



LINKING HUMAN CAPITAL TO COMPETITIVE ADVANTAGES: FLEXIBILITY IN A MANUFACTURING FIRM'S SUPPLY CHAIN

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Flexibility in a manufacturing firm is a strategic choice that advances the firm's superior performance. This is especially true in the emerging supply chain, which makes the firm's environment particularly turbulent. This paper examines the critical relationships between a manufacturing firm's human capital, the firm's flexibility, suppliers' flexibility, and the firm's competitive advantages. Based on questionnaire responses from 201 senior supply chain management professionals in several manufacturing industries, this study establishes direct links between a manufacturing firm's human capital and the firm's superior flexibility, and between a manufacturing firm's flexibility and its competitive advantages. In addition, this research finds that the firm's flexibility mediates the relationship between the firm's human capital and its competitive advantages, as does the connection between the suppliers' flexibility and the firm's competitive advantages. © 2010 Wiley Periodicals, Inc.

Keywords: human capital, supply chain management, flexibility of a manufacturing firm, flexibility of suppliers, competitive advantages

Introduction

In this research, we assert that a critical relationship exists between a manufacturing firm's human capital and the firm's flexibility. We define a manufacturing firm's flexibility as the ability to respond efficiently and effectively to changing customer requirements by altering various functions such as product development, production, procurement, and distribution (Koste & Malhotra, 1999; Slack,

1987; Swafford, Ghosh, & Murthy, 2006). Organizations are increasingly designing both their structure and business strategy to be more flexible to strengthen their competitive advantage. To increase worker flexibility, human resource practices now focus on human capital core competencies that will align with the organization's overall strategy, rather than focusing on competencies needed for one specific position within the organization (Barney, 1991; Carmeli & Schaubroeck, 2005; Mohrman,

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Human Resource Management, September–October 2010, Vol. 49, No. 5, Pp. 939–963

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Published online in Wiley Online Library (wileyonlinelibrary.com).

DOI: 10.1002/hrm.20385

Galbraith, & Lawler, 1998; Pfeffer, 1994, 1998; Wright, Dunford, & Snell, 2001).

Despite the increased attention to human capital in organizations, research on the firm's flexibility in the supply chain literature has focused largely on technological factors (e.g., a just-in-time [JIT] system). Rapid advances in

technology and increased interest in organizational change have intensified the need to account for the individual competencies of human capital (Upton, 1995). Individuals' ability to be flexible and adaptable to work in various situations and with different technology cannot be underestimated. Although technologies have dramatically improved manufacturing firms' production capacity, which allows the firm to be more flexible, human capital determines the effective use of technology and productivity.

Some criticism has noted that research on human capital has focused too generally on human resource practices and profit performance rather than more directly on the human capital capabilities and intermediate outcomes (Becker & Huselid, 2006; Wright et al., 2001) critical to translating

a firm's best practices into profitability. Another agenda examines the black box process through which human resource practices render superior firm performance (Wright, Gardner, & Moynihan, 2003). Becker and Huselid (1998) shared that human resource practices directly influence human capital skills and capabilities, which subsequently translate into promoted operational performance and impact profitability. This research examines the black box process directly by investigating human capital and its relationship to firm flexibility and competitive advantages.

Attention to firm flexibility has been somewhat overlooked in the human resource management literature, particularly as it relates to human capital. While some research has investigated employee flexibility and the influence of this flexibility on a firm's perfor-

mance (e.g., Bhattacharya, Gibson, & Doty, 2005; Dyer & Ericksen, 2005), the firm's overall flexibility has not been examined. We argue that it is vital to understand how human capital relates to firm flexibility and subsequent competitive advantages. With such knowledge, firms can enact more effective human resource practices.

Beyond human capital, it could be difficult for a manufacturing firm to perform flexibly without the help of flexible suppliers (Slack, 2005; Vickery, Calantone, & Droge, 1999). In particular, the emerging supply chain requires increasing cooperation between suppliers and the manufacturing firm (Swafford et al., 2006). With rising interdependence, employees from the manufacturing firm have more opportunities to interact with their suppliers, exchange information and knowledge, and make suppliers more flexible. In turn, improving the suppliers' flexibility improves the manufacturing firm's own flexibility and further strengthens the firm's competitive advantages. Examining both internal human capital and external suppliers' flexibility in the same model, we provide a more comprehensive picture of what determines a manufacturing firm's flexibility in its supply chain context.

This study contributes to the extant literature in several ways. First, we confirm the links among human capital, firm flexibility, and firm performance, establishing new relationships and adding to our understanding of the importance of human capital in the supply chain. Second, we identify the emerging role of flexibility for a firm's performance, which raises new challenges for human resource management to identify a competent workforce aimed at improving the firm's flexibility. Third, we examine the significance of suppliers' flexibility, which has not been investigated simultaneously with human capital in prior supply chain literature.

Theory and Hypothesis

A Manufacturing Firm's Human Capital

A manufacturing firm's human capital is assessed by the degree of managers' and work-

ers' knowledge and skills that are valuable to the firm (Hayes, Clark, & Wheelwright, 1988; Katz, 1974; Upton, 1995; Wright et al., 2001). Managerial skills include technical, human, and conceptual skills (Katz, 1974; Porter, 1980). Technical skills (a manager's specialized and analytical abilities within his or her specialty) are important for making the right decisions (Benson, Saraph, & Schroeder, 1991) and solving technical conflicts effectively. Human skills (a manager's ability to work effectively with people) are essential for developing group collaboration, inspiring individuals to excel, and facilitating communication (Beatty, 1992; Ford & Noe, 1987). Conceptual skills (a manager's ability to view an organization from a broad system perspective) enable a manager to understand the relationships between departments and between the firm and its suppliers and to understand the influence of departmental decisions on the firm and the influence of the firm's decisions on its suppliers (Beatty, 1992; Waters, 1980).

Worker capital is another important factor in a manufacturing firm's competitive human capital. Although advanced technologies have changed firms' operations dramatically and replaced many low-skilled jobs, optimizing the potential of these technologies relies on highly skilled workers (Jaikumar, 1986; Upton, 1995; Youndt, Snell, Dean, & Lepak, 1996). Workers' technological skills, problem-solving skills, operations knowledge, and creativity shift these employees from routine workers to knowledge workers, providing the manufacturing firm with distinct competencies (Graham & Rosenthal, 1986; Levy & Murnane, 2004; Youndt et al., 1996). Workers' people skills are important as well, especially in a teamwork environment (Gupta & Goyal, 1989; Norman, Tharmmaphornphila, Needy, Bidanda, & Warner, 2002). For example, in a just-in-time (JIT) system, the minimized work-in-process inventory shifts independent individual jobs to more collaborative tasks (Johnson & Manoochchetri, 1990).

These valuable managerial and worker competencies transcend one singular "job" and become the center on which human resource management has been developing

processes and practices such as selection, training, and performance appraisal (e.g., Finegold, Lawler, & Ledford, 1998). With the increased focus on these competencies, researchers and human resource professionals have applied the resource-based view (RBV) theory and found that the heterogeneity of human capital resources across firms can account for differences in competitive advantage (Barney, 1991; Wright et al., 2001). Organizations with superior human capital resources that are aligned with the overall organizational strategy will outperform their competition and have long-term success (Carmeli & Schaubroeck, 2005; Peteraf, 1993). The reasons underlying this argument are that (1) the skills and knowledge of the workforce increase the firm's productivity, which makes human capital a valuable resource; (2) these skills and knowledge need time to develop and should be updated constantly, which is costly and not possible for all organizations, making human capital a rare resource; (3) the tacit knowledge developed by social interaction in the firm makes human capital an imperfectly imitable resource; and (4) the process of developing human capital is unique to each individual because it includes such things as background and experience, such that human capital is a non-substitutable resource (Barney, 1991; Lado & Wilson, 1994; Penrose, 1959; Wernerfelt, 1984).

In addition to being valuable, rare, imperfectly imitable, and non-substitutable, a manufacturing firm's human capital contributes to its competitive advantages by improving the firm's flexibility. Superior human resources provide adaptive performance, which increases the firm's flexibility as a whole (Pulakos, Arad, Donovan, & Plamondon, 2000). Pulakos and colleagues (2000) found evidence for eight distinct adaptive performance dimensions: handling emergencies or crises; handling work stress; solving problems creatively; dealing with uncertain and unpre-

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dictable work situations; learning work tasks, technologies, and procedures; demonstrating interpersonal adaptability; demonstrating cultural adaptability; and demonstrating physically oriented adaptability. While these authors did not outline the specific human capital resources needed to perform well in these eight dimensions, they contended that these dimensions are likely to have implications for selecting and training employees to ensure their adaptability and flexibility within the workplace.

To improve employees' knowledge and skills and to make them more adaptive, appropriate human resource practices are needed (Lengnick-Hall & Lengnick-Hall, 2003). For example, cross-training and job rotations are typically used to develop a broad range of skills for individual employees and are likely to contribute to developing adaptive behavior and the transfer of this adaptability to the job. From a selection perspective, it is necessary to determine which adaptive behaviors are essential for the job and to establish what competencies are required for those behaviors. Thus, a manufacturing firm's human capital, coordinated with integrated human resource practices, develops the firm's dynamic capabilities that sustain the firm's competitive advantages (Burke & Cooper, 2008; Burke, Pierce, & Salas, 2006; Eisenhardt & Martin, 2000; Lawler, 2008; Smith & Rupp, 2002; Teece, Pisano, & Shuen, 1997; Wright & Snell, 1998).

A Manufacturing Firm's Flexibility

A manufacturing firm's flexibility improves the firm's adaptability in dynamic environments and the firm's ability to sustain its competitive advantages in the supply chain (Gerwin, 1993; Narasimhan, Talluri, & Das, 2004; Swamidass & Newell, 1987). As defined, a manufacturing firm's flexibility in a supply chain context includes product development, production, procurement, and distribution flexibilities (Koste & Malhotra, 1999; Prater, Biehl, & Smith, 2001; Sethi & Sethi, 1990; Vickery et al., 1999; Zhang, Vonderembse, & Lim, 2006). Product development flexibility is the manufacturing firm's ability to introduce

new products and to make modifications effectively and efficiently (Dixon, 1992; Koste & Malhotra, 1999). Production flexibility is the firm's ability to provide a variety of production volumes and product mixes effectively and efficiently (Koste & Malhotra, 1999; Upton, 1997; Zhang, Vonderembse, & Lim, 2003). Procurement flexibility and distribution flexibility define the ability of the firm's inbound and outbound logistics systems, respectively, to accommodate delivery requests effectively and efficiently (Prater et al., 2001; Zhang et al., 2006).

These four functional flexibilities are highly interrelated. Production, procurement, and distribution are the main components of a manufacturing firm's supply chain operations. While any one of them can compensate for deficiencies in the other two (Prater et al., 2001), together these three components provide a foundation that supports product development. Without sound production and logistics capabilities, the benefits of innovative products and new modifications will decline quickly (Teece, 1986). Because of the integrated effect among these functions in a manufacturing firm, we treat a manufacturing firm's flexibility as a latent variable and specify product development flexibility, production flexibility, procurement flexibility, and distribution flexibility as dimensions of that latent variable.

A Manufacturing Firm's Human Capital and Flexibility

A manufacturing firm's superior human capital provides a foundation for the firm's flexibility (Wright & Snell, 1998), which contributes in turn to the adaptive performance that advances the firm's overall flexibility (Pulakos et al., 2000). For example, sufficient technical skills allow workers to apply knowledge and skills to new tasks quickly and to apply new approaches to older tasks. Excellent people skills support open communication, which eases the resistance to change (e.g., Harvey & Brown, 2005). With a high degree of human capital, a manufacturing firm can redeploy its employees easily and quickly; employees can adapt to new jobs quickly and

work well with new co-workers; and necessary adjustments can be made in human resource management practices to strengthen employee performance in new situations (Bhattacharya et al., 2005; Graham & Rosenthal, 1986). Such smooth transitions in a manufacturing firm's supply chain operations promote the firm's flexibility so the firm can respond to customer requests effectively and efficiently. The effective and efficient coordination of its human capital makes a firm more flexible (Kathuria & Partovi, 1999; Suarez, Cusumano, & Fine, 1995). It is hypothesized, therefore, that:

Hypothesis 1: A manufacturing firm's human capital has a direct positive relationship with the firm's flexibility.

A Manufacturing Firm's Competitive Advantage

Competitive advantage indicates the extent to which an organization is able to create a defensible position over its competitors (Porter, 1985). The most frequently cited competitive advantages of a manufacturing firm are delivery speed, delivery reliability, quality, price/cost, and product customization (Hill, 2000; Koufteros, Vonderembse, & Doll, 1998; Roth & Miller, 1990; Skinner, 1985; Vickery et al., 1999; White, 1996). Delivery speed focuses on providing products quickly, while delivery reliability refers to consistently delivering the right product at the right time. Quality is having products that consistently meet or exceed the customer's expectations; price/cost refers to having the lowest price in the market for the same or better quality of products; and product customization focuses on offering various features, options, and models that customers need. Because it is possible for a manufacturing firm to compete on a combination of competitive advantages, instead of trading one priority for another (Ferdows & De Meyer, 1990; Flynn & Flynn, 1996; Garvin, 1988), we operationalize the bundle of competitive advantages as a single latent variable that includes delivery speed, delivery reliability, quality, price/cost, and product customization as measurement items.

A Manufacturing Firm's Human Capital and Its Competitive Advantages

Human capital resources distinguish one firm from another and are essential to a firm's competitive advantage (Carmeli & Schaubroeck, 2005; Pfeffer 1994, 1998).

A manufacturing firm's human capital determines the firm's workforce infrastructure, management involvement, and training, each of which is a key component of a manufacturing firm's success in implementing its strategic initiatives (e.g., Six Sigma, lean manufacturing) (Henderson & Evans, 2000).

For example, a manufacturing firm's workers and managers who have multiple skills and sufficient knowledge allow the firm to have a more productive workforce infrastructure with minimal layers of management. Workers are able to self-manage and stay highly motivated, thereby allowing the firm to function more efficiently with a lower number of employees (Anell & Wilson, 2000; Finegold et al., 1998; Huselid, 1995). Managers' conceptual and people skills determine the degree of management involvement in strategic initiatives. Management commitment is critical in ensuring a supportive culture in which employees hold the same goals and are able to be productive in implementing these initiatives (Finegold et al., 1998). The people skills of both managers and workers enhance the open communication necessary for synergy among the firm's workforce, making collaboration and team-based work more effective. In sum, superior human capital makes the organization more productive and effective in implementing strategic initiatives that aim to improve competitive advantages (Kraatz & Zajac, 2001). Thus, it is hypothesized that:

With a high degree of human capital, a manufacturing firm can redeploy its employees easily and quickly; employees can adapt to new jobs quickly and work well with new co-workers; and necessary adjustments can be made in human resource management practices to strengthen employee performance in new situations.

Hypothesis 2: A manufacturing firm's human capital has a direct positive relationship with the firm's competitive advantages.

A Manufacturing Firm's Flexibility and Its Competitive Advantages

We discuss the impact of a manufacturing firm's flexibility on its competitive advantage based on range, mobility, and uniformity, all of which are embedded in the four functional flexibilities of product development, production, procurement, and distribution (Koste & Malhotra, 1999; Sethi & Sethi, 1990; Slack, 1983, 1987; Upton, 1994). Range represents the extent of flexibility, mobility indicates the responsiveness within the range, and uniformity is a measure of consistent performance across the entire range.

Because flexibility (range) is the manufacturing firm's ability to provide a wide variety of products, production outputs, and delivery options, it gives the firm the ability to compete on product features, configurations, quantities, and deliveries. Mobility allows manufacturing firms with a high level of flexibility (range) to introduce new products, modify existing products, adjust output volumes and product mixes, and change logistics systems quickly and cost-effectively. As a result, the firm will be able to compete by responding to changes in the environment quickly. In terms of uniformity, a manufacturing firm's flexibility (range) is the ability to maintain a high level of performance during changes in product development, production, and logistics, so that it can offer high-quality products with consistent delivery. Because all three dimensions (range, mobility, and uniformity) are incorporated in all four functional flexibilities, and because these four flexibilities are interrelated, a manufacturing firm's flexibility supports its competitive advantage. Therefore, it is hypothesized that:

Hypothesis 3: A manufacturing firm's flexibility has a direct positive relationship with the firm's competitive advantages.

Suppliers' Flexibility

As discussed earlier, a manufacturing firm's success relies not only on its internal strategic resources (e.g., human capital), but also on its suppliers' flexibility (Duclos, Vokurka, & Lummus, 2003; Garavelli, 2003). While outsourcing, subcontracting, and moving production abroad may be seen as methods by which to gain a competitive advantage by lowering the cost of human resources, these methods do not create the flexibility at the firm level that sustains a successful, long-term supplier-manufacturer relationship (Anell & Wilson, 2000). A manufacturing firm's human capital has an indirect influence on suppliers' flexibility because, for example, skilled employees with excellent people skills can help suppliers identify the causes of problems and make the right decisions so suppliers can easily and quickly overcome technical hurdles (Dyer & Hatch, 2004). Moreover, collaborative managers demonstrate the manufacturing firm's willingness to develop a long-term partnership with suppliers. In response, suppliers are more likely to be open and to be less resistant to meeting the manufacturing firm's requests (Johnston, McCutcheon, Stuart, & Kerwood, 2004).

In light of the importance of suppliers' flexibility to a manufacturing firm's flexibility and the close relationship of suppliers' flexibility to a manufacturing firm's human capital, we include suppliers' flexibility as another determinant of the firm's flexibility. Suppliers' flexibility refers to the ability of suppliers to adapt efficiently and effectively to a manufacturing firm's changing requirements in terms of order quantity, product variety, and delivery (Handfield, Ragatz, Peterson, & Monczka, 1999; Lau, 1999; Narasimhan & Das, 2000; Pujawan, 2004; Swafford et al., 2006). Because a manufacturing firm is striving to satisfy its customers on multiple competitive dimensions simultaneously, the firm views its interest in suppliers' flexibility as an integrated unit. Accordingly, we consider suppliers' flexibility as a latent variable and order quantity, product variety, and delivery flexibilities as dimensions of this variable.

The Relationship Between Suppliers' Flexibility and a Manufacturing Firm's Flexibility

Because of the firm's increasing dependence on its suppliers, relationships between the manufacturing firm and its suppliers tend to be close. For example, without suppliers' support in providing the right quantity of components and materials of desired specifications and delivering them at the requested time, a manufacturing firm cannot expect to make the products its customers need (Lau, 1999). The importance of suppliers' flexibility in a supply chain has been tested by considering suppliers' flexibility as part of a manufacturing firm's flexibility and by considering the alignment between the flexibility of suppliers and the flexibility of a manufacturing firm (Avittathur & Swamidass, 2007; Handfield et al., 1999; Narasimhan & Das, 2000; Pujawan, 2004; Swafford et al., 2006). Narasimhan and Das (2000) found that suppliers' responsiveness to volume requests was positively correlated with a manufacturer's volume flexibility. Pujawan (2004) and Swafford et al. (2006) revealed the close connection between suppliers' flexibility in providing products and a manufacturer's logistics flexibility. Therefore, it is hypothesized that:

Hypothesis 4: Suppliers' flexibility has a direct positive relationship with a manufacturing firm's flexibility.

The Relationship Between Suppliers' Flexibility and a Manufacturing Firm's Competitive Advantage

Suppliers that are highly flexible can adapt to changes in product orders and provide a variety of order quantities without sacrificing their cost advantage, quality advantage, or delivery advantage. With flexible suppliers, the manufacturing firm is able to transfer the advantages embedded in the suppliers' products to the firm's final products in order to compete with a bundle of competitive advantages (e.g., quick response, high quality, consistent delivery, low price, and excellent

product design). For example, Swafford et al. (2006) found that suppliers' delivery flexibility has a positive influence on supply chain agility in terms of responsiveness, reliability, customer service, and innovation. Given the important role of suppliers' flexibility in a manufacturing firm's competitive position, it is hypothesized that:

Hypothesis 5: Suppliers' flexibility has a direct positive relationship with a manufacturing firm's competitive advantages.

Figure 1 depicts the hypothesized research model. A manufacturing firm's human capital and flexibility and suppliers' flexibility are measured by nine sub-dimensions, and the fourth variable, a manufacturing firm's competitive advantage, is measured by three observed items. Sub-dimensions and observed items are depicted in rectangles.

Research Methodology

Data Collection

The data collection took place from September to December 2007. The study population included supply chain professionals in various U.S. manufacturing companies. An initial invitation was sent to each of the 7,909 potential respondents via an e-mail that included a link to a Web site where he or she could complete the survey online. Reminder e-mails were sent out at two weeks and again at three weeks following the initial e-mail. In addition to reminder e-mails, we offered respondents the research results as an incentive for participating and provided other options (e.g., mail survey, fax survey, phone survey) for them to answer the survey. Finally, we obtained 201 usable responses from a pool of 6,485 after excluding 1,424 undeliverable e-mail addresses.

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and excellent
product design).*

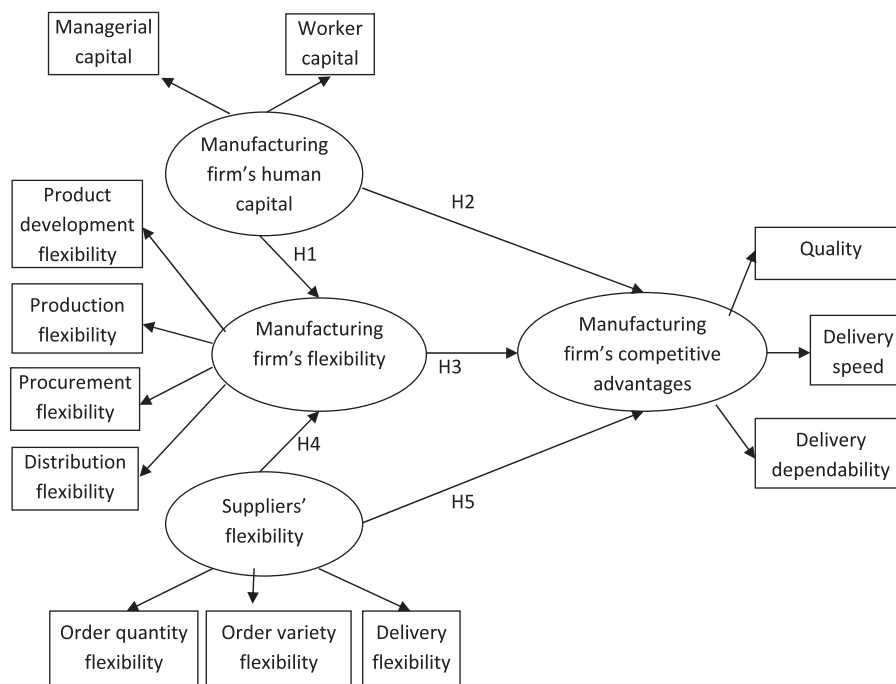


FIGURE 1. Hypothesized Model: Relationships Among a Manufacturing Firm's Human Capital, Flexibility, and Competitive Advantages and Suppliers' Flexibility

Although Web-based surveys have yielded fewer responses than mail surveys because of technological issues (Klassen & Jacobs, 2001) such as security systems that filter a large amount of e-mail to the junk mail box without notifying the sender and a large number of idle e-mails that are not active because of relocation, the online survey has numerous advantages. These include fewer data entry errors, faster data collection, and lower cost. Considering the limitations of the online survey method (Klassen & Jacobs, 2001) and the continuous decline of responses from top managers and organizational representatives to requests from academic studies (Baruch & Holtom, 2008), our response rate was comparable to recent research in the manufacturing management and human resource management literature (Beltran-Martin, Roca-Puig, Escrig-Tena, & Bou-Llusar, 2008; Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005).

The external validity of the sample was examined based on the sampling design, its representativeness, and sample size (Short, Ketchen, & Palmer, 2002). The sample design was a purposive sample in that the sample included particular groups based on criteria

such as job title and responsibility in U.S. manufacturing firms (Short et al., 2002). The study population was collected from three databases of executive contacts: RSATeleservices, Lead411, and the Council of Supply Chain Management Professionals (CSCMP), the three of which account for a large percentage of the population of U.S. manufacturing firms. The manufacturing industry was chosen because manufacturing firms face increasing uncertainties that require a high level of flexibility, and suppliers have a great impact on a manufacturing firm's operations in the supply chain (Gerwin, 1993; Narasimhan et al., 2004; Pujawan, 2004).

For industry types, we included manufacturing firms that represented nine SIC-coded manufacturing sectors and offered an "other" option on the survey so our findings could be generalized across a variety of manufacturing industries. The sample had a good balance among those industries, with no one industry accounting for more than 30% of the total respondents (Table I). We set no limits for company size or annual sales so we could generalize our results for small, medium, and large companies. Fifty-eight percent of

respondents were in companies numbering more than 1,000 employees, 29% had 100 to 1,000 employees, and 22% had fewer than 100 employees, while 54% of respondents were in companies with over \$500M sales, 36% were in companies with \$10M to \$500M sales, and 8% were in companies with less than \$10M sales. The majority (71%) of respondents were CEOs, VPs, or directors in charge of production, logistics, purchasing, or other supply chain functional areas. Fifty-seven percent of these high-ranking professionals had at least five years' tenure in their organizations. Given their rank and tenure, we expected that the respondents would have knowledge of the skills and capabilities of employees in the firm, as well as knowledge of suppliers' performance and the firm performance in the supply chain context.

Next, we examined the representativeness of our sample based on company size and annual sales,¹ both of which are frequently used criteria in the management literature (e.g., Beltran-Martin et al., 2008; Bhattacharya et al., 2005). We compared the differences between the 201 respondents² and the population³ by using chi-squared tests to check for non-response bias (Malhotra & Grover, 1998; Short et al., 2002). The results ($\chi^2 = 2.98$, $df = 3$, $p > 0.1$ for company size, and $\chi^2 = 1.87$, $df = 4$, $p > 0.5$ for annual sales) indicated no significant differences between our sample and the population; thus, we are reasonably confident that response bias is not an issue in our sample.

It is equally important to have an adequate sample size that represents the population in order to perform the structural equation modeling (SEM) statistical analysis (Hair, Black, Babin, & Anderson, 2005; Kerlinger, 1986). A sample size over 150 or 200 is commonly considered adequate for performing a stable and rigorous SEM model (Hoyle, 1995; Loehlin, 1992; Schumacker & Lomax, 2004), and our sample size of 201 usable respondents met this requirement. Another rule of thumb is to determine the sample size by the number of variables in the SEM model (e.g., Mitchell, 1993; Stevens, 1996). Mitchell (1993) suggested that the sample should have 10 to 20 cases per indicator, while Stevens (1996) allowed 15 cases per indicator. Our SEM model included three observed items and nine sub-dimensions (see Figure 1); therefore, our sample size met these recommended ratios.

In summary, our research incorporated a sampling design comparable to the majority of management empirical research, our sample was suitable for our research purpose overall, it represented the population in terms of company size and annual sales, and its size was adequate to perform the SEM analysis. Our sample size of 201 respondents was therefore acceptable in terms of satisfactory external validity.

Measurement Development

Construct Measures

All measurement items were developed on 5-point Likert scales, with 1 representing

TABLE I Profile of Respondents

Industries (SIC Code)	Frequency	Percentage
Electronic/electrical equipment (36)	55	28%
Industrial/commercial machinery (35)	32	16%
Instruments and related products (38)	25	12%
Chemicals (28)	20	10%
Furniture and fixtures (25)	11	6%
Transportation equipment (37)	11	6%
Rubber and plastic products (30)	9	4%
Fabricated metal products (34)	9	4%
Food (20)	7	3%
Others (39)	22	11%

“strongly disagree” and 5 representing “strongly agree.” A manufacturing firm’s human capital was assessed by two dimensions, managerial capital and worker capital, which were measured by seven and five items, respectively. For the human capital items, we asked the respondents to “circle the number that best indicates the extent to which you agree or disagree with each statement as applicable to your company.” Although using single respondents has been criticized for not providing the most valid information regarding the firm’s human capital, in many cases a single respondent is the best and perhaps the only choice to provide such information in the firm (Huselid & Becker, 2000). Wright and Boswell (2002) suggested that the macro human resource management research that uses the organization as the analysis unit focuses on the variances in human resources across organizations, not on the individual variances within the organization. We used single respondents who held jobs at high levels in their organizations who were likely to be reliable sources of information regarding the human capital in the organization as a whole (Miller & Roth, 1994).

For the manufacturing firm’s flexibility, we asked the respondents to “circle the number that best indicates the extent to which you agree or disagree with each statement in comparison to industry norms” in regard to the firm’s product development, production, procurement, and distribution flexibilities (Koste & Malhotra, 1999; Prater et al., 2001; Sethi & Sethi, 1990; Vickery et al., 1999; Zhang et al., 2006). For suppliers’ flexibility, we asked the respondents to “circle the number that best indicates the extent to which you agree or disagree with each statement as it applies to your suppliers” in regard to suppliers’ product variety, product quantity, and order delivery-related flexibilities (Lau, 1999; Narasimhan & Das, 2000). For a manufacturing firm’s competitive advantage, we asked the respondents to “circle the number that best indicates the extent to which you agree or disagree with each statement as compared to industry norms” in regard to delivery speed, delivery reliability, quality, price/cost,

and product customization (Hill, 2000; Koufteros et al., 1998; Roth & Miller, 1990; Skinner, 1985; Vickery et al., 1999; White, 1996).

The questionnaire was developed after conducting a literature review to ensure the initial content validity of the instrument (Churchill, 1979; Haynes, Richard, & Kubany, 1995). The questionnaire was pre-tested to refine the content validity by consulting with professionals and practitioners with extensive knowledge in this field. Then a Q-sort method was applied in a pilot study to assess the preliminary convergent validity and discriminant validity of the instrument (Moore & Benbasat, 1991), and items were revised as necessary. The final version of items appears in the Appendix.

Common Method Variance

Because a single respondent was used in the survey, we checked for common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). This issue occurs when correlations between variables are not due to the actual relationships but to their being measured by a single respondent (Podsakoff & Organ, 1986). We used a measurement model that included all items to determine whether most of the variances could be explained by a single factor (Podsakoff et al., 2003). The common model-fit indexes (e.g., goodness of fit [GFI], adjusted goodness of fit [AGFI], chi-square, root mean square residual [RMR], normed fit index [NFI], comparative fit index [CFI], Tucker-Lewis coefficient [TLI], and root mean square error of approximation [RMSEA]) were calculated to judge the measurement model’s validity (Byrne, 2001; Joreskog & Sorbom, 1989). Because all indexes except RMR were far from acceptable values⁴ (GFI = 0.463; AGFI = 0.409; RMR = 0.09; NFI = 0.441; CFI = 0.383; TLI = 0.414; RMSEA = 0.130), common method variance was not a concern.

Validity and Reliability

Data collected from the survey was used to verify convergent and discriminant validity

and the reliability of the questionnaire. Convergent validity measures the extent to which the observed items converge into unobserved latent variables (Campbell, 1960). In this research, each sub-dimension of three of the constructs (a manufacturing firm's human capital and flexibility and suppliers' flexibility) and the construct of a manufacturing firm's competitive advantage is a latent variable. We used AMOS (Analysis of Moment Structure) 7.0 to develop a single-factor measurement model for each variable,⁵ which was used to explore the underlying relationships between the variable and the observed items included to estimate that variable. The common model-fit indexes were calculated to judge the validity of the measurement model. Where necessary, items that had high covariance with other items that measured the same variable were revised, and items with low factor loadings were removed (e.g., price/cost and product customization were removed as measures of competitive advantages). All values of assessment indexes for each variable in the final measurement model were above the cutoff values or very close to these values, which indicated acceptable convergent validity.

Discriminant validity refers to the uniqueness and independence of two different latent variables that are measured by two groups of observed variables (Bagozzi & Phillips, 1982; Campbell, 1960). We compared a fully correlated measurement model against two other potential models to assess discriminant validity (Yamamoto, DeCieri, & Hutchings, 2009). A full measurement model correlating ten latent variables was developed, including two factors of a manufacturing firm's human capital, four factors of a manufacturing firm's flexibility, three factors of suppliers' flexibility, and one factor of a manufacturing firm's competitive advantage. The two potential models were a one-factor model that included all observed items and a four-factor model that included a manufacturing firm's human capital, flexibility, and competitive advantage, along with suppliers' flexibility. The comparison results revealed a significant

difference between the two potential models and the full measurement model (at the $p < 0.01$ level). The fit indices of the other two models were significantly worse than the fit of the full measurement model; therefore, the discriminant validity of all variables was adequate.

Reliability concerns the extent to which the observed items that measure a latent variable relate to one another in a consistent manner. The reliability was evaluated using Cronbach's alpha, where a value over 0.7 is considered acceptable (Nunnally, 1978). Cronbach's alpha values for all variables were over 0.7 or, in one case, very close to 0.7, which indicated acceptable reliability for all variables (Table II).

Results of the Structural Model

The descriptive statistics, correlations, and reliabilities for the ten variables are shown in Table II.

Because the validity and reliability of the nine sub-dimensions were verified, we were able to model each of the nine variables as a measurement item in the structural model. We calculated the composite score of each sub-dimension by taking the average values of items designed to measure a sub-dimension that remained after the validation process. The results of the structural model (Figure 2) indicate that three of the five hypotheses were supported at the 0.001 level, and the structural model had a good model fit (GFI = 0.90; AGFI = 0.85; RMR = 0.05; CFI = 0.92; NFI = 0.88; TLI = 0.89; RMSEA = 0.09).

Hypothesis 1 examined the relationship between a manufacturing firm's human capital and the firm's flexibility. The t value and the standardized estimated coefficient were 3.76 and 0.37, respectively, supporting the hypothesis at the 0.001 level. Hypothesis 2, which assessed the connection between a manufacturing firm's human capital and its competitive advantages, was not supported ($t = -1.24$ and standardized estimated coefficient = -0.12). The results ($t = 5.30$ and standardized estimated coefficient = 0.95) supported Hypothesis 3, con-

TABLE II Descriptive Statistics, Correlations, and Reliabilities

Variables	Mean	SD	Manufacturing Firm's Managerial Capital	Manufacturing Firm's Worker Capital	Manufacturing Firm's Product Development Flexibility	Manufacturing Firm's Production Flexibility	Manufacturing Firm's Procurement Flexibility	Manufacturing Firm's Distribution Flexibility	Suppliers' Order Quantity Flexibility	Suppliers' Order Variety Flexibility	Suppliers' Delivery Flexibility	Manufacturing Firm's Competitive Advantages
Manufacturing firm's managerial capital	4.12	.60	.85									
Manufacturing firm's worker capital	4.09	.58	.60**	.74								
Manufacturing firm's product development flexibility	3.81	.75	.32**	.28**	.82							
Manufacturing firm's production flexibility	3.84	.79	.31**	.27**	.64**	.87						
Manufacturing firm's procurement flexibility	3.71	.79	.32**	.23**	.44**	.50**	.90					
Manufacturing firm's distribution flexibility	3.98	.77	.31**	.23**	.38**	.43**	.60**	.92				
Suppliers' order quantity flexibility	3.62	.79	.20**	.17*	.34**	.42**	.37**	.35**	.81			
Suppliers' order variety flexibility	3.65	.69	.30**	.20**	.33**	.48**	.39**	.38**	.58**	.78		
Suppliers' delivery flexibility	3.60	.69	.20**	.17*	.31**	.45**	.43**	.39**	.65**	.68**	.82	
Manufacturing firm's competitive advantages	4.18	.69	.26**	.12	.53**	.51**	.48**	.43**	.32**	.26**	.34**	.69

Note: All variables were measured by 5-point Likert scales. Values highlighted in bold in the diagonal are reliabilities.

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

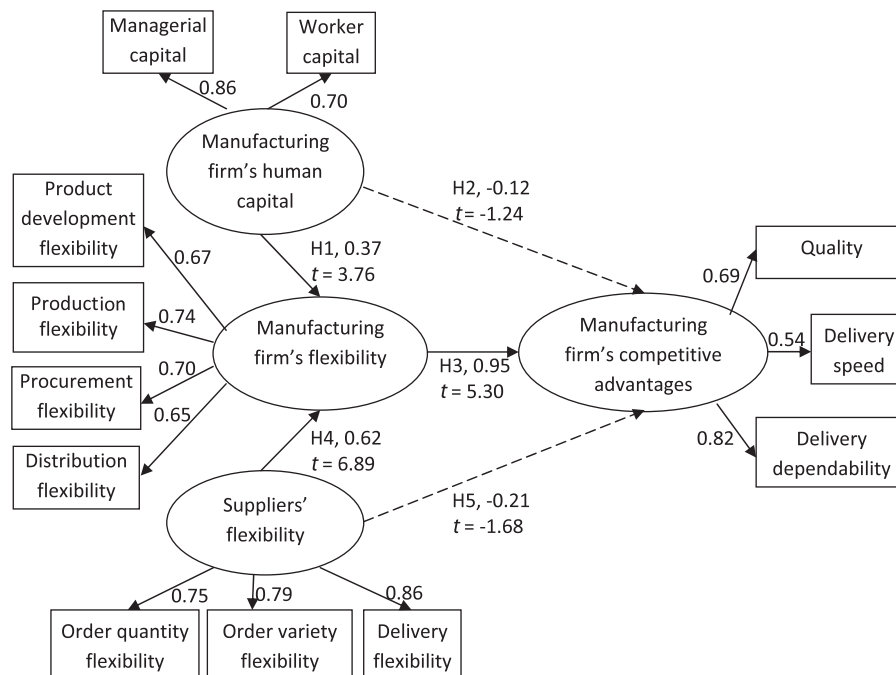


FIGURE 2. Direct and Indirect Relationships Among a Manufacturing Firm's Human Capital, Flexibility, and Competitive Advantages and Suppliers' Flexibility

cerning the links between a manufacturing firm's flexibility and its competitive advantages, at the 0.001 level. Hypothesis 4 explored the relationship between suppliers' flexibility and a manufacturing firm's flexibility. The t value and the standardized estimated coefficient were 6.89 and 0.62, respectively, supporting this hypothesis at the 0.001 level. Results ($t = -1.68$ and standardized estimated coefficient = -0.21) did not support Hypothesis 5, concerning the connection between suppliers' flexibility and a manufacturing firm's competitive advantage.

Because the direct effects of a manufacturing firm's human capital and suppliers' flexibility on the firm's competitive advantage (H2 and H5, respectively) were not supported, a post hoc analysis examined the indirect effects of both relationships (Baron & Kenny, 1986). Following Cheung and Lau (2008), a bias-corrected bootstrap analysis was conducted to test for mediating effects, with the result that the indirect effect of a manufacturing firm's human capital on the firm's competitive advantage was significant at the 0.001 level and the indirect effect of suppliers' flexibility on the manufacturing

firm's competitive advantage was significant at the 0.002 level.

Discussion

Our research underscores the importance of a manufacturing firm's human capital in a supply chain context and establishes four critical relationships among a manufacturing firm's human capital, flexibility, and competitive advantage and a suppliers' flexibility.

First, a manufacturing firm's human capital positively relates to a firm's flexibility. While technology contributes to flexibility, the people who use the technology matter more. For example, successfully implementing Six Sigma is not determined by the type of software to purchase, but by the skills of the employees who use the software. Second, even though the connection between a manufacturing firm's human capital and the firm's competitive advantage is not directly supported, the results illustrate that a manufacturing firm's flexibility has a very strong mediating effect in the relationship between the firm's human capital and its performance. Although most human resource management literature has

focused on the direct relationship between a firm's human capital and the firm's performance, the firm's flexibility, which is particularly important in today's turbulent environment, is the underlying linkage that explains this relationship. In light of the trend in the human resource management literature toward refocusing on intermediate outcomes, rather than on financial profitability (Becker & Huselid, 2006), our results suggest that a firm's flexibility, with its mediating mechanism, is a good intermediate indicator to explain the black box process through which human capital creates profits for the manufacturing firm.

Third, a strong and positive link between a manufacturing firm's flexibility and the firm's competitive advantages was found. This relationship confirms that in today's dynamic business world and tumultuous environment, illustrated by the current drastic decrease in customer demand in an economic downturn, achieving flexibility is strategically important for manufacturing firms that want to sustain their distinct competitiveness.

Finally, it is important for a manufacturing firm to be able not only to manage its internal processes, but also to influence the external supply chain activities. A firm's success depends on its ability to assemble a supply chain in which supply chain members work flexibly (Rice & Hoppe, 2001). One source of suppliers' flexibility comes from its specificity, such as when it has the technology that suits particular product needs. As a result, suppliers who are flexible with one manufacturing firm's requests may not be able to be flexible with another firm's requests (Subramani & Venkatraman, 2003). These characteristics of suppliers' flexibility provide a manufacturing firm its own flexibility and, as a result, a competitive position

in the market. Again, the firm's flexibility is significant as a mediating effect, this time between suppliers' flexibility and the manufacturing firm's competitive advantage.

Implications for Practitioners

Flexibility, defined as the ability to respond to changing customer requirements through a variety of supply chain functions, is an especially important capability for a manufacturing firm. The current study found that a firm's human capital contributes to its overall flexibility, but achieving and maintaining flexibility in this way require targeted human resource strategies and practices. The implementation of a strategic human resource management system with specific, targeted practices has been shown to increase overall firm performance and to enhance a firm's ability to maintain its competitive advantage by being difficult to imitate (Liu, Combs, Ketchen, & Ireland, 2007).

Many believe that human resource systems are most applicable to service organizations, where organizational performance depends almost solely on human capital performance. In actuality, however, the effects of human resource systems are greater for firms in manufacturing contexts (Liu et al., 2007) where practices designed to achieve and maintain highly skilled human capital will result in employees who are well equipped to handle complex and often dangerous machinery.

Specific, targeted practices within the human resource areas of selection, training and development, and reward can increase the overall flexibility of a manufacturing firm in several ways. The selection of individuals with skills related to flexibility is the first step in achieving flexibility within a firm. The current study found that skills such as technical skills, people skills, technology skills, and conceptual skills increase a firm's flexibility, subsequently increasing a firm's competitive advantage. Thus, firms should use selection practices that lead to obtaining human capital with these types of skills. Proper selection methods ensure that employees with high levels of the skills nec-

essary to contribute to firm flexibility are hired and can also increase employees' fit with the values and culture of a firm, which is key to retaining quality human capital (Bernardin, 2010; Liu et al., 2007). Job knowledge tests, which have a relatively high level of validity, are appropriate for assessing technical skills (Schmitt, Rogers, Chan, Sheppard, & Jennings, 1997) with relatively low administrative costs or adverse impact (Ryan & Tippins, 2004). People skills are often measured through either personality inventories or structured interviews, although we recommend the use of structured interviews because they can assess a variety of different skills, they are highly valid (Huffcutt & Roth, 1998) and they have a low occurrence of adverse impact, whereas personality tests are not equally valid for all jobs and not all people skills are related to personality (Noe, Hollenbeck, Gerhart, & Wright, 2010). Conceptual skills and, to a lesser extent, technology skills can be assessed through the use of cognitive ability tests, which have a very high comparative validity and low developmental and administrative costs (Hough, Oswald, & Ployhart, 2001). Evidence exists, however, that cognitive ability tests can have an adverse impact if they are not administered properly (see Ryan & Tippins, 2004). Using specific, targeted selection tools should allow firms to obtain human capital with the necessary skills for the firm to become more flexible, but firms that use effective selection practices also have higher profit margins, sales growth, and overall performance (Terpstra & Rozell, 1993).

Although selecting individuals with the technical, people, conceptual, and technology skills necessary to create flexibility within a firm is an essential first step, supporting these skills through training and development is essential, especially in highly dynamic industries. Training not only allows for continuing to develop these skills, but also for applying them appropriately by employees within the work context (Noe et al., 2010). Training practices such as cross-training are necessary to maintain the flexibility of a firm's workforce and increases their tech-

nical and conceptual skills. As a result, the workers are more flexible in terms of their skills and the contributions that they can make, and they have a greater understanding of the overall firm's functioning. Thus, cross-training is likely to better equip workers to display Pulakos et al.'s (2000) adaptive performance dimensions (e.g., handling emergencies or crisis situations, solving problems creatively, and dealing with uncertain and unpredictable work situations).

Another reason to offer continued training and development is that employees often forget skills they do not use frequently or that are not refreshed through training (Hottenstein & Bowman, 1998). For example, maintaining technical skills is important for continued flexibility, but managers may not have regular opportunities to use their technical skills because their time is often occupied by non-technical managerial duties (i.e., planning, coordinating). Another focal area for training is to train with a teamwork focus, because most manufacturing firms use team-based processes (Hottenstein & Bowman, 1998). Teamwork training should focus on interpersonal skills that engender increased collaboration and communication (Beatty, 1992). Such training can also provide workers a unique opportunity to develop their people skills through active listening, public speaking, conflict management, and emotional intelligence development.

Beyond selecting individuals with skills that will aid in firm flexibility, and beyond training and developing those skills, it is important to ensure employees are motivated to use their skills through reward practices. Proper compensation based on industry and market value and levels of knowledge, skills, and abilities is the first step in ensuring motivation. Suitable compensation also gives firms a competitive advantage when they seek to hire individuals with superior skills and aids in retaining employees with the requisite skills and training (e.g., Liu et al., 2007). Where possible, firms should also provide incentive compensation, at either the individual or group level, to promote continued effort and application of skills. The type of incentive plan depends greatly on the strate-

gic goals of the firm, its work structure (e.g., individual versus team design), and the work context (Noe et al., 2010; Ryan & Tippins, 2004). Another human resource management practice that has been linked to increasing motivation is internal promotion practices that motivate employees to do well in

their current position and to increase their skill levels in order to qualify for promotion.

For their part, suppliers must have the ability to adjust their production quickly in a dynamic economic cycle to avoid hampering the manufacturing firm's flexibility to meet demand. Therefore, targeted practices in selection, training and development, and rewards for individuals who work closely with suppliers (e.g., purchasing specialists) may be particularly important.

For their part, suppliers must have the ability to adjust their production quickly in a dynamic economic cycle to avoid hampering the manufacturing firm's flexibility to meet demand. Therefore, targeted practices in selection, training and development, and rewards for individuals who work closely with suppliers (e.g., purchasing specialists) may be particularly important. For example, skills in the selection and evaluation of suppliers, such as negotiating and problem solving, are integral capabilities for those in supplier-interface roles in order to identify capable suppliers who will respond flexibly to the firm's requests. In addition, the capacity to develop strong relationships with suppliers will contribute to a more cooperative exchange of information and nurture long-term partnerships. Such partnerships are important to the ability to respond to changes in demand. For example, in late 2009, Caterpillar informed its major suppliers of an anticipated rise in demand and helped the suppliers prepare for this sudden increase (Aeppel, 2010). Attending to targeted human resource management practices that reinforce essential

skills for those in supplier-interface roles will help firms in their efforts to be more flexible and more responsive to their customers, and ultimately to enjoy a competitive advantage.

Taken together, selection, training and development, and reward systems can greatly

enhance the quality of skills a firm's employees possess. It is essential, however, for the firm to match its strategic human resource management practices with its overall strategy (i.e., to achieve vertical alignment) (Baird & Meshoulam, 1988). Human resource practices can be designed and implemented based on the strategy of the organization. For example, a firm that has core values of inclusion and teamwork would not want to implement a reward system with an individual focus.

Taking into account both the industry and the strategy, firms should also ensure that their human resource management practices are aligned with one another (i.e., horizontal alignment) (Liu et al., 2007). In certain contexts human resource practices can complement one another, and in other contexts they may compete, so to use human resources effectively, a firm must understand how these practices align. For example, a firm in a highly technological industry with short product life cycles and the need for fast responsiveness to customer demands is likely to focus on selecting employees with high levels of technical and conceptual skill that will aid in non-routine problem solving and creative thinking (e.g., Anell & Wilson, 2000). Because this firm will have invested a substantial amount in the selection of these skills, additional training could be redundant, contradictory, and/or distracting (Liu et al., 2007).

Finally, understanding the robust interdependencies among a firm's human capital, its flexibility, and its competitive advantage may assist practitioners in creating novel human resource management practices that result in greater efficiencies, effectiveness, and profitability overall.

Limitations and Future Research

Although this research provides several significant contributions, several limitations should be addressed in future research. First, the data is cross-sectional. While we examined the relationships among the firm's human capital, the firm's flexibility, and the firm's competitive advantages, a manufactur-

ing firm that holds a competitive position because of its superior flexibility may have an advantage in recruiting employees with important competencies. Similarly, suppliers may be more flexible to the requests of a manufacturing firm that has a strong market position. Future research may provide further insights into what underlies the relationships between a manufacturing firm's human capital and its competitive advantages, and between the firm's competitive advantages and its suppliers' flexibility.

Second, although we attempted to minimize the response bias that may be due to a single informant by selecting high-ranking respondents, examining the common method variance, and checking reliability and validity, multiple respondents would provide more robust information, especially for the perceptual measures (Becker & Huselid, 2006; Lepak & Snell, 2002). Future research should seek to identify multiple informants using procedures outlined by Youndt et al. (1996), obtain measures of variables from multiple methods, or randomize the order of measurement items (Miller & Roth, 1994; Podsakoff & Organ, 1986).

Third, while we took steps to justify the external validity of the research data, the small response rate is not desirable. Future research could use different media for data collection, reach the intended respondents via state-of-the-art techniques, shorten the questionnaire, or establish collaborative relationships between researchers and respondents to increase the response rate (Baruch & Holtom, 2008; Dillman et al., 2009).

Fourth, the construct of a manufacturing firm's competitive advantage should be modified because of its low reliability. Each item in this research could be a latent variable measured by several observed scales (Zhang, Vonderembse, & Lim, 2002), so a second-order construct of competitive advantage may be considered to represent this variable more effectively in future research.

In addition to these methodological limitations, future research could use different research models. For example, although all managers and workers are important to a firm's success, certain positions are more

pivotal to the strategic vision of the organization (Boudreau & Ramstad, 2007; Kaplan & Norton, 2004). Given our findings that flexibility is an essential part of a firm's strategy, future research could decouple the manufacturing firm's human capital construct in order to distinguish the unique relationships between worker capital and managerial capital, on one hand, and the firm's flexibility and performance on the other.

In addition, technology has changed the roadmap of business in every respect, and technology diffusion may worsen the firm's operations if the technologies are not managed appropriately (Brynjolfsson, 1993). Future research should explore the interdependencies of technology factors and human factors in a firm, especially as they relate to the firm's flexibility and competitive advantage.

Conclusion

Our results illustrate the important links between a manufacturing firm's human capital and its flexibility, as well as between human capital and firm performance in a supply chain context, relationships that have not been clearly defined in prior supply chain management or human resource management literature. Our comprehensive model demonstrates that a manufacturing firm's human capital is related to the firm's flexibility and performance in two ways: there is a direct positive relationship between human capital and the manufacturing firm's flexibility, and human capital resources indirectly relate to the firm's competitive advantages through the flexibility of the firm. In addition, both internal strategic human capital and external suppliers' flexibility are critical to a manufacturing firm's ability to retain the flexibility that brings it competitive advantage.

Notes

1. The classification of industries and job functions among the three sources from which the e-mail list was obtained and the questionnaire developed for this research are not comparable. For this reason, we cannot compare the differences between/simi-

- larities of the respondents and the three source lists using job functions and industry as criteria.
2. The total number of respondents was 201. Three respondents, however, did not provide company size or annual sale information; therefore, only 198 were used to calculate the non-respondent bias.
 3. One source that provided a mailing list did not disclose information about company size and annual sales. Because this source provided less than 15% of contacts, we calculated the non-respondent bias by comparing the respondents with the population from the two sources from which the company size and annual sales information were available.
 4. By convention, for GFI, AGFI, NFI, and CFI, values above 0.8 represent a reasonable model-fit, and for RMR values below 0.1 represent an acceptable model-fit (Byrne, 2001; Joreskog & Sorbom, 1989).
 5. Each of five sub-constructs (suppliers' flexibility in order quantity, order variety, and delivery, and a manufacturing firm's flexibility in procurement and distribution) has only three items. Four or more items are needed in a single-factor measurement model in AMOS. A correlated measurement model, therefore, was developed for three sub-constructs of suppliers' flexibility and another correlated measurement model was developed for the manufacturing firm's procurement flexibility and distribution flexibility. After removing two items because of low factor loadings, a measurement model could not be developed for the manufacturing firm's competitive advantage; therefore, no model-fit indexes are calculated for this variable.

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APPENDIX List of Items in Survey Questionnaire

Manufacturing Firm's Human Capital (MHC)
Manufacturing Firm's Managerial Capital (MHC_MC)

- Our managers have technical knowledge of the industry in which our firm competes*
- Our managers have technical knowledge that is relevant to their responsibilities
- Our managers have general people management skills (planning, organizing, directing, evaluating, and motivating)
- Our managers have knowledge of the strengths and weaknesses of our firm
- Our managers have knowledge of the strengths and weaknesses of our suppliers*
- Our managers have the necessary coordination skills to work well with other departments in our firm
- Our managers have the necessary coordination skills to work well with our suppliers

Manufacturing Firm's Worker Capital (MHC_WC)

- Our workers have multiple technological skills
- Our workers have problem-solving skills
- Our workers have the necessary interpersonal skills to work well with their coworkers
- Our workers have knowledge of production processes and machine operations*
- Our workers have experience that is relevant to their jobs

Manufacturing Firm's Flexibility (MF)
Manufacturing Firm's Product Development Flexibility (MF_PDF)

- Our firm can introduce many different new products*
- Our firm can introduce new products efficiently
- Our firm can achieve high quality across all new products introductions*
- Our firm can implement many different product modifications
- Our firm can implement product modifications efficiently
- Our firm can achieve high quality across all product modifications

Manufacturing Firm's Production Flexibility (MF_PF)

- Our firm's manufacturing system can operate at many high and low production volumes*
- Our firm's manufacturing system can change production volumes efficiently
- Our firm's manufacturing system can achieve high quality across all production volumes*
- Our firm's manufacturing system can accommodate many different product mixes
- Our firm's manufacturing system can change product mixes efficiently
- Our firm's manufacturing system can achieve high quality across all product mixes

Manufacturing Firm's Procurement Flexibility (MF_IBF)

- Our firm's procurement system can fill many different in-bound shipment requests
- Our firm's procurement system can respond to changes of in-bound shipment requests efficiently
- Our firm's procurement system can achieve high reliability for all in-bound shipment requests

Manufacturing Firm's Distribution Flexibility (MF_OBF)

- Our firm's distribution system can fill many different out-bound delivery requests
- Our firm's distribution system can respond to changes of out-bound delivery requests efficiently
- Our firm's distribution system can achieve high reliability for all out-bound delivery requests

Appendix Continued on Next Page

APPENDIX List of Items in Survey Questionnaire (Continued)**Suppliers' Flexibility (SF)****Suppliers' Delivery Flexibility (SF_QF)**

- Our suppliers can fill many different delivery requests for our firm
- Our suppliers can respond efficiently to changes in our firm's delivery requests
- Our suppliers can meet all of our firm's delivery requests with high reliability*

Suppliers' Order Variety Flexibility (SF_VF)

- Our suppliers can produce a large number of various products for our firm
- Our suppliers can respond efficiently to changes in our firm's product variety requests
- Our suppliers can meet all of our firm's product variety requests with high quality

Suppliers' Order Quantity Flexibility (SF_DF)

- Our suppliers can satisfy our firm's needs at many low and high order quantities
- Our suppliers can respond efficiently to changes in our firm's order quantity requests
- Our suppliers can meet all of our firm's order quantity requests with high quality

Manufacturing Firm's Competitive Advantages (CA)

- Our firm competes with other firms by offering competitive prices to our customers*
- Our firm competes with other firms by offering high quality products to our customers
- Our firm competes with other firms by offering dependable delivery to our customers
- Our firm competes with other firms by quickly introducing product in the market
- Our firm competes with other firms by offering customized products to our customers*

Note: * Deleted item after purification in the confirmative factor analysis.

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