internal manufacturing knowledge is positively related to resource-based orientation (β_{41}).

Hypothesis 12. External manufacturing knowledge is positively related to resource-based orientation (β_{42}).

Hypothesis 13. Manufacturing cross-functional orientation is positively related to resource-based orientation (β_{43}).

4.4. *Empirical model*

The proposed model (Fig. 1) shows the hypothesized relationships among the independent variables *internal information sources* (IS) and *external information sources* (ES), and the four dependent variables *external manufacturing knowledge* (EK), *internal manufacturing knowledge* (IK), *cross-functional orientation* (CF), and *resource-based orientation* (RBO).

5. Research methodology

We carried out path analyses of the hypothesized model (Fig. 1) using the statistical software package Amos 5.1 (Hair et al., 1995). We used confirmatory factor to evaluate the psychometric properties of the multi-item scales tapping into the constructs. These results confirm the initial proposal in all constructs:

internal and external sources of information, external and internal manufacturing knowledge, cross-functional orientation, and resource-based orientation.

A self-administered questionnaire was used to collect field data. The first step for the questionnaire construction was a discussion about the framework with executives from two Brazilian companies—one from the plastics industry and the other from the machine industry. These interviews aided the formulation of the first version of the questionnaire.

A pilot test was then performed with 19 companies from the machine manufacturing and plastics industries. We obtained 9 responses (47.36%), and conducted a follow-up interview for additional information on the questionnaire concerning clarity, time necessary to complete it, and questions ordering. The contact list consisted of 243 companies located in the southern region of Brazil. These companies were selected from the database of Sebrae (Brazilian Support Service for Small and Medium Enterprises). All these companies have more than 100 employees and belong to the food, electronics, transport equipment, or machine manufacturing industries.

A dynamic characteristic of the Brazilian competitive environment is identified by the sharp increase of both exports and imports in the last 5 years (around 100%). The industries studied are the main exporters in the Brazilian economy. These industries also are characterized by active participation of Transnational Companies (TNCs) through investments in plants and increasing imports. Besides, the region where these companies are located at presents the highest ratio between exports and Gross Product in Brazil (approximately 35%).

A first mailing of the definitive questionnaire was then sent to the selected sample. The first wave return rate was 21% (51 respondents). One month later a second mailing was sent to the non-respondents and 27 more questionnaires returned. A final effort was done and 26 new questionnaires returned. The return rate after this last wave reached 43% (104 companies). The respondents were CEOs (11), Directors (23), Manufacturing Managers (48), Quality Managers (15) and others (7). The response rate obtained for the survey can be considered satisfactory (Boyd et al., 1985).

An ANOVA analysis was initially used in order to compare the three groups of respondents (first *versus* second *versus* third mailings) based on the six constructs, applying Bonferroni and Tukey tests (Evrard et al., 1993). Only the construct related to Internal Information Sources showed a statistically significant difference between the second and first waves. This difference may be caused by the small sample size in the one group. (Table 2).

Table 2
ANOVA analysis for the three waves of surveys

	F	*p*-Value
Internal sources of information (IS)	2.99	0.06
External sources of information (ES)	0.83	0.44
Internal knowledge (IK)	1.93	0.15
External knowledge (EK)	1.81	0.17
Cross-functional orientation (CF)	1.08	0.34
Resource-based orientation (RBO)	1.62	0.20

5.1. Validity and reliability analysis

Because we had developed constructs and items tapping into them that were of theoretical importance, we used confirmatory factor analysis (CFA) to evaluate the validity and reliability of the resulting multi-item measurement scales. Different authors have identified limitations in the traditional exploratory factor analysis method in scale development. For example, threats to validity may occur when items load simultaneously on multiple factors and are omitted and/or the correlation of among items cannot be explained theoretically, Cronbach's alpha also has limitations under some circumstances, and unidimensionality is checked only after the reliability analysis (Bollen and Long, 1993; Heck, 1998; Ahire et al., 1996; Jiang et al., 2000; Das et al., 2000). In the last few years, the use of CFA has become widespread tool in operations management studies to evaluate both discriminant and convergent validity of constructs (see, among others, Koufteros, 1999; Koufteros et al., 2001; Dong et al., 2001; Krause et al., 2001; Detert et al., 2003).

Because of our study's sample size limitation, we analyzed the reliability, unidimensionality, convergent validity, and discriminant validity the constructs using three separate CFA nested models. Although the small sample size is a clear limitation, the nested model orientation reduces the possibility of interpretational confusion common in complex models (Burt, 1971). However, it forms the basis of the NFI goodness-of-fit measure (Gerbing and Anderson, 1993).

The advisable minimum size for the appropriate use of maximum likelihood estimate (MLE) is 100. Hair et al. (1995) state that even a small sample such as 50 cases may provide a valid result for MLE. The ratio between the number of subjects and parameters is above 5:1. To Kline (1998), the model stability would be really doubtful when a ratio is less than this value. Also, Monte Carlo studies analyzing sample size variation

Table 3
Regression parameter standard error estimates related to bootstraps analysis

Parameter		S.E.	S.E.–S.E.	Mean	Bias	S.E.-Bias
EK	ES	0.071	0.002	0.293	−0.001	0.002
EK	IS	0.088	0.002	0.246	0.001	0.003
EK	CF	0.177	0.004	0.103	−0.005	0.006
IK	IS	0.088	0.002	0.383	0.003	0.003
IK	EK	0.082	0.002	0.256	0.007	0.003
IK	ES	0.073	0.002	0.173	0.000	0.002
CF	IK	0.163	0.004	0.201	−0.006	0.005
CF	IS	0.166	0.004	0.686	0.000	0.005
CF	ES	0.104	0.002	0.112	0.011	0.003
RBO	CF	0.052	0.001	0.252	0.002	0.002
RBO	IK	0.121	0.003	0.125	0.000	0.004
RBO	EK	0.137	0.003	0.356	−0.020	0.004

and its influence on goodness-of-fit measures showed that GFI, AGFI and NFI are sensitive to the increment of the sample sizes (Kline, 1998).

Increasing sample size would improve the results for these measures. On the other hand, some goodness-of-fit measures, such as the Tucker–Lewis index (TLI), were not greatly affected by the sample size. These studies show that some goodness-of-fit measures may present artificially strong results if the sample is large. Nevertheless, invalid solutions such as in the *Heywood case* may arise when there is a combination of small sample size and two indicators per factor, as in this study (Kline, 1998).

A bootstrap analysis was carried out with 1000 bootstrap samples. According to Kline (1998), this technique provides additional empirical information about the variability of parameters estimates and fit indexes. Mardia's coefficient equal to 4.460 indicated a significant kurtosis or non-normality in the data, justifying bootstrapping. In the first step, a large number of samples with replacement were taken and parameter estimates were computed for each one (Table 3).

If the majority of bootstrap $\chi^2_{\text{difference}}$ statistics exceeds the values required for statistical difference, we may not state that relative fits of the two models, the original and the second from the bootstrap analysis, are equal. The parameters are adequate as shown in the Table 3, especially the values in the columns ‘‘SE SE’’ and ‘‘Bias’’ (low as expected).

One last concern was the social desirability of the responses (SDR). We evaluated the samples variances for all the constructs. All of them presented a normal distribution with exception of Internal Information Sources. Again, this result may have a random cause in consequence of the small sample size. Besides, like Richman et al. (1999) stated, there is less distortion of SDR when respondents are alone and can backtrack.

The measurement model analysis included three different nested models. The first model is related to the External and Internal Information Sources. The second model integrates the External and Internal Knowledge constructs. Finally, the third model presents the Cross-functional Orientation and Resource-based Orientation constructs.

The results of the CFA for the Information Sources model show all the measures of goodness-of-fit at acceptable levels. It shows a χ^2 equal to 19.548 ($p < 0.012$). GFI (0.944), AGFI (0.854), NFI (0.894) and TLI (8.72) indicate a satisfactory fit. RMSEA is equal to zero. Internal and External Information Sources, as expected, are positively related, providing support for concepts such as absorptive capacity (Cohen and Levinthal, 1990).

In the second model, which analyzes Internal Knowledge and External Knowledge, all the fit indices also indicate a satisfactory model fit (GFI = 0.981, CFI = 0.990, NFI = 0.955, and TLI = 0.975 and AGFI = 0.931). RMSEA is close to 0. The first measure of goodness-of-fit is the likelihood ratio χ^2 statistic. The value ($\chi^2 = 5.015$) does not have statistical significance ($p < 0.286$). This statistic suggests that the differences between the predicted and real matrices are non significant. As expected, internal and external knowledge are positively correlated, corroborating the concept of knowledge integration (Grant, 1996). Additional measures also indicated acceptable levels

Table 4
Basic statistics and composite reliability

Constructs	Mean	Standard deviation	Variance extracted (%)	Composite reliability
Internal information sources	4.09	0.63	53.3	0.90
External information sources	3.19	0.89	67.8	0.92
Internal knowledge	3.76	0.70	82.0	0.92
External knowledge	3.43	0.69	80.8	0.96
Cross-functional orientation	3.37	1.23	51.0	0.85
Resource-based orientation	3.68	0.80	69.8	0.94

of fit, including GFI, AGFI, CFI and NFI, with all values above 0.93.

A similar situation was found in the third model, which analyzes cross-functional orientation and resource-based orientation. The χ^2 statistic indicated a non-significant value ($p < 0.268$) and all the other measures of fitness are within acceptable levels (GFI = 0.981, CFI = 0.993, NFI = 0.972, and TLI = 0.983 and AGFI = 0.927). Also, in this model, the two endogenous latent variables, resource-based orientation and cross-functionality, are statistically significant. This provides evidence that cross-functional activities influence the development of a resource-based orientation and corroborates the capability-creation views of researchers such as Coates and McDermott (2002) and Schroeder et al. (2002).

Convergent validity can be assessed through the individual item loadings. The loading varies from 0.46 to 0.98 in the first model. At the same time, item loadings are from 0.91 to 0.99, with $p < 0.01$ in the second model. The last model also presents item loadings within the expected values (from 0.61 to 0.92), with $p < 0.01$. The *Heywood case* was not identified in any model analyzed; all models showed indication-factor correlations lower than 1 and no error variance was less than 0. We calculated the composite reliability and all of the values are above 0.80 as expected (Raykov and Shrout, 2002) (see Table 4).

Finally, we used a χ^2 difference test to check discriminant validity (Anderson, 1987; Ahire et al., 1996; Stratman and Roth, 2002). All the models indicated statistically significant differences, when one of their scales had its correlation fixed at 1. Repeating this procedure for all the 15 pairs of scales in the instrument, they showed a statistically significant difference.

The relationships for each construct scale pair are presented in Table 5. Also, each correlation is significantly different from 1.0, as indicate by its values plus two standard errors (Anderson, 1987). Correlations between the factors are not excessively high as expected (Kline, 1998). Significant correlations were expected because the variables present clear theoretical links (Kaynak, 2003).

A final test for discriminant validity is to compare the average extracted by the items of a construct to the average shared variance (square of the correlations) between two constructs (Fornell and Larker, 1981). The results found suggest the existence of discriminant validity (see Table 6).

The number of variables in each construct ranged originally from 3 to 4. Only Internal Knowledge and

Table 5
Results of confirmatory factor analysis test of measurement scale discriminant validity

Construct scale pairs	Unconstrained		Constrained		χ^2 difference
	χ^2	d.f.	χ^2	d.f.	
Internal information sources					
External information sources	19.5	8	63.0	9	43.5*
Internal knowledge	7.2	4	36.9	5	29.7*
External knowledge	28.4	8	73.4	9	45*
Cross-functional orientation	1.7	4	23.2	5	21.5*
Resource-based orientation	5.9	8	58.3	9	52.4*
External information sources					
Internal knowledge	4.9	4	23.8	5	18.9*
External knowledge	25.5	8	45.1	9	19.6*
Cross-functional orientation	4.1	4	24.1	5	20*
Resource-based orientation	10.5	8	24.7	9	14.2*
Internal knowledge					
External knowledge	5.0	4	35.0	5	30*
Cross-functional orientation	0.9	1	15.2	2	14.3*
Resource-based orientation	3.1	4	26.5	5	23.4*
External knowledge					
Cross-functional orientation	11.5	4	29.8	5	18.3*
Resource-based orientation	8.5	8	41.0	9	32.5*
Cross-functional orientation					
Resource-based orientation	5.2	4	29.1	5	23.9*

* Significant at $p < 0.01$.

Table 6
Extracted variance average, correlations and standard error calculated pairwise

Construct scale pairs		Variance construct 1	Variance construct 2	Estimated correlation	S.E.
Construct 1	Construct 2				
Internal information sources	External information sources	0.55	0.38	0.33	0.05
	Internal knowledge	0.88	0.53	0.63	0.05
	External knowledge	0.75	0.54	0.35	0.05
	Cross-functional orientation	0.75	0.54	0.51	0.07
	Resource-based orientation	0.73	0.53	0.42	0.04
External Information Sources	Internal knowledge	0.85	0.39	0.56	0.06
	External knowledge	0.78	0.39	0.59	0.08
	Cross-functional orientation	0.65	0.38	0.27	0.08
	Resource-based orientation	0.73	0.39	0.53	0.06
Internal Knowledge	External knowledge	0.85	0.85	0.60	0.05
	Cross-functional orientation	0.70	0.89	0.38	0.08
	Resource-based orientation	0.73	0.87	0.56	0.05
External Knowledge	Cross-functional orientation	0.76	0.75	0.39	0.06
	Resource-based orientation	0.73	0.77	0.58	0.05
Cross-functional Orientation	Resource-based orientation	0.73	0.69	0.50	0.07

Cross-functional Orientation dropped one variable (one each), leaving each one with two variables. Those variables were dropped because they presented low weights in the nested models (see Appendix A). It is worth mentioning that this number of variables in some situations needs to be regarded with caution (Gerbing and Anderson, 1985; Marsh et al., 1998). On the other hand, the other four constructs (Internal Information Sources, External Information Sources, External Knowledge and Resource-based Orientation) are composed by three variables at the end. Based on the results of the confirmatory factor analysis, we can identify the five constructs and their variables (Appendix A).

5.2. Common method variance analysis

We also analyzed the common method variance (CMV) of the proposed constructs. Kline et al. (2000) claim that correlation coefficients in some studies might be measuring spurious relationships due to CMV (Kline et al., 2000; Lindell and Whitney, 2001). Therefore, to evaluate the possibility of CMV in our study, the Lindell and Whitney (2001) method was applied. We used a Global Orientation (GO) scale that is posited to be unrelated to the theoretically important constructs in our model. The GO scale was similar to the criterion variable (Resource-based Orientation, RBO) in terms of semantic content,

Table 7
CMV analysis correlations among model variables

	Internal information sources (x_1)	External information sources (x_2)	Internal knowledge (x_3)	External knowledge (x_4)	Cross-functional orientation (x_5)	Resource-based orientation (x_6)	Global orientation (y)
Internal information sources (x_1)	1.00						
External information sources (x_2)	0.21*	1.00					
Internal knowledge (x_3)	0.43**	0.36**	1.00				
External knowledge (x_4)	0.33**	0.34**					
	0.38**	1.00					
Cross-functional orientation (x_5)	0.41**	0.14	0.33**	0.20**	1.00		
Resource-based orientation (x_6)	0.25**	0.58**	0.45**	0.39**	0.32**	1.00	
Global orientation (GO) (y)	−0.07	0.08	−0.21	−0.10	−0.12	0.08	1.00
r_{yiM}[a]	0.29**	0.54**	0.54**	0.44**	0.39**	0.00	

Note: $^*p < 0.05$; $^{**}p < 0.01$.
[a] $r_{yM} = (r_{yi} - r_s)/(1 - r_s)$, where r_s is the correlation between the predictor variables and unrelated variable and r_{yi} is the correlation coefficient suspected of CMV.

and narrowness of definition (Lindell and Whitney, 2001).

Predictor variables are Internal Information Sources (x_1), External Information Sources (x_2), Internal Knowledge (x_3), External Knowledge (x_4) and Cross-functional Orientation (x_5).

The criterion variable is Resource-based Orientation (y), and r_s is the equal to the correlation between the predictor variable (RBO) and unrelated variable (GO). Using a correlation matrix, we evaluated CMV by analyzing the partial–correlation adjustment of the r_s and its significance. All the correlations remained significant after the adjustments (Table 7). These results indicate that there is a low degree of CMV between the scales analyzed (Lindell and Whitney, 2001), as expected.

6. Structural equation modeling results

We used the path analysis technique to identify the relationships among internal and external information sources, internal and external manufacturing knowledge, cross-functional orientation, and resource-based orientation. Information sources were considered the main input of the internal and external knowledge. Higher levels of knowledge lead to cross-functional and resource-based orientation. This means that resources tend to be better explored when functional areas are integrated. All these relationships were considered in the 12 hypotheses displayed in Fig. 1. The scores for each relationship are reported in Fig. 2. We used the covariance matrix among the constructs identified by the theory. According to Hoyle (1995), path diagram is a primary form to communicate structural equation modeling hypotheses and results. We analyzed the path model using the AMOS software.

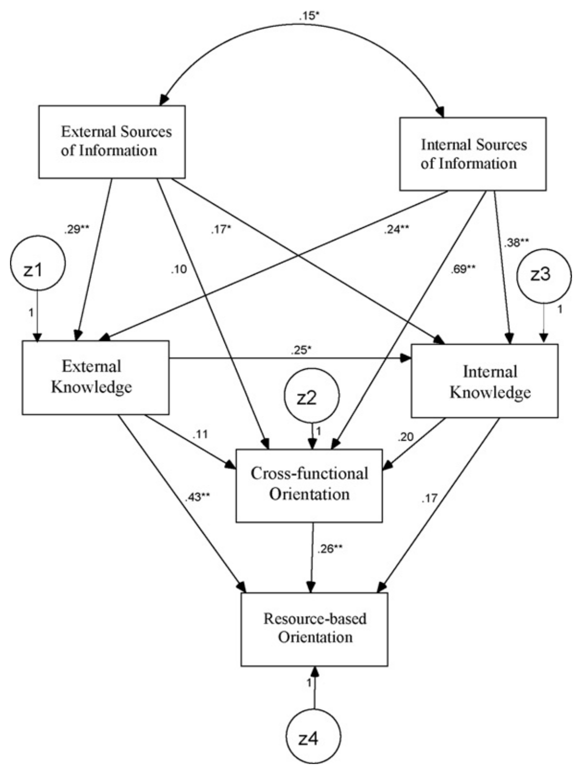

Fig. 2. Path analysis coefficients related to the proposed model of manufacturing strategy formulation. $*p < 0.05$; $**p < 0.01$.

Table 8
General statistics for goodness-of-fit

Stand alone indices	
Chi-square	4.057
Degrees of freedom (d.f.)	2
Probability level	0.13
Goodness of Fit (GFI)	0.987
Adjusted goodness of fit (AGFI)	0.870
Standardized RMR	0.019
RMSEA	0.100
Incremental indices	
Normed fit index (NFI)	0.978
Incremental fit index (IFI)	0.989
Comparative fit index (CFI)	0.988
Tucker–Lewis coefficient (TLI)	0.910

The result ($\chi^2 = 4.057$, d.f. = 2, $p = 0.13$) indicates that there is a non-significant difference between the actual and the predicted matrices (Hair et al., 1995). However, other statistical tests are necessary to indicate significant results, due to the small sample size. GFI and AGFI values indicate a reasonable fit of the data with the hypothesized model (GFI = 0.987; AGFI = 0.870). All other tests also show a good overall fit (RMR = 0.006; RMSEA $<$ 0.100; NFI = 0.978; IFI = 0.989; CFI = 0.988; TLI = 0.910). The results are summarized in Table 8. The direct, indirect and total effects are presented in Table 9.

7. Discussion and conclusions

Hypothesis 1 states that internal information sources positively influence internal manufacturing knowledge. The path coefficient γ_{11} is equal to 0.38 ($p < 0.01$). Therefore, this first hypothesis is confirmed. The results also support the second hypothesis—internal information sources influences positively external manufacturing knowledge ($\gamma_{21} = 0.24$, $p < 0.05$).

External information sources positively influence both external and internal manufacturing knowledge

Table 9
Effects of exogenous and prior endogenous/variables on/model/constructs ($n = 104$)

Variable	Effect external knowledge		Effect internal knowledge		Effect cross-functional orientation		Effect resource-based orientation	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
Internal information sources (x_1)	0.245	–	0.380	0.061	0.686	0.118	–	0.387
External information sources (x_2)	0.293	–	0.173	0.073	0.102	0.083		0.216
Internal knowledge (y_1)	–	–	–	–	0.207	–	0.167	0.054
External knowledge (y_2)	–	–	0.249	–	0.108	0.052	0.432	0.083
Cross-functional orientation (y_3)	–	–	–	–	–	–	0.259	–

($\gamma_{22} = 0.29$, $p < 0.01$; $\gamma_{12} = 0.17$, $p < 0.05$), supporting Hypotheses 3 and 4. Between external and internal information sources, the path coefficient $\varnothing_{12}$ is equal to 0.15 ($p < 0.05$) confirming Hypothesis 5.

Hypothesis 6 states that internal information sources are positively related to manufacturing cross-functional orientation. The path coefficient of 0.69 ($p < 0.01$) is statistically significant, providing support for this hypothesis as well. The same was not found for the Hypothesis 7. It is only partially confirmed because the path coefficient equal to 0.10 is not statistically significant.

Hypothesis 8 states that external manufacturing knowledge is positively related to internal manufacturing knowledge. The path coefficient $\beta_{12} = 0.25$ ($p < 0.05$) confirms this hypothesis. Also internal and external knowledge presented positive coefficients related to cross-functional orientation ($\beta_{31} = 0.20$, $\beta_{32} = 0.11$). Nevertheless, hypotheses 9 and 10 are partially confirmed, since their regression weights are not statistically significant. Similarly, Hypothesis 12, which states that internal manufacturing knowledge (β_{41}) is positively related to resource-based orientation, is only partially confirmed ($\beta_{41} = 0.17$), since it is not statistically significant. On the other hand, external manufacturing knowledge is positively related to resource-based orientation, with a statistically significant coefficient ($\beta_{42} = 0.43$, $p < 0.01$).

Finally, Hypothesis 13 asserts that manufacturing cross-functional orientation is positively related to resource-based orientation. In this case, the path coefficient β_{43} is equal to 0.26 ($p < 0.01$), supporting this last hypothesis.

These results show the need for a new manufacturing manager's profile under the current environmental conditions. In his pioneering study, Skinner (1969) argued that a cost orientation was not sufficient. The results corroborate this statement, as they make clear that manufacturing organizational knowledge is created from the identification of competitive resources and an awareness of marketing conditions under circumstances of fast changes in the competitive environment. Nevertheless, differently from the authors who link manufacturing strategy to the traditional strategic planning or trade-offs, the results show the role of organizational knowledge as the key input for the manufacturing strategy process leading to the development of capabilities that will create product value. As a result, manufacturing should be able to organize internal resources and to interact with other functions in order to respond to the needs from the market place.

It follows from the above discussion that manufacturing managers need to seek information not only from manufacturing, but also from other functional areas and company's partners. External information sources are relevant, since manufacturing managers need to know about their competitors and their competitors' performance, thus identifying threats and opportunities in the marketplace. A view from the external environment is needed and therefore necessary to enhance competitiveness.

These results go in the same direction of those obtained by Hult et al. (2006) and Modi and Mabert (2007), concerning the role of knowledge integration in the supply chain, and those of Ward et al. (1994), Dyer and Nobeoka (2000), Germain et al. (2001), and Hausman et al. (2002), which highlight cross-functional issues.

Therefore, manufacturing management should view beyond its silos, as Hayes (2002) stated. A narrow view of the manufacturing management's role, focused only on produced volumes, operational costs and shop-floor control is no longer adequate. Currently, manufacturing needs to know how to improve its integration with other functions and with suppliers and customers. External information sources will complement internal sources, providing a richer view to manufacturing managers. Additionally, manufacturing managers must be aware of the full range of strategic issues, for otherwise their companies may lose competitive advantages or fail to develop the necessary ones.

8. Conclusion

The results of this study suggest that knowledge as an organizational resource allows the manufacturing function to seek a higher integration with other functional areas under current environment conditions. This finding corroborates manufacturing strategy proposals related to a more proactive role of manufacturing in strategic decisions (Wheelwright, 1978; Hayes and Wheelwright, 1985), and a new manufacturing managerial profile (Hayes, 2002).

Diversely from the first references on manufacturing strategy, this article explored the role of manufacturing knowledge as a key strategic resource. In this manner, manufacturing will be able to participate more proactively in strategic decisions because it knows the goals, the threats and the opportunities in the marketplace, and knows which competencies are key to the support of competitiveness. In short, manufacturing attains a higher level of organizational knowledge. Instead of seeing the process the manufacturing strategy as a decision process related to trade-offs or sequence of capabilities creation, the model proposed showed the integration of resources related to this process. This occurs through the information sources and the cross-functional orientation. Given that knowledge integration leads to a higher level of knowledge (Grant, 1996), there is an interactive process between manufacturing knowledge and cross-functional activities. Management activities, like participatory processes in strategic planning, play a double role: they both build up the firm's manufacturing knowledge and also provide the right conditions for the development of a cross-functional view within the company. Like other current studies, such as Hult et al. (2006), and Modi and Mabert (2007), a high level of knowledge present in the process of manufacturing strategy lead to a better results.

This study also suggests that manufacturing cross-functional integration is positively related to resource-based orientation. It is not surprising that more integration among distinct functional areas allows the creation of product characteristics that are valued by clients and not easily found. Internal competencies, it must be reinforced, are not restricted to a specific area, but are the output of an integrated effort among different functions (Dyer and Nobeoka, 2000; Germain et al., 2001). Therefore, companies that are strengthening cross-functionality should obtain better results in more dynamic environments. In this case, a resource-based orientation is not restricted to manufacturing but results from a coordinated effort with other functional areas to maintain or increase competitive advantage. At the same time, manufacturing knowledge allows managers to better explore their internal resources, creating and sustaining their company's competencies.

Although the results of this study should be viewed with a certain degree of caution, considering the limitations of sample size, they nevertheless offer some relevant theoretical contributions to the process of manufacturing strategy formulation. The most important finding is the central role of knowledge in this process. Through organizational knowledge, manufacturing will be able to develop activities that are more highly integrated with other areas and, consequently, to achieve or sustain greater competitive advantages.

Several areas for future research may be identified from these results. Given that we used companies from different industries, one might ask whether there are distinct strategy-formulation processes and information sources used in different industries? Do different product life cycles influence the issues considered in this research, either manufacturing cross-functional or resource-based orientation? Is it possible to relate certain elements of the proposed model to companies' performance? Answers to these questions would complement the results presented here and provide management with further tools to succeed in today's dynamic manufacturing environment.

Appendix A

Scale	
Never	1
Rarely	2
Sometimes	3
Frequently	4
Always	5

Questions:

IS1: Managers' opinions are used as input for manufacturing planning within a participatory process.
IS2: Manufacturing managers' opinions are used as input for manufacturing policy settings within a participatory process.
IS3: Manufacturing uses IT to evaluate internal data on manufacturing performance.
ES1: The company has developed alliances with suppliers to develop new products and technologies.
ES2: The company has developed alliances with customers to develop new products and technologies.

ES3: Manufacturing uses IT to receive information directly from the clients.

IK1: Manufacturing knows how to explore the company's internal resources, which lead to a competitive advantage.

IK2: Manufacturing knows how to seek more integration with other functional areas of the company in order to reinforce their internal resources.

IK3: Manufacturing knows clearly the future objectives of this BU (dropped).

EK1: Manufacturing clearly understands the primary opportunities to be explored in the market place.

EK 2: Manufacturing knows the performance of its main competitors.

EK3: Manufacturing clearly understands the existing threats in the marketplace.

CFO: Indicate to what extent the following activities are based on cross-functional activities:

1. Decisions related to manufacturing, marketing and R&D strategies.
2. Decisions related to the growth strategy of the business unit.
3. Production and service decisions related to manufacturing strategies, marketing and R&D (dropped).

RBO: Indicate the extent that the manufacturing strategy formulation is related to the following:

1. Providing product characteristics that are valued by the customers.
2. Seeking competitive resources, which the competitors do not have.
3. Creating resources not easily imitable by the competitors.

Scale	
Strongly disagree	1
Disagree	2
Sometimes agree, sometimes not	3
Agree	4
Strongly agree	5

GO1: Most of our revenues comes from exports.

GO2: Our exports increased considerably in the last period.

References

Adam, E.E., Swamidass, P.M., 1992. Assessing operations management from a strategic perspective. In: Voss, C. (Ed.), Manufacturing Strategy—Process and Content. Chapman & Hall, London, pp. 373–400.

Ahire, S.L., Golhar, D.Y., Waller, M.A., 1996. Development and validation of TQM implementation constructs. Decision Sciences 27 (1), 23–56.

Amundson, S.D., 1998. Relationships between theory-driven empirical research in operations management and other disciplines. Journal of Operations Management 16 (4), 341–359.

Anderson, J.C., 1987. An approach for confirmatory measurement and structural equation modeling of organizational properties. Management Science 33 (4), 525–541.

Anderson, J.C., Schroeder, R.G., Cleveland, G., 1991. The process of manufacturing strategy: Some empirical observations and conclusions. International Journal of Operations Management 11 (3), 86–110.

Andrews, K.R., 1971. The concept of corporate strategy. McGraw-Hill/Irwin, New York.

Badri, M.A., Davis, D., Davis, D., 2000. Operations strategy, environmental uncertainty and performance: a path analytic model of industries in developing countries. Omega 28 (2), 155–173.

Barney, J., 1991. The resource-based model of the firm: origins, implications, and prospects. Journal of Management 17 (1), 97–117.

Bell, D., 1999. The Coming of the Post-industrial Society. Basic Books, New York.

Bensao, M., Venkatraman, N., 1995. Configurations of interorganizational relationships: a comparison between U.S. and Japanese automakers. Management Science 41 (9), 1471–1490.

Bollen, K.A., Long, J.S., 1993. Testing Structural Equation Models. Sage Publications, Newbury Park.

Boyd, H.W., Westfall, R., Stasch, S., 1985. Marketing Research: Text and Cases. Irwin, Boston.

Boyer, K.K., Lewis, M.W., 2002. Competitive priorities: investing the need for trade-offs in operations strategy. Production and Operations Management 11 (1), 9–20.

Boyer, K.K., McDermott, C., 1999. Strategic consensus in operations strategy. Journal of Operations Management 17 (3), 289–305.

Brown, S., 1998. Research that reinvents the organization. In: Harvard Business Review on Knowledge Management, Harvard Business School Press, Boston, pp. 153–180.

Burt, R.S., 1971. Interpretational confounding of unidimensional variables in structural equations modeling. Sociological Methods and Research 5, 3–51.

Carr, A.S., Pearson, J.N., 1999. Strategically managed buyer–supplier relationships and performance outcomes. Journal of Operations Management 17 (5), 497–519.

Chandler, A., 1962. Strategy and Structure: Chapters in the History of the American Enterprise. MIT Press, Cambridge.

Cheng, T.C.E., Musaphir, H., 1996. Theory and practice of manufacturing strategy. International Journal of Production Research 34 (5), 1243–1259.

Cleveland, G., Schoereder, R.G., Anderson, J.C., 1989. A theory of production competence. Decision Sciences 20 (4), 655–668.

Coates, T.T., McDermott, C.M., 2002. An exploratory analysis of new competencies: a resource based view perspective. Journal of Operations Management 20 (5), 435–450.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly 35 (1), 128–152.

Collis, D.J., Montgomery, C.A., 1995. Competing on resources: strategy in the 1990s. Harvard Business Review 73 (4), 118–128.

Crittenden, V.L., 1992. Close the marketing/manufacturing gap. Sloan Management Review 33 (3), 41–53.

Daft, R., 1983. Organization Theory and Design. West, New York.

Das, A., Handfield, R.B., Ghosh, S., 2000. A contingent view of quality management—the impact of international competition on quality. Decision Sciences 31 (3), 649–690.

Davenport, T.H., De Leong, D.W., Beers, M.C., 1998. Successful knowledge projects. Sloan Management Review 39 (1), 43–57.

Davenport, T.H., Prusak, L., 1998. Working Knowledge. Harvard Business School Press, Boston.

Detert, J.R., Schroeder, R.G., Cudeck, R., 2003. The measurement of quality management culture in schools: development and validation of the SQMCS. Journal of Operations Management 21 (3), 307–328.

Dong, Y., Carter, C.R., Dresner, M.E., 2001. JIT purchasing and performance: an exploratory analysis of buyer and supplier perspectives. Journal of Operations Management 19 (4), 471–483.

Dyer, J., Nobeoka, K., 2000. Creating and managing a high-performance knowledge-sharing network: the Toyota case. Strategic Management Journal 21 (3), 345–367.

Evrard, Y., Pras, B., Roux, E., 1993. Études et recherchers en marketing—Fondements. In: Méthods, Edition Nathan, Paris.

Ferdows, K., De Meyer, A., 1990. Lasting improvements in manufacturing performance: in search of a new theory. Journal of Operations Management 9 (2), 168–184.

Fine, C.H., Hax, A.C., 1985. Manufacturing strategy: a methodology and an illustration. Interfaces 15 (6), 28–46.

Flynn, B.B., Flynn, E.J., 2004. An exploratory study of the nature of cumulative capabilities. Journal of Operations Management 22 (5), 439–457.

Fornell, C., Larker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research 18 (1), 39–50.

Garvin, D., 1998. Building a learning organization. In: Harvard Business Review on Knowledge Management, Harvard Business School Press, Boston.

Gerbing, D.W., Anderson, J.C., 1985. The effects of sampling and model characteristics on parameter estimation for maximum likelihood confirmatory factor analysis. Multivariate Behavioral Research 20 (3), 255–271.

Gerbing, D.W., Anderson, J.C., 1993. Monte Carlo evaluations of goodness-of-fit indices for structural equation models. In: Bollen, K.A., Long, J.S. (Eds.), Testing Structural Equation Models. Sage Publications, Newbury Park, pp. 40–65.

Germain, R., Droge, C., Christensen, W., 2001. The mediating role of operations knowledge in the relationship of context with performance. Journal of Operations Management 19 (4), 453–469.

Giffi, C., Roth, A.V., Seal, G.M., 1990. In: Richard, D. (Ed.), Competing in World-class Manufacturing: 21st Century Challenge. Irwin Inc., New York.

Grant, R.M., 1991. The resource-based theory of competitive advantage: implications for strategy formulation. California Management Review 33 (3), 114–136.

Grant, R.M., 1996. Prospering in dynamic-competitive environments: organizational capability as knowledge integration. Organization Science 7 (4), 375–387.

Grant, R.M., 1997. The knowledge-based view of the firm: implications for management practice. Long Range Planning 30 (3), 450–454.

Grant, R.M., 2002. The knowledge-based view of the firm. In: Choo, C.W., Bontis, N. (Eds.), The Strategic Management of Intellectual Capital and Organizational Knowledge. Oxford University Press, New York, pp. 133–148.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1995. Multivariate Data Analysis. Prentice-Hall, New York.

Hamel, G., 1997. Killer strategies that make shareholders rich. Fortune 23, 70–88.

Hausman, W.H., Montgomery, D.B., Roth, A.V., 2002. Why should marketing and manufacturing work together? Some exploratory empirical results. Journal of Operations Management 20 (3), 241–257.

Hayes, R.H., 2002. Challenges posed to operations management by the ‘‘new economy’’. Production and Operations Management 11 (1), 21–32.

Hayes, R.H., Pisano, G.P., 1994. Beyond world-class: the new manufacturing strategy. Harvard Business Review 72 (1), 77–86.

Hayes, R.H., Upton, D.M., 1998. Operations-based strategy. California Management Review 40 (4), 8–25.

Hayes, R.H., Wheelwright, R., 1985. Competing through manufacturing. Harvard Business Review 63 (1), 99–110.

Hayes, R.H., Wheelwright, R., Clark, K.B., 1988. Dynamic Manufacturing: Creating the Learning Organization. The Free Press, New York.

Heck, R.H., 1998. Factor analysis: exploratory and confirmatory approaches. In: Marcoulides, G.A. (Ed.), Modern Methods for Business Research. Lawrence Erlbaum Associates, Mahwah, NJ.

Helper, S.R., Sako, M., 1995. Supplier relations in Japan and United States: are they converging? Sloan Management Review 36 (3), 77–84.

Hill, T., 1989. Manufacturing Strategy—Text and Cases. McGraw Hill, London.

Hoyle, R.H., 1995. Structural equation modelling approach: basic concepts and fundamental issues. In: Hoyle, R.H. (Ed.), Structural Equation Modelling: Concepts, issues and applications. Sage Publications, Thousand Oaks, CA, pp. 1–15.

Hult, G.T., Ketchen Jr., D.J., Cavusgil, S.T., Calantone, R.J., 2006. Knowledge as strategic resource in supply chain. Journal of Operations Management 24 (5), 458–475.

Jiang, J.J., Gary, K., Crampton, S., 2000. A note on SERVQUAL reliability and validity in information system service quality measurement. Decision Sciences 31 (3), 725–744.

Kathuria, R., Anandarajan, M., Igbaria, M., 1999. Linking IT applications with manufacturing strategy: an intelligent decision support system approach. Decision Sciences 30 (4), 959–991.

Kaynak, H., 2003. The relationship between total quality management practices and their effects on firm performance. Journal of Operations Management 21 (4), 405–435.

Kline, R.B., 1998. Principles and Practice of Structural Equation Modeling. Guilford Press, London.

Kline, T.J.B., Sulsky, L.M., Rever-Moriyama, S.D., 2000. Common method variance and specification errors: a practical approach to detection. The Journal of Psychology 134 (4), 401–421.

Kogut, B., Zander, U., 1992. Knowledge of the firm, combinative capabilities, and the replications of technology. Organization Science 3 (3), 383–396.

Kotha, S., Swamidass, P.M., 2000. Strategy, advanced manufacturing technology and performance: empirical evidence from U.S. manufacturing firms. Journal of Operations Management 18 (3), 257–277.

Koufteros, X.A., 1999. Testing a model of pull production: a paradigm for manufacturing research using structural equation modeling. Journal of Operations Management 17 (4), 467–488.

Koufteros, X., Vonderembse, M., Doll, W., 2001. Concurrent engineering and its consequences. Journal of Operations Management 19 (1), 97–115.

Krause, D.R., Pagell, M., Curkovic, S., 2001. Toward a measure of competitive priorities for purchasing. Journal of Operations Management 19 (4), 497–512.

Leonard-Barton, D., 1994. Wellsprings of Knowledge. Harvard Business School Press, Boston.

Liebeskind, J.P., 1996. Knowledge, strategy, and the theory of the firm. Strategic Management Journal 17, 93–107.

Liedtka, J.M., Rosenblum, J.W., 1996. Shaping conversations: making strategy, managing change. California Management Review 9 (1), 141–157.

Lindell, M.K., Whitney, D.J., 2001. Accounting for common method variance in cross-sectional research designs. Journal of Applied Psychology 86 (1), 114–121.

Malhotra, M.K., Sharma, S., 2002. Spanning the continuum between marketing and operations. Journal of Operations Management 20 (3), 209–219.

Marsh, H.W., Kit-Tai Hau, Balla, J.R., Grayson, D., 1998. Is more ever too much? The number of indicators per factor in confirmatory factor analysis. Multivariate Behavioral Research 33 (2), 181–220.

Marucheck, A., Pannesi, R., Anderson, C., 1990. An exploratory study of the manufacturing strategy process in practice. Journal of Operations Management 9 (1), 101–123.

Mata, F.J., Fuerst, W.L., Barney, J.B., 1995. Information technology and sustained competitive advantage: a resource-based analysis. MIS Quarterly 19 (4), 487–505.

McCarter, M.W., Northcraft, G.B., 2007. Happy together? Insights and implications of viewing managed supply chains as a social dilemma. Journal of Operations Management 25 (2), 498–511.

McCutcheon, D., Ian, S.F., 2000. Issues in the choice of supplier alliance partners. Journal of Operations Management 18 (3), 279–301.

Menda, R., Dilts, D., 1997. The manufacturing strategic formulation process: linking multifunctional viewpoints. Journal of Operations Management 15 (4), 223–241.

Miller, J.G., Roth, A., 1994. A taxonomy of manufacturing strategies. Management Science 40 (3), 285–304.

Modi, S.B., Mabert, V.A., 2007. Supplier development: improving supplier performance through knowledge transfer. Journal of Operations Management 25 (1), 42–64.

Narasimhan, R., Wang, X., 2000. A reexamination of 'measuring the congruence between market requirements and manufacturing: a methodology and illustration'. Decision Sciences 31 (1), 223–231.

Nonaka, I., 1995. A dynamic theory of organizational knowledge creation. Organization Science 5 (1), 14–37.

Nonaka, I., Takeuchi, H., 1995. The Knowledge Creating Company. Oxford University Press, Oxford.

Nonaka, I., Konno, N., 1998. The concept of "Ba": building a foundation for knowledge creation. California Management Review 40 (3), 40–54.

Papke-Shields, K.E., Malhotra, M.K., Varun, G., 2002. Strategic manufacturing planning systems and their linkage to planning system success. Decision Sciences 33 (1), 1–30.

Peteraf, M.A., 1993. The cornerstones of competitive advantage: a resource-based view. Strategic Management Journal 14 (3), 179–191.

Platts, K.W., Gregory, M.J., 1992. Manufacturing audit approach to strategy formulation. In: Voss, C.A. (Ed.), Manufacturing Strategy—Process and Content. Chapman Hall, London, pp. 29–55.

Porter, M.E., 1980. Competitive Strategy. Free Press, New York.

Porter, M.E., 1986. Competitive Advantage. Free Press, New York.

Quinn, J.B., Anderson, P., Filkestein, S., 1996. Managing professional intellect: making the most of the best. In: Harvard Business Review on Knowledge Management, Harvard Business School Press, Boston, pp. 181–205.

Raykov, T., Shrout, P.E., 2002. Reliability of scales with general structure: point and interval estimation using a structural equation modeling approach. Structural Equation Modeling 9 (2), 195–212.

Richman, W.L., Kiesler, S., Weisband, S., Drasgow, F., 1999. A meta-analytic study of social desirability distortion in computer-administered questionnaires, traditional questionnaires, and interviews. Journal of Applied Psychology 84, 754–775.

Roth, A.V., 1996a. Neo-operations strategy: linking capabilities-based competition to technology. In: Gaynor, G.H. (Ed.), Handbook of Technology Management. McGraw-Hill, New York.

Roth, A., 1996b. Achieving strategic agility through economies of knowledge. Strategy and Leadership 24 (2), 30–36.

Roth, A., Jackson, W.E., 1995. Strategic determinants of service quality and performance: evidence from baking industry. Management Science 41 (11), 39–57.

Roth, A.V., Marucheck, A.S., Kemp, A., Trimble, D., 1994. The knowledge factory for accelerated learning practices. Planning Review 22 (3), 26–33.

Rosenzweig, E.D., Roth, A.V., 2004. Towards a theory of competitive progression: evidence from high-tech manufacturing. Production and Operations Management 13 (4), 354–368.

Rumelt, R.P., Schendel, D.E., Teece, D.J., 1994. Fundamental Issues in Strategy. Harvard Business School Press, New York.

Schmenner, R.W., Swink, M.L., 1998. On theory in operations management. Journal of Operations Management 17 (1), 97–113.

Schroeder, R.G., Bates, K.A., Juntilla, M.M., 2002. A resource-based view of manufacturing strategy and the relationship to manufacturing performance. Strategic Management Journal 23, 105–117.

Skinner, W., 1969. Manufacturing—the missing link in corporate strategy. Harvard Business Review 47 (3), 136–145.

Slack, N., 1994. The importance–performance matrix as a determinant of improvement priority. International Journal of Operations & Production Management 14 (5), 59–75.

Stalk, G., Evans, P., Shulman, L., 1992. Competing on capabilities: the new rules of corporate strategy. Harvard Business Review 20 (5), 57–69.

St. John, C.H., Cannon, A.R., Pouder, R.W., 2001. Change drivers in the new millennium: implications for manufacturing strategy research. Journal of Operations Management 19 (2), 143–160.

Stratman, J.K., Roth, A.V., 2002. Enterprise resource planning (ERP) competence constructs: two-stage multi-item scale development and validation. Decision Sciences 33 (4), 601–628.

Swamidass, P., Newell, W.T., 1987. Manufacturing strategy, environmental uncertainty and performance: a path analysis model. Management Science 33 (4), 509–524.

Taylor, W.A., 1998. TQM implementation: organization practices and information infrastructures. Omega 26 (6), 715–727.

Teece, D., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18 (7), 509–533.

Tracey, M., Vonderembse, M.A., Lim, J.S., 1999. Manufacturing technology and strategy formulation: Keys to enhancing competitiveness and improving performance. Journal of Operations Management 17 (4), 411–428.

Verma, R., Thompson, G.M., Moore, W.L., Louviere, J.J., 2001. Effective design of products/services: an approach based on integration of marketing and operations management decisions. Decisions Sciences 32 (1), 165–193.

Vickery, S.K., 1991. A theory of production competence revisited. Decision Sciences 22 (3), 635–643.

Vickery, S.K., Droge, C.E., Markland, R.E., 1993. Production competence and business strategy: do they affect business performance? Decision Sciences 24 (2), 435–455.

Von Hippel, E., 1994. Sticky information and the locus of problem solving: implications for innovation. Management Science 40 (4), 429–439.

Voss, C.A., 1992. Manufacturing strategy as a process. In: Voss, C.A. (Ed.), Manufacturing Strategy: Process and Content. Chapman Hall, London, pp. 121–132.

Ward, P.T., Duray, R., 2000. Manufacturing strategy in context: environment, competitive strategy and manufacturing strategy. Journal of Operations Management 18 (2), 123–138.

Ward, P.T., Leong, G.K., Boyer, K.K., 1994. Manufacturing proactiveness and performance. Decision Sciences 25 (3), 337–358.

Wernerfelt, B., 1984. A resource-based view of the firm. Strategic Management Journal 5 (2), 171–180.

Wheelwright, S.C., 1978. Reflecting corporate strategy in manufacturing decisions. Business Horizons 21 (1), 57–66.

Wheelwright, S.C., 1984. Manufacturing strategy: defining the missing link. Strategic Management Journal 5 (1), 77–91.

Womack, J.P., Jones, D.T., Roos, D., 1992. The Machine that Changed the World: The Story of Lean Production. HarperCollins Publishers, New York.

Zahra, E., Das, S.R., 1993. Building competitive advantage on manufacturing resources. Long Range Planning 28 (2), 90–100.