Examining the Influence of Operational Intellectual Capital on Capabilities and Performance

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Managers have long been challenged by an abundance of internal and external demands and uncertainties in their operating environments. Anecdotal evidence and a growing number of research studies have advocated process flexibility and product innovation as organization-level operating capabilities critical for responding to such demands and uncertainties, and have highlighted the need for more efficient and effective management of the firm’s knowledge-based resources. Leveraging arguments from the resource-based and knowledge-based views of the firm, we introduce a second-order latent construct called operational intellectual capital, which represents the organization’s operating know-how embedded in a system of complementary (i.e., covarying) knowledge-based resources. We argue that operational intellectual capital influences organization-level operating capabilities such as process flexibility and product innovation, which, in turn, influence business performance. We empirically examine these relationships using structural equation modeling on a cross-section of U.S. manufacturing survey data. Statistical results from the estimation of a coalignment model and comparisons with several other models support our operational intellectual capacity conceptualization and its impact on operating capabilities and business performance, respectively. Our research thus suggests the importance of possessing and leveraging a system of complementary knowledge-based operating resources, and addresses the need for the reformulation of operations strategy theory in terms of the emergent knowledge-based view of the firm.

Key words: operations strategy; operational intellectual capital; operating capabilities; business performance; structural equation modeling

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resource-based view (RBV) of the firm—to generate a research model relating knowledge-based resources, capabilities, and performance. The KBV suggests that “it is the existence of knowledge of internal production techniques or external opportunities in the hands of a small number of firms that creates the market imperfections necessary to generate rents for the firm. Put another way, it is proprietary knowledge that creates a competitive advantage for the firm” (Cyert et al. 1993, p. 57). Following this argument, and those offered by Eisenhardt and Santos (2002), we posit that an organization’s operational intellectual capital (OIC), or operating know-how, constitutes a strategic knowledge-based resource—one that is valuable, rare, and difficult to substitute or imitate. This OIC results in asymmetries that, when effectively leveraged, become a source of operational and competitive advantage (cf. Miller 2003, Conner and Prahalad 1996).

Building on these theoretical arguments, our research examines the influence of OIC on the organization-level operating capabilities of PF and PI and on business performance. OIC comprises knowledge-based resource dimensions analogous to human capital (e.g., tacit and explicit knowledge manifested in the technical skills of the work force and relative organizational learning capabilities), structural capital (e.g., codified knowledge in state-of-the-art manufacturing processes and superior information systems), and social capital (i.e., “the knowledge embedded within, available through, and utilized by interactions among individuals and their networks of interrelationships” (Subramaniam and Youndt 2005, p. 451)). Consistent with the dominant logic of the operations strategy literature, human and structural capital represent knowledge-based elements of infrastructural and structural strategic choices (see Roth 1996, Gifﬁ et al. 1990, Hayes and Wheelwright 1984), respectively. We employ supply chain integration (Rosenzweig et al. 2003) as an operational proxy for social capital, which is akin to the Gifﬁ et al. (1990) integration choices.

Knowledge management research suggests that firms with higher intellectual capital are more capable of responding to varying and unpredictable marketplace demands and are more apt to be competitively successful (Chakravarthy et al. 2003, Zack 2003). However, this view has not as yet been rigorously examined in relation to OIC. We argue that leveraging a system of complementary knowledge-based resources is critical to the development of OIC, as it is the complementarity of these resources that yields operating capabilities that can be more effectively leveraged for improved business performance. Complementarity—as conceptualized in economics, strategy, and in this research—exists when a resource is more valuable in the presence of another resource than when considered alone (Cassiman and Veugelers 2006, Milgrom and Roberts 1990, Dierickx and Cool 1989). Stated another way, complimentarity implies that resources positively, and significantly, covary.

This study furthers operations strategy understanding and theory in several unique ways. First, we explicitly examine knowledge as an antecedent for operational and business success, and are among the first in operations management to leverage KBV arguments to motivate and frame our operations strategy arguments. Our empirical findings complement knowledge-based research examining process change (Carrillo and Gaimon 2004, Pisano 1994), quality and productivity improvement (Lapre and Van Wassenhove 2001, Mukherjee et al. 1998), and the management of operational information (Paiva et al. 2002).

Second, we subject to rigorous empirical scrutiny the multidimensional nature of OIC (as opposed to examining independent effects) and its impact on operating capabilities and business performance. Recognizing that a firm’s knowledge base is embedded in people, organizational routines, cultures, technologies, etc. (Argote et al. 2003), we conceptualize the complementarity underlying OIC in terms of the interactions—or covariation—among human capital, structural capital, and supply chain integration. We find support for this covariation and its impact on capabilities and performance through examination of a coalignment model (Venkatraman 1989, 1990), which specifies OIC as a second-order latent factor that parsimoniously reflects the covariation among the three OIC dimensions. A comparison between our coalignment model and an alternative direct-effects model further corroborates our complementary, multidimensional conceptualization of OIC.

Third, following state-of-the-art procedures for structural equation modeling (Shah and Goldstein
2006), we also formulate a coalignement model specifying the mediating effects of PF and PI on the relationship between OIC and business performance (cf. James et al. 2006, Brown 1997, Bollen 1987). This analysis facilitates greater understanding of the complex relationship between OIC and business performance. Overall, our research offers practitioners insights into the benefits of managing knowledge assets for improved operational response and business performance, as well as illustrating how scholars may better leverage KBV arguments for improved understanding and theory in operations strategy.

Following our literature review and the introduction of our research model and hypotheses, the remainder of this paper is organized as follows. First, we describe the database and sample used in the empirical analysis and detail the measurement of the research constructs. Second, we evaluate the measurement models, followed by the structural models, to test our research hypotheses. We then discuss the empirical results and their managerial and research implications. Finally, we conclude with the study’s limitations and areas for future research.

2. Literature Review
The study of operations strategy has advanced considerably over the past three decades. Early emphasis on identifying strategic content and processes (Adam and Swamidass 1989, Anderson et al. 1989) has shifted toward the current focus on investigating the relationship between competitive capabilities and performance (Hayes et al. 2005, Rosenzweig et al. 2003, Schroeder et al. 2002, Roth and Miller 1990). Competitive, or operating, capabilities are the firm’s realized competitive strengths on its operational tasks relative to competitors in its target markets (Miller and Roth 1994, Stalk et al. 1992), and companies gain an enduring competitive advantage through leveraging the resources underlying these operating capabilities (Hayes and Upton 1998, Roth 1996).

The RBV of the firm underlies much research in operations strategy (Voss 1995, 2005; Schroeder et al. 2002) that highlights the need to examine the activities, routines, and business processes upon which competitive capabilities are based (Ethiraj et al. 2005, Ray et al. 2004). However, operations strategy scholars have generally used the RBV “primarily to help establish the context of some empirical research, for example, that the focus is on the performance implications of some internal attribute of the firm” (Barney 2001, p. 46) and not to test the performance advantages associated with specific operating resources. A continuing challenge for many is the need to understand how specific types of activities, routines, and processes that have the characteristics of strategic resources (i.e., valuable, rare, and difficult to substitute or imitate) affect capabilities development and performance (Barney and Arikan 2001). Knowledge, in particular, is a strategic resource that remains relatively unexamined in operations strategy research despite its acknowledged importance in the general management and practitioner literatures.

According to advocates of the KBV of the firm, knowledge is the most important strategic resource of the firm (Chakravarthy et al. 2003; Eisenhardt and Santos 2002; Grant 1996a, b). Further, to develop and sustain a competitive advantage, firms need to manage the system of complementary resources that constitute its knowledge base. The management of this system of interacting resources forms the basis for a “complex” strategy that is difficult to imitate (cf. Bromiley 2005, Rivkin 2000). Such a strategy, in turn, results in capabilities critical for operational and business success (Dierickx and Cool 1989).

2.1. OIC
Building on Rosenzweig and Roth’s (2004) operational know-how construct and Roth’s (1996) technological leadership construct, which she conceptualized and operationalized using elements of both human and structural capital, we define OIC as the firm’s operating know-how, embedded in the use of a system of knowledge-based operating resources. Complementarities among these resources—including individuals, processes, and relationships—form the basis for stronger operating capabilities and improved business performance. Consistent with Subramaniam and Youndt (2005), we view OIC as reflecting the aggregation of all knowledge embedded in the firm’s operating resources—human, structural, and social (i.e., supply chain integration). These dimensions also reflect the prevalent operations strategy elements of infrastructural policies and systems and structural decisions (Hayes et al. 2005, Hayes and Wheelwright
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1984), as well as integration strategy choices (Giffi et al. 1990). In addition, the complementarities underlying OIC are consistent with the prevailing view that an operations strategy constitutes a portfolio of aligned operating choices (Roth 1996).

By way of contrast, the management literature on intellectual capital (see Pennings et al. 1998, Edvinsson and Malone 1997, Stewart 1997) generally conceptualizes intellectual capital broadly in terms of the organization’s knowledge resources. Moreover, a number of scholars have examined individual dimensions of intellectual capital (see Gupta and Govindarajan 2000 and Nahapiet and Ghoshal 1998 on social capital, and the work of Bharadwaj 2000, Stewart 1997, and Carrillo and Gaimon 2004 on structural capital).

We posit that the level of OIC a firm possesses is a function of the complementarity-based strengths of its system of knowledge-based resources. More specifically, we propose that higher OIC, on average, will be reflected by simultaneously higher levels of human capital, structural capital, and supply chain integration. OIC, modeled as a second-order latent factor, is related to operating capabilities and business performance (see Figure 1).

PROPOSITION. OIC is a multidimensional, second-order construct reflected by superior strength on a system of complementary knowledge resources comprising human capital, structural capital, and supply chain integration.

2.2. OIC and PF

We propose that a firm’s OIC is critical to the development and leveraging of operating capabilities such as PF and PI. PF refers to the ability to modify operational processes to speedily accommodate changes in production (e.g., in product volume or mix). In both research and practice, PF has gained increasing recognition as an operating capability through which a firm can further differentiate itself (Koste and Malhotra 1999, Berry and Cooper 1999). It is often required for responding proactively or defensively to uncertainty in the operating environment (Ketokivi 2006, de Groote 1994, Gerwin 1993, Swamidass and Newell 1987), as it provides the ability to be strategically flexible (Hitt et al. 1998). Like Hayes et al. (2005), we conceptualize PF as an organization-based operating capability that is difficult to replicate.

A number of recent studies examine the role of knowledge in process management. Okhuysen and Eisenhardt (2002) suggest that the integration of individual and collective knowledge facilitates manufacturing process improvements and ultimately leads to more versatile processes. Similarly, Carrillo and Gaimon (2004) study the important role that knowledge plays in process change, while Lapre and Van Wassenhove (2001) investigate the effect of knowledge on process improvement. Two major vehicles enable this process-based knowledge capture and dissemination: people, who transfer knowledge internally among departments and externally with supply chain partners, and information systems that codify past experiences, thereby “supporting the transfer of past experiences to future projects” (Corso et al. 2003, p. 398). As a result, OIC is expected to positively influence the organization’s PF; that is, its ability to modify existing manufacturing systems.

HYPOTHESIS 1. OIC is positively related to PF.

2.3. OIC and PI

PI is an operating capability that has been infrequently cited in the operations strategy literature as critical to firm success (Swink and Hegarty 1998, Giffi et al. 1990). Much of the general literature on innovation implicitly assumes that innovation is beneficial for an organization (Gopalakrishnan and Damanpour 1997, Wind and Mahajan 1997). Bayus et al. (2003) demonstrated that new product introductions positively influence profit rate and asset growth (see also Lancaster and Ratchford 1990, Datar et al. 1997). Changing competitive environments compel firms to
come up with new ideas to generate rents (Mallick and Schroeder 2005, Giffi et al. 1990, Schoonhoven et al. 1990). These innovations are often in the form of processes that combine existing knowledge in new ways (Smith et al. 2005). New product development is thus an integrative process that combines new and old knowledge (Almeida et al. 2003), which requires a variety of knowledge resources (Carlile and Rebentisch 2003).

Subramaniam and Youndt (2005, p. 450) note that it is “widely accepted that an organization’s capability to innovate is closely tied to its intellectual capital, or its ability to utilize its knowledge resources.” Others have posited that innovation is a knowledge management process (e.g., Majchrzak et al. 2004, Madhavan and Grover 1998) and have examined the use of knowledge resources for improved innovation outcomes (Subramaniam and Venkatraman 2001, Tsai and Ghoshal 1998). Indeed, a firm’s absorptive capacity (Cohen and Levinthal 1990) involves the leveraging of knowledge-based resources that constitute OIC. Thus we hypothesize as follows:

Hypothesis 2. OIC is positively related to PI.

2.4. PF and PI
Long-standing evidence exists that flexible production processes enable manufacturers to excel at new product introduction (Abegglen and Stalk 1985). Suarez et al. (1996), similar to Koste and Malhotra’s (1999) hierarchy of flexibility arguments, suggest that first-order dimensions such as mix and new product flexibility are enabled by lower order flexibility types like routing, system, and/or component flexibility. These authors posit that higher levels of PF likely lead to greater PI (cf. Narasimhan et al. 2004). Thus we propose the following hypothesis:

Hypothesis 3. PF is positively related to PI.

2.5. OIC, Operating Capabilities, and Business Performance
The prevailing view in operations strategy is that operational effectiveness not only supports an organization’s existing competitive position and business performance, but also is inherently difficult to imitate when based on organization-level operating capabilities that are embedded in the firm’s resources (Hayes et al. 2005, Hayes and Upton 1998). We have proposed that firms with higher levels of OIC also possess stronger operating capabilities, which are essential to achieving any performance advantage (Eisenhardt and Santos 2002, Garud 1997, Kogut and Zander 1992). We therefore posit that PF and PI mediate the relationship between OIC and business performance (see Figure 1). Hence, in accordance with the resources-capabilities-performance relationship underlying both the RBV and the KBV, OIC may have a direct and/or indirect effect on business performance. We operationalize business performance in terms of both market performance (MP) and financial performance (FP). Our hypotheses are as follows:

Hypothesis 4. PF (PI) mediates the relationship between OIC and business performance.

Hypothesis 4A. PF (PI) is positively related to MP.

Hypothesis 4B. PF (PI) is positively related to FP.

3. Research Design
3.1. Research Database
We test our hypotheses using secondary data drawn from the Vision in Manufacturing Project (VIM), a research project jointly administered since 1989 by Deloitte Consulting and Professor Aleda Roth, now at Clemson University (Roth et al. 1997). VIM aims to identify manufacturers’ needs, to assess levels of operating capabilities and competitive strengths, and to benchmark factors deemed critical for competing effectively in the twenty first century. The VIM data used in this study emanate from the 1997 survey, which comprised more than 900 perceptual and objective items, including measures pertaining to OIC.

Several professional, independent survey research organizations assisted in the design and implementation of the data collection procedures, following the guidelines set forth in Dillman (1978). The Gallup Organization helped identify the sample frame, constructed from databases of global public manufacturing companies, along with the list of corresponding respondents. To ensure adequate coverage, the

1 Other academic studies that utilize the 1997 VIM database include Rosenzweig et al. (2003), Rosenzweig and Roth (2004), and Gray et al. (2006).
sample frame was cross-referenced and supplemented with individual country lists. The resulting sample frame comprised manufacturers in the top quartile in sales in each of 35 countries. A probability sample stratified by broad industrial sectors was taken from this sample frame, thereby providing sufficient representation.

The survey was translated into potential respondents’ local dialects, and multilingual interviewers followed up with these target respondents via telephone to ensure adequate response across countries and industries. Overall, 867 respondents completed the 1997 survey, for a response rate of 10%.

VIM targeted senior manufacturing executives as firm contacts. These contacts were responsible for gathering data from their management teams as well as communicating the team’s collective perspective. Note that while VIM data collection is to some extent based on single informants, prior operations strategy research suggests that senior-level informants are likely to be more reliable sources of information than their lower ranking colleagues (see Miller and Roth 1994). The unit of analysis is the manufacturing business unit (MBU), which represents the highest level in the organization where the operations strategy is formulated for the primary product in target markets (Roth 1996, Miller and Roth 1994, Ferdows and De Meyer 1990).

3.2. U.S. Sample
This study employs a sample of U.S. manufacturing organizations, which comprises 30.5% (N = 264) of the 1997 VIM survey respondents. We focus solely on U.S. manufacturers because of the nature of the research, the complexity of the proposed model, and the subsequent concerns regarding statistical power (Verma and Goodale 1995). Merging the data from multiple countries would risk confounding the results, because national culture may influence the ways in which manufacturers develop and deploy knowledge-based resources, as well as how these resources influence performance (Voss et al. 2004, Roth et al. 1989, Hofstede 1984).

Table 1 provides an overview of the demographic characteristics of the U.S. sample we examine. The majority of manufacturers in our sample held one of the top four positions in the marketplace for their primary products. Responding organizations represent a variety of industrial sectors, with the largest percentage belonging to the consumer products sector (27.7%).

To test for nonresponse bias, we compared the consumer products portion of our sample to a U.S. sample of consumer products manufacturers from
the 1996 Global Vantage database. The number of employees and sales volume were not statistically different for the two groups, suggesting that our sample is representative of the research population (Baruch 1999).

3.3. Measures
Building on standard definitions of operating resources and Stewart’s (1997) components of intellectual capital, we view OIC in terms of multiple operating resources encompassing human capital, structural capital, and supply chain integration.


Consistent with prior operationalizations of advanced manufacturing technologies, our structural capital construct is reflected by the use of state-of-the-art manufacturing processes and superior organizational information systems and databases (Kotha and Swamidass 2000, Tracey et al. 1999, Boyer et al. 1997, Dean and Snell 1996, Goldhar and Lei 1995).

In the management literature, social capital represents the knowledge embedded within intrafirm and upstream or downstream interactions and relationships. Operations strategy researchers Stevens (1989), Frohlich and Westbrook (2001), and Rosenzweig et al. (2003) conceptualize this notion of social capital as the level of integration among entities across the supply chain. Rosenzweig et al. (2003) develop a multi-item scale that captures the extent to which the MBU is integrated internally as well as externally with suppliers; distributors and retailers; and end customers. We use this supply chain integration measure as a reasonable proxy for the social capital construct.

We also consider PF, PI, MP, and FP as latent multidimensional constructs operationalized through multiple items. Consistent with prior research (e.g., Rosenzweig et al. 2003, D’Souza and Williams 2000, Roth 1996, Roth et al. 1992, Giffi et al. 1990), we operationalize PF as a multidimensional construct consisting of product mix, volume, and customization elements. Giffi et al. (1990) highlight PI as a key attribute of world-class manufacturers. Following Giffi et al. (1990) and Roth (1996), among others (e.g., Mallick and Schroeder 2005, Cooper and Kleinschmidt 1995, Treacy and Wiersema 1993), we operationalize PI using three items that capture the extent to which the MBU is capable of rapidly introducing innovative, high R&D content-type products to the marketplace. Finally, similar to the approach of Narasimhan and Kim (2002), our MP and FP constructs are operationalized using perceptual items on return on assets, return to shareholders, market share, and sales growth.

The VIM items for each construct are measured on five-point Likert scales (see Appendix A). Note that we also include in our analysis a single-item measure of organization size (number of employees) as a control variable. Organization size (or size) is an important control variable in organizational studies (cf. Chen and Hambrick 1995), as larger organizations are likely to have more levels of management, more formalization, and greater resources.

In the next section, we demonstrate the reliability and validity of our measures and test our model using structural equation modeling (SEM). Importantly for SEM, all items used in the analysis are univariate normal (see Table A1 of the online supplement2). However, some information is missing for each of these items. Our subsequent analyses employ the Full Information Maximum Likelihood approach to missing values (Arbuckle 2005, Schafer and Olsen 1998, Bollen 1989); see also Appendix B in the online supplement for details regarding our treatment of missing data. Descriptive statistics and bivariate correlations for all model variables are reported in Table 2.

4. Model Fit and Evaluation
4.1. Measurement Models
We evaluate our proposed measurement and structural models following procedures outlined in Anderson and Gerbing (1988). To begin, we analyze the OIC, operating capabilities, and business performance measurement models depicted in Appendix B using

2 An online appendix to this paper is available on the Manufacturing & Service Operations Management website (http://msom.pubs.informs.org/ecompanion.html).
Table 2  Item Descriptive Statistics and Bivariate Correlations for the 1997 VIM U.S. Sample

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<th>$x_2$</th>
<th>$x_3$</th>
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<th>$x_5$</th>
<th>$x_6$</th>
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<td>0.05***</td>
<td>0.13***</td>
<td>0.02***</td>
<td>0.17***</td>
<td>0.20***</td>
<td>0.18***</td>
<td>0.32***</td>
</tr>
<tr>
<td>$y_9$</td>
<td>3.32</td>
<td>1.09</td>
<td>0.24***</td>
<td>0.23***</td>
<td>0.12***</td>
<td>0.15***</td>
<td>0.11***</td>
<td>0.16***</td>
<td>0.13***</td>
<td>0.09***</td>
<td>0.17***</td>
<td>0.13***</td>
<td>0.49***</td>
<td>0.20***</td>
</tr>
<tr>
<td>$y_{10}$</td>
<td>3.33</td>
<td>0.91</td>
<td>0.06***</td>
<td>0.09***</td>
<td>0.11***</td>
<td>0.13***</td>
<td>0.13***</td>
<td>0.07***</td>
<td>0.15***</td>
<td>0.10***</td>
<td>0.09***</td>
<td>0.11***</td>
<td>0.07***</td>
<td>0.30***</td>
</tr>
<tr>
<td>$y_{11}$</td>
<td>3.18</td>
<td>0.91</td>
<td>0.21***</td>
<td>0.12***</td>
<td>0.14***</td>
<td>0.09***</td>
<td>0.11***</td>
<td>0.21***</td>
<td>0.06***</td>
<td>0.02***</td>
<td>0.16***</td>
<td>0.10***</td>
<td>0.15***</td>
<td>0.01***</td>
</tr>
<tr>
<td>$y_{12}$</td>
<td>3.22</td>
<td>1.05</td>
<td>0.23***</td>
<td>0.33***</td>
<td>0.16***</td>
<td>0.15***</td>
<td>0.27***</td>
<td>0.25***</td>
<td>0.11***</td>
<td>0.11***</td>
<td>0.15***</td>
<td>0.11***</td>
<td>0.22***</td>
<td>0.17***</td>
</tr>
<tr>
<td>$x_{(Size)}$</td>
<td>2.92</td>
<td>1.11</td>
<td>−0.03</td>
<td>−0.01</td>
<td>−0.14</td>
<td>0.09</td>
<td>−0.11</td>
<td>−0.06</td>
<td>−0.07</td>
<td>−0.08</td>
<td>−0.05</td>
<td>−0.06</td>
<td>−0.10</td>
<td>−0.14</td>
</tr>
</tbody>
</table>

*Items described in Appendix A.

*p < 0.10, **p < 0.05, ***p < 0.01.
confirmatory factor analysis (CFA). In doing so, we employ a split-sample approach to estimation in which we randomly assign each of the 264 observations to either the calibration ($n_C = 132$) or validation ($n_V = 132$) sample (Bollen 1989, Froehle and Roth 2004).

In the calibration sample, the CFA results indicate that the data fit the operating capabilities measurement model fairly well ($\chi^2 = 19.76$, $p$-value = 0.41, $\chi^2$/df = 1.04, Bollen’s incremental fit index [IFI] = 1.00, Bentler-Bonett nonnormed fit index [NNFI] = 1.00, comparative fit index [CFI] = 1.00, root mean square error approximation [RMSEA] = 0.02) (Bentler 1990, Bollen 1989). Likewise, the business performance measurement model is consistent with the data ($\chi^2 = 0.12$, $p$-value = 0.73, $\chi^2$/df = 0.12, IFI = 1.01, NNFI = 1.10, CFI = 1.00, RMSEA < 0.01); see also Table C1 of the online supplement. At the same time, the composite reliabilities for all latent constructs exceed the norm of 0.60, indicating acceptable reliability (Nunnally 1978). Nonetheless, the overall fit statistics associated with the OIC measurement model ($\chi^2 = 40.34$, $p$-value = 0.00, $\chi^2$/df = 2.37, IFI = 0.92, NNFI = 0.82, CFI = 0.91, RMSEA = 0.10) suggest that some of the items may not adequately reflect their intended constructs, at least in the calibration sample.

Closer examination of the first-order latent construct for supply chain integration reveals one relatively low item loading: “Integrated closely with customers” ($x_8$; standardized path loading = 0.47, item reliability = 0.22). Although prior research has shown the proposed supply chain integration construct to be reliable and unidimensional (Rosenzweig et al. 2003), we removed $x_8$ from the measurement model because of its low item reliability. After its removal, the overall fit statistics associated with the OIC measurement model improved significantly ($\chi^2 = 16.28$, $p$-value = 0.13, $\chi^2$/df = 1.48, IFI = 0.98, NNFI = 0.94, CFI = 0.98, RMSEA = 0.06; see the revised calibration model results in Table C1 of the online supplement).

We also assess the extent to which these measurement model results can be replicated in the validation sample ($n_V$) using multiple-group analysis (see Appendix D of the online supplement). Our analysis indicates no substantive difference in results across the two samples ($n_C, n_V$), which provides additional validation for the initial (i.e., unchanged) operating capabilities and business performance measurement models (see Models B2 and B3, respectively, in Appendix B) and for the revised OIC measurement model (Model B1 in Appendix B, excluding item $x_8$).

Using the combined sample ($N = 264$), we further examine the reliability and validity of the items and constructs comprising the measurement models. The squared correlations of the CFA path loadings (Table 2) show all items to have reliability scores close to or greater than the 0.30 rule-of-thumb cut-off value, indicating adequate item reliability (Bagozzi 1981, Froehle and Roth 2004). The composite reliability and average variance extracted (AVE) statistics, gleaned from the CFA results, also indicate acceptable reliability levels for the constructs (Bollen 1989, Fornell and Larcker 1981), with composite reliability values close to or greater than 0.60, and AVE statistics ranging between 0.39 and 0.76 (see Table 3). Although the suggested threshold value for the AVE statistic is 0.50, AVE statistics at the level of 0.40 are acceptable (Hatcher 2003).

Consistent with Anderson and Gerbing (1988), we also utilize the CFA results to test the unidimensionality of the latent constructs (Table 3). Because the results indicate that all items are significantly associated with their constructs, and each measurement model shows good overall fit, we conclude that the constructs exhibit unidimensionality.

To assess convergent validity, we examine the extent to which each individual item’s path loading is greater than twice its standard error (Anderson and Gerbing 1988). The path loadings and corresponding standard errors easily meet this criterion (Table 3). Further, all path loadings are significant at the 0.01 level, which, in addition to providing support for convergent validity, also helps to establish unidimensionality.

We evaluated the discriminant validity of the scales using CFA. Following Bagozzi et al. (1991), we formed all possible pairs of latent constructs and tested each pair first by allowing each pair to freely correlate, and then by setting the correlation between the two constructs to 1.00. The $p$-values associated with each of the $\chi^2$ differences are statistically significant ($p < 0.01$), so we conclude that our constructs represent distinct scales (O’Leary-Kelly and Vokurka 1998).
To evaluate our proposition and hypotheses, we first establish the criterion validity of the business performance measures. For each construct, we use SEM to estimate the structural parameters of the relationship between the endogenous and the exogenous variables. The fit of the model is assessed based on the overall fit indices (e.g., NNFI, IFI, CFI, RMSEA). The results indicate that the proposed coalignment model fits the data fairly well ($\chi^2 = 287.04$, df = 161, $p$-value = 0.00, IFI = 0.91, NNFI = 0.88, CFI = 0.91, RMSEA = 0.06). Along with the overall fit of the model, the positive and significant paths linking the three first-order constructs—human capital ($\gamma = 0.93$, $p \leq 0.01$), structural capital ($\gamma = 0.91$, $p \leq 0.01$), and supply chain integration ($\gamma = 0.54$, $p \leq 0.01$)—support our proposition (see Figure 2). In addition, the results support Hypotheses 1 and 2, which relate OIC to PF ($\gamma = 0.65$, $p \leq 0.01$) and to PI ($\gamma = 0.58$, $p \leq 0.01$). The coalignment model results also support the relationship between strong PF and improved PI, as posited in Hypothesis 3 ($\beta = 0.22$, $p \leq 0.05$).

Additional analyses are required to test Hypothesis 4, which posits that PF and PI mediate the relationship between OIC and business performance. A variable may be characterized as a mediator “to the extent that it accounts for the relation between the predictor and the criterion” (Baron and Kenny 1986, p. 1176). Following approaches described by Bollen (1987) and James et al. (2006), we decompose the coalignment model relationships into direct effects (i.e., the influence of a predictor variable on a criterion variable that is unmediated by an intervening variable), indirect effects (i.e., the effect of a predictor variable on a criterion variable that is mediated by an intervening variable), and total effects. The mediation effects are then evaluated based on changes to the effect of the predictor variable on the criterion variable after controlling for an intervening variable (Judd and Kenny 1981). As a result, we added two direct paths to our original coalignment model: one linking OIC and MP and one linking OIC and FP. We refer to this model as the coalignment mediation model, illustrated in Appendix E of the online supplement. In Table 4, we report path estimates relevant for testing Hypothesis 4. As in the coalignment model results, the effects of size on both MP and FP were not statistically significant in the revised model.

The coalignment mediation model overall fit indices indicate that this model is consistent with the

### Table 3: Confirmatory Factor Analysis Results for the Combined Sample (N = 264)

<table>
<thead>
<tr>
<th>Measurement item</th>
<th>Standardized path loadings</th>
<th>Standard error</th>
<th>Item reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIC measurement model ($\chi^2 = 12.36$, $p = 0.34$, $\chi^2$/df = 1.12, IFI = 1.00, NNFI = 0.99, CFI = 1.00, RMSEA = 0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human capital (AVE = 0.54; Composite reliability = 0.70)</td>
<td>$x_1$ 0.68</td>
<td>0.10</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>$x_2$ 0.79</td>
<td>—</td>
<td>0.62</td>
</tr>
<tr>
<td>Structural capital (AVE = 0.39; Composite reliability = 0.56)</td>
<td>$x_3$ 0.60</td>
<td>0.16</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>$x_4$ 0.64</td>
<td>—</td>
<td>0.41</td>
</tr>
<tr>
<td>Supply chain integration (AVE = 0.43; Composite reliability = 0.69)</td>
<td>$x_5$ 0.71</td>
<td>—</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>$x_6$ 0.70</td>
<td>0.14</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>$x_7$ 0.52</td>
<td>0.12</td>
<td>0.27</td>
</tr>
<tr>
<td>Operating capabilities measurement model ($\chi^2 = 34.59$, $p = 0.02$, $\chi^2$/df = 1.82, IFI = 0.97, NNFI = 0.95, CFI = 0.97, RMSEA = 0.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process flexibility (PF) (AVE = 0.48; Composite reliability = 0.82)</td>
<td>$y_1$ 0.69</td>
<td>—</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>$y_2$ 0.64</td>
<td>0.11</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>$y_3$ 0.68</td>
<td>0.12</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>$y_4$ 0.72</td>
<td>0.09</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>$y_5$ 0.72</td>
<td>0.10</td>
<td>0.52</td>
</tr>
<tr>
<td>Product innovation (PI) (AVE = 0.47; Composite reliability = 0.73)</td>
<td>$y_6$ 0.63</td>
<td>—</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>$y_7$ 0.73</td>
<td>0.14</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>$y_8$ 0.70</td>
<td>0.14</td>
<td>0.48</td>
</tr>
<tr>
<td>Business performance measurement model ($\chi^2 = 18.18$, $p = 0.68$, $\chi^2$/df = 0.18, IFI = 1.00, NNFI = 1.03, CFI = 1.00, RMSEA &lt; 0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market performance (MP) (AVE = 0.49; Composite reliability = 0.66)</td>
<td>$y_9$ 0.75</td>
<td>—</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>$y_{10}$ 0.63</td>
<td>0.12</td>
<td>0.39</td>
</tr>
<tr>
<td>Financial performance (FP) (AVE = 0.76; Composite reliability = 0.86)</td>
<td>$y_{11}$ 0.91</td>
<td>—</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>$y_{12}$ 0.81</td>
<td>0.10</td>
<td>0.68</td>
</tr>
</tbody>
</table>

*All of the path loadings are significant at the 0.01 level.

Finally, we assess criterion-related validity for the business performance measures (see Appendix A). As expected, a measure of profitability correlated positively and significantly with our MP ($p < 0.05$) and FP ($p < 0.001$) scales. Likewise, we observed positive and significant correlations between a measure of the relative percentage of revenues from new products and the MP and FP scales ($p < 0.10$), which further establishes the criterion validity of the business performance measures.

### 4.2. Structural Models

To evaluate our proposition and hypotheses, we first analyze the fit of the combined sample data (N = 264)
Figure 2  Coalignment Model Results Using the Combined Sample (N = 264): Standardized Maximum Likelihood Parameter Estimates

![Diagram of the Coalignment Model with parameter estimates]

Given that the first two paths—both of which include PF as a mediator—are not statistically significant, we conclude that PI fully mediates the relationship between OIC and MP.

We find that OIC has a direct positive effect on FP (D.E. = 0.31, p < 0.05). In terms of indirect effects, three paths link these constructs: OIC → PF → PI → MP (I.E. = 0.05, p > 0.10), OIC → PF → MP (I.E. = 0.03, p > 0.10), and OIC → PI → MP (I.E. = 0.16, p < 0.10). The nonsignificant indirect effects indicate that neither PF nor PI mediates the relationship between OIC and FP in our sample of U.S. manufacturers. Our results thus provide only partial support for Hypothesis 4.

Turning to the empirical results for Hypotheses 4A and 4B, we find that PI is a key determinant of MP and FP (Mallick and Schroeder 2005, Bayus et al. 2003, Ettlie 1998). That is, PI not only has a direct positive effect on MP (D.E. = 0.31, p < 0.05), but it also plays a weak, but full, mediating role in the relationship between PF and MP (I.E. = −0.10, p < 0.05). These findings support Hypothesis 4A. The coalignment mediation model results indicate partial support for Hypothesis 4B, as only PI has a direct, albeit weak, effect on FP (D.E. = 0.23, p < 0.10).

The results of this coalignment mediation model highlight the role that PI plays in mediating the relationship between OIC and MP, as well as illustrating...
the direct effect of OIC on FP. We elaborate on these mediation results below.

Finally, consistent with the examination of coalignment models (Venkatraman 1989, 1990), we evaluate a direct-effects model in which the three correlated OIC dimensions are posited to be directly related to PF and PI. In this alternative model, illustrated in Appendix E of the online supplement, we assess the effects of the first-order constructs of human capital, structural capital, and supply chain integration on the operating capabilities and business performance constructs. The resulting overall fit statistics for this direct-effects model indicate reasonable fit ($\chi^2 = 272.23$, df = 157, $p$-value = 0.00, IFI = 0.92, NNFI = 0.89, CFI = 0.92, RMSEA = 0.05). Given that the direct-effects model and coalignment model (Figure 2) are nonnested, and despite the recommendation of Venkatraman (1989), we are unable to compare the overall fit of these corresponding models statistically using a chi-square-based test (e.g., the target coefficient of Marsh and Hocevar 1985). However, while the direct-effects model results indicate that the human capital, structural capital, and supply chain integration constructs are significantly correlated (ranging between $r = 0.42$ and $r = 0.85$, all at the $p < 0.001$ level), other than for the effect of human capital on PI ($r = 0.76$, $p \leq 0.05$), these dimensions have no statistically significant direct effects on PF or PI, which is inconsistent with what is posited in the literature. In our view, these results primarily reinforce our earlier finding of the importance of capturing the complementarities among the OIC dimensions.

5. Discussion

This research represents a noteworthy contribution to the growing literature in operations strategy (see Boyer et al. 2005, Roth 1996, Miller and Roth 1994), and an advancement of the understudied knowledge management views in operations management initially highlighted by Roth et al. (1994). Specifically, our study broadens the understanding and theory of the resources-capabilities-performance relationship by demonstrating the importance of developing and leveraging OIC, which we posit to be embedded in a firm’s use of a system of complementary knowledge-based operating resources. We find that the covariation of human capital, structural capital, and supply chain integration—specified as the second-order latent construct OIC—constitutes an important antecedent for the PF and PI operating capabilities, and for business performance.

On average, greater OIC is associated with better MP and FP, as well as with higher levels of human capital, structural capital, and to a lesser degree supply chain integration. We suspect that our removal of $x_8$ (Integrated closely with customers) may explain the smaller supply chain integration path loading. This removal is statistically justifiable given our measurement model results (see Table C1 in the online supplement) and the fact that a subsequent re-estimation of the coalignment model, which included $x_8$ as an indicator of the supply chain integration construct, yielded a marginally poorer model fit ($\chi^2 = 331.40$, df = 180, $p$-value = 0.000, IFI = 0.89, NNFI = 0.86, CFI = 0.89, RMSEA = 0.06) but no substantive changes to the structural model results reported earlier. Future research should specifically examine the effect of customer integration on OIC.

Even so, our empirical results demonstrate that the development of OIC requires the management of all three knowledge-based operating resources, which suggests that managers need to simultaneously invest in such resources and ensure their effective alignment. Results from the direct-effects model further reinforce the importance of leveraging the complementarity-based nature of OIC. To our knowledge, this study is among the first in the operations management literature to empirically support such a view of OIC.

Further, this research provides evidence that the management of OIC really matters in several distinct ways. First, a higher level of OIC is associated with greater MP and PI, organization-level operating capabilities frequently noted in the practitioner and academic literatures as being important for quick response to business environment uncertainties (Ketokivi 2006, Mallick and Schroeder 2005, Prastacos et al. 2002, Christensen et al. 1998). Second, as fully mediated through PI, greater OIC is indirectly associated with higher MP. The finding that greater operational know-how is associated with more innovative and rapidly introduced new products that, in turn, drive higher sales growth and market share is an important insight given the limited study of PI as
a requisite operating capability or operations strategy consideration (cf. Krishnan and Loch 2005). Finally, and most importantly, we found a significant, positive direct effect of OIC on FP.

Several additional findings are also worth noting. First, while the literature abounds with research demonstrating the importance of competing through operating capabilities such as PF, there is much less study of the antecedents of these capabilities (Ketokivi 2006). Our study contributes an intriguing new perspective to the operations strategy debate about how best to produce greater PF and PI through the management of a system of complementary knowledge-based operating resources (cf. Subramaniam and Youndt 2005).

Our coalignment mediation model findings indicate only an indirect effect of PF on MP, and no statistically significant association between PF and FP. Given all the operational benefits posited to result from greater PF (see Parker and Wirth 1999, Suarez et al. 1996), we caution readers against concluding that our findings suggest that firms not invest in the development of PF capability. Our measure of PF encompasses several lower order elements such as product volume and component flexibility that may not directly result in improved MP or FP (Koste and Malhotra 1999). Thus, these findings may simply reflect our not having measured more strategic elements associated with flexibility, such as flexibility responsiveness (Gerwin 1993) or range flexibility (Upton 1997). We encourage further investigation with a more encompassing PF measure.

Second, our results also help to explain the existence of wide-ranging interest in the management of intellectual capital (e.g., Brown et al. 2005). From a scholarly perspective, OIC not only facilitates greater operational learning (Roth et al. 1994), but also affects an organization’s business success. Researchers are not only increasingly applying resource-based logic to develop better understanding and theory across a variety of business issues (Barney and Arikan 2001), but they are also starting to examine with greater urgency the robustness of arguments advocating the management of knowledge-based resources (Zack 2003). Froehle and Roth (2006), for example, propose the criticality of leveraging intellectual resources for new service development; their conceptualization of intellectual resources encompasses the three OIC elements empirically examined here. Hence we believe that our findings are likely robust to a variety of operational and business settings.

Finally, our research findings provide empirical support for the conceptual and anecdotal arguments set forth by Hayes and Upton (1998) that firms must not only differentiate their competitive position, but also execute their strategy effectively. Managers need to align appropriately a wide array of structural, infrastructural, and integration choices to attain higher levels of operating capabilities and business performance. Our conceptualization of OIC in terms of a system of complementary knowledge-based dimensions captures, in essence, the alignment of operating resources across all three choice domains in operations strategy. Additionally, our analyses highlight the complexities underlying the resources-capabilities-performance relationship, especially in situations where managers must develop strength on diverse resources, manage a broad set of operating capabilities, and meet an array of performance objectives. In this way, our research provides intriguing insights for practitioners and scholars seeking a greater conceptual and theoretical understanding of the management of the OIC strategic resource.

5.1. Limitations and Areas for Future Research

To achieve our research objectives, we have made several research design choices resulting in conceptual and methodological limitations. First, our use of secondary, cross-sectional survey data limits discussion of research generalizability and causality. Regarding research generalizability, we were unable to control with our use of secondary data who or what was measured by the VIM survey, nor were we able to take the specific characteristics of the field setting into account while trying to interpret our findings. That said, we believe that examination of a firm’s OIC—for the reasons stated earlier in our manuscript—represents one of those critical twenty first century factors for manufacturers that the VIM survey was designed to examine. Regarding research causality, we utilized reliable and valid perception-based measures to assess organizations’ OIC, but did not examine its actual development. Future research could employ more of a longitudinal approach to further understand this
critical twenty-first century resource. If this research is extended to cross-country comparisons, however, consideration of the context-specific issues associated with the development of OIC will likely be warranted.

Second, as with all survey research utilizing single key informants in the data collection, our study may be vulnerable to the effects of common methods variance. We followed an approach suggested by Podsakoff et al. (2003) whereby, using the entire U.S. sample, we created a single measurement model encompassing all seven first-order constructs. We then introduced an additional method factor into this measurement model to control for the effects of an unmeasured latent methods factor. Our analysis shows that all the items were still statistically significant, indicating that common methods variance was not problematic. Nonetheless, future research should further validate our measurement and structural models using data collected from multiple key informants within an organization.

Third, the VIM database used in our analysis had a relatively low response rate of 10%, which is likely the result of targeting senior executive key informants and also of the length and complexity of the survey. Baruch (1999) asserts that lower survey response rates are likely if the target respondents hold more senior-level positions within an organization. However, our tests for nonresponse bias suggest that the sample is representative of the research population. Indeed, our findings are likely to be most generalizable to market-leading organizations.

Fourth, this research involved the examination of U.S. manufacturers operating in different industrial sectors (see Table 1), which could potentially confound the results we report (Cool and Schendel 1987). Bowman and Helfat (2001) recommend considering the effects of industry relationships on business performance; however, concerns about small sample size precluded the incorporation of a categorical industrial sector membership variable into the structural models evaluated in §4.2. We therefore compared the means of our business performance measures by industrial sector using item parcels (the average of the individual items for each construct; see Hagtvet and Nasser 2004). The analysis of variance results show no significant differences between the group means, which suggests that industrial sector membership does not appear to be a significant determinant of business performance in our study. However, future research could test our structural models using a multiple-group analysis in which industrial sector membership is considered a relevant moderating variable.

Finally, while our analyses controlled for size, we were unable to find suitable proxies that would allow us to employ additional controls (e.g., environmental dynamism). Future research should examine the impact of other control variables to attenuate concerns regarding the omitted variables problem.

6. Conclusion

We began this research by noting that managers face an abundance of demands and uncertainties in their operating environments. As a result, there is heightened practitioner interest in understanding how firms can best develop and compete on organization-level operating capabilities such as PF and PI. Concurrently, scholarly interest regarding the ways that firms can best leverage the intellectual capital embedded in people, systems, and routines and in upstream and downstream relationships has increased because of the recognition that knowledge represents the organization’s most important strategic resource. The research presented here employed RBV and KBV arguments to highlight the importance of possessing higher levels of OIC for improved operations capabilities and business performance. Our research results advance operations strategy theory and our understanding of the management of knowledge-based operating resources, and they lend credence to the emerging view that the future success of many firms will depend on whether their managers reap the full benefits of high levels of intellectual capital.

Acknowledgments

The authors would like to thank the special issue’s guest editor, the senior editor, and two anonymous referees for their constructive and insightful comments. Their input has resulted in notable changes and improvements to our research. The authors would also like to thank the administrators of the Vision in Manufacturing Project for granting us access to their database, and for allowing us to use the data in the empirical analyses reported in this paper.
Appendix A
In this appendix, we operationalize the constructs in Figure 1 and summarize the criterion validity measures. Each of the VIM study items listed for Human Capital and Structural Capital was originally conceptualized as a component of a critical success factor or capability for competing within an industry. Informants were asked, “Indicate how strong you feel your business unit is for each capability relative to your primary competitors in the same market.” (Scaled 1–5: (1) Lower, (3) Average, (5) Market Leader)

<table>
<thead>
<tr>
<th>Construct/Items</th>
<th>Representative references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital ($\eta_1$): Tacit and explicit knowledge manifested through the technical skill levels of the work force and relative organizational learning capabilities.</td>
<td>Menor and Roth (2000), Jayaram et al. (1999), Lynn et al. (1998), Miller (1996), Roth (1996), Cohen and Levinthal (1990), Giffi et al. (1990), Roth et al. (1989), Roth and Miller (1988), Fiol and Lyles (1985)</td>
</tr>
<tr>
<td>$x_1$: Work force with superior technical skills.</td>
<td></td>
</tr>
<tr>
<td>$x_2$: Organization’s learning capabilities or knowledge base.</td>
<td></td>
</tr>
<tr>
<td>$x_3$: Superior organizational information systems and databases.</td>
<td></td>
</tr>
<tr>
<td>$x_4$: Use state-of-the-art manufacturing processes.</td>
<td></td>
</tr>
</tbody>
</table>

Each of the VIM study items listed for Supply Chain Integration, a proxy for social capital, was conceptualized as an indicator of the integration of the business unit’s supply chain. Informants were asked to respond to the question, “How integrated is your business unit’s supply chain?” (Scaled 1–5: (1) None, (3) Medium, (5) High)

<table>
<thead>
<tr>
<th>Construct/Items</th>
<th>Representative references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain integration ($\eta_3$): The relative degree of strategic internal integration and of external integration with suppliers and customers. (Adapted from Rosenzweig et al. 2003.)</td>
<td>Subramaniam and Youndt (2005), Rosenzweig et al. (2003), Frohlich and Westbrook (2001), Stevens (1989)</td>
</tr>
<tr>
<td>$x_5$: Integrated closely within your own organization (e.g., cross-functional management).</td>
<td></td>
</tr>
<tr>
<td>$x_6$: Integrated closely with raw materials suppliers.</td>
<td></td>
</tr>
<tr>
<td>$x_7$: Integrated closely with distributors or retailers.</td>
<td></td>
</tr>
<tr>
<td>$x_8$: Integrated closely with customers (item dropped from the analyses after the measurement model analysis stage).</td>
<td></td>
</tr>
</tbody>
</table>

Each of the VIM study items listed for PF and PI was originally conceptualized as a component of a critical success factor or capability for competing within an industry. Informants were asked, “Indicate how strong you feel your business unit is for each capability relative to your primary competitors in the same market.” (Scaled 1–5: (1) Lower, (3) Average, (5) Market Leader)

<table>
<thead>
<tr>
<th>Constructs/Items</th>
<th>Representative references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process flexibility ($\eta_4$): The ability to adjust or modify operational processes to speedily accommodate changes in production.</td>
<td>Rosenzweig et al. (2003), D'Souza and Williams (2000), Roth (1996), Roth et al. (1989), Roth and Miller (1988)</td>
</tr>
</tbody>
</table>
Appendix A (cont’d.)

<table>
<thead>
<tr>
<th>Constructs/Items</th>
<th>Representative references</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_2$: Manufacture broad product mix within same facilities.</td>
<td></td>
</tr>
<tr>
<td>$y_3$: Rapidly handle custom orders or engineer to order.</td>
<td></td>
</tr>
<tr>
<td>$y_4$: Ability to rapidly modify methods for material or component.</td>
<td></td>
</tr>
<tr>
<td>$y_5$: Ability to rapidly change production volumes.</td>
<td></td>
</tr>
<tr>
<td>Product innovation ($\eta_5$): The ability to rapidly develop and deploy new products that exceed existing performance boundaries.</td>
<td></td>
</tr>
<tr>
<td>$y_6$: Offer products with high R&amp;D or new technology content.</td>
<td></td>
</tr>
<tr>
<td>$y_7$: Ability to rapidly introduce new products.</td>
<td></td>
</tr>
<tr>
<td>$y_8$: Offer innovative products.</td>
<td></td>
</tr>
</tbody>
</table>

Each of the VIM study items listed for Market Performance and Financial Performance was originally conceptualized as an indicator of performance of the informant’s business unit on the measure. Informants were asked to respond to the question, “About how have you performed against these measures over the past 3 years?” (Scaled 1–5: (1) Poor Performance, (3) OK—Met Goals, (5) Exceptional Performance)

<table>
<thead>
<tr>
<th>Constructs/Items</th>
<th>Representative references</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_9$: Sales growth</td>
<td></td>
</tr>
<tr>
<td>$y_{10}$: Market share of primary products</td>
<td></td>
</tr>
<tr>
<td>Financial performance ($\eta_7$)</td>
<td>Narasimhan and Kim (2002)</td>
</tr>
<tr>
<td>$y_{11}$: Return to shareholders (percent/year)</td>
<td></td>
</tr>
<tr>
<td>$y_{12}$: Pretax return on assets</td>
<td></td>
</tr>
</tbody>
</table>

This VIM study item measures organization size by asking respondents to indicate the number of employees working in their business unit. (Scaled 1–6: (1) Less than 100 workers, (3) Over 500 to 1,000, (6) Over 10,000)

<table>
<thead>
<tr>
<th>Construct/Item</th>
<th>Representative references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>$x_9$: The approximate number of personnel employed in your business unit worldwide.</td>
<td>Chen and Hambrick (1995), Kimberly (1976)</td>
</tr>
</tbody>
</table>

**VIM study criterion validity measures:**

1. What was your business unit’s profit level (before taxes) for the most recent fiscal year?
   a. Negative (net loss)
   b. Break even (no profit/no loss)
   c. Up to 5% profit
   d. Over 5% to 10%
   e. Over 10% to 15%
   f. Over 15% to 25%
   g. Over 25%
2. About what percent of your total business unit sales revenues can be attributed to new products?
Appendix B  Proposed Measurement Models

OIC measurement model (Model B1)

Operating capabilities measurement model (Model B2)

Business performance measurement model (Model B3)

References


