Journal of Applied Psychology
2003, Vol. 88, No. 4, 620–634

0021-9010/03/$12.00 DOI: 10.1037/0021-9010.88.4.620

Longitudinal Effects of Lean Production on Employee Outcomes and the Mediating Role of Work Characteristics

Sharon K. Parker
The University of New South Wales and University of Sydney

The author discusses results from a 3 year quasi-experimental field study ($N = 368$), which suggest negative effects on employee outcomes after the implementation of 3 lean production practices: lean teams, assembly lines, and workflow formalization. Employees in all lean production groups were negatively affected, but those in assembly lines fared the worst, with reduced organizational commitment and role breadth self-efficacy and increased job depression. A nonequivalent control group had no negative changes in outcomes. Mediational analyses showed that the negative effects of lean production were at least partly attributable to declines in perceived work characteristics (job autonomy, skill utilization, and participation in decision making). The study also shows the longitudinal effects of these work characteristics on psychological outcomes. Implications for lean production, work design, and employee well-being are discussed.

Although originating in Toyota, Japan, lean production has spread to organizations throughout the world (MacDuffie & Pil, 1996) and has been applied beyond auto manufacturing into new production domains and the service sector (Landsbergis, Cahill, & Schnall, 1999). The lean production approach combines various practices so as to simultaneously improve efficiency, quality, and responsiveness to customers (Applebaum & Batt, 1994). It is a broad concept with implications for many aspects, such as product design, supplier relations, industrial relations, and sales. In the current article, I focus on its implications for work organization, which is a contentious issue. Several scholars see lean production as having negative consequences for employees' and their job quality, but others view lean production as a way of achieving world-class performance in a humane way with positive effects on employees.

The current article pertains to this debate. First, in an area in which there are few rigorous studies, it presents a quasi-experimental study of lean production and its effects on job quality and employee outcomes. Second, rather than assuming a singular production concept, the study compares the effects of three distinct practices adopted in lean production contexts. Third, linking lean production to the well-established research on work design, the study tests a theoretical framework that proposes that the effects of lean production on outcomes are mediated by work characteristics. The background behind these goals is elaborated next.

Lean Production, Work Characteristics, and Employee Outcomes

The extent to which lean production differs from mass production, and consequently its effect on work characteristics and employee outcomes, is hotly debated. Womack, Jones, and Roos (1990, p. 99), the key advocates of lean production, identified two ways lean production is distinct from mass production. First, "it transfers the maximum number of tasks and responsibilities to those workers actually adding value to the car on the line." This means that there is an emphasis on removing wasted time and motions so as to maximize the value-adding proportion of working time. Various techniques are used to ensure maximum work loads, but, in contrast to Taylorism, the work standards are determined by the employees themselves rather than solely by management or engineers. The second key feature of lean production identified by Womack et al. (1990, p. 99) is that "it has in place a system of detecting defects that quickly traces every problem, once discovered, to its ultimate cause." The system involves multiskilled operators, typically organized into small teams, being responsible for quality, continuous improvement, and problem solving (Niepce & Molleman, 1998; Taira, 1996). The inclusion of nonproduction tasks within teams, and the emphasis on employee participation in improvement and problem solving, is argued to result in greater job enlargement, cross-training, and challenge than mass production (Taira, 1996; Womack et al., 1990). As such, lean production is purported to remove the "mind-numbing stress" associated with mass production (Womack et al., 1990, p.102) and to create "a highly motivating work environment" (Adler, 1993, p. 86).

Others, however, do not view lean production as a fundamentally distinct and more humane system. Rather, lean production is

Sharon K. Parker, Australian Graduate School of Management, The University of New South Wales and the University of Sydney.

Earlier versions of this article were presented at the 1999 American Psychological Association/National Institute for Occupational Safety and Health International Conference on Work, Stress, and Health, Baltimore, Maryland, and the 1998 British Psychological Society Annual Occupational Psychology Conference, Eastbourne, United Kingdom.

I thank the United Kingdom Health and Safety Executive who partially funded this research, especially Ann Needham for her assistance and support. I also acknowledge the participants in the collaborating organization, colleagues and students at the University of Sheffield who helped to collect the field data, and Nick Turner and Mark Griffin for their very helpful comments on drafts of the article.

Correspondence concerning this article should be addressed to Sharon K. Parker, Australian Graduate School of Management, The University of New South Wales, Sydney, New South Wales 2052, Australia. E-mail: sharonp@agsm.edu.au

considered to be intensified mass production or *neo-Taylorism* (Dankbaar, 1993; Tsutsui, 1998). It is argued that the multiple tasks are variations of similar simple jobs with short training requirements, representing multitasking rather than multiskilling (Delbridge, Turnbull, & Wilkinson, 1992). The level of employee participation in decision making is suggested to be very limited (Berggren, 1992; M. Parker & Slaughter, 1988), and the teamworking element of lean production, portrayed so positively by advocates, has been argued to exploit peer pressure to "facilitate the process of work intensification" (Turnbull, 1988, p. 14). Critics (e.g., Babson, 1993; Delbridge et al., 1992; Turnbull, 1988) have used terms such as *mean production* or *management by stress* to convey the negative consequences of lean production for employee motivation and well-being.

Unfortunately, this debate about the effect of lean production on work characteristics and employee outcomes is not resolved by empirical evidence. On one hand, negative consequences of lean production have been documented in detailed case studies (e.g., Fucini & Fucini, 1990; M. Parker & Slaughter, 1988), large scale surveys (Lewchuk & Robertson, 1996), and comparative or longitudinal studies (e.g., Berggren, 1992; Jackson & Martin, 1996; Kaminski, 1996; Klein, 1991). Landsbergis et al. (1999) tentatively concluded in a review of lean production studies that this practice is likely to result in increased demands and work pace and in modest or no changes in decision latitude and autonomy. On the other hand, several studies have identified positive consequences of lean production and related practices (e.g., Adler & Cole, 1993; Mullarkey, Jackson, & Parker, 1995), or a mixture of both positive and negative consequences (Berg, Appelbaum, Bailey, & Kalleberg, 1996; Jackson & Mullarkey, 2000).

One explanation for these inconsistent findings resides in the methodological inadequacies of many of the existing studies of lean production, which leave open alternative interpretations of the findings. For example, in their review, Landsbergis et al. (1999) were forced to rely on many case studies, rather than rigorous empirical studies, and on studies that had not been published in peer reviewed journals. The current study has a longitudinal quasi-experimental research design that allows stronger inferences of causality than most existing lean production studies.

A second reason for the inconsistent findings is that what constitutes lean production varies considerably among studies. As Kochan, Lansbury, and MacDuffie (1995, p. 303) observed, lean practices "are not as singular in cause, character, or effect as Womack, Jones, and Roos thought they would be." Consistent with a nondeterministic approach to technology implementation (Corbett, 1992), it has been argued that many factors influence the shape of particular production strategies, including product markets, technology, labor market conditions, and the role of trade unions, government policies, and national institutions (Berggren, 1992). Thus, when lean production is introduced, it is often accompanied by modifications that adapt it to local conditions. For example, Adler and Cole (1993) described how the harsher elements of the lean model were modified at the Toyota-General Motors joint venture plant in California, New United Motor Manufacturing Incorporated (NUMMI). Similarly, organizations often introduce hybrid systems that include aspects of both lean and mass production systems (MacDuffie & Pil, 1996). Lean production can also vary in how it is implemented. Adler and Borys (1996) predicted that the workflow formalization component of lean production (i.e., the systematic recording and standardizing of work procedures) will have more negative effects on jobs and outcomes if it is designed to be coercive (i.e., a means by which management attempts to coerce employees' effort and compliance) rather than enabling (i.e., a means by which employees can carry out their tasks more effectively).

Lean production is thus not a single unitary production concept, either in its design or in its implementation. This has two important research consequences. First, it is important to understand precisely what elements of lean production are being introduced in the particular context. As Landsbergis et al. (1999) urged, researchers should not rely on labels but should carefully describe the work reform. Indeed, because some lean production practices might have positive effects (e.g., team working), whereas others might have negative effects (e.g., short cycle times), researchers should separately evaluate the particular initiatives being introduced. In the current study, three types of lean production practices (described later) are compared with each other and with a comparison group that has not experienced lean production. The second consequence of variation in lean production is that it is important to develop a theoretical framework for understanding the processes by which the various practices affect outcomes. By understanding how and why lean production practices affect outcomes, we can better identify what factors moderate the relationship. I address this framework next.

Mediational Framework for Understanding Lean Production

I propose that work characteristics mediate the link between lean production practices and employee outcomes. In other words, the effect of lean production on outcomes depends, at least in part, on its effects on employees' work characteristics. Figure 1 depicts this framework.

This mediational framework draws on job characteristics theory, which proposes that work characteristics such as job autonomy and skill variety should be present in jobs to achieve outcomes such as employee morale, work motivation, and performance (Hackman & Oldham, 1976). Meta-analyses and reviews support the notion that the presence of core work characteristics, particularly job autonomy, can lead to positive employee attitudinal outcomes (Fried & Ferris, 1987; S. K. Parker & Wall, 1998). Job characteristics theory provides a framework for understanding the effects of lean production because it is expected that this practice will systematically affect important work characteristics.

This idea that the effects of a particular organizational structure or practice depend, at least to some degree, on how it impinges on work characteristics is not a new one. Rousseau (1978; see also Brass, 1981) showed that job characteristics largely accounted for the relationship between organizational structure and technology and individual attitudes and behavior (e.g., job satisfaction, propensity to leave). More recently, the indirect or mediating role of work characteristics has been suggested (S. K. Parker, Wall, & Cordery, 2001), and in some cases demonstrated, in relation to practices such as just-in-time (Jackson & Martin, 1996) and temporary employment status (S. K. Parker, Griffin, Sprigg, & Wall, 2002). However, with the exception of one study (Jackson & Mullarkey, 2000), the mediating role of work characteristics has not been explicitly examined in relation to lean production. Adler

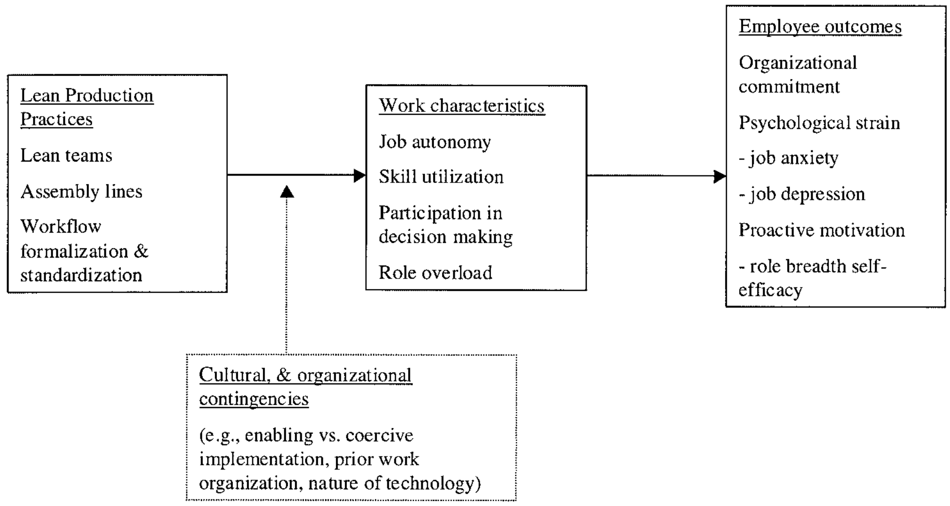

Figure 1. Model of the effects of lean production of work characteristics and employee outcomes. The dotted lines represent hypothesized relationships that are not tested in the current study.

and Borys (1996) implicated work characteristics when they explained why enabling approaches to workflow formalization have positive benefits, such as how employee participation in developing standard work procedures might increase participation in decision making and thus support, rather than degrade, skill use. However, these researchers did not specifically posit any mediational pathways nor did they consider the effect of workflow formalization on job autonomy, a key work characteristic that is very likely to be affected by lean production.

The mediational framework in the current study includes the following key work characteristics: job autonomy, skill utilization, participation in decision making, and role overload. Each of these is known to affect employee outcomes, and each is salient in the context of lean production. Job autonomy, or an employee's control of the timing and method of his or her work tasks (S. K. Parker & Wall, 1998), is pertinent given reports of increasingly standardized work processes and tightly linked work flows that can reduce employee control (Turnbull, 1988). Skill utilization, or an employee's opportunity to use his or her existing skills and to acquire new ones (Warr, 1999), is relevant because some believe skill utilization is increased as a result of lean production (Womack et al., 1990), whereas others argue that it will be diminished (Turnbull, 1988).

The effects on participation in decision making, or the degree to which employees have influence over more distal issues that affect their task domain (Ashforth, 1989), are equally contentious. Adler (1993) suggested that employee participation in decision making differentiates aspects of lean production from mass production and that it is the reason for the (presumed) enhanced productivity of the former. Adler further suggested that employees accept low autonomy and narrower jobs because of their greater involvement in decision making. Other researchers, however, have suggested that the level and kind of employee participation in decision making is very limited in lean production and that any productivity gains are attributable to work intensification more than employee participation (e.g., Berggren, 1992). The latter point highlights the importance of including role overload in any evaluation of lean production. Although some researchers have shown increased work load as a result of lean practices (Jackson & Mullarkey, 2000), others have argued that employees work "smarter" with lean production but not necessarily "harder" (Womack et al., 1990). Including role overload is also important in the current study given that there were changes other than lean production (increased production targets) that might have enhanced work demands.

Each of these work characteristics have been shown to affect employee outcomes, suggesting that it is appropriate to include them as mediators. Job autonomy has been shown to enhance well-being (Warr, 1999), affective organizational commitment (Meyer & Allen, 1997), and role breadth self-efficacy (RBSE; S. K. Parker, 1998). Skill utilization and participation in decision making have also been shown to promote employee well-being (Spector, 1986; Warr, 1999), and participative decision making can also affect RBSE (S. K. Parker, 1998). Role overload has been linked to negative employee outcomes, such as strain (Parkes, 1995) and lowered commitment (Mathieu & Zajac, 1990).

One criticism of work design research has been its focus on a narrow set of outcome variables (S. K. Parker & Wall, 1998). Organizational commitment is a commonly used outcome variable, and it is investigated here. However, the mediational framework includes two types of outcome that have received less attention in work design studies: employees' psychological strain (i.e., job anxiety and job depression) and their RBSE. Psychological strain is an important outcome to include given the arguments that lean production can damage employee mental health. Considerable cross-sectional evidence has shown that work characteristics affect employees' psychological strain (e.g., S. K. Parker, Turner, & Griffin, 2003; Warr, 1999). Rather than using a global strain measure, which has been criticized for confusing distinct aspects of strain (Warr, 1999), the current study distinguishes between job anxiety and job depression. Evidence has suggested that high demands (e.g., role overload) are more predictive of job anxiety than of job depression, whereas low job autonomy links more strongly to job depression than to job anxiety (Warr, 1990).

In the context of improvement-focused organizations where employees are required to use their initiative and suggest better methods, a further important outcome is RBSE (S. K. Parker, 1998). RBSE refers to employees' confidence that they can carry out a range of proactive, integrative, and interpersonal tasks (S. K. Parker, 1998). RBSE is considered to be an indicator of proactive motivation (S. K. Parker, 2000), or the internal forces that drive an individual to be proactive, such as taking initiative to improve current circumstances or challenging the status quo (Crant, 2000; Frese, Kring, Soose, & Zempel, 1996). Consistent with this, RBSE has been shown to predict proactive behaviors, such as employees' making innovative suggestions (Axtell et al., 2000). Apart from anecdotal reports in case studies, the effect of lean production on proactive motivation has not been investigated; yet, such outcomes are likely to be affected if lean production affects job characteristics. There is evidence that autonomous and complex work can promote proactive outcomes such as an active role orientation (S. K. Parker, Wall, & Jackson, 1997), personal initiative (Frese et al., 1996), a desire for self-direction (Kohn & Schooler, 1982), and increased RBSE (S. K. Parker, 1998). Therefore, one would expect positive effects of lean production on RBSE if work characteristics such as job autonomy are enhanced, but negative effects if the reverse occurs.

As described above, the nature and shape of lean production varies across contexts. It is therefore important to describe the particular practices implemented by the organization focused on in this study, as well as the wider context, prior to developing the specific research hypotheses. The next section describes the study context and the research hypotheses.

Study Design, Context, and Hypotheses

Organizational Context

The organization investigated was a UK-based company that manufactures and assembles large vehicles. Prior to the first survey, senior management of the family-owned company had introduced new initiatives to improve product quality (e.g., a business unit structure, continuous improvement groups, and increased training). Researchers were invited into the company to evaluate progress and to recommend ways to develop the workforce.

Shortly after the initial survey, the company was taken over by a US-owned multinational company who had been the major customer. Demand for the product increased because the take-over company had a greater market share. Over the 3-year study period, the number of vehicles produced per day doubled. To match the demand, the size of production workforce was increased through the growth of a large contingent work force. This change was controlled for in the current study by covarying out the effects of employment status. Inclusion of the measure of role overload also allowed for an investigation of the effects of the increased production targets on work demands. Within production, three lean production practices were introduced: lean teams, assembly lines, and workflow formalization and standardization. Although the organization had a way to go before it approached the "pure" lean plants observed in Japan, the changes were a clear move in that direction.

Lean Teams

Lean teams were introduced to replace a total quality initiative involving voluntary continuous improvement teams that the management team felt had lost impetus. Lean teams were introduced in a staggered way, according to management requirements. Each team was composed of a group of highly interdependent assemblers who needed to work together as a cell to complete their tasks. Team members were expected to take responsibility for support tasks such as quality management and improvement. They were involved in systematic activities to reduce waste and enhance the smooth flow of parts through the cell, which included the following: start up (e.g., select team champion), preparation (e.g., generate process flowcharts), defect reduction (e.g., waste reduction activities), certification (e.g., planned method audits), and approval (e.g., certification audit). The time from the formation of a team to final certification took an average of 18 months. Although teams had a nominated team champion, teams continued to be managed by supervisors who directed employee activities. The lean teams approach to workflow formalization and standardization can be characterized as enabling rather than coercive (Adler & Borys, 1996) because employees redesigned procedures themselves.

Assembly Lines

Assembly lines are important features of both mass production and lean production. In the current organization, they were seen as a precursor to full-scale lean production. Initially, a pilot assembly line was installed within one area of assembly. The prior system, a stall build technique, involved groups of fitters carrying out all or most of the operations needed to assemble the part. Installing the moving assembly line involved breaking the production process into a set of six stages, each to be performed by two skilled operators (*fitters*). At 4-hr intervals, the part was lifted to the next stage. Operators remained at their station throughout the shift. Procedures were simplified so that parts could be assembled without any need for fitting. Various subassemblies fed the required parts directly into the stages of the line. The lead time for building a part was markedly reduced within the first few months. At a later stage of development, one of the subassemblies was included in the line, and the process was broken into 12 stages with a cycle time of 2 hr. A second assembly line was also installed. The lead time required to build the part continued to be reduced, although the effect on quality was unclear. Some employees had been involved in the design of the assembly lines because their knowledge was needed to balance the line, but this participation did not continue after installation.[1] In terms of the Adler and Borys (1996) typology, this approach to workflow formalization can be characterized as coercive rather than enabling.

Workflow Formalization and Standardization

Several generic changes occurred that affected the rest of the direct production employees. Efforts were made to reduce inventory levels and to pull rather than push parts through the system. Methods to simplify and standardize processes were also intro-

[1] Only three operators in the longitudinal sample were involved in the design phase. Separate analyses to those reported here suggest that these employees experienced even more negative reactions to lean production than did those who had not been involved, in large part because of the former's raised expectations for continued involvement that subsequently were not followed through.

duced with the help of a technical resources department, comprising engineers and operators, that was specifically established for this purpose. There was a greater focus on designing products for ease of manufacture, with tighter specifications and tolerances. The goal was to make simpler parts that required fast assembly rather than slower fitting. Controls were installed to ensure that operators followed standard work procedures.

Research Design

A quasi-experimental research design was used. Four groups were surveyed twice over a 3-year period. The first group (*lean teams*) was 77 employees who became members of active lean teams over the study period (i.e., these employees were not in lean teams at Time 1, but were in lean teams at Time 2). The second group (*assembly lines*) was 31 employees whose work was reorganized into moving assembly lines over the study period. These employees were not working in assembly lines at Time 1, but were working in lines at Time 2. The third group (*formalization*) was 231 production employees who had been affected by site-wide workflow formalization and standardization that occurred during the study period but who were not involved in lean teams or assembly lines. The fourth group (*technical support*) was 29 employees who provided technical support to production, such as design, development and production engineers and maintenance personnel. The jobs of these employees were not directly affected by lean production, hence this group served as a comparison group (or a nonequivalent control group). If no change, or differential change, occurred in this group in the expected ways, then stronger causal inferences regarding the link between lean production, work characteristics, and outcomes could be made.

Hypothesized Effect of Lean Production Practices on Work Characteristics

It was expected that all production employees would report a decline in job autonomy because of the increased emphasis on standardization of procedures, which removed control over work methods. However, the decline in job autonomy was expected to be greatest for the assembly lines group. These employees not only had narrower jobs that could be more readily standardized, but their work pace was fixed by the line, resulting in reduced discretion over the timing of their work. Job autonomy was not expected to decline for the technical support group. Therefore:

> *Hypothesis 1a*: All lean production groups will report reduced job autonomy, but assembly lines will report the greatest decline. There will be no decrease in job autonomy for technical support.

Skill utilization was also hypothesized to decrease for all production employees because of the emphasis on simplifying procedures and parts, which meant less skilled fitting elements of the job and more unskilled assembly work. A particularly acute decrease was expected for assembly lines because, after the reorganization, these employees worked on a much narrower stage of the process. A less acute decrease in skill utilization was predicted for lean teams because these employees were involved in improvement activities, which was expected to compensate for reduced levels of technical skill. No decrease in skill use was hypothesized for the technical support group. Therefore, I hypothesized the following:

> *Hypothesis 1b*: All lean production groups will report reduced skill utilization, but assembly lines will report the greatest decline and lean teams the least decline. There will be no decrease in skill utilization for technical support.

Employee participation via continuous improvement groups was the primary mechanism for employee involvement at the start of the study prior to lean production. However, the improvement group initiative declined over the study period and was replaced by two initiatives. The first was the introduction of lean teams, which represented a structure for involving production employees in decisions about their work so as to identify the best and most efficient methods of executing the tasks. The second initiative was the introduction of concurrent product and process development teams, or multidisciplinary project groups that worked on integrating the product design phase with the planning, tooling design, and tooling manufacturing phases (these activities were traditionally carried out sequentially). This initiative primarily involved members of the technical support group, although some production employees (particularly those in lean teams) were also involved. Participation in decision making for lean teams and technical support was expected to remain stable or to increase as a result of these initiatives. However, employees in formalization or assembly lines were not involved in lean teams, had marginal involvement in the concurrent product and process development teams, and had declining involvement in improvement groups. Therefore, I hypothesized the following:

> *Hypothesis 1c*: Formalization and assembly lines will report reduced participation in decision making, but there will be no decline for lean teams or technical support.

As discussed earlier, existing evidence for the effects of lean production on quantitative role overload are mixed, with some reports of increased load and some reports of no change in work load. The situation was complicated in the current study by increases in demand for the product and by increases in the size of the workforce; both are changes that are likely to affect work load. I therefore examined the change in work load across the four groups but did not make a precise hypothesis because any changes cannot be attributed solely to the work reorganization.

Hypothesized Effect of Lean Production Practices on Employee Outcomes

The mediating framework proposes that the effects of the lean production practices on employee outcomes will depend on how they affect work characteristics. As described earlier, linkages between work characteristics and traditional outcome variables, such as organizational commitment, are well established. Associations between work characteristics and both psychological strain (i.e., job anxiety, job depression) and RBSE have also been demonstrated. Thus, assuming support for the hypothesized effects on work characteristics, reductions in all of the outcome variables for all lean production groups were expected. Because the assembly lines group is likely to experience the greatest detriment in job autonomy and skill utilization, as well as a decline in participative decision making, this group is likely to report the most negative outcomes. By the same reasoning, the effects on outcomes were not expected to be as negative for lean teams for whom no decline in participative decision making was hypothesized. Because no negative changes in work characteristics were proposed for technical support, negative changes in outcomes were not expected for this group. Therefore, I hypothesized:

> *Hypothesis 2*: All production groups will report reduced organizational commitment, increased job anxiety, increased job depression, and reduced RBSE, and these negative changes will be greatest for assembly lines and least for lean teams. Technical support will not report negative changes in the outcomes.

The above hypothesis is based on the assumption that the effects of the work reorganization on outcomes depend on its effect on work characteristics. Therefore, I hypothesize the following final hypothesis:

> *Hypothesis 3*: The effects of lean production on employee outcomes will be mediated by change in work characteristics.

Method

Procedure and Sample

Participants in the lean production groups included direct, hourly-paid production employees who carried out jobs such as fabrication, fitting, and assembly. Participants in the nonequivalent control group included engineers, technical staff, and nonadministrative support staff. All participants completed questionnaires during work time in sessions facilitated by a research team. A repeat survey occurred 3 years after the first survey. The response rate on each occasion was over 70%. A representative group of employees and managers was established to assist the researchers with the research process. To keep up to date with changes occurring in the organization, the researcher met with this group many times over the study and also met regularly with key organizational stakeholders (e.g., the manufacturing director, the human resources director, the production manager, and union representatives).

Only those employees who completed both surveys and whose data could be matched were included in the longitudinal analyses ($N = 368$). The mean age and tenure in years of the longitudinal sample at Time 1 was 37.34 ($SD = 7.49$) and 10.11 ($SD = 6.47$), respectively. There were seven women (2%) and 361 men (98%). Twenty-one percent were employed on temporary contracts at Time 1, but all of these employees had been made permanent by the repeat survey. The Time 1 sample partially overlaps with the Time 1 sample used in the second study of S. K. Parker (1998) and with the Time 1 sample used in the study by S. K. Parker, Griffin, Sprigg, and Wall, 2002.[2]

Analyses of variance were conducted to compare the four groups on their age, tenure, and employment status. The groups did not differ significantly in age, but there were significant differences in their tenure, $F(3, 363) = 3.68$, $p < .05$, and employment status, $F(3, 363) = 5.18$, $p < .01$. Assembly lines had shorter tenure ($M = 3.90$, $SD = 4.82$) than lean teams ($M = 8.08$, $SD = 6.36$), formalization ($M = 7.51$, $SD = 7.28$), and technical support ($M = 9.17$, $SD = 7.26$). Assembly lines also had more employees on temporary contracts at Time 1 (39%) than either lean teams (9%), formalization (23%), or technical support (17%). Because the groups differed on these potentially confounding variables, tenure and employment status were controlled in the main analyses. Controlling for employment status also controlled for the change from temporary to permanent status that occurred for some employees in the study.

It is important to note that only those employees who reported being in an active team that met regularly and that had been in existence for at least 3 months by Time 2 were included in lean teams. This was to ensure that the lean teams group did not include inactive teams that existed in name only or teams that had been operational for such a short time by Time 2 that job characteristics were unlikely to have been affected. In total, five employees who reported being in an inactive team at Time 2, or a team less than 3-months old at Time 2, were excluded from the sample (the results were unchanged if these employees were retained in the sample). The mean length of time employees had been in a lean team was 18.4 months ($SD = 12.7$). The assembly line group included all those who had been working on a line for at least 3 months at Time 2. On average, these employees had been in a line for 15.43 months ($SD = 11.5$), which is a similar length of exposure to the new practice as those in the lean teams.

Mortality, or the possibility that having some participants drop out of the study affected the results, is a possible threat to the internal validity of this nonequivalent control group design (Campbell & Stanley, 1966). Additional analyses were therefore conducted to investigate the possibility that those participants who remained in the study (i.e., the matched sample) differed substantively from those who dropped out (i.e., those who participated at Time 1 but not Time 2, either because they chose not to take part in the study or because they left the organization). There were no significant differences in any of the biographical, work characteristic, or outcome variables (full details available from Sharon K. Parker) between those who were present on both measurement occasions ($N = 368$) and those who completed the survey at Time 1 but not at Time 2 ($N = 142$). The finding suggests that mortality is unlikely to be a major problem for the current study.

Survey Measures

Biographical information. Age (in years), length of service (in years), employment status (i.e., permanent or temporary contract), gender, and job title were assessed.

Work characteristics. Job autonomy (Time 1, $\alpha = .72$; Time 2, $\alpha = .78$) was assessed using a shortened version of Jackson, Wall, Martin, and Davids's (1993) measure of task control. Two items assessed autonomy over timing of activities (i.e., deciding on the order for doing tasks and setting own pace of work), and two items assessed autonomy over methods (i.e., varying how work is carried out and deciding how to get the job done). For each item, employees indicated how much control they had on a scale from 1 (*not at all*) to 5 (*a great deal*). Four items (based on Jackson & Mullarkey, 2000) assessed skill utilization (Time 1, $\alpha = .72$; Time 2, $\alpha = .77$). Three items asked the extent to which individuals carry out a range of different tasks, use a variety of skills, and make full use of their skills (using the same response scale as for job autonomy); the fourth item assessed how satisfied individuals were with the amount of variety in their work on a 5-point scale. Participation in decision making was assessed by three items (Time 1, $\alpha = .78$; Time 2, $\alpha = .78$), with the same response scale as for job autonomy. Employees indicated the extent that they can influence various decisions outside their immediate tasks, such as changes in their area. Three items (Time 1, $\alpha = .85$; Time 2, $\alpha = .80$) derived from Caplan, Cobb, French, Van Harrison, and Pinneau's (1975) measure were used to assess role overload, such as how often employees feel that they have too much for one person to do. The response scale for items was from 1 (*rarely or never*) to 5 (*constantly*).

Employee outcomes. Affective organizational commitment, an individual's emotional attachment to the organization, was assessed using four items (Time 1, $\alpha = .72$; Time 2, $\alpha = .76$) from the Cook and Wall (1980)

[2] Common variables across the studies at Time 1 included autonomy, skill use, participative decision making, and RBSE (S. K. Parker, 1998, Study 2), and participative decision making, role overload, and job strain (S. K. Parker, Griffin, Sprigg, & Wall, 2002).

measure. Respondents indicated on a 5-point scale whether they agreed or disagreed with four statements (e.g., "I feel myself to be part of this company"). Job anxiety (Time 1, $\alpha = .86$; Time 2, $\alpha = .87$) and job depression (Time 1, $\alpha = .76$; Time 2, $\alpha = .78$) were each assessed using three items from Warr's (1990) measures of job-related anxiety–contentment (calm, relaxed, and comfortable) and job-related depression–enthusiasm (optimistic, enthusiastic, and motivated), respectively. Respondents indicated how much, in the past month, their job had made them feel these reactions on a 5-point scale, from 1 (*never*) to 5 (*all of the time*). All items were reverse scored. RBSE was assessed with the use of four items from S. K. Parker's (1998) measure of the concept (Time 1, $\alpha = .86$; Time 2, $\alpha = .89$). Employees were asked how confident they would feel carrying out a range of proactive, interpersonal, and integrative tasks, such as making suggestions to management about ways to improve their work and helping to set targets in their work area. The response scale was from 1 (*not at all confident*) to 5 (*very confident*).

Confirmatory Factor Analysis of Measures

To ensure that the work characteristic and outcome variables were distinct from each other and as a minimum check against common method variance, a confirmatory factor analysis was conducted on the items at both Time 1 ($N = 510$) and Time 2 ($N = 492$). All participants at each time, rather than the longitudinal sample, were included to maximize sample size. The hypothesized eight-factor structure (i.e., one factor for each work characteristic and each outcome measure) was compared with a series of alternative models. The fit indexes for these models (summarized in Table 1) included Jöreskog and Sörbom's (1993) goodness-of-fit index (GFI), the nonnormed fit index (NNFI; Bentler & Bonnett, 1980), the comparative fit index (CFI; Bentler, 1990) and the root-mean-square error of approximation (RMSEA; Hu & Bentler, 1999). The NNFI takes account of the parsimony of the estimated parameters, and the CFI has been identified as the best approximation of the population value for a single model (Medsker, Williams, & Holahan, 1994). The RMSEA has a known distribution and compensates for model complexity (Hu & Bentler, 1999). A good fit is indicated if the GFI, CFI, and NNFI are above .90 and the RMSEA is lower than .05.

A one-factor model with all items loaded on a single factor tested the possibility that a single factor would adequately account for covariation among the items. The model was a poor fit at both time points, which provides supporting evidence against bias from common method variance (Podsakoff & Organ, 1986). A five-factor model with all work characteristics loading on a single factor but with each outcome variable loading on a separate factor was also a poor fit to the data. Similarly, a five-factor model with all outcome variables loading on a single factor but with each work characteristic loading on a separate factor was a poor fit to the data. A seven-factor model that had both job anxiety and job depression loading on a single factor was a better fit to the data but was nevertheless still inadequate (e.g., the GFIs were below .90 and the RMSEAs were above .05 at both times). The hypothesized eight-factor model that differentiated each of the work characteristic and outcome variables provided a much better fit than all comparison models at both time points. All fit indices for this model were within acceptable levels, and most standardized factor loadings were above .70 (the lowest loading item at Time 1 was .55 and at Time 2 was .55). On the basis of fit of this model, I concluded that the eight-factor model was the most appropriate representation of the factor structure of the items. Each of the work characteristics and outcome variables is therefore a separate construct, and there is no confounding across the independent and dependent variables.

Results

Table 2 shows the correlations between the major variables for the matched longitudinal sample at both Time 1 and Time 2, and Table 3 shows the longitudinal correlations. Table 4 shows the means and standard deviations for the major variables at each time separately for each group.

To test the effect of the work reorganization on work characteristics (Hypothesis 1a to Hypothesis 1c) and outcomes (Hypothesis 2), I conducted a series of repeated measures analyses of covariance for each variable by using SPSSX multivariate analysis of variance (MANOVA). Group was the between-subjects variable, and time was the within-subjects variable. Two covariates, tenure and employment status (temporary vs. permanent employment contract), were included. Tenure was included as a covariate because the groups differed on this variable. Employment status was included because groups differed on this variable; previous research using the Time 1 employees from this sample showed that employment status can influence work characteristics (S. K. Parker et al., 2002), and many employees' employment status changed over the study period.

The first step was to examine the main effects of group and time and the interaction effect of Group × Time. As recommended by Tabachnick and Fidell (1989), if the Group × Time interaction effect was significant, the next step was to examine the results of simple effect tests that examine change separately for each group and that differences between groups at each time. One-tailed tests were used to evaluate the change-simple-effect tests for hypotheses with specified directions. Because significance tests are affected by sample size, for statistically significant findings, I show the results of partial eta squared statistics (η_p^2) to provide an estimate of effect size in the sample. Partial eta squared, or the proportion of the effect plus error variance that is attributable to

Table 1
Comparison of Alternative Factor Structures at Time 1 and Time 2

		Time 1 ($N = 510$)					Time 2 ($N = 492$)				
Model	*df*	χ^2	GFI	CFI	NNFI	RMSEA	χ^2	GFI	CFI	NNFI	RMSEA
Hypothesized 8-factor	322	628.41	.92	.94	.93	.04	670.58	.91	.94	.93	.05
7-factor	329	975.76	.86	.88	.86	.06	886.57	.87	.91	.90	.06
5-factor (a)	340	2,140.29	.72	.66	.62	.10	2,297.10	.70	.68	.65	.11
5-factor (b)	340	1,876.92	.76	.71	.68	.09	1,761.65	.77	.77	.74	.09
1-factor	350	3,745.56	.57	.36	.31	.14	4,183.07	.52	.38	.33	.15

Note. Five-factor model (a) has the dependent variables as one latent variable but has each work characteristic as a separate latent variable. Five-factor model (b) has the work characteristics as one latent variable but has each dependent variable as a separate latent variable. GFI = goodness-of-fit index; CFI = comparative fit index; NNFI = nonnormed fit index; RMSEA = root-mean-square error of approximation.

Table 2
Correlations Between Variables at Time 1 (Above Diagonal) and Time 2 (Below Diagonal) for the Matched Longitudinal Sample

Variable	1	2	3	4	5	6	7	8	9	10
1. Tenure	—	−.54**	.14*	.14*	.01	.24**	−.05	.19**	.18**	.11*
2. Employment status (temp)	−.16**	—	−.09	−.10	−.07	−.17**	.00	−.15**	−.18**	−.07
3. Job autonomy	.15**	.03	—	.29**	.25**	.10	.06	−.07	−.10	.20**
4. Skill utilization	.21**	−.03	.47**	—	.21**	.15**	.29**	−.16**	−.30**	.12*
5. Participation	.12*	−.04	.44**	.48**	—	.01	.21**	−.13*	−.24**	.24**
6. Role overload	.03	−.10	.16**	.17**	.18**	—	.00	.34**	.05	.23**
7. Organizational commitment	.16**	−.13*	.12*	.33**	.23**	−.10	—	−.36**	−.55**	.06
8. Job anxiety	−.04	−.05	−.11*	−.17**	−.06	.26**	−.42**	—	.52**	.02
9. Job depression	−.14*	−.01	−.19**	−.36**	−.33**	.04	−.55**	.57**	—	−.07
10. Role breadth self-efficacy	.18**	.00	.27**	.28**	.34**	.20**	.10	−.02	−.13*	—

Note. $N = 368$. temp = temporary contact.
* $p < .05$. ** $p < .01$.

the effect of interest, is recommended as a measure of effect size for more complex factorial and covariate designs such as in the present study (Tabachnick & Fidell, 1989). For the simple effect tests examining group differences, where these were significant, orthogonal planned contrasts were carried out to identify how the groups differed at each time. First, the technical support group was compared with all the lean production groups combined. Second, because several hypotheses predicted this group would have the most negative changes, the assembly lines group was compared with the lean teams and the formalization group combined. Finally, lean teams were compared with the formalization group because less negative effects were predicted for lean teams.

Effect of Lean Production Practices on Work Characteristics

Table 5 shows the results of these analyses with the work characteristics as outcomes (see Table 4 for the means for each group at both time points). For job autonomy, there were significant main effects of group and time, and a significant Group × Time effect. Results of simple effect tests showed that lean teams, assembly lines, and formalization all had a significant decline in job autonomy, but the decline was sharpest for assembly lines such that this group had significantly lower job autonomy at Time 2 than the other lean production groups combined, despite starting out with similar levels. Consistent with this, the effect size for change in assembly lines was large ($\eta_p^2 = .098$) and was greater than the comparable effect size for lean teams ($\eta_p^2 = .028$) or formalization ($\eta_p^2 = .022$). As expected, there was no significant change in job autonomy for technical support, and this group had higher job autonomy than the lean production groups combined by Time 2, despite starting out with similar levels. These findings support Hypothesis 1a.

A similar pattern to that for job autonomy was observed for skill utilization. There was a significant time effect and a significant Group × Time effect. Skill utilization declined for all the lean production groups but not for technical support. By Time 2, despite starting out with similar levels, technical support reported higher skill use than all other groups. The degree of decline in skill use for the three production groups was about the same, as shown by the relatively similar partial eta^2 for the change-simple-effect tests for each group. The results provide only partial support for Hypothesis 1b because it was expected that there would be differential degrees of decline for the three lean production groups.

Table 3
Longitudinal Correlations Between Variables for the Matched Longitudinal Sample

	Time 1									
Variable	1	2	3	4	5	6	7	8	9	10
Time 2										
1. Tenure	.91**	−.51**	.12*	.14**	−.01	.21**	−.01	.14**	.14**	.13*
2. Employment status (temp)	−.01	.12*	.04	.07	−.01	.09	−.13*	.07	.06	.05
3. Job autonomy	.13**	−.09	.41**	.24**	.15**	.14**	−.01	.04	−.01	.16
4. Skill utilization	.20**	−.19**	.27**	.48**	.22**	.18**	.18**	−.07	−.18**	.21**
5. Participation	.08	−.10	.23	.21**	.40**	.16**	.11*	.02	−.10*	.25**
6. Role overload	.00	.03	.15**	.07	.01	.46**	.03	.21**	−.04	.15**
7. Organizational commitment	.16**	−.18**	.00	.17**	.21**	.06	.54**	−.19**	−.26**	.04
8. Job anxiety	−.05	.09	−.09	−.16**	−.13*	.09	−.23**	.47**	.24**	−.01
9. Job depression	−.12*	.14**	−.10	−.22**	−.23**	−.10	−.37**	.26**	.43**	−.12*
10. Role breadth self-efficacy	.15**	−.10	.21**	.03	.13*	.25**	−.04	.05	−.02	.65**

Note. $N = 368$. temp = temporary contact.
* $p < .05$. ** $p < .01$.

Table 4
Means and Standard Deviations of Work Characteristics and Employee Outcomes by Group at Time 1 and Time 2

	Lean teams (N = 77)				Assembly lines (N = 31)				Formalization (N = 231)				Technical support (N = 29)			
	Time 1		Time 2		Time 1		Time 2		Time 1		Time 2		Time 1		Time 2	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Work characteristics																
Job autonomy	3.57	0.78	3.27	0.74	3.69	0.88	2.66	0.88	3.59	0.82	3.44	0.91	3.97	0.77	4.05	0.61
Skill utilization	3.28	0.91	2.79	0.93	3.27	0.87	2.44	0.97	3.26	0.81	2.87	0.96	3.33	0.67	3.22	0.65
Participation in decision making	1.94	0.83	1.94	0.82	1.87	0.75	1.51	0.54	1.79	0.69	1.68	0.72	1.64	0.66	2.18	0.75
Role overload	2.52	0.87	2.42	0.87	2.42	0.80	2.74	0.90	2.47	0.87	2.52	0.86	3.30	0.88	2.14	0.94
Employee outcomes																
Organizational commitment	4.06	0.67	3.83	0.74	4.01	0.56	3.31	0.65	4.00	0.67	3.67	0.69	3.35	0.65	3.31	0.72
Job anxiety	2.63	0.93	2.71	0.92	2.83	0.99	3.25	0.77	2.74	0.87	2.93	0.85	3.42	0.80	3.40	0.81
Job depression	2.97	0.84	3.04	0.86	2.90	0.83	3.72	0.79	2.98	0.78	3.24	0.82	3.29	0.92	3.31	0.90
Role breadth self-efficacy	3.17	1.02	3.23	1.11	2.93	1.15	2.51	1.14	2.76	0.97	2.81	0.99	3.53	1.02	3.66	1.04

Table 5
Results of Repeated Measures Analyses of Variance for Work Characteristics With Tenure and Employment Status as Covariates

	Main and interaction effects (F)			Change for each group (F)[b]				Group comparisons (F)[a] and contrasts (t)[c]							
Variable	G[a]	T[b]	G × T[a]	1	2	3	4	Time 1	4 vs. 1, 2, 3	2 vs. 1, 3	1 vs. 3	Time 2	4 vs. 1, 2, 3	2 vs. 1, 3	1 vs. 3
Job autonomy	6.31** (.050)	27.02** (.069)	9.17** (.071)	10.60** (.028)	39.33** (.098)	8.36** (.022)	0.00	2.07	−1.91	−1.13	−0.37	10.77** (.082)	−4.69**	−3.68**	−1.50
Skill utilization	1.04	30.63** (.078)	3.35* (.027)	18.82** (.050)	22.44** (0.58)	24.15** (.062)	0.37	0.11	−0.08	0.52	−0.09	2.70* (.022)	−2.47*	−1.62	−0.83
Participative decision making	2.39	1.02	7.47** (.058)	0.77	9.19** (.025)	9.18** (.025)	9.01** (.024)	1.27	1.54	0.21	1.34	6.77** (.053)	−3.13**	−1.81	2.62**
Role overload	8.61** (.066)	2.84	0.93					7.52** (0.58)	−4.47**	0.35	0.08	7.60** (.059)	−3.96**	1.78	−0.97

Note. Partial η^2 shown in parentheses. G = group; T = time; Group 1 = lean teams; Group 2 = assembly lines; Group 3 = formalization; Group 4 = technical support.
[a] *df*s = 3, 363. [b] *df*s = 1, 363. [c] *df* = 363.
* $p < .05$. ** $p < .01$.

There was a significant Group × Time effect for participation in decision making. Consistent with Hypothesis 1c, there was a significant decline in participation for assembly lines and formalization, but no significant decrease for either technical support or lean teams. Indeed, the level of participation was increased for the technical support group.

There was no significant time or Group × Time effect for role overload, but there was a significant main effect of group. Members of the technical support group reported significantly higher levels of role overload at both times. It is important to note that the mean levels of role overload for the lean production groups were around 2.5, or the midpoint of the 5-point response scale for these items. This suggests that the lack of change in role overload was unlikely to reflect ceiling (or floor) effects in this measure.

In summary, as expected, findings showed a decline in work characteristics for all the lean production groups. The picture was most negative for the assembly line group, which had the greatest reduction in job autonomy and also reduced skill use and lowered participation in decision making. Those in lean teams fared the best because their level of participation in decision making did not decline. Supporting the validity of the findings, there were no negative changes in these work characteristics for the technical support group; indeed, there was an improvement in the level of participative decision making for these employees.

Effect of Lean Production Practices on Employee Outcomes

Table 6 shows the results of the repeated measures analyses for the outcome variables. There were significant main effects of group and time, and a significant Group × Time effect for organizational commitment. Simple effect tests of change showed that commitment was significantly reduced for all lean production groups, but that the decline was greatest for assembly lines (η_p^2 = .055) and for formalization (η_p^2 = .047) relative to lean teams (η_p^2 = .016). Comparisons of group differences at each time showed that the lean production groups did not differ in their commitment at the outset, but by Time 2, assembly lines had lower commitment than the other lean production groups combined. As expected, commitment did not change for technical support. This group had lower commitment than the other groups at both times.

In relation to psychological strain, different results occurred for job anxiety and job depression. There was no time or Group × Time effect for job anxiety. Although this contradicts Hypothesis 2, this finding can be interpreted in the light of the above result showing that role overload was not affected by the work reorganization. Role overload was expected to be a key driver of the effect of job anxiety. Consistent with this, the technical support group—who had greater role overload than others—also had significantly higher job anxiety than the lean production groups at both times. Inspection of the means showed that job anxiety scores for the lean production groups were just above the midpoint for the scale, suggesting that the lack of change over time did not reflect a ceiling effect.

For job depression, there was a significant Group × Time effect and time effect. Simple effect tests showed that depression levels significantly increased for assembly lines and for formalization. However, the size of this change was much higher for the former group (η_p^2 = .037) than the latter (η_p^2 = .008). There were no

Table 6
Results of Repeated Measures Analyses of Variance for Outcomes With Tenure and Employment Status as Covariates

	Main and interaction effects (F)			Change for each group (F)[b]				Group comparisons (F)[a] and contrasts (t)[c]							
Variable	G[a]	T[b]	G × T[a]	1	2	3	4	Time 1	4 vs. 1, 2, 3	2 vs. 1, 3	1 vs. 3	Time 2	4 vs. 1, 2, 3	2 vs. 1, 3	1 vs. 3
Organizational commitment	7.44** (.058)	15.91** (.042)	4.54** (.036)	3.63* (.010)	21.29** (.055)	18.22** (.047)	0.07	8.95** (.069)	4.98**	−0.26	0.54	5.11** (0.40)	1.97*	−2.80**	1.67
Job anxiety	7.95** (.062)	0.01	0.49					6.38** (.050)	−3.60**	1.56	−1.39	6.93** (.054)	−3.07**	2.49*	−1.92
Job depression	2.24	6.09* (.016)	3.75* (.030)	0.04	13.97** (.037)	2.76* (.008)	0.00	1.30	−1.84	0.23	−0.56	4.19** (.033)	−0.36	3.22**	−1.71*
Role breadth self-efficacy	8.71** (.068)	0.75	2.74** (.022)	0.11	6.80** (.019)	0.16	0.40	6.83** (.054)	−2.68**	0.08	3.02**	8.11**	−3.54**	−2.05*	2.95**

Note. Partial η^2 shown in parentheses. G = group; T = time; Group 1 = lean teams; Group 2 = assembly lines; Group 3 = formalization; Group 4 = technical support.
[a] *dfs* = 3, 363. [b] *dfs* = 1, 363. [c] *df* = 363.
* $p < .05$. ** $p < .01$.

significant differences between the groups at Time 1, but by Time 2, assembly lines had significantly higher job depression than the other lean production groups combined. Job depression did not change for technical support.

For RBSE, there was a significant group effect and a significant Group × Time effect. Simple effect analyses and inspection of effect size statistics showed that RBSE declined only for assembly lines ($\eta_p^2 = .019$). Consistent with this, the assembly lines group did not differ from the other lean production groups at Time 1 but had significantly lower self-efficacy at Time 2. Lean teams had higher self-efficacy than formalization at both times, and technical support had higher self-efficacy than any of the lean production groups at both times.

In summary, consistent with Hypothesis 2, all lean production groups, but not the nonequivalent control group, experienced negative change in psychological outcomes. The most consistent and pervasive negative effects on outcomes occurred for the assembly line group, who had substantially reduced commitment, increased depression, and lowered RBSE. The least negative change occurred for the lean teams group, who had somewhat reduced commitment but no change in their level of depression or self-efficacy.

Findings from both sets of analyses are thus far consistent with the idea that the negative effects of lean production on work characteristics at least partly accounts for its negative effect on employee outcomes. However, the mediating role has not yet been tested. I turn to this next.

Mediating Role of Work Characteristics

The above analyses established links between the lean production practices and work characteristics and between lean production and outcomes, that is, $X \rightarrow M$ and $X \rightarrow Y$, respectively, in terms of the mediational model $X \rightarrow M \rightarrow Y$ (where X is the independent variable, Y is the outcome variable, and M is the mediating variable; Baron & Kenny, 1986). The conventional approach to testing mediation (i.e., a series of hierarchical regression analyses or partial correlations) was not the most appropriate test here because of the quasi-experimental design of the study. Instead, the above repeated measures analyses of covariance with employee outcomes as dependent variables were repeated with the work characteristics variables that changed included as covariates (i.e., job autonomy, skill utilization, and participation in decision making). These work characteristics at Time 1 and Time 2 were included. Two results from these analyses were important for assessing mediation. The first was whether the work characteristic as a covariate was significantly related to change in the dependent variable ($M \rightarrow Y$). This is represented by a significant beta weight for the work characteristic as a covariate. The second was whether the inclusion of work characteristic covariates reduced significant Group × Time or time effects associated with the work reorganization (i.e., $X \rightarrow Y$ controlling for M). Baron and Kenny (1986) suggested that a given variable, M, functions as a mediator when the significant effect of X is rendered nonsignificant after controlling for M. Table 7 shows the F values for group, time, and Group × Time effects of these analyses and the beta weights of the covariates. The percentage change in effect size is shown to indicate the strength of the mediation and is used in conjunction with the change in significance levels to evaluate the presence of

Table 7
Repeated Measures Analyses of Variance for Outcomes With Work Characteristics as Covariates

Variable	Main and interaction effects (F)			Δ Effect size (%)			Beta weights				
	G	T	G × T	G	T	G × T	Employment status	Tenure	Job autonomy	Skill utilization	Participative decision making
Organizational commitment	8.78** (.069)	4.26* (.012)	2.39 (.020)	19 (+)	71 (−)	44 (−)	.12*	−.11	.12*	−.22**	.00
Job depression	2.72* (.023)	1.01 (.003)	2.07 (.011)		81 (−)	43 (−)	−.27**	.04	−.07	−.16**	−.13*
Role breadth self-efficacy	7.06** (.057)	.00 (.000)	1.45 (.012)	16 (+)		45 (−)	.00	.00	.01	.11*	.19**

Note. Partial η^2 shown in parentheses. Plus or minus signs in parentheses indicate an increase or decrease in percentages, respectively. G = group; T = time.
* $p < .05$. ** $p < .01$.

mediation. Job anxiety is not examined here because this outcome had neither a significant time or Group × Time effect.

For organizational commitment, entering the work design covariates reduced the previously significant Group × Time effect to nonsignificance, which was a decrease in the effect size of 44%. The main effect of time remained significant but was reduced by 71%. Job autonomy ($\beta = .12$, $p < .05$) and skill utilization ($\beta = .22$, $p < .01$) were significant work characteristic covariates, suggesting that a decline in these variables partly explained the negative association of lean production with commitment. The main effect of group remained significant, suggesting that there were group differences in commitment that were not accounted for by work characteristics.

For job depression, entering the work characteristics as covariates reduced the previously significant main effect of time to nonsignificance (effect size reduced by 81%), as well as the Group × Time effect to nonsignificance (effect size reduced by 43%). The main effect of group remained significant. Skill utilization ($\beta = -.16$, $p < .01$) and participation in decision making ($\beta = -.13$, $p < .05$) were both significant covariates, suggesting that changes in these aspects were the key drivers of the differential changes in depression for the various groups.

For RBSE, including the work design covariates, reduced the previously significant Group × Time effect to nonsignificance (effect size reduced by 45%). The significant group effect remained after entering covariates. The significant work covariates were participation in decision making ($\beta = .19$, $p < .01$) and skill utilization ($\beta = .11$, $p < .05$).

In summary, these results largely support Hypothesis 3. Each of the work characteristics covariates was an important predictor of one or more outcomes. Significant time and Group × Time effects in the main analyses were reduced to nonsignificance for job depression and RBSE, suggesting that the effects of implementing lean production on these outcomes were fully mediated by the work characteristics. For organizational commitment, the finding that the time effect remained significant after entering the covariates (albeit considerably reduced in size) suggests that the effect of lean production on this outcome was partially mediated by work characteristics.

Discussion

Implications for Understanding Lean Production

This study, one of the few rigorous evaluations of lean production, adds to our understanding in several ways. Consistent with existing observations (e.g., Landsbergis et al., 1999), the findings suggest that lean production can be damaging to employees. Although the current organization was in the early stages of a lean production initiative, negative human consequences emerged. After the work reorganization, all groups reported poorer quality work designs, and at the least, experienced a decline in organizational commitment. These changes were not likely to reflect an undifferentiated negative response set because the same employees also reported no change in role overload or job anxiety. These findings are also unlikely to reflect a deterioration in work characteristics as a result of generic organization-wide changes because there was no negative change in work characteristics (and some positive change) for a comparison group of support staff who did not directly experience lean production.

These results suggest caution for companies considering lean production initiatives, especially if they aspire to have a mentally healthy, self-efficacious and committed work force. In the light of research that suggests reduced job autonomy can increase the risk of cardiovascular disease (e.g., Theorell & Karasek, 1996), this study also raises questions about the long-term physical health effects of these practices. Similarly, given evidence that commitment, RBSE, and psychological strain affect behaviors like contextual performance, attendance, and innovation (Axtell et al., 2000; Mathieu & Zajac, 1990), there might well be negative long-term performance consequences of lean production.

This study also suggests that different elements of lean production have different consequences. In particular, the installation of the moving assembly line appeared to be a clear move backward for the employees involved, being associated with severe negative effects on work characteristics as well as increased job depression, lowered job commitment, and reduced RBSE. These findings are of concern because assembly lines are central to both mass and lean production settings. As Jürgens, Malsch, and Dohse (1993, p. 345) observed, lean production methods have led to “a further perfecting of the assembly line organization.”

Although not as extreme as for the assembly line group, those employees working in lean teams and those exposed to workflow formalization and standardization also reported negative work design changes and outcomes. For those in lean teams, the lower autonomy and use of skills concurs with arguments that the multiskilling in these lean teams is more akin to multitasking (Berggren, 1992; Delbridge et al., 1992). The fact that participation was not enhanced in lean teams is consistent with the view that employee participation in decision making remains restricted in these types of teams. The decline in commitment observed for those in lean teams, albeit relatively small, contradicts Adler’s (1993) suggestion that the high discipline inherent in lean jobs results in a motivating work environment. Nevertheless, those in lean teams did not experience increased depression or reduced self-efficacy, nor did they experience the same degree of decline in commitment as the other lean production groups. This might have been because participation in decision making did not decline for this group, and as suggested by Adler and Borys (1996), an enabling approach to workflow formalization is likely to have more positive effects (or at least, fewer negative effects) than a coercive one. It is also possible that the lean teams had some counterbalancing positive consequences for employees who were not measured, such as increased coworker trust (Jackson & Mullarkey, 2000).

The findings of the current study support a model in which work characteristics mediate, at least partially, the effect of lean production practices on employee outcomes. There was evidence of full mediation for job depression and RBSE and partial mediation for organizational commitment. The mediational model provides a framework for systematically predicting, and refining our understanding of, the potential effects on employees of various forms of work reorganization. From a practical view point, the model suggests that, to the extent that management introduces lean production in such a way that it has positive effects on job autonomy, skill use, or participative decision making, there is more likely to be positive consequences for employees well-being and motivation. The model also helps to resolve inconsistencies in the literature because it identifies that the same intervention—such as lean production—is likely to have different consequences for work characteristics, depending on factors such as the different elements of lean production that are introduced, the degree to which an enabling approach is adopted, the way the intervention is implemented, the preexisting work design, or the nature of the technology. These contingency factors can be systematically investigated in subsequent research and then can be built into the theoretical framework, and ultimately, into tools to develop more effective management practice.

Implications for Work Design Research and Practice

The study demonstrated that reducing work design quality can increase employees' level of job depression. There are relatively few longitudinal studies that have established a link between work characteristics and mental health dimensions other than job satisfaction (S. K. Parker et al., 2003). The current investigation is also one of the few work-design studies to distinguish between job anxiety and job depression, and as expected, they operated differently.

Just as important for work design research, the current study shows how negative work redesigns can diminish employees' RBSE, which is significant in an era in which the proactive, self-directed employee is argued to be critical (Crant, 2000). Only a handful of studies have shown a link between work design and proactive outcomes such as RBSE (S. K. Parker, 2000), and most have focused on the positive effects of work enrichment rather than the negative effects of work simplification. This suggests that organizations that wish for proactive and self-directed employees should pay more attention to work characteristics, in practice as well as in rhetoric. Call centers, for example, are often designed along Taylorist lines, with tight control over employees' behavior and narrow sets of tasks. Such work designs are not likely to be conducive to employee self-efficacy.

Limitations and Further Research

A limitation of the current study is that it focused on only one factory, thereby raising questions about generalizability. As argued earlier, there are likely to be contingency factors that moderate the relationship between a work reorganization and its effects on work characteristics, such as the preexisting work organization and the style of implementation. If these factors are relatively similar to those observed here, similar consequences for jobs and employees are likely. The plant represented a fairly typical one in terms of the type of work organization it had prior to lean production, with traditional work groups, a hierarchical structure, and production employees involved mostly in direct tasks. The work reorganization also involved a mixture of mass production and lean production principles, which is typical in non-Japanese companies introducing lean production (MacDuffie & Pil, 1996). Therefore, it is probable that negative consequences of lean production will be observed in sites elsewhere.

A further issue for the current study is the reliance on perceptual measures of job characteristics, which might have inflated associations with the self-reported outcomes. However, the confirmatory factor analysis suggested that employees discriminated between different aspects, contrary to what would be expected if monomethod bias was present. In addition, there is evidence that perceived job characteristics map closely to observer ratings (Fried & Ferris, 1987) and that properly developed measures are resistant to the method variance problem (Spector, 1987). The longitudinal design also controlled for the possible confounding effects of stable third variables such as personality on self-report ratings. Finally, and perhaps most important, in the current study, changes in perceived job characteristics corresponded closely with the observed effects of the lean production practices. Overall, the use of perceptual measures of job characteristics is unlikely to be a serious threat in this study.

Another issue with the current study is that it had a nonequivalent control group (rather than an equivalent control group), which means some threats to internal validity (e.g., selection, and the interactions between selection and other validity threats) cannot be ruled out. In particular, it is possible that the negative outcomes are attributable to a change other than lean production that affected only the direct production employees. Nevertheless, as a result of gathering considerable qualitative data (see Method), all major changes likely to affect production employees were known to the researcher. The major co-occurring change that did occur within production (i.e., changes in employment status for some employees) was identified and controlled for in the analyses. In addition, there were different consequences of what were, in essence, different levels of the intervention (i.e., lean teams, assembly lines, workflow formalization). Because differential changes occurred for these groups, largely as hypothesized, this increases confidence that the change occurred in response to the lean production practices rather than any other change.

Another criticism that could be leveled at the study is that no objective outcome measures were used. In fact, extensive behavioral data were obtained throughout the project (e.g., that assessing absence, quality, delivery times, and accidents); however, it proved impossible to interpret these data in any meaningful way. First, over the period, the company's methods for collecting the information often changed. For example, as part of revisions to personnel policies associated with the take over, the way that absence was recorded, monitored, and followed-up was altered. It is not possible to tease out real changes in absence from changes in reporting procedures. Second, any comparisons of performance data, such as quality or lead times, were confounded by the increase in production levels over the period. Thus, although such objective data are potentially insightful and an important complement to self-report data, practical issues did not allow the meaningful use of these data here.

Nevertheless, the effect of lean production on indicators such as those mentioned remains an important issue for future research. In the same way that the effects for employees are contentious, there is also debate about its productivity implications. Some see lean production as the only way to achieve world class performance (e.g. Adler & Cole, 1993), but others (e.g., Berggren, 1994) have argued that it is not always the most competitive option. Pertinent to this issue is whether management in the current organization could have made different choices to reduce the negative employee consequences of lean production without sacrificing (or even enhancing) productivity. For example, adopting an approach that has been successful elsewhere (Berggren, 1992), employees on the assembly line could have been allowed to move with the product rather than staying at a fixed station, thereby reducing physical fatigue because of repetition and retaining employees' skill utilization. Another option might have been to allow the employees greater collective autonomy over operational decisions, such as when to stop the line, or to adopt a more enabling approach in which employees are involved in wider decisions, such as those concerning the merging of different lines. What the effects on performance and productivity would be of such interventions is unclear in the current case, and indeed, more generally. It is an important issue to address. Otherwise employers might assume lean production is the one best way, with the workforce paying the price of this myopia.

References

Adler, P. S. (1993). The ‘learning bureaucracy’: New United Motor Manufacturing, Inc. In B. M. Staw & L. L. Cummings (Eds.), *Research in organizational behavior* (Vol. 15, pp. 111–194). Greenwich, CT: JAI Press.

Adler, P. S., & Borys, B. (1996). Two types of bureaucracy: Enabling and coercive. *Administrative Science Quarterly, 41,* 61–89.

Adler, P. S., & Cole, R. E. (1993). Designed for learning: A tale of two auto plants. *Sloan Management Review, 34,* 85–94.

Applebaum, E., & Batt, R. (1994). *The new American workplace: Transforming work systems in the United States.* Ithaca, NY: ILR Press.

Ashforth, B. E. (1989). The experience of powerlessness in organizations. *Organizational Behavior and Human Decision Processes, 43,* 207–242.

Axtell, C. M., Holman, D. J., Unsworth, K. L., Wall, T. D., Waterson, P. E., & Harrington, E. (2000). Shopfloor innovation: Facilitating the suggestion and implementation of ideas. *Journal of Occupational & Organizational Psychology, 73,* 265–285.

Babson, S. (1993). Lean or mean: The MIT model and lean production at Mazda. *Labour Studies Journal, 18,* 3–24.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51,* 1173–1182.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107,* 238–246.

Bentler, P. M., & Bonnet, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88,* 588–606.

Berg, P., Appelbaum, E., Bailey, T., & Kalleberg, A. I. (1996). The performance effects of modular production in the apparel industry. *Industrial Relations, 35,* 356–373.

Berggren, C. (1992). *Alternatives to lean production: Work organization in the Swedish auto industry.* Ithaca, NY: ILR Press.

Berggren, C. (1994). NUMMI vs. Uddvella. *Sloan Management Review, 35,* 37–45.

Brass, D. J. (1981). Structural relationships, job characteristics, and worker satisfaction and performance. *Administrative Science Quarterly, 26,* 331–348.

Campbell, T. D., & Stanley, J. C. (1966). *Experimental and quasi-experimental designs for research.* Chicago: Rand McNally.

Caplan, R. D., Cobb, S., French, J. R. P., Jr., Van Harrison, R. V., & Pinneau, S. R., Jr. (1975). *Job demands and worker health: Main effects and occupational differences.* Washington, DC: U.S. Department of Health, Education, and Welfare.

Cook, J., & Wall, T. D. (1980). New work attitude measures of trust, organizational commitment and personal need non-fulfillment. *Journal of Occupational Psychology, 53,* 39–52.

Corbett, M. (1992). Work at the interface: Advanced manufacturing technology and job design. In P. S. Adler & T. A. Winograd (Eds.), *Usability: Turning technologies into tools* (pp. 133–163). New York: Oxford University Press.

Crant, J. M. (2000). Proactive behavior in organizations. *Journal of Management, 26,* 435–462.

Dankbaar, B. (1993). *Economic crisis and institutional change: The crisis of Fordism from the perspective of the automobile industry.* Maastricht, the Netherlands: University Press.

Delbridge, R., Turnbull, P., & Wilkinson, B. (1992). Pushing back the frontiers: Management control and work intensification under JIT/TQM regimes. *New Technology, Work and Employment, 7,* 97–105.

Frese, M., Kring, W., Soose, A., & Zempel, J. (1996). Personal initiative at work: Differences between East and West Germany. *Academy of Management Journal, 39,* 37–63.

Fried, Y., & Ferris, G. R. (1987). The validity of the job characteristics model: A review and meta-analysis. *Personnel Psychology, 40,* 287–322.

Fucini, J., & Fucini, S. (1990). *Working for the Japanese: Inside Mazda's American auto plant.* New York: Free Press.

Hackman, J. R., & Oldham, G. R. (1976). Motivation through the design of work: Test of a theory. *Organizational Behaviour and Human Performance, 16,* 250–279.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1–55.

Jackson, P. R., & Martin, R. (1996). Impact of just-in-time on job content, employee attitudes, and well-being: A longitudinal analysis. *Ergonomics, 39,* 1–16.

Jackson, P. R., & Mullarkey, S. (2000). Lean production teams and health in garment manufacture. *Journal of Occupational Health Psychology, 5,* 231–245.

Jackson, P. R., Wall, T. D., Martin, R., & Davids, K. (1993). New measures of job control, cognitive demand, and production responsibility. *Journal of Applied Psychology, 78,* 753–762.

Jöreskog, K. G., & Sörbom, D. (1993). *LISREL VIII: User's reference and guide.* Mooresville, IN: Scientific Software.

Jürgens, U., Malsch, T., & Dohse, K. (1993). *Breaking from Taylorism: Changing forms of work in the automobile industry.* Cambridge, Great Britain: Cambridge University Press.

Kaminski, M. (1996). John Deere Horicon Works: JAM Local Lodge 873. In M. Kaminski, D. Bertell., M. Moye, & J. Yudken (Eds.), *Making change happen: Six cases of unions and companies transforming their workplaces* (pp. 71–89). Washington, DC: Work & Technology Institute.

Klein, J. A. (1991). A re-examination of autonomy in light of new manufacturing practices. *Human Relations, 44,* 21–38.

Kochan, T. A., Lansbury, R. D., & MacDuffie, J. P. (1995). *After lean production: Evolving employment practices in the world auto industry.* Ithaca, NY: Cornell University Press.

Kohn, M. L., & Schooler, C. (1982). Job conditions and personality: A longitudinal assessment of their reciprocal effects. *American Journal of Sociology, 87,* 1257–1286.

Landsbergis, P. A., Cahill, J., & Schnall, P. (1999). The impact of lean production and related new systems of work organization on worker health. *Journal of Occupational Health Psychology, 4,* 108–130.

Lewchuk, W., & Robertson, D. (1996). Working conditions under lean production: A worker-based benchmarking study. *Asia Pacific Business Review, 2,* 60–81.

MacDuffie, J. P., & Pil, F. K. (1996). Changes in auto industry employment practices: An international overview. In Kochan, T. A., Lansbury, R. D., & MacDuffie, J. P. (Eds.), *After lean production: Evolving employment practices in the world auto industry.* Ithaca, NY: Cornell University Press.

Mathieu, J. E., & Zajac, D. (1990). A review and meta-analysis of the antecedents, correlates, and consequences of organizational commitment. *Psychological Bulletin, 108,* 171–194.

Medsker, G. J., Williams, L. J., & Holahan, P. J. (1994). A review of current practices for evaluating causal models in organizational behavior and human resources management research. *Journal of Management, 20,* 439–464.

Meyer, J. P., & Allen, N. J. (1997). *Commitment in the workplace: Theory, research, and application.* Thousand Oaks, CA: Sage.

Mullarkey, S., Jackson, P. R., & Parker, S. K. (1995). Introducing JIT within product-based work-teams. *International Journal of Operations and Production Management, 15,* 62–79.

Niepce, W., & Molleman, E. (1998). Work design issues in lean production from a sociotechnical systems perspective: NeoTaylorism or the next step in sociotechnical design. *Human Relations, 51,* 259–287.

Parker, M., & Slaughter, J. (1988). *Choosing sides: Unions and team concept.* Boston: South End Press.

Parker, S. K. (1998). Role breadth self-efficacy: Relationship with work enrichment and other organizational practices. *Journal of Applied Psychology, 83,* 835–852.

Parker, S. K. (2000). From passive to proactive motivation: The importance of flexible role orientations and role breadth self-efficacy. *Applied Psychology: An International Review, 49,* 447–469.

Parker, S. K., Griffin, M. A., Sprigg, C., & Wall, T. D. (2002). Effect of temporary contracts on perceived work characteristics and job strain: A longitudinal study. *Personnel Psychology, 55,* 689–719.

Parker, S. K., Turner, N., & Griffin, M. A. (2003). Designing healthy work. In D. A. Hofmann & L. E. Tetrick (Eds.), *Health and safety in organizations: A multi-level perspective* (pp. 91–130). San Francisco: Jossey-Bass.

Parker, S. K., & Wall, T. D. (1998). *Job and work design: Organizing work to promote well-being and effectiveness.* Thousand Oaks, CA: Sage.

Parker, S. K., Wall, T. D., & Cordery, J. (2001). Future work design research and practice: Towards an elaborated model of work design. *Journal of Occupational and Organizational Psychology, 74,* 413–440.

Parker, S. K., Wall, T. D., & Jackson, P. R. (1997). "That's not my job": Developing flexible employee work orientations. *Academy of Management Journal, 40,* 899–929.

Parkes, K. R. (1995). The effects of objective workload on cognitive performance in a field setting: A two-period cross-over trial. *Applied Cognitive Psychology, 9,* S153-S157.

Podsakoff, P. M., & Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. *Journal of Management, 12,* 531–544.

Rousseau, D. M. (1978). Characteristics of departments, positions and individuals: Contexts for attitudes and behavior. *Administrative Science Quarterly, 23,* 521–540.

Spector, P. E. (1986). Perceived control by employees: A meta-analysis of studies concerning autonomy and participation at work. *Human Relations, 39,* 1005–1016.

Spector, P. E. (1987). Method variance as an artifact in self-reported affect and perceptions at work: Myth or significant problem? *Journal of Applied Psychology, 72,* 438–443.

Tabachnick, B. G., & Fidell, L. S. (1989). *Using multivariate statistics* (2nd ed.). New York: Harper Collins.

Taira, K. (1996). Compatibility of human resource management, industrial relations, and engineering under mass production and lean production: An exploration. *Applied Psychology: An International Review, 45,* 97–117.

Theorell, T., & Karasek, R. A. (1996). Current issues relating to psychosocial job strain and cardiovascular disease research. *Journal of Occupational Health Psychology, 1,* 9–26.

Tsutsui, W. M. (1998). *Manufacturing ideology: Scientific management in twentieth-century Japan.* Princeton, NJ: Princeton University Press.

Turnbull, P. J. (1988). The limits to "Japanisation"—just-in-time, labour relations and the UK automotive industry. *New Technology, Work and Employment, 3,* 7–20.

Warr, P. (1990). The measurement of well-being and other aspects of mental health. *Journal of Occupational Psychology, 63,* 193–210.

Warr, P. (1999). Well-being and the workplace. In D. Kahneman, E. Diener, & N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology* (pp. 392–412). New York: Russell Sage Foundation.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world.* New York: Rawson.

Received July 9, 2002
Revision received October 1, 2002
Accepted November 4, 2002 ■