

THE IMPACT OF HUMAN RESOURCE AND OPERATIONAL MANAGEMENT PRACTICES ON COMPANY PRODUCTIVITY: A LONGITUDINAL STUDY

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Within the strategic human resource management (SHRM) perspective, psychology-based practices, especially empowerment, extensive training, and teamwork, are seen as vital to sustained competitive advantage. Other approaches, such as those of integrated manufacturing and lean production, place greater emphasis on operational initiatives such as total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering as determinants of organizational performance. We investigated the relative merits of these practices through a study of the productivity of 308 companies over 22 years, during which

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time they implemented some or all of these 7 practices. Consistent with SHRM theory we found performance benefits from empowerment and extensive training, with the adoption of teamwork serving to enhance both. In contrast, none of the operational practices were directly related to productivity nor did they interact with other practices in ways fully consistent with the notions of integrated manufacturing or lean production.

For many decades, personnel and I-O psychologists have been interested in employee-oriented practices such as empowerment, training, and teamwork. Historically, that interest was focused at the individual and job level. Walton (1985), however, advanced the argument that such practices are integral to the kind of "high commitment management" necessary to promote organizational effectiveness for modern volatile and increasingly competitive economic conditions. Similarly, Lawler's (1986) notion of "high involvement management" emphasizes employee empowerment and development as the key to organizational performance, and these are integral to subsequent notions of "high-performance work practices" (Huselid, 1995). The emphasis is placed on the importance of both developing human capital and ensuring that the environment is right for employees to reap the benefits of this, and particularly that they are provided with sufficient job discretion and a supportive team environment. This has led to the notion of strategic human resources management (SHRM) that builds on these foundations in two ways. First, it focuses on the impact of implementing such practices on organizational rather than individual performance, and second it emphasizes the synergistic link between practices so that the impact of each on organizational performance is enhanced when others are present (Becker & Huselid, 2006; Combs, Liu, Hall, & Ketchen, 2006).

Recent research that addressed whether such psychology-based practices are related to organizational-level outcomes has tended to approach them in isolation of other, possibly related, operational management initiatives. A major exception to this was one of the earlier pioneer studies by MacDuffie (1995), who located them in the context of lean production. We shall follow this lead and examine the effectiveness of psychology-based human relations systems relative to the practices that are associated with such concepts as integrated manufacturing and lean production, as well as whether the effect of the human resource practices is enhanced by the use of those operational ones.

The concept of integrated manufacturing technology centers on the combined use of three operational practices, total quality management, just-in-time, and advanced manufacturing technology (Dean & Snell, 1991; Snell & Dean, 1992, 1994), especially in manufacturing. Even more influential in the management and practitioner literature has been

the notion of lean production, which extends the operational practices to include supply-chain partnering (Womack, Jones, & Roos, 1990). It also connects to the psychology-based practices as in its fuller versions, lean production encompasses human resource practices (Parker, 2003; Shah & Ward, 2003; Wood, 2005), seeing organizational performance as resulting from the combination of both types of practice. In this paper, we report a study that evaluates the individual and collective impact on manufacturing performance of the seven managerial practices most associated with these three theoretical perspectives: empowerment, training, teamwork, total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering

In addition to the theoretical case for focusing on these seven practices is an applied one, as studies show that each is now used by a substantial proportion of manufacturing companies. For example, a survey of UK manufacturing companies in 1996 showed these seven were the most popular in the modern management practitioner literature, and all were implemented by over half of companies, with use ranging from 52% for empowerment to 67% for total quality management, respectively (Waterson et al., 1999). Four years later, the use of all seven practices had increased, with empowerment adopted by 60% of companies and total quality management by 84% of companies (Wood, Stride, Wall, & Clegg, 2004).

There remains, however, little compelling empirical evidence of the extent to which these practices, individually or collectively, are causally related to company performance or of the extent to which the effects of particular practices are enhanced by the use of the other practices. The evidence to date is mostly based on cross-sectional data or case studies. Longitudinal evidence is needed to show that companies that adopt specific practices, or particular combinations of practices, subsequently improve their performance (Wall & Wood, 2005; Wright & Gardner, 2003). Furthermore, the SHRM and operations management literature can be criticized for providing little specificity on how long after an intervention one may expect to see performance benefits; such temporal delays may serve to hide any intervention–outcome relationships (Kozlowski & Klein, 2000; Mitchell & James, 2001; Whetten & Cameron, 1994). We respond to this methodological challenge by presenting a longitudinal study in 308 manufacturing companies incorporating measures of performance for up to 22 years.

More specifically the study was designed to (a) determine the performance effect of the introduction of each of the human resource or operational practices separately; (b) establish whether the synergies among the practices that are predicted by theory are demonstrated in practice; and (c) where effects are established, examine how long before they emerge and

for how long they persist. For each set of management practices, we elaborate on the theoretical justification, describe the component practices, and present the arguments for their separate and combined effect on company performance. Finally, we critique available evidence on the performance effects of the practices to provide the rationale for our research design.

Human Resource Practices and Company Performance

Becker and Huselid (2006) note that the “field of strategic human resource management (SHRM) has enjoyed a remarkable ascendancy during the past two decades, as both an academic literature and focus of management practice” (p. 898). A core theoretical rationale for this approach stems from the resource-based view of the firm (Barney, 2001; Harvey & Denton, 1999; Power & Waddell, 2004; Senge, 1990; Wright, Dunford, & Snell, 2001; Wright & McMahan, 1992). This suggests that human resource practices contribute to sustained competitive advantage by enabling the development of knowledge that is embedded in the firm’s culture and history and, by virtue of this context-specificity, is largely inimitable (Lado & Wilson, 1994). Given this focus, it is easy to understand why the knowledge-based view of the firm gained acceptance within resource-based theorizing (e.g., Kogut & Zander, 1992; Spender & Grant, 1996). Similarly, from an organizational behavior perspective, it is proposed that HR practices work to develop individual knowledge and skills, as well as employee attitudes and behaviors. If these effects are prevalent enough in the employee population, then the collective changes in human capital, attitudes, behaviors, and associated organizational climate, should be strong enough to influence organizational performance (Bowen & Ostroff, 2004; Kozlowski & Klein, 2000; Ostroff & Bowen, 2000).

In this study, we focus on the human resource management practices of empowerment, training, and teamwork for a number of reasons. First, following the human capital and resource-based view, we would expect these practices to enhance employee knowledge specific to the company and allow employees to exploit it (Appelbaum, Bailey, Berg, & Kalleberg, 2000; Lawler, Mohrman, & Ledford, 1992, 1995; Pfeffer, 1994; Way, 2002). Second, the practices are theoretically linked to the extended concept of lean production (e.g., MacDuffie, 1995), which will be discussed later and empirically evaluated by this study. Third, these practices are among the most popular in both the research literature and organizational practice (Waterson et al., 1999; Wood et al., 2004). Of course, other HRM practices such as selection, recruitment, and appraisal can have a role to play in influencing organizational performance, but in this study context they were considered to be of less direct relevance to the notion

of “inimitable knowledge,” that is, learning specific to, and developed within, the organization rather than imported from outside.

Empowerment entails the passing of considerable responsibility for operational management to individuals or teams, rather than keeping such decision making in the hands of line management. It encompasses a range of initiatives including job enrichment and delayering (Wall, Wood, & Leach, 2004). There are many ways in which such increased autonomy is expected to enhance company performance, for example by motivating employees to work harder and more flexibly (Hackman & Oldham, 1976), encouraging the use of initiative (Frese, Kring, Soose, & Zempel, 1996) or proactivity (Parker, Williams, & Turner, 2006), reducing the costs of supervision and other indirect costs (Batt, 2001; Parker & Wall, 1998), as well as providing the opportunity for individuals to develop and use new knowledge and skills (Leach, Wall, & Jackson, 2003). Most empirical investigation of the effect of empowerment on performance has been at the job level, but within management theory, from McGregor’s (1960) and Likert’s (1961) early work to contemporary approaches to human resource management (e.g., Appelbaum et al., 2000; Pfeffer, 1994, 1998), these effects are predicted to work through into performance gains at the organizational level.

Similarly, investment in the training and education of employees manifestly would enhance organizationally specific knowledge, particularly where this has a broad perspective that includes helping employees to learn a wide range of skills, rather than equipping them simply to complete a restricted job. Pfeffer (1998) uses the term “extensive training” (p. 96) to represent this approach. The rationale for an effect of extensive training on organizational performance is further strengthened by work on learning organizations (Harvey & Denton, 1999; Power & Waddell, 2004; Senge, 1990). The argument is that by upgrading employees’ skills and knowledge, they are in a better position to produce high-quality products and services in the most cost-effective way, adapt to change, and contribute to company competitiveness through product or process innovation.

Finally, teamwork provides the opportunity for people to share knowledge. Teamwork can be defined as groups of employees working together on a common task. The form of teamwork most commonly expected to promote performance is one where the group is given extensive responsibility, as in the autonomous or self-managing teams developed within the sociotechnical systems approach to work organization (Cherns, 1987). The assumption is that such teams enhance performance by motivating their members, ensuring the availability of the range of skills necessary for the completion of interdependent tasks, lessening labor costs because of the reduced need for direct supervision, and providing the opportunity

for members to learn from one another (e.g., Allen & Hecht, 2004; Leach, Wall, Rogelberg, & Jackson, 2005; Orsburn & Moran, 2000).

On the basis of such arguments, we would expect that each of the human resource practices will contribute to company performance. Thus, we predict:

Hypothesis 1a: The adoption of empowerment, extensive training, and teamwork will independently enhance company performance.

In addition, we would expect that the practices are synergistically related, so that empowerment, extensive training, and teamwork are predicted to interact to promote performance (Appelbaum et al., 2000; Combs et al., 2006; Pfeffer, 1994; Wood & Wall, 2007). The argument (see Bailey, 1983) is that, to be fully effective, empowerment requires skilled and knowledgeable employees and that asking them to take on additional responsibility and make decisions without the wherewithal to do so is likely to be counterproductive. Thus, extensive training and development is a necessary prerequisite for empowerment to work. Conversely, investing in the training and development of employees will be of limited benefit if their jobs and roles are structured in such a way as to deny them the opportunity to put their knowledge and skills into practice, making empowerment key (Patterson, West, & Wall, 2004). Likewise, both empowerment and extensive training should underscore the effectiveness of teams. Teams contribute to performance by marshalling the wider range of skills and abilities afforded by their membership as appropriate to the task. Learning from extensive training may often encompass teamwork and problem-solving skills, which in turn help provide the competencies on which team performance depends. An emphasis on empowerment throughout the organization should also help teams to make decisions, and in the more particular case of self-managing teams, it ensures that their internal processes are compatible with and supported within the wider organizational context. Thus, we predict that:

Hypothesis 1b: Empowerment, extensive training, and teamwork will interact positively to predict company performance.

Operational Management Practices and Company Performance

Integrated manufacturing (Dean & Snell, 1991) and the core view of lean production (Womack et al., 1990) are two largely overlapping approaches that emphasize operational management practices as sources of competitive advantage. Of these, the more narrowly conceived is integrated manufacturing, which encompasses total quality management,

just-in-time, and advanced manufacturing technology. Each of these operational practices is promoted as effective in its own right, as well as in combination with the other. Total quality management is based on the principle that quality control should be an integral part of the production process, and thus a primary responsibility of operators, rather than a separate policing and rectification function. Key features include continuous improvement to reduce waste, doing things right first time, and quantitative measurement to analyze deviations from target quality levels (Crosby, 1989; Hackman & Wageman, 1995; Legge, 1995; Nair, 2006; Sila, 2007). The expected performance benefits arise not only from lower costs, as total quality management should reduce waste and eliminate the labor costs of inspection and rectification, but also from increased revenue as high quality may allow the company to place a premium on the price of its products and is likely to result in repeat orders.

Just-in-time is a system geared to making products in direct response to internal and external customer demand rather than building for stock that is a "pull" rather than a "push" system. Each stage in production is completed just in time to allow the next to be completed immediately following it, and the customer to be guaranteed just-in-time delivery (Ledford, 1995; Oliver, 1991; Schonberger, 1982). The aim is to minimize capital tied up in raw materials, work in progress, and stocks of unsold finished goods so that payment follows as soon as possible after investment. The performance advantage of just-in-time inventory control is that it reduces inventory and material costs, and may increase the attractiveness of the firm's products. In addition, the reduction in, and the speeding up of the throughput of, inventory is likely to have a positive impact on quality as the products and materials spend much less time lying around factories in buffer stocks where they are prone to damage.

Advanced manufacturing technology encompasses a range of computer-based machinery such as computer numerically controlled machines, robots, and computer-aided design and process planning. Such technologies are also sometimes combined into even larger systems through shared computer control and by materials handling and transfer devices to create flexible manufacturing systems or CAD/CAM (computer-aided design and computer-aided manufacturing) systems (Jelinek & Goldhar, 1984; Parker & Wall, 1998). It is because of this integrated use that sometimes they are referred to as "integrated computer-based technology," which also covers nonmanufacturing applications. Organizations investing in advanced manufacturing technology should achieve the normally assumed performance benefits of automation in terms of reduced labor costs, higher output, and enhanced quality. But in addition, a particular advantage compared with traditional automation is that changes between products can be effected more easily by simply

loading different software rather than physically resetting machines, thus reducing nonproductive time and response times, and increasing production flexibility.

The three components of integrated manufacturing are central to lean production (Womack et al., 1990), which incorporates the additional practice of supply-chain partnering. The last of these involves the development of strategic alliances through long-term relationships with suppliers (and customers) to guarantee that the right materials and components are provided to the required standard and at the minimum cost (Bhattacharya, Coleman, & Brace, 1995; Boddy, Macbeth, & Wagner, 2000). The aim is to ensure the integrity of materials and components to prevent any quality problems and to minimize any shortfalls or delays in supply, hence improving performance. In some cases, it is also a means of improving quality further by outsourcing work where internal expertise is not sufficient.

The models of integrated manufacturing and lean production assume that their key practices will contribute to company performance. Thus, we predict:

Hypothesis 2a: The adoption of total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering, in each case, will independently enhance company performance.

As for the SHRM approach, a feature of both integrated manufacturing and lean production is the expected synergy among the practices. The argument for integrated manufacturing is as follows. The objective of just-in-time is to minimize work in progress and in stock, which requires each stage of production to be completed just when the next needs to start, with the final stage completed just in time to meet the delivery date. As delay at any stage would be highly detrimental, there must be no unforeseen quality problems that cascade down the process, therefore making the role of total quality management in eliminating such delays crucial to success. Likewise, the minimization of work in progress, together with making the specific number of products required by the customer (rather than for stock), means that products have to pass rapidly from one stage to the next, typically in smaller batches. This makes set-up and changeover times a critical issue, where the programmable nature of advanced manufacturing technology plays its part. In integrated manufacturing the three practices thus form a synergistic set, with each having more effect when the others are used. Lean production adds supply-chain partnering into the mix, which is expected to bolster the other practices by helping to ensure prompt delivery of components for just-in-time, ensuring quality problems are not imported into the process, and securing materials and components

appropriate to the technology. The assumed interdependence among the operational practices leads us to predict:

Hypothesis 2b: Total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering will interact positively to predict company performance.

Linking Human Resources and Operational Management Practices

A final consideration concerns the relationship between human resource and operational management practices. Sociotechnical systems theory would lead us to expect company performance to be a product of both types of practice. The extended concept of lean production is often taken to include human resource practices, and even though Womack and colleagues are widely regarded (MacDuffie, 1995; Wickens, 1987) as underplaying them, they do (1990, p. 99) suggest that lean production involves empowering employees as it “transfers the maximum number of tasks and responsibilities to those workers actually adding value to the car on the line.” In a similar vein, Parker (2003) argues that lean production depends on “multiskilled operators, typically organized into small teams, being responsible for quality, continuous improvement and problem solving” (p. 620; see also Taira, 1996). Consequently, we would expect synergies within both the operational management and the human resource management practices and between the two types. This is consistent with Ahmad, Schroeder, and Sinha’s (2003) finding that HRM practices moderate the relationship between just-in-time and performance, and Wall, Corbett, Martin, Clegg, and Jackson’s (1990) results showing that operator empowerment can enhance the performance of advanced manufacturing technology. Thus, we predict:

Hypothesis 3: Empowerment, extensive training, and teamwork will positively interact with total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering to predict company performance.

Evidence of the Effects of the Management Practices on Company Performance

Currently, direct evidence on the association between the seven management practices and company performance is surprisingly scant. There is indirect evidence in the form of associations between some of the individual practices and job-level outcomes. For example, there are many

studies of the relationship of job enrichment, a key aspect of empowerment, with job performance (e.g., Guzzo, Jette, & Katzell, 1985; Kopelman, 1985; Miller & Monge, 1986; Parker & Wall, 1998). Similarly, there are studies of the relationship of training and of teamwork with job performance (e.g., Barrick, Stewart, Neubert, & Mount, 1998; Colquitt, LePine, & Noe, 2000; Frayne & Geringer, 2000; Kirkman, Rosen, Tesluk, & Gibson, 2006; Warr, Allan, & Birdi, 1999). But although individual performance may contribute to organizational performance, it is not necessarily the case, as organizational performance is not simply an aggregate of individual performance (Guzzo, 1988; Guzzo & Shea, 1992).

Studies focusing directly on organizational performance are less common and in many cases rely on subjective outcome measures. For example, Waterson et al.'s (1999) survey of UK manufacturing companies, which covered all the seven practices that we are focusing upon, examined how use related to reported company success in terms of responsiveness, quality, and cost, and found systematically positive but modest relationships. Sale and Inman (2003) investigated the association between just-in-time and reported manufacturing business unit financial performance, finding none. Other studies of this type provide more positive findings, for instance those by Cua, McKone, and Schroeder (2001) on just-in-time and total quality management and Shah and Ward (2003) on lean production and HRM. The limitation of such evidence is that subjective assessments of performance are of unknown validity and also often come from the same source as the measures of the practices themselves, so a lack of relationship might be attributable to poor measurement validity or an observed relationship to common method bias.

There are, however, studies that relate the use of some of the practices to independent measures of organizational performance. For example, Lawler et al. (1992, 1995) focused on employee involvement (akin to our notion of empowerment) and total quality management and found both positively associated with various indices of company performance, including productivity, sales per employee, return on assets, and return on equity. Similarly, Bhattacharya, Gibson, and Doty (2005) investigated the relationship of flexibility of employee skills and human resource practices with accounting measures of firm performance (see also Kato & Morishima, 2002). As such evidence is generally consistent with expected effects it is encouraging. Nonetheless, it is far from definitive, as it is based on cross-sectional data that provide an inadequate basis for causal inference.

The study by Patterson et al. (2004) is an exception as it was longitudinal and used independent measures of company performance. These investigators focused on five of our seven practices and examined how the use of each related to change in productivity and profit, where the latter

was derived from audited company accounts. They found that neither total quality management nor just-in-time was associated with performance in the subsequent year (controlling for prior performance). In contrast, advanced manufacturing technology, empowerment (job enrichment), and extensive training (skill enhancement) all predicted subsequent productivity, though only the latter two also predicted profit. There was no pattern of interactions among the practices consistent with the concepts of integrated manufacturing or SHRM. However, this study also has its weaknesses: It is based on a small unrepresentative sample of UK single-site manufacturing companies; there is a lag in reporting financial data, which means that the figures could partly reflect contemporaneous performance; and the sample size of 80 is unlikely to be enough to detect interactions among practices (Busmeyer & Jones, 1983).

Perhaps the most coherent relevant body of evidence on company performance is in the human resource management field, where attention is mostly limited to the effects on organizational performance of the practices associated with SHRM. Measures of SHRM typically have empowerment, extensive training, and teamwork as key components, and several studies have shown positive relationships with company performance (e.g., Combs et al., 2006; Guthrie, 2001; Huselid, 1995), measured either subjectively or objectively. Although many commentators interpret such evidence as indicating a causal effect, thorough analysis suggests this is at best premature (e.g., Wright & Gardner, 2003), not least because not all studies find associations and again they are largely cross sectional.

Wall and Wood's (2005) analysis of 25 leading studies focusing on human resource management and performance showed that 21 were purely cross sectional and many used subjective performance measures. Two studies (Guest, Michie, Conway, & Shehan, 2003; Huselid, Jackson, & Schuler, 1997) were described as "quasi-longitudinal," relating use of the practices at a given point in time to change in company performance from a prior occasion to a subsequent one (as was the case for Patterson et al., 2004). This creates problems of interpretation, where use of the practices predicts subsequent performance ignoring prior performance but fails to show such an effect when prior performance is controlled (to capture change). Given that the date of the introduction of the practice is unknown, it may have already been in place at the time of the first performance measurement. Thus, by controlling for prior performance, one may at the same time remove the very effect being investigated (Guest et al., 2003) so any interpretation is thus ambiguous. Wall and Wood (2005) found only two studies that were truly longitudinal, in which the introduction of human resource practices was related to change in subsequent performance. One was by Ichniowski, Shaw, and Prennushi (1997) on 36 U.S. steel lines that suggested a positive effect, using line rather

than company performance as an outcome; the other was by Capelli and Neumark (2001) with a sample of over 400 U.S. manufacturing companies showing no effect. Subsequently, further longitudinal studies have been published. For example, Collins and Smith (2006) studied the relationship between high-commitment HRM practices (assessed by a mix of selection, training, and compensation items), social climate, knowledge sharing, and firm revenue from new products and sales growth over the subsequent year for technology companies. A positive relationship was demonstrated between the HRM practices and financial performance, mediated by climate and knowledge exchange/combination. Wright, Gardner, Moynihan, and Allen's (2005) study of business units in a food service organization found that aggregated HRM practices (selection, training, rewards, and participation) were related to past, current, and future firm performance. However, as mentioned earlier, controlling for past or concurrent performance removed any significant relationship between the practices and future performance. Other recent studies also suggest a link between HRM practices and subsequent organizational performance (e.g., Peterson & Luthans, 2006; Zatick & Iverson, 2006). However, studies still tend to be limited in terms of: their focus on human resource management practices only; utilizing a restricted timeframe when collecting organizational performance data (typically one or two years before and after practice measurement); and lack of performance information for the period before the management practice was introduced.

Wall and Wood (2005), therefore, identified a number of methodological priorities for human resource management research that apply equally to our current concerns. In addition to stressing the need for studies that span other areas of management, Wall and Wood (2005) argue that first, independent measures of organizational performance (i.e., from financial accounts) should be used. Second, studies should have large samples, to improve generalizability and ensure sufficient power, especially in the testing of interaction effects. Third, use should be made of longitudinal designs involving the repeated measurement of performance before and after the introduction of practices. Such designs allow one to explore temporal precedence in terms of management practices and performance (Wright et al., 2005). It could well be that any relationship between practices and performance may be partly due to high-performing companies possessing enough resources to invest in new practices. Furthermore, as organizational performance can be regarded as an emergent outcome, we would expect to see a time lag between the introduction of a management practice and a subsequent change in organizational performance (Kozlowski & Klein, 2000). These temporal issues are rarely considered in organizational theory and research (Mitchell & James, 2001). In the absence of *a priori* guidance of the time it takes for practices to take effect,

and how long such effects persist, extended performance measurement ensures that effects will not be missed through choosing the wrong time frame. Finally, examination should be made of the role of individual as well as combinations of practices.

To the best of our knowledge, no existing study matches those criteria for any of the practices we have identified as central to SHRM, integrated manufacturing, or lean production. The study that follows does.

Method

Sample

We obtained the data set for this study by matching evidence on management practices in UK manufacturing companies from three surveys conducted over 7 years to audited records of company performance. The aim of the surveys was to establish the use of our seven management practices and identify when they were first introduced into the organization. The first survey was conducted in 1996 and provided a sample of 562 companies (Waterson et al., 1999). It was carried out by structured telephone interview with the Managing Director or a senior colleague (e.g., Director of HRM or Production). The second survey in 2000 included a follow-up of 126 of the manufacturing companies from the first survey, using the same telephone interview method (Wood et al., 2004). The third survey of management practices was conducted in 2003 and provided data on 254 manufacturing companies, using either telephone interview or postal questionnaire methods. Analysis comparing the interview with the questionnaire data collection methods showed no systematic differences in background characteristics or in the effects of the practices on company performance. In summary, across the three surveys, 684 manufacturing organizations provided information on their management practices. With some companies we had survey information from one time point only (69%), others from two time points only (25%), and the rest three time points (6%). The process for choosing the final sample for analyses is described below.

Measures

Management practices. Descriptions of the core characteristics of the management practices were developed using a mixture of interviews with experts, literature reviews, discussion groups, and piloting in the field (see Bolden, Waterson, Warr, Clegg, & Wall, 1997). During the telephone interviews, respondents were read out a definition of each of the seven practices (see Table 1) and asked if they were in use across

TABLE 1

Definitions of the Management Practices Used in the Study

Empowerment: Passing considerable responsibility for operational management to individuals or teams (rather than keeping all decision-making at the managerial level).
Extensive training: Providing a range of development opportunities for all employees (rather than training people occasionally to meet specific job needs).
Team-based working: Placing employees into teams with their own responsibilities and giving them the freedom to allocate work among team members (rather than having everyone work as individuals).
Total quality management: Seeking continuous change to improve quality and making all staff responsible for the quality of their work. (Such practices include Kaizen and continuous improvement).
Just-in-time production: Making products or providing services in direct response to internal or external customer demands (rather than building in advance to maintain stock levels).
Advanced manufacturing technology: Linking together computerized equipment to enable enhanced integration (such as CAD/CAM, computer-integrated manufacturing and flexible manufacturing systems).
Supply-chain partnering: Developing strategic alliances and long-term relationships with suppliers and customers (rather than negotiating on a short-term basis).

their organization (1996, 2000, and 2003 surveys). If a practice was used, they were then requested to state the year in which it had been introduced (1996 and 2003 surveys only). The questionnaire version of the survey deployed the same approach.

When the data set was arranged at the "time level" (i.e., each case was a year nested within a company), the year of introduction was used to calculate a simple dichotomous measure of practice use, which was coded as 0 "no use" or 1 "any use," for any particular year within each company. In the cases where a practice was not being used, we were able to impute 0s (i.e., "no use") for all the years up to the survey date. In those few occasions (1% of the total practices by firms) where a practice was reported as being used at one survey time point and then not used in a subsequent survey (i.e., the practice was dropped), we coded the subsequent years back to 0.

A consistency check on reported year of introduction and stated practice use was conducted using the subsample of 213 cases on which we had repeated survey measures. This enabled us to confirm, for example, whether the date of introduction for a given practice reported in 2003 was consistent with either reported use or nonuse of that practice in either or both 1996 and 2000. Agreement between the use and date of introduction measures was high. Only 16% of cases showed any discrepancies. In those few instances where we had differing responses for year of introduction from the same company (less than 20 cases for each practice), we used

the most recent respondent's figure. Analyses using the earlier respondent's dates in cases of discrepancy showed no meaningful difference in findings.

Company productivity. Following our theoretical stance, our study was designed to measure company productivity rather than profitability as an index of performance because such organizational efficiency indices should more directly reflect the impact of implementing the management practices (Combs et al., 2006; Patterson et al., 2004). Datta, Guthrie, and Wright (2005) consider that productivity is a crucial indicator of workforce performance and represents a direct link between human capital and organizational performance. Our focus on productivity rather than profitability measures, such as return on assets, is also based on the fact that the latter are more likely to be affected by a wider range of external factors that are beyond the control of the firm. Moreover, in reality the choice of performance indicator may be less significant than it appears, as a recent meta-analysis by Combs et al. (2006) showed no effect of performance measure on the relationship of HRM practices to company performance.

To measure productivity we employed a production function framework, representing the relationship between a firm's inputs and its outputs. Specifically, we estimated an augmented Cobb-Douglas production function

$$\ln Q_{it} = \beta_K \ln K_{it} + \beta_L \ln L_{it} + \beta_1 \text{PRACTICES}_{it} + u_{it}$$

where Q_{it} is the output of firm i in year t , K_{it} is the capital stock, L_{it} is labor, and PRACTICES captures the effects of the management practice(s). Value added is preferred to sales as a measure of output because it indicates the extent to which a firm's sales stem from their own production rather than production that is bought-in (for example, materials and components that are valued elsewhere), a distinction that is not made in the sales based measure. As such, value added provides the theoretically preferred measure of output because it evaluates efficiency by measuring its inputs to its own outputs (Kato & Morishima, 2002). The value of fixed assets is used as a measure of capital stock, and labor is measured by the number of employees.

Information on these variables was constructed from a data set provided by a UK credit reference agency. The data set covers the whole population of UK firms and provides a history of the financial performance of each firm between 1980 and 2003, though due to the small number of cases in the first two years of this period, we discarded the data prior to 1982. The data stem primarily from annual audited accounts held at Companies House in London. This information goes through various

checks and balances by the agency to ensure that any anomalies are corrected. This data set provides a measure of value added taken from information contained in each firm's profit and loss account (operating profit, labor costs, and depreciation). Both our measures of value added and capital stock were adjusted by a GDP-deflator so that each measure is standardized to 2001 prices.

Assembling the data at the time level we were able to collate, calculate, impute, and match up information on the use of all seven management practices and financial variables of interest for 4,184 cases, which comprise 4,184 years nested within 308 of our original 684 manufacturing companies (with a maximum of 22 years information between 1982 and 2003 for each company). This subsample of complete time-level data was used for our subsequent analyses.

Analysis Procedure

The data were analyzed by hierarchical linear modeling (also known as multilevel modeling) because of its natural two-level structure. This consisted of responses collected over a series of time points nested within subjects (i.e., companies). Hierarchical linear models partition the within and between subjects variance of the dependent variable at the simplest level by fitting random intercept terms for each company. Improvement in model fit between stages of analyses is determined by the change in -2 times the log-likelihood statistic (hereafter referred to as $-2LL$) relative to the change in degrees of freedom, which has a chi-square distribution.

Such techniques have a number of advantages, particularly within a longitudinal setting. First, they possess the flexibility to deal with unbalanced data structures such as ours (i.e., repeated measures data where data for some companies are incomplete over the period of the study) without resorting to listwise deletion of companies (Snijders & Bosker, 1999). Second, compared to standard regression techniques, they allow examination of within-subjects and between-subjects variance separately. In our case, this allows investigation of how much of the variation in performance explained by the use of a specific practice was variance within companies across time, and how much was between-companies variance. Third, it enables the testing of whether the effect of practice use is consistent across companies. Finally, the software used for this modeling (SPSS Mixed) allowed us to model the nonindependence of observations within companies by fitting an appropriate correlation structure to the level 1 residuals. In the case of longitudinal data, this is often the natural autoregressive correlation structure expected when measuring the same variable on the same subject over repeated time points. We chose multilevel modeling in preference to latent growth modeling because the former copes better with missing data, allows incorporation of autocorrelation structures

and deals with testing of alternative within-subjects variance-covariance matrix-type options.

The analytic strategy was to establish an initial baseline model for productivity, containing the control variables specified by the Cobb Douglas production function (labor and fixed assets, see Jones & Kato, 1995), a time effect and, if it significantly improved the model fit, an appropriate correlation structure to the time-level residuals. The inclusion of a time effect means that we can assess the effects of practice use over and above any underlying trends. Any significant variation across companies in the growth effect was tested by allowing the slope coefficient to vary, and this was retained in the model if it offered significant improvement.

Having established our baseline model, we investigated the main effect of each practice in turn by entering the dichotomous (dummy) variable indicating whether that practice was being used by a company at a specific time. Again, the size and direction of these effects was allowed to vary by company to see if this offered a significant gain in the fit of the model. We then investigated the nature of any gain in performance offered by the practices with respect to time, by first examining linear and quadratic models for growth in performance after the introduction, and then with a full decomposition of time-since-introduction effects for the 10 years following the adoption of a practice. For this we used means of a series of dummy variables representing each of the years since it was first used, with all the years preceding introduction as the reference category.

Finally, we fitted a series of models including multiple practices, based upon our additive or synergistic hypothesis. For each of the SHRM, integrated manufacturing, and lean production models, we first looked at the unique main effects of the relevant practices when entered together, and then the interactions among them. When fitting the interactions, we considered the full-factorial models for the SHRM (empowerment, extensive training, teamwork), integrated manufacturing (total quality management, just-in-time, and advanced manufacturing technology), and core lean production (total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering) models. However, following this procedure for the extended lean production model would require the addition of up to seven-way interaction terms, which has practical model-fitting and interpretability problems. The effect of measurement error when using multiplicative terms in regression is to exponentially decrease sensitivity for each extra level of interaction (Aiken & West, 1991; Busmeyer & Jones, 1983). Such analyses are sensitive to two-way interactions, less so to three-way and four-way ones, and certainly incapable of detecting the seven-way interaction implied by lean production. Thus, although we test the three-way interactions for the variables that make up the SHRM and integrated manufacturing approaches, we focused our tests of the synergy hypothesis for lean production management on the relative size

and direction of the two-way interactions to see how they correspond to expectations.

It is relevant to note that our methodology is similar to the Ichniowski et al. (1997) small scale study of 36 steel production lines in that they also took longitudinal productivity data and related this to adoption of different HRM practices. However, our approach advances that study by: examining a larger, more diverse sample of manufacturing companies; assessing operational management as well as HRM practices; analyzing a much longer time period of performance data; and using multilevel statistical modeling techniques rather than standard regression.

Results

Extent of Adoption

Within our 308 manufacturing companies, there was a high rate of up-take of the practices during the 22-year period. 20.5% of companies had adopted all seven practices during this time, 37.6% four to six practices, 30.2% one to three practices, and only 11.7% had not implemented any. With regard to the type of practice, 63% of companies had adopted total quality management, 53% just-in-time, 55% advanced manufacturing technology, 65% supply-chain partnering, 53% teamwork, 58% empowerment, and 55% extensive training.

Table 2 shows the average intercorrelations between practice adoption from the years 1982 to 2002 (the year 2003 included insufficient data for all practices). The overall level of correlations is moderate, ranging from 0.18 (for just-in-time and empowerment) to 0.38 (for teamwork and empowerment), suggesting that they can be dealt with as separate initiatives rather than cooccurring sets of practices. In general, the HRM practices showed slightly higher levels of intercorrelation among themselves compared to the operational management practices.

Preliminary Analyses

The first stage of the modeling process was the construction of a baseline model, which consisted of the Cobb Douglas production function (labor and fixed assets), a time effect, and the appropriate level 1 residual correlation structure. As recommended by Singer and Willett (2003), we initially fitted the unconditional means (intercept only) model, shown in Table 3, Step 1, which simply partitions the variance into between- and within- company, followed by the unconditional growth model (intercept and time), before introducing labor and fixed assets as predictors. Unsurprisingly, the within-company variation in productivity over the study

TABLE 2
Intercorrelations Between Practice Adoption Averaged Over Period 1982–2002

	EMP	ET	TMW	TQM	JIT	AMT
Empowerment (EMP)						
Extensive training (ET)	.33 (.14)					
Teamwork (TMW)	.38 (.16)	.26 (.10)				
Total quality management (TQM)	.25 (.13)	.28 (.12)	.25 (.10)			
Just-in-time (JIT)	.18 (.08)	.23 (.09)	.20 (.08)	.24 (.10)		
Advanced manufacturing technology (AMT)	.24 (.12)	.22 (.15)	.13 (.09)	.18 (.10)	.22 (.13)	
Supply-chain partnering (SCP)	.31 (.07)	.24 (.09)	.31 (.10)	.33 (.10)	.33 (.08)	.15 (.11)

Phi coefficients derived from averaging yearly correlations between practices from 1982 to 2002.

N varies from minimum of 122 organizations to maximum of 284 organizations in any one year.

Figures in brackets indicate standard deviation of phi coefficient.

period was substantially less than the between-company differences, resulting in a large intra-class correlation (the proportion of the total variation that lies between companies) of .79, justifying our use of a technique that enables us to separate the variance into its constituent parts.

Introducing the time variable, simply the year of observation rescaled to aid the model fitting procedure (so that the first year of the study period, that is, 1982 took a value = 0, 1983 = 1, etc.), reduced the unexplained time-level variance by almost half. The effect of time was positive ($B = .04, p < .01$) indicating a growth in productivity over the period, with a dramatic improvement in model fit ($-2LL = 6,088, \Delta -2LL = 1,956$). The significant slope variance coupled with the negative intercept-slope covariance suggest that the strength of this effect varies significantly among companies, and that those companies starting the period with relatively low productivity were more likely to have productivity growth.

Both variables that form the Cobb Douglas function had a significant impact on productivity, with labor showing a stronger effect than fixed assets. Together they explained a large portion of the between companies variance, reducing the $-2LL$ statistic to 2,654 ($\Delta -2LL = 3,434$).

The baseline model was completed by selecting a correlation structure to model the within-company residuals, which we would expect to be positively related at adjacent time points with the relationship weakening as the gap between time points increases. To this end, both first-order autoregressive (AR1) and first-order autoregressive moving average (ARMA) structures could be appropriate. We then investigated whether either significantly improved the fit of the model, with the former chosen

TABLE 3
Effects of Extended Lean Production Practices on Productivity from Multilevel Longitudinal Regression

	Fixed effects B	Fixed effects SE	Random effects variance	Random variance	-2LL	Δ -2LL [‡]
<i>Step 1: Unconditional means model</i>				.301	8,044	
Intercept	15.851**	.061	1.142**			
<i>Step 2: Baseline model</i>				.103	2,255	5,789
Intercept	9.263**	.131	.166**			
Time	.009**	.002	.001**			
Fixed assets (log)	.109**	.012				
Labor (log n employees)	.839**	.017				
<i>Step 3: Practices entered individually</i>						
Empowerment	.068**	.023	.016	.097	2,237	18
Extensive training	.063**	.025	.036**	.101	2,236	19
Teamwork	.039	.032	.146**	.101	2,149	106
Total quality management	.031	.020	.041**	.098	2,235	20
Just-in-time	.031	.026	.058**	.099	2,233	22
Advanced manufacturing technology	.015	.025	.051**	.101	2,232	23
Supply-chain partnering	-.027	.032	.129**	.099	2,155	100

N = 4,184 cases from 308 manufacturing companies.

[‡]Model estimation by restricted maximum likelihood hence significance test for change in -2LL due to additional fixed effects is not applicable.

p* < .05 (one-tailed tests). *p* < .01 (one-tailed tests).

due to its relative simplicity, and because of the latter's tendency to produce nonconvergent model solutions. This reduced the -2LL model fit statistic to 2255. The full set of statistics for the final baseline model is given in Table 3, Step 2.

Practice Effects on Company Performance

Hypotheses 1a and 2a stated that each of the seven management practices would lead to improved company productivity. To test this, in the next stage of the modeling process, we added the dichotomous measure of each practice use separately to the baseline model as a fixed effect, and then allowed random slopes for these effects (see Table 3, Step 3). Of the seven practices, empowerment (*B* = .068, *p* < .01) and extensive training (*B* = .063, *p* < .01) each has a significant positive main effect on productivity. For empowerment the effect is consistent across the sample, with the variance of the slope effects being nonsignificant; but for extensive

training the model fit is significantly improved by allowing slopes to vary by company. The fixed effects of the remaining five practices are not statistically significant. However, allowing the effect of use to vary by company produced a significant slope variance and model improvement for each of the other practices, suggesting that each of them has a substantial positive effect on performance in at least some of the 308 companies, but no effect or negative effects in others. Further investigation confirmed that this significant variance across companies in the effects of six of the seven practices is not accounted for by interactions of the practices with size, sector, or each other.

Linear and quadratic fits of “years since practice introduction” were then explored for each practice. There is no evidence of any practice driving a continuous improvement in productivity that would fit a linear model, nor the clearly structured increase followed by leveling off or decline that a significant quadratic fit would have implied.

To examine exactly how the effect of practice use did manifest itself, each years-since-practice-introduction variable was decomposed into 11 dummy variables as described above. For each practice in turn, we examined the effects of these dummy variables in comparison to the period before introduction, adjusting for the effects of multiple testing by using a Bonferroni correction (i.e., dividing our significance level by 11). Of the seven practices, only empowerment and teamwork yield a clear pattern of adjacent years showing significant effects. Empowerment is at its most effective in terms of improving performance between 1 and 7 years after it was first used, whereas teamwork only offered a significant positive effect after 6 years of use, maintaining this benefit until the 10th year post introduction. Of the other practices only extensive training has significant effects for any year since introduction, though there was no obvious pattern to its sequential effects. The fixed effects coefficients for empowerment, extensive training and teamwork as a function of year since introduction are given in Table 4. Hypothesis 1a regarding the independent effects of the SHRM practices therefore gathers some support, whereas Hypothesis 2a regarding the direct impact of the operational practices is not supported.

Interactions Among Practices as Predictors of Company Performance

To assess Hypotheses 1b, 2b, and 3, which concern the multipractice models, we first considered the unique effects of individual practices that constitute the SHRM, integrated manufacturing, and extended lean production systems by entering those practices together. The fixed effects for all three models are given in Table 5. For the SHRM model, empowerment and extensive training have statistically significant unique effects.

TABLE 4
*Fixed Effects of Empowerment, Extensive Training and Teamwork on
 Productivity as a Function of Years Since Introduction*

	Empowerment		Extensive training		Teamwork	
	B	SE	B	SE	B	SE
Controls						
Time	.006**	.003	.006**	.003	.006**	.003
Fixed assets	.108**	.012	.109**	.012	.107**	.012
Labor	.839**	.017	.840**	.017	.841**	.017
Years since implementation						
Same year	.007	.023	.010	.023	-.006	.024
1 year	.075*	.029	.061	.030	.031	.030
2 years	.092*	.032	.087*	.033	.069	.033
3 years	.093*	.035	.044	.035	.053	.035
4 years	.099*	.038	.083	.038	.071	.038
5 years	.102	.040	.041	.041	.087	.040
6 years	.106	.043	.079	.043	.110*	.043
7 years	.139*	.046	.102	.046	.145*	.046
8 years	.014	.050	.091	.049	.137*	.049
9 years	.049	.054	.091	.052	.154*	.052
10+ years	.075	.053	.105	.050	.102	.051

N = 4,184 cases from 308 manufacturing companies. Significance levels of year dummies adjusted by Bonferroni correction for multiple testing.

p* < .05 (one-tailed tests). *p* < .01 (one-tailed tests).

In contrast for the integrated manufacturing model, none of total quality management, just-in-time nor advanced manufacturing technology has a statistically significant effect on productivity. The findings for the extended lean production model simply replicate findings for the SHRM practices of empowerment and extensive training, showing these remain statistically significant even when the four operational practices of core lean production also are taken into account.

To test for synergy we examined the interactions among practices within each set. Neither the three-way interaction for SHRM nor that for integrated manufacturing is statistically significant (having controlled for constituent two-way interactions), nor is the four-way interaction for the core lean production model. Hypotheses 1b and 2b are therefore not supported. With regards to the 7-practice extended lean production model we considered just the 21 possible pairs of two-way interactions, for the sake of parsimony, interpretability, and practicality. Considering each pair in turn, it is evident that virtually all interactions are positive and two-thirds are statistically significant at *p* < .05, providing evidence for the existence of some synergy between various practices and indicating partial support for Hypothesis 3 (see Table 6). The impact of teamwork is particularly significant as it moderates the effect of all other practices.

TABLE 5
Unique Fixed Effects of Management Practices on Productivity in Theoretical Multipractice Models

	Strategic human resource management		Integrated manufacturing		Extended lean production	
	B	SE	B	SE	B	SE
Controls						
Time	.005**	.002	.007**	.003	.006**	.003
Fixed assets	.107**	.012	.108**	.012	.106**	.012
Labor	.840**	.017	.840**	.017	.841**	.017
Practices						
Empowerment	.047*	.023			.049*	.024
Extensive training	.043*	.022			.043*	.023
Teamwork	.010	.023			.008	.024
Total quality management			.024	.021	.012	.022
Just-in-time			.031	.021	.028	.022
Advanced manufacturing technology			.007	.022	-.001	.022
Supply-chain partnering					-.043	.021

N = 4,184 cases from 308 manufacturing companies.
 p* < .05 (one-tailed tests). *p* < .01 (one-tailed tests).

TABLE 6
B Coefficients from Tests for Two-Way Interactions Among the Lean Production Practices in the Prediction of Company Productivity

	EMP	ET	TMW	TQM	JIT	AMT
Empowerment (EMP)						
Extensive training (ET)	.059					
Teamwork (TMW)	.101*	.075*				
Total quality management (TQM)	.072*	.060*	.093**			
Just-in-time (JIT)	.043	.086**	.083*	.078*		
Advanced manufacturing technology (AMT)	.052	.001	.097**	-.004	.010	
Supply-chain partnering (SCP)	.111*	.011	.073*	.077*	.093*	.063*

N = 4,184 cases from 308 manufacturing companies.
 p* < .05 (one-tailed tests). *p* < .01 (one-tailed tests).

Supplementary Analyses

In order to address the issue that other HRM practices might be responsible for the potentially spurious relationships shown by empowerment, extensive training, and teamwork, we conducted some additional analyses. The 2003 survey contained additional questions about the use or not of

selection, appraisal, and performance-related rewards practices. We reran the analyses for Tables 3 and 5 including these three additional practices. There were no significant fixed or random effects for selection, appraisal, or reward practices though it should be noted, this involved a reduced sample of 936 observations from 55 companies.

Discussion

Theoretical Implications of Individual Practice Effects

We hypothesized that the introduction of each of the three SHRM practices and each of the four operational manufacturing management practices would independently promote company productivity. That was supported for the SHRM practices of empowerment and extensive training, but not for teamwork. However, none of the four operational practices of total quality management, just-in-time, advanced manufacturing technology, or supply-chain partnering showed a significant effect. This essentially replicates the findings of Patterson et al. (2004), who also found effects for empowerment (job enrichment) and skill enhancement, but not for total quality management or just-in-time, and only a limited effect for advanced manufacturing technology.

The findings for empowerment and extensive training in our study were not only statistically significant but also practically meaningful, with the effect for empowerment representing a gain of nearly 7% in value added per employee, and that for extensive training a gain of over 6%. The findings were also robust in that both effects remained statistically significant when controlling for all other practices, and together empowerment and extensive training accounted for a 9% increase in value added per employee. The results also support the view that there is a time lag before the effects of a management practice translate to changes in organizational performance (Kozlowski & Klein, 2000; Wright et al., 2005). Interestingly, the pattern of these time lags differed between our HRM practices. For empowerment, productivity improvements were shown from 1 to 4 years after its introduction, whereas for teamworking productivity increases were not evident until 6 to 9 years after implementation. It may be the case that with empowerment employees already have useful knowledge but they are simply given the freedom to apply it more immediately for performance benefits (Leach et al., 2003) but with teamworking it may take a longer period of time for employees to learn to work together effectively and hence delay organizational impact. Future theory and research needs to uncover the reasons for these differential time lags. This study therefore highlights the need to examine practice effects longitudinally and also individually, rather than just aggregating across practices.

A strength of our multilevel regression analysis is that it provided not only a conventional test for the overall effect (the fixed effect) as considered so far, but also a test of whether that effect was consistent across companies (random effects variance). The fact that the random effects variance for empowerment was statistically insignificant indicates that its effect was equivalent across all companies in the sample, which supports a universalistic interpretation. In contrast, the statistically significant random effects variance for extensive training shows that its impact differs across the companies, which suggests a contingency approach is more appropriate for this practice. The variation ranged from substantial positive effects in some cases to weak negative effects in others. Further analysis of potential contingency variables (size, sector, and other practices) revealed that they did not account for these differences across companies. This suggests a major line of inquiry for further research. One possibility, of course, is that the variation of effect across companies results from differences in how well they implemented the practice in question, a point we broach when we discuss the limitations of this study. But this argument could imply that companies introduced empowerment equally well but differed in their ability to successfully introduce extensive training and it is not clear why this should be so.

In contrast to the results for empowerment and extensive training, we found no overall performance effect for the other five practices. As with extensive training, however, the statistically significant random effects variance for teamwork and for all of the four operational practices indicates that their effects vary across companies. This shows that the introduction of these practices led to improved productivity in some companies, consistent with reports of success in cases studies in the literature, but not an overall general positive effect. For this reason, identification of the contingencies that determine when these practices have a positive effect is of considerable importance. Moreover, as we found for extensive training, the search for these contingencies needs to go beyond the variables considered in this study as these also fail to account for the observed differences in effects across companies.

There are a number of potential reasons for the failure of the operational management practices to demonstrate a significant main effect with productivity. First, it may be that these types of practices are so diffuse within the industry that they fail to provide any competitive advantage as so many other organizations have also implemented them (Goodman, 2000). In our sample, total quality management (adopted by 63% of companies) and supply-chain partnering (adopted by 65% of companies) were indeed the most prevalent practices but these figures were not that much greater than those for the HRM practices. Second, the operational management practices are more complex systems than the HRM ones and hence our

core description may not have captured the full diversity of these systems in place, that is, there may have been more room for measurement error. Third, we did not assess the quality of implementation of the practices, and due to the complexity of the operational management practices, there may have been issues with regards to this that were not captured. For example, Patterson et al. (2004), who reported similar findings to ours, interviewed the managers in their study and found that although they reported adopting total quality management and just-in-time processes, they commonly felt they did not have the resources to fully implement them. These issues lead to the suggestion for future studies to evaluate the implementation of practices in more detail.

In discussing our results, it is worth mentioning the possibility that any significant relationships between the management practices and performance could, in fact, reflect a third omitted factor (Becker & Huselid, 2006). We found that there was a degree of intercorrelation between the HRM practices and this has been found in other studies (e.g., Huselid et al., 1997; Patterson et al., 2004). It may therefore be the case that alternative, omitted practices were responsible for the observed effects. We examined this possibility through supplementary analyses, adding selection, appraisal, and performance-related pay to the existing practices but found no significant effect of them on productivity. Alternatively, Wright et al. (2005) suggest that organizational culture or effective leadership can lead to both higher organizational performance and HRM practice use. For example, Huselid and colleagues (Huselid & Becker, 1997; Huselid et al., 1997) found that rated management effectiveness accounted for some of the variance in the practice–performance relationships in their research. If a general third variable were responsible for the effects found, we would have expected a systematic pattern of relationships across the practices we examined, for example, all the HRM practices having a positive main effect and in the same time frame. This was not the case in our study. However, the issue can only be clarified if, in future, potential confounding factors such as leadership effectiveness are assessed along with a wider range of practices.

Theoretical Implications of the Interactions Among Practices

The second stage in our analysis was driven by three theoretical perspectives, which led us to consider the effects of particular sets of practices and the interactions among them. The first of these is that of strategic human resource management, where two of the three constituent practices, empowerment and extensive training, were found to have effects in their own right. The third practice, teamwork, though not having an equivalent

direct effect, nonetheless was shown to enhance the effect of the other two high-performance practices. This gives credence to the theoretical position that it is through the development of human resources that companies are likely to gain competitive advantage, a view further strengthened by the lack of effects for the operational practices (see next). Nonetheless, because the three-way interaction is not significant, the results do not fully support the SHRM model.

In contrast the results for integrated manufacturing, represented by three of the operational practices, namely total quality management, just-in-time, and advanced manufacturing technology, did not support the underlying theory. The three together were expected to affect performance as a complementary set and through the interactions among them. The findings fail to support that prediction as neither direct effects nor the full set of interactions were evident. There was a positive two-way interaction between total quality management and just-in-time, indicating that each practice had a more positive effect on performance when accompanied by the other, but the other two-way interactions, and crucially the three-way interaction, were not found.

The findings with regard to our final theoretical perspective of lean production are less clear cut. With regard to core lean production we have already established the lack of effects for total quality management, just-in-time, and advanced manufacturing technology, and the additional practice of supply-chain partnering also failed to have a direct effect. Even taking all four practices together there is no evidence of an effect on company performance. However, there is some evidence of synergy, as supply-chain partnering appears to enhance the effectiveness of all the other three operational practices. Turning to the extended form of lean production, which also includes the three human resource practices, collectively they show the expected effect (albeit this is due basically only to empowerment and extensive training). However, the pattern of significant interactions among practices provides some support for this perspective. There is evidence of synergy among the four operational practices, as four of the six two-way interactions were statistically significant. At the same time, the high proportion of positive two-way interactions between the three human resource practices and the four operational ones supports the lean production assumption that the effectiveness of operational practices depends on human resource ones (Parker, 2003). It may well be the case that variations in the success of operational management practices reported in previous literature could have been explained by the presence or absence of SHRM practices but which were not measured at the time. As discussed earlier, higher order interactions consistent with the lean production construct (e.g., a seven-way interaction) were not examined because it was not viable to do so.

Overall, we conclude that there is partial support for both the SHRM and the extended lean production perspectives, but no definitive confirmation of the full forms of either. The Combs et al. (2006) meta-analysis of HRM practices and performance also indicated that high-performance work practice (HPWP) systems showed stronger relationships than did individual practices with organizational performance. However, in their study, they did not distinguish between different groupings of HPWP systems, whereas we demonstrated that theoretical clusters of practices differ in their relationship with organizational performance. The clearest and most parsimonious theoretical implication of this study, however, is the support it provides for the resource-based view of the firm (Barney, 1991) that underlies the SHRM approach (Becker & Huselid, 2006). The implication of this approach is that empowerment, extensive training, and teamwork should have stronger positive effects on company performance than their operational counterparts. The rationale is that knowledge specific to a company that these SHRM practices are likely to enhance will not benefit their competitors, whereas total quality management, just-in-time, advanced manufacturing technology, and supply-chain partnering are more easily transplanted according to need. Although the estimation method used in the analyses, based on restricted maximum likelihood, precludes a formal test of the significance of the difference between the SHRM and operational practice effects, the pattern of findings is clear. Consistent with the resource-based view, it is the SHRM variables that stand out as determinants of company performance, and their effects are stronger than those of the other operational practices.

Limitations

This study has many strengths relative to its precursors, the most prominent being: its longitudinal design with multiple measures of performance before and after the introduction of the practices; use of an objective company performance measure (i.e., externally audited financial data); and a large sample of companies. Nonetheless, it does have limitations. The first of these concerns the measurement of the practices. We used conceptually based descriptions of the practices that were derived from expert interviews and a review of the literature but these may have been too simple in overview and response to capture the variance in adoption and implementation by firms. Furthermore, the frame of reference for the respondents was the total employee population and future studies could do with examining if there are any differential practice effects when comparing various sections of the workforce, for example, empowerment of sales versus manufacturing teams. The date of introduction was obtained by self-report from a single respondent, and we have only limited evidence of its reliability and validity. There are reasons, however, for

believing that this may not be a major concern. The data from a sample of over 200 cases on which we had repeated measures for the same company from different respondents, showed 84% consistency with regard to whether or not and when a practice was in use. It could be argued that where there were discrepancies, these could have been for reasons such as the inaccurate recall or lack of sufficient organizational tenure of respondents; or that the breadth of the definition of practices led to some differences in interpreting what would be considered an introduction of a practice. However, the pattern of findings suggests the given date had some validity because all recorded effects were subsequent to the stated year of introduction, with none either before or even contemporaneous. We also reanalyzed the data using the earlier respondents' date of introduction in cases of discrepancy and this had a minimal impact on our findings.

Another limitation is our focus on the use of practices rather than on their effective use. Though use or extent of use, has been the metric in almost all studies to date (for an exception measuring effectiveness in the human resource management field see Huselid et al., 1997), there is a strong argument that the impact of practices will be affected by how well they are implemented. For example, implementing teamwork without ensuring individuals have the need, willingness, and ability to work together is likely to disrupt their performance rather than enhance it. It is likely, of course, that use and effective use are strongly linked, as inadequate initiatives are likely to be improved or abandoned. Nonetheless, if effective implementation moderates the effects of these practices, then findings based simply on use will be attenuated. This means that our positive findings for empowerment and extensive training would stand and be even stronger, but that the absence of effects for the other practices may be incorrect. The implication is that future studies should attempt to measure effective implementation, which suggests the need to assess practices against explicit criteria. Some form of independent auditing would be ideal in order to gauge this as well as to further check the reliability and validity of the measures. However, given the sample sizes required, this leads to a need for much larger and more labor-intensive research programs than have been used to date (Wall & Wood, 2005). A more cost-effective method would be to use self-report surveys that ask respondents systematically to assess in detail key elements of the practices and indicators of successful implementation. Another situational contingency to consider is the strategic approach of the firm. It is often argued that certain practices are more appropriate for certain strategies, the implication being that they will yield more or less performance benefits depending on the strategic context (e.g., Miles & Snow, 1984). We might, for example, hypothesize that in firms whose goals are developing innovative, niche products HR practices will have a greater link to performance than operational ones,

while in firms focused on speed of delivery and cost reduction both sets of practices may be equally significant.

A final limitation is that our work focuses solely on manufacturing companies. This is appropriate for advanced manufacturing technology that is sector-specific, and to a lesser extent to just-in-time and supply-chain partnering, which are used elsewhere such as in retailing. However, total quality management, and especially the human resource management practices of empowerment, extensive training, and teamwork, are much more widely applied. Interestingly, Combs et al. (2006) suggest that the effects of high-performance work practices is stronger in manufacturing rather than service industries. It has yet to be determined whether our findings for all these practices generalize to other sectors, or indeed to other countries outside the UK.

Practical and Policy Implications

The practice that stands out as most likely to promote company productivity is empowerment, consistent with the resource-based view of the firm and SHRM perspectives put forward by many such as Barney (1991), Pfeffer (1994), and Lawler et al. (1995). Thus, additional to any normative and quality of working life arguments in favor of promoting empowerment there is an economic one. The next best practice is extensive training, which means investment in training and education beyond the requirements of the immediate task. Our findings suggest that the adoption of this practice will enhance company performance, though effects are variable. Together, empowerment and extensive training accounted for a 9% increase in value added per employee in our study. Moreover, teamwork seems to enhance the effect of all other practices and supply-chain partnering had the same effect on all but extensive training. There is no practice that does not appear to have some effect when combined with one or more other practices. There is thus no evidence to suggest that those using any of the practices that do not have a strong independent effect on performance should stop doing so. However, in cases where the effects of a practice are situationally contingent there may be a certain type of company or context in which the practice may currently be having detrimental effects on performance. This makes the quest to explain such diversity an even more telling concern for future research.

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