Firm and Employee Effects of an Enterprise Information System: Micro-econometric Evidence

Abstract:

Using monthly performance data for stores in a retail chain for over six years and new surveys of managers and employees, we investigate the impact of the adoption of an enterprise resource planning (ERP) system, especially for the time profile of performance changes. Representative findings (depending on specification) are that: (i) sales and inventory turnover initially drop by 7 %, and recover in 6-12 months; (ii) inventory turnover recovers more quickly for establishments that adopt ERP later; (iii) the impact on business performance depends on the way the ERP system is used and, in turn, this reflects the extent and quality of training received by employees and the use of information; (v) HRM practices have little role in the successful implementation of ERP; (vi) employee outcomes, including increased workload, greater job difficulty and enhanced multitasking, vary significantly over time, though the implications for employee welfare are ambiguous.

I. Introduction

Nowadays Enterprise Resource Planning (ERP) systems are widely used and form a significant part of IT investments by large and medium-sized firms (e.g., Aral et al. 2006 and Hitt et al. 2002). A growing literature has emerged that examines these information systems that integrate many functional areas of management such as supply chain management, inventory control, financial and cost accounting, and human resources (e.g., Ragowsky and Somers 2002), While that literature recognizes that investing in an ERP is costly and that significant risks of failure in implementation are involved, the analysis and evaluation of ERP success has been hampered by two broad sets of issues.

First is a raft of matters surrounding *the nature, meaning and reasons for success*. At center stage is the size and the time profile of the impact of ERP on performance. For Markus et al. (2000), the success of ERP systems needs to be evaluated in different phases. They identify three phases: 1) the project phase when the ERP is rolled out; 2) the "shakedown" during which the ERP system goes live and the company returns to "normal operations"; 3) the onward and upward phase in which most of the potential gains are reaped. Furthermore, they find that most of the firms they study experience a dip in performance during the shakedown phase. Also Ross and Vitale (2000) provide anecdotal evidence of on initial dip in performance and a subsequent recovery. Despite the importance of understanding the time profile of the impact of ERP adoption, as Gattiger and Goodhue (2005) point out, most of the ERP literature is concerned with selection and implementation while studies on post adoption performance are rare. Another closely-related issue concerns the mechanism*s* that underpin the links between ERP and its effects. For example, Staehr et al. 2002 emphasize that research on how and *why* ERP affects performance in the post implementation stage is needed. The way factors such as human resource management, training and the way the system is used affects the impact have not received enough attention. A final matter concerns the appropriate ways to evaluate effects. As some have noted (e.g. Dery et al., 2006) there are also large gaps in the research literature concerning the impact of ERP adoption on outcomes for employees, especially on the nature of work for shop floor employees.

The other broad set of issues stem from concerns over *data and methods*. While the bulk of quantitative research has been conducted using firm-level data, it is generally recognized that it is preferable to evaluate ERP systems at the level of the business unit (e.g. Barua et al. 1995, Kelley 1994, McAfee 2002). Measurement at this more disaggregated level enables more effective study of "local benefits", which are often a sizable part of overall benefits (Gattiker and Goodhue 2005), and to study operational measures of performance as well as financial measures (McAfee 2002). Also, research based on firm level data may be adversely affected by measurement issues. For example, a firm may adopt an

ERP system in only some of its plants, and often this cannot be controlled for[1]. Such measurement error may affect the size and precision of the key coefficients in performance regressions. Indeed, in the 1990s the "productivity paradox" was resolved by looking at more disaggregated data, in this case, firm-level data (see e.g. Brynjolfsson and Hitt 1996). The other central matter concerns controls and causality. A key question is whether more successful firms adopt ERP systems or whether ERP systems make firms more successful. In part because of the lack of suitable instruments, addressing the issue of reverse causality has proven to be a persistent problem and thus casts doubt on the reliability of findings from earlier studies. McAfee (2002) has recently suggested that case studies can help in isolating the effect of ERP adoption on performance, since other possible explanations can be ruled out. Finally the reliability of findings of some studies may be undermined by the inability or the failure to control for crucial variables that potentially affect performance. Prominent among these are the roles of management quality and overall economic conditions.

To respond to several of these concerns, we undertake an econometric case study (for reviews of the method see Jones et al., 2006). Since the decision to introduce ERP was made by headquarters, rather than individual establishments, the adoption of ERP may reliably be considered to be exogenous to the productivity of individual establishments. Hence we can investigate the impact of ERP with lessened concerns over reverse causality. For 49 different establishments within the case we assemble new disaggregated data[2]. Our core performance data constitute an unusually long panel -- monthly observations for more than six years. Also we have detailed measures of inputs as well as data on the HRM environment. To investigate the impact of ERP on worker outcomes, and matters including the actual use of the ERP, we designed and administered separate surveys to managers and sales personnel. Finally we are fortunate that our data include a rich set of controls, notably measures of managerial turnover. Altogether these new data and our research design allow us to address various challenges identified in the literature and to make contributions in three broad areas.

The long nature of our panel permits us to use econometric methods to estimate the impact on productivity and on inventory turnover with more precision than was possible in previous case studies. Moreover, the period after implementation is sufficiently long to allow for estimation of the magnitude of the dip in performance following implementation and estimation of the time that recovery takes. As such

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[1] This is the case for example in Hitt et al., 2002 and Aral et al. 2006.

[2] Thus our approach is that of an econometric case study. Econometric case studies are comparatively rare due to the stringent data requirements of such studies. However, this it is a method that is becoming increasingly common and which many view as an important complementary approach to firm-level studies. (For reviews of such studies see for example Bartel et al. 2004 and Jones et al. 2006).

we provide new evidence on what recently has been pointed out as a significant open question in the literature (McAfee 2002). In addition, we have detailed information on the timing of the implementation of the ERP. Hence we can study how establishments adopting the system later fare when compared to early adopters. This feature of multisite adoptions has rarely been studied[3].

Our second set of contributions follow from using both panel data on performance and new survey data to investigate key mechanisms that might help to explain the time profile of performance after the introduction of ERP. Earlier research has suggested that the success of ERP implementation may depend on employee training in its use (e.g. Bingi et al. 1999, Peslak et al. 2007/2008), while other studies find that the payoff from IT investments in general may depend on the way the system is used (e.g. Devaraj and Kohli 2003) and on HRM (e.g. Breshnahan et al. 2002). We study the effect that training, use, and HRM have on the time profile of the impact of ERP on performance. By interpreting the new survey evidence as indicating behavioral changes by employees, this may also help us to better understand the underlying processes surrounding the initial adoption and the time profile of subsequent changes in performance.

Our third contribution is that our study includes an examination of the impact of ERP adoption from the perspective of employees. We use findings from our new survey to investigate how employees viewed the ERP and to see how their views on matters such as employee workload may have changed after implementation.

The structure of the paper is as follows. We continue by discussing key institutional features of the case. After reviewing relevant literature we develop five sets of hypotheses. In the main parts of the paper we describe the performance and financial data, outline the empirical methods and present our econometric findings concerning the impact on matters such as productivity and inventory turnover. In the penultimate section we discuss the new survey data we collected and findings concerning the actual use of ERP, problems with ERP and the impact on outcomes for workers. This discussion also leads us to better understand some of the findings from the earlier econometric analysis, especially concerning the mechanisms underlying the observed changes in performance. In the final section we consider implications of our findings.

II The Case

Our case is a Finnish firm in the non-food retailing sector. During our observation period it had 49 retail outlets around Finland, making it one of the largest retail firms in Finland. All stores are rather homogenous carrying similar product assortments, although larger stores have a wider selection of

[3] Ross and Vitale (2000, pp.237) provide interview evidence on this issue.

products. The chain serves the mass market, and cannot be considered a discount seller or an up-market retailer. Each store has three different departments: home (including a variety of items from cosmetics to electronics), clothing, and leisure (including sports goods). Self-service is the norm in all departments.

The first establishments adopted the ERP in February 2004 and the last did so in December 2004. The whole process encompassed roughly four waves: 6 establishments went live between February 2004 and June 2004, 14 in August 2004, 12 in September 2004 and 17 between October and December 2004. The roll out occurred gradually because one training team from the central unit was responsible for implementation and they did not have resources to train all stores at the same time. The go-live date for an individual store was primarily determined by geographical location as the roll out team proceeded from one area to another.

The decision to invest in ERP was made by headquarters--individual establishments and their managers did not affect this decision. Also, the roll-out timetable was laid out by headquarters. The introduction of ERP was expected to produce cost savings by standardizing operations. After the introduction of ERP, items for sale would be determined centrally by the chain and not, as in the past, by individual stores. It was also expected that the introduction of ERP would enable the process of receiving goods to be performed faster. Whereas in the past ordering was based on casual observations made in a store, henceforth ordering was to reflect analysis of data bases from in-store computers. It was anticipated that at a later stage ordering goods would become fully automated. Another area in which cost savings were expected was inventory management which, prior to the introduction of ERP, was undertaken on the basis of realized billing and not by checking of actual inventories.[4]

It was anticipated that these changes would lead to a broadening of the work to be performed by employees. Previously ordering and receiving of goods were duties undertaken mainly by department managers and their deputies. After the introduction of ERP, all employees (with the exception of temporary workers) were supposed to be involved in these tasks, thus enabling department managers to spend more time on planning and development. It was also believed that the ERP system would produce time savings that could be used to improve the level of customer service in departments.

Top management knew that successful introduction of the ERP system required that employees were adequately trained to operate the system. To ensure this, a team of trainers from the central unit would be sent to organize training on-site in all units before the introduction of the SAP system. This training lasted 1.5 days. It consisted of general training in the system followed by more detailed, hands-on training with the program. The retail chain wanted as many employees as possible to participate in this

[4] In fact, prior to the introduction of ERP, inventories were counted only twice a year and then not by employees, but typically by members of local youth sports organizations.

training and to become comfortable using the new technology and better aware of the information gains that this could produce. Successful training would help to mitigate the inevitable teething problems that would accompany the adoption of ERP. In turn, this would limit the adjustment period during which time the benefits flowing from the new system might be delayed.

From the foregoing it is clear that key decisions concerning ERP took place centrally. Equally, it is also clear that local management could still exercise much influence at the store level on matters such as how broadly employees would use ERP.

III Hypotheses

After reviewing pertinent literature and also recalling key institutional features of the case just discussed, we derive four sets of hypotheses concerning *firm outcomes*. We begin by focusing on econometric studies of the impact of ERP on organizational performance which, by using multiple performance measures, often find that ERP adopters fare significantly better (see e.g. Hitt et al. 2002 and Aral et al. 2006). However, few studies exist of the time profile of the impact. Moreover, studies typically use annual firm level data, which makes the estimation of the time profile difficult. On the other hand, there is ample anecdotal evidence that firms experience a dip in performance during the implementation of ERP systems and that recovery from this dip may take a long time (e.g. Markus and Tanis 1999, Ross and Vitale 2000.). The length of the dip naturally depends on measures used and varies from firm to firm, but interview evidence often finds that recovery may take over a year (e.g. Cosgrove Ware 2002) One of the few econometric studies is McAfee (2002) who finds that when the ERP system is introduced performance dips and that recovery to the original level takes several months. Interestingly, using annual data Hitt et al. (2002) show that for firms in their sample most of the gains from ERP adoption are made during implementation, while the gains typically disappear in the post-adoption period.

Consequently, we formulate the following hypotheses:

H1a: The initial effect of the adoption of ERP on performance is expected to be negative.

H1b: Eventually, the impact of the adoption of ERP is expected to become positive.

In multisite implementations the time profile of the impact may vary according to the wave of implementation (e.g. Ross and Vitale 2000). Most problems concerning the practical implementation of multisite ERP systems are likely to appear in the beginning. According to Markus et al. (2000) some of the most important problems in the "shakedown phase" have to do with data quality. Poor quality of data entered to the ERP system leads to severe problems in its use. As these system-wide problems are fixed gradually over time, it is likely that in the case of a phased roll-out, the establishments going live later on are less likely to suffer from these problems (e.g. Ross & Vitale 2000). In other words we hypothesize:

H2: The impact of ERP depends on the time of adoption; later adopters benefit from learning by early adopters and thus experience lowers initial adverse effects on performance.

Turning to the mechanisms that underlie changes in performance, one theme emphasized in recent work is *employee training* (e.g. Bingi et al 1999, Peslak et al. 2007/2008, Ross and Vitale 2000). Lack of training has been identified by Markus et al. (2000) as a key element in problems often experienced during the shakedown period. Insufficient training may produce mistakes in data entry, which are costly in ERP environments. They also argue that inadequate training during the project phase leads to problems in other phases besides the shakedown phase. Another key driver of ERP success is the *willingness of end users to actually utilize* the ERP system (Nah et al. 2004, Scott and Vessey 2002, Umble and Umble 2002). The problem may be particularly acute for ERP systems since often they are associated with a notable change in business processes and thus resistance to use and working around the system may prevail (Robey et al. 2002). However, many studies have failed to distinguish between the actual use (rather than the simple acquisition) of IT. Devaraj and Kohli (2003) emphasize that IT investment may be an imperfect measure of IT use. Also, for a sample of hospitals, when measures of actual (rather than self-reported) use are employed, they show that the intensity of IT use is related to performance. ERP systems increase the quantity and quality of *information* available to managers, and thus they should lead to better decision making and consequently to better performance (e.g. Davenport 2000). However, managers may fail to utilize the information provided by the system and hence fail to realize the benefits and there is evidence of this phenomenon (Ross and Vitale 2000, Davenport 2000).

Consequently we formulate the following related hypotheses.

H3a: Broader *training* of employees in the use of the ERP system is expected to enhance performance.

H3b: Broader *use* of the ERP system is expected to enhance performance.

H3c: More intensive *use of information* is expected to enhance performance.

Another theme stressed in much literature is the importance of links between workplace reorganization and ICT (e.g. Brynjolfsson and Hitt, 2000; Black and Lynch, 2001.) Equally, as other work makes clear (e.g. Bertschek and Kaiser, 2004), most studies have not fully captured the nature of these relationships. For example, while previous studies have argued that performance dips during the implementation of new technology are related to information sharing (Chew 1985, cited by McAfee 2002), typically econometric studies of ERP have not systematically considered the impact on business performance of HRM policies such as information sharing and employee participation in decision making. Thus while Black and Lynch (2001) do control for workplace practices, such as policies promoting joint decision making, they do not investigate whether the impact of IT depends on these HRM policies. However, Breshnahan et al. (2002) argue that decentralized decision making helps in getting the most out of investment in IT. Moreover, in their empirical work, they find that firms that have

decentralized workplace organization benefit more from their IT investments. Based on this discussion of the literature we formulate the following hypotheses:

H4a: Employee participation will have a positive interaction with ERP adoption on performance.

H4b: Information sharing will have a positive interaction with ERP adoption on performance.

Finally, and more briefly, we review literature on the expected impact of the adoption of ERP for *employee outcomes* and the way that changes in employee behavior may account for fluctuations in performance. Adoption of an ERP system has various implications for organization of work. First, the disciplining and integrating potential of ERP systems has been emphasized (e.g. Davenport 2000: 120). These systems lead to standardization of work processes which in turn may lead to decreased discretion for employees (e.g. Hall, 2005.) Koch and Buhl (2001) also find that ERP systems generally fail to support team work. Second, the adoption of an ERP system may also lead to tasks that were previously undertaken by supervisors or employees in other functional areas such as purchasing or accounting becoming new responsibilities for front line employees (e.g Koch and Buhl 2001:169). For them these new tasks may lead to increased complexity of work (Robey et al. 2002), increased perceived responsibility, and work intensification. The work load of employees who are responsible for inputting data to the ERP system is especially likely to increase. Based on five case studies, Hall (2005) finds that work intensity indeed tends to increase for key users of ERP. Overall, the changes in the organization of work means that employees need to learn new things, and unlearn old ways of doing things (Robey et al. 2002). This suggests that the impact of ERP adoption on employees may be greatest at the beginning, when large scale inputting of data takes place and new work processes need to be learned. Over time, these effects should dissipate, while the effects from the new tasks on workload should not.

Another theme emphasized recently is that the use of an ERP is "mandated" in the sense that one has to use the system in order to keep and perform ones job (Brown et al. 2002). Employees may accept to use the system, but such mandated use may produce a negative impact on job satisfaction, and on loyalty towards the organization (Zuboff 1988). Thus we hypothesize:

H5: While the impact of ERP on employee discretion, perceived responsibility, workload, and motivation is uncertain, we expect that the perceived adverse effects will lessen over time.

IV Testing for Firm Outcomes: Data and Methods

We use data for 49 establishments that were operating during 2001-2007. In total the firm had 53 establishments, of which 37 were observed for the whole period, while the remaining 16 started operations between 3/2001-11/2005. No establishments closed during 2001-2007. The four most recent establishments to open are excluded from the analysis, since they started operations after the ERP system was in operation. Our data consist of 75 monthly observations (2001:1 to 2007:3) and roughly 45 % of

observations are post implementation. Since we do not know the number of days a new store operated during the first month , and the first month may be special in other ways as well, we treated observations for the first month of operations as missing for all new establishments. The firm also adopted a performance-related pay (PRP) scheme in 4/2006. We will control for the PRP scheme in all the regressions.

The performance measures we use are productivity and the inventory turnover rate. Productivity, or the ratio of output to inputs, is a fundamental measure of competitiveness and, in our analysis, output is measured sales and value added[5]. The inventory turnover rate is significant for profitability since a large fraction of a retailer's assets is invested in inventory and increasing inventory turnover was one of the goals of the ERP project. The inventory turnover rate is defined as the ratio of 12 month moving average of costs of goods sold and inventory value. Data on the turnover rate cover the years 2002-2007. For core input measures we use hours worked and floor space area, both of which have been used in prior studies (e.g., Reardon et al., 1996, 447.) Importantly, since we know the timing of changes in store management, we are able to introduce manager fixed effects to control for management quality.

To test hypotheses 3a, 3b, and 3c we use our new survey data. While we discuss these surveys in more detail in part VI, here we note that the surveys yield several alternative measures that capture different facets of ERP use. The key measure is the fraction of the workforce that receives training in ERP (hypothesis 3a). Other measures are constructed to capture how broadly employees use ERP (hypothesis 3b)—such as the fraction of employees using ERP for different tasks such as ordering, receiving, and inventory purposes. Intensity of information use (hypothesis 3c) is captured by the variable "reporting" which equals unity if department managers utilize the reporting features of the system more often than once a month, and zero otherwise.

For hypotheses concerning the effects of HRM, we use data from a personnel survey that is administered annually in October-November by an independent consulting firm. The questions in the survey deal with employee perceptions of their own work, supervisor, store manager, and the company. We received the data directly from the case firm. The survey respondents are the sales clerks at the departments. Although the survey contains around 75 items, we can only utilize a small subset since the survey instrument changed in 2004, and only a handful of questions are the same through out our sample. However, the survey does allow us to measure components of the HRM environment that have been considered central in previous studies, i.e. employee participation and information sharing (e.g. Jones et al 2006). The opportunity to participate in substantive decisions, "Participation", is measured by the mean of

[5] Value added is measured as net sales minus purchases. In addition we subtracted from net sales estimates for reduced prices, lost items, and value added tax (VAT).

the answers to the statement "I can participate in planning and development of my work" using a five point Likert-scale ranging from "disagree strongly" (=1) to "completely agree" (=5). The prior discussion also suggests that effective implementation of and ERP system requires not only appropriate channels for employee participation but also adequate and appropriate information. "Information sharing" is the mean of the answers to the statement "I get enough information that is needed to manage in my job". In the analysis we use an additive index based on these variables. Descriptive statistics of outputs, inputs, and HRM variables are presented in Table 1.

Estimation strategy

To study how the adoption of the ERP system affected performance and to estimate a time profile of the impact, the baseline regressions we will estimate are:

$$y_{it} = \alpha_i + \beta x_{it} + month_j + prp + \delta t + \phi ERP_{it} + \eta ERP_{it}\left(t - t_{ERP}\right) + man_h + \varepsilon_{it} \quad (1)$$

where; y_{it} is a performance measure (either log value added, log sales or log inventory turnover) for establishment *i* at date *t*; the vector x_{it} comprises two key inputs, namely log hours worked and log retail space; $month_j$, *j=2,..12* is a set of month dummies; *t* is a trend variable; PRP is a dummy variable that equals unity after 4/2006; ERP_{it} equals unity if the ERP system has gone live and zero otherwise; $ERP_{it}\left(t - t_{ERP}\right)$is an interaction of ERP and time elapsed since the introduction of the ERP; α_i is the establishment fixed effect; man_h is a manager dummy variable; and ε_{it} is an error term. We allow the unit effect to be correlated with the other explanatory variables, i.e. we use fixed effects methods. To capture the impact of overall economic conditions all regressions include an industry level index of sales volume. We allow the error terms ε_{it} to be heteroscedastic and serially correlated within each establishment in all equations. Even though the time dimension is quite long in our data, "cluster robust" standard errors are valid and perform quite well with the kind of dimensions our dataset has (Hansen 2007).

The preceding equation shows that we allow the ERP system to have two kinds of effects, in line with hypothesis 1. First it may affect the level of the series by changing the intercept and secondly it may affect the time trend. Thus ϕ measures the initial impact of the introduction of the ERP system and η measures that change in the growth of the dependent variable after the introduction of the ERP system. If ϕ <0, then the introduction of the ERP system initially decreases performance. However, if $\eta > 0$ ERP

increases the performance growth, and thus the end effect may be positive. If performance dips initially, the "recovery" time may be estimated by $-\phi/\eta$.

Identification of the key parameters of interest, ϕ, and η, is essentially based on a before and after comparison[6]. All the units adopt the plan within 12 months, so this variation is limited (although we utilize it later on). Since establishments did not participate in the adoption decision, adoption is exogenous to the performance of individual establishments, in other words, there is no reason to expect that unit level performance shocks are correlated with the ERP variable[7]. The key threat to internal validity is that any unobserved changes between the two periods are attributed to the ERP system. Possible (unobserved) changes include common performance shocks (e.g. increasing performance could be due to the business cycle or changes in competitive pressures) and changes in the measurement of dependent or independent variables. We control for business cycle effects by including a monthly industry level sales value index in all of the regressions. A more potent problem is the changes in measurement. Our measure of value added was affected by the problems in the implementation of the ERP system. These problems lead to large swings in value added during a couple of months. We control for these months by including dummy variables.

Hypothesis 2 is concerned with the effect of the time of adoption of the ERP system on time profile of the impact. Here we use the fact that the system was implemented in four waves. We will let both ϕ and η depend on the wave of adoption. More formally, we estimate:

$$y_{it} = \alpha_i + \beta x_{it} + month_j + prp + \delta t + \phi ERP_{it} + \eta ERP_{it}\left(t - t_{ERP}\right) + \sum_{w=2}^{4} \phi_w ERP_{it} I_w + \sum_{w=2}^{4} \eta_w ERP_{it}\left(t - t_{ERP}\right) I_w + \varepsilon_{it} \quad (2)$$

where, in addition to notation introduced before, I_w equals unity if the wave of adoption is *w* and zero otherwise. Thus ϕ and η are the baseline values for the impact of the ERP system and ϕ_w's and η_w's measure deviations from them. According to hypothesis 2, we would expect the initial dip to be larger for establishments adopting the system earlier and recovery to be quicker for establishments adopting the system in later waves.

To investigate whether the impact of the ERP system depends on the way it is used (Hypotheses 3), we augment the baseline regressions as follows:

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[6] McAfee (2002) is another study that uses a similar identification strategy in the ERP context.

[7] We also checked whether the better performing establishments went live first by including the time of adoption in the performance regressions using data from the period *before* ERP. We found no evidence for this proposition.

$$y_{it} = \alpha_i + \beta x_{it} + month_j + prp + \delta t + \phi ERP_{it} + \eta ERP_{it}\left(t - t_{ERP}\right) + \sum_k \kappa_k ERP_{it} use_k + \sum_k \lambda_k ERP_{it} use_k \left(t - t_{ERP}\right) + man_h + \varepsilon_{it} \quad (3)$$

Here use_k is a variable depicting the way the ERP system is used and we exploit the fact that the new survey data enable us to develop several alternative ways of measuring the way the ERP system is used. Now κ measures the effect that use_k has on the initial impact and λ measures its impact on the trend after the implementation of the ERP system. Note that the main effects of use_k are not included since they are perfectly collinear with ERP_{it}. The variables use_k are standardized to have mean zero in Equation (3). This means that the main effects of the ERP variables can be interpreted as the impact of ERP on the dependent variable evaluated at the mean of the use variables. Training is measured by the share of employees participating in initial training (hypothesis 3a). Breadth of use (hypothesis 3b) is measured by the shares of employees using the ERP system for ordering, receiving, and inventory purposes. Intensity of information use (hypothesis 3c) is captured by the variable "reporting" which equals unity if department managers utilize the reporting features of the system more often than once a month, and zero otherwise.

HRM may also affect the impact that the ERP system has on performance (Hypothesis 4). When studying this relation we include also the main effects of HRM as shown in the equation below. Otherwise the coefficients have similar interpretation to those in the previous equation.

$$y_{it} = \alpha_i + \beta x_{it} + month_j + prp + \delta t + \phi ERP_{it} + \eta ERP_{it}\left(t - t_{ERP}\right) + \sum_l \mu_l HRM_l + \sum_l \nu_l ERP_{it} HRM_l + \sum_l \pi_l ERP_{it} HRM_l \left(t - t_{ERP}\right) + man_h + \varepsilon_{it} \quad (4)$$

Again, the HRM variable is standardized to have mean zero to facilitate the interpretation of the main effects of the ERP variables. Since the ERP variables are not standardized, the main effects of the HRM variables measure the impact of HRM before the introduction of the ERP system. The HRM variable is a scale measuring information sharing and employee participation.

V Econometric Findings

Table 2 reports findings from the baseline regressions, i.e. estimates of equation 1. The first column shows the results of the production function estimation using sales as the dependent variable. It can be seen that both inputs in the production function are statistically significant, but that the coefficients

are somewhat low[8].The initial drop in sales is estimated to be around 7 %. The value of the trend term increases after the introduction ERP, and the estimates imply that it takes around 12 months for sales to reach the level where it would have been in the absence of the ERP.

TABLE 2 AROUND HERE

The next column uses value added as the dependent variable. Now the drop is somewhat smaller, about 4%, but the estimated change in the trend is insignificant. Thus these estimates imply that value added does not recover from the drop within our observation period. The additional analysis reported in Table A1 shows that when the PRP dummy is omitted from equation 1, the estimated drop in value added is around 7% and recovery takes roughly 22 months. Together these findings imply that the recovery of value added is quite slow, and takes place after the PRP scheme was adopted. In other words, with these data it is hard to distinguish the separate effects that the ERP system and the PRP scheme had on performance when value added is the dependent variable. At the same time, sales and inventory turnover recover more quickly and the estimates are not affected as much by the inclusion of the PRP dummy.

The third column reports the results for inventory turnover. Now the initial drop is estimated to be quite similar when compared to sales, about 7%, but the gains from the system accrue more quickly. The estimated time for inventory turnover to recover from the initial drop is around six months. These results support our hypothesis 1.

Findings that relate to our investigation of hypothesis 2 are reported in last three columns of Table 2. In these columns we allow the coefficients on ERP and ERP*t to vary depending on when the system was adopted, thus utilizing the fact that the roll-out was introduced in phases. The regressions include the baseline measures ERP and ERP*t, and interaction terms for ERP and ERP*t with indicators for the second, third, and fourth wave of adopters. The results for value added and sales show little difference among the groups. However, the establishments in the last wave experience a smaller drop in value added compared to other waves. The results for inventory turnover are quite different. In the last column of Table 2 it is seen that establishments in later waves have reaped the gains from ERP more quickly when compared to earlier adopters. Therefore hypothesis 2 does receive some limited support from the data: the wave of adoption matters for inventory turnover, suggesting that the problems with ERP were gradually overcome.

Next we turn to hypothesis 3, concerning the question of whether the way that ERP is used affects performance. Table 3 reports the estimation results for Equation (3)[9]. Overall the findings are mixed.

[8] However, this is quite common when estimating production functions with fixed effects models.

There is some evidence that share of employees initially participating in ERP training is associated with a smaller initial drop in performance. However, this effect is statistically significant only when performance is measured by value added. The coefficient is of similar magnitude in other equations as well, but standard errors are larger. There is also weak evidence that initial training leads to quicker recovery. Again, the magnitude of the coefficients is about the same in all equations, but is statistically significant only in the sales equation. Thus hypothesis 3a receives weak support.

To test hypothesis 3b we use several measures of the share of workers using ERP in different activities. Overall our results provide weak support for this hypothesis. Thus when we measure use by the share of employees involved in receiving training during the initial stage, we find that this is associated with a larger initial drop in sales. Time used for receiving is not used in other sales activities and thus may lead to drop in sales. However, as the interactive term shows, the larger the share of employees participating in receiving leads to a quicker recovery. However, we do not find evidence of similar effects from employees involved in receiving either for value added or on inventory turnover.

For the three remaining measures, the share of employees involved in ordering, reporting and in inventory, we do not observe any statistically significant relationships in any of the three reported regressions.

Intensity of information use (hypothesis 3c) is captured by the variable "reporting" which equals unity if department managers utilize the reporting features of the system more often than once a month, and zero otherwise. This variable is usually insignificant, although in the value added equation establishments where the reporting features are used more often seem to recovery more quickly. Thus hypothesis 3c is very weakly supported.

TABLE 3 AROUND HERE

Net we turn to hypothesis 4, concerning the impact of HRM on the link between ERP and performance. Table 4 reports the results for estimating Equation (4). The results indicate that the HRM environment has a positive effect on both value added and inventory turnover, but it does not have any statistically significant associations with either the initial ERP effect nor with the subsequent recovery. Therefore, our fourth hypothesis on the impact of HRM environment as a mediating factor between ERP adoption and performance receives little support from the econometric analysis.

TABLE 4 AROUND HERE

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[9] Table A2 in the Appedix shows the results for equation 3 when the ERP variables are entered one at a time. To keep the table manageable, only sales and inventory turnover are used as performance measures. The results are very similar to those reported in the text.

IV Findings from Surveys and Interviews

In most econometric case studies, interview and survey data constitute an important part of the overall data base that is used in the empirical analysis. The interview and survey data obtained from field research helps the researcher to better understand process and context at the case and also helps to provide more informed interpretation of findings based on the econometric analysis (in this paper, based on the objective panel data on performance and reported in the previous section.)

In our case, the process of collecting survey data was preceded by a series of interviews. The initial interview was with the central unit manager who had responsibility for ERP implementation and first hand knowledge of the aims of the ERP implementation and practical challenges encountered at the store level. We continued by interviewing diverse personnel, including store managers, department managers and sales employees at two different stores. One store was an early adopter in the Helsinki area and the other a late adopter in a provincial town. The interviews took place in late 2004 and early 2005 and also helped us to design our survey instruments.

The surveys were designed to provide a more informed understanding of the implications of the implementation of the ERP system on matters in three particular areas, namely: (i) how the ERP system was being actually used; (ii) problems with the ERP; (iii) implications of the adoption for organizational change and the experiences of employees. As we shall see, some of the findings under the first two headers provide additional evidence that bears on the first three hypotheses examined earlier while the survey data collected under the third topic provide evidence that relates to the fifth hypothesis.

Survey Design and Samples

Three surveys were carried out, with two directed to department managers while the other one targeted sales personnel. To capture the situation when implementation had already taken place in all stores, but while the learning process was still on-going, the first department manager survey took place in May 2005. A web-based survey was used and we received 129 responses, a response rate to of 84%. A second wave of this web-based survey of department managers was organized in October 2006 and yielded 98 responses (response rate of 64%). 86 respondents (56%) participated in both surveys. At the store level we received at least one response from all 51 stores in the 2005 survey and from 49 stores in the 2006 survey. Both surveys included structured parts with multiple choice and Likert-scale types of question, as well as possibilities for respondents to give feedback in free format. Respondents were guaranteed anonymity, and the results were shared by us with the central unit only in aggregate form.

Since the other key data that we use in our performance analysis (financial data and information on HRM policies) are available only at store level, for consistency we also report our survey results aggregated to the store level. To minimize bias due to different sample composition, we construct this

data set from the subset of 86 department level observations which we observe on both dates.[10] We also restrict our analysis to the same 49 stores we use in the econometric analysis.

A separate survey was administered to sales personnel in October 2005. The key aim was to cross-check findings with responses from department managers-- to make sure that department managers do not misrepresent employee views. This survey produced 454 usable responses (a response rate of 50%). These data were collected by using hard-copy questionnaires that were returned by mail in sealed envelopes. Since the data collection process for the surveys of sales personnel differed from that used with department managers, we did not use data gathered from these sales personnel surveys in the econometric analysis of business performance. However, we discuss findings from both types of survey in the following mainly descriptive section and show that the conclusions emerging from the two sources are highly consistent.

Use of ERP

The survey data show that the aim that employees be well trained in the ERP system was only partially met. According to the 2005 survey of department managers, 72 % of employees participated in training. The comparable figure from the survey of sales personnel was 78 % and, more troublesome, only about half of respondents regarded the training as wholly or partially sufficient. In interviews and in the free format responses in the surveys, many respondents indicated that training had taken place too early, before trainees had real experience of how the program was supposed to work and before they realized what potential bottlenecks might be. Such significant gaps in initial training may well help to account for the initial performance dip that we identified in the econometric analysis. Moreover, from Table 5, Panel A, where information on the distribution of ERP use is presented, we also see that the percentage of employees using the ERP system has been increasing over time. This trend is consistent with the recovery in performance identified earlier. All in all the pattern of the training data may help to account for the positive but somewhat weak link that we identified earlier between performance and the extent of training.

In both surveys ordering has been the activity where employees have participated most broadly, 68 % of employees ordering goods according to the first survey and 80 % in the second survey. This difference in means is statistically significant at the 1% level. Also, the share of employees involved in receiving goods has increased over time, from 62 % to 71 % and the difference is means is statistically significant (10% level.) Inventory is the activity where there is most dispersion in involvement. There are

[10] The differences to the case if department level results were reported or if all available data were used are minimal, and these results are available upon request.

many stores where all or virtually all employees help with stock-taking, but in other stores department managers alone manage inventories. The percentage of employees doing inventory has increased over time, from 57 % to 61 %, but the difference is not statistically significant. Responses to the sales personnel survey tell a story that is broadly similar.

The chain also envisaged the new ERP system as an active method of transmitting feedback weekly on inventory results and other issues. From Table 5, part A we see that that there is still much to do in this respect. In May 2005, 35 % of department managers gave an ERP report to the store manager at least monthly. By October 2006 this percentage had increased somewhat to 47%. As such these survey data help to account for our earlier findings of weak support for hypothesis 3c.

Problems with the ERP

Both interviews conducted with sales personnel when the ERP was in its early stages and free format responses in the 2005 survey of department managers, point to various problems being experienced when using the ERP system. Many troubles reflected coordination difficulties between the central unit and the stores, and one would expect these to moderate over time as both parties learned to use the system more effectively. Other difficulties were of a more technical nature, and the stores and the central unit attempted to solve them collaboratively. Finally, problems emerged because suppliers' information systems sometimes were not fully compatible with the ERP system of the chain. Documenting these challenges provides deeper understanding for our earlier finding concerning the observed initial dip in performance.

Evidence from surveys reported in Table 5, Panel B also suggests that the problems with ERP were declining over time. In three of four problem areas considerable improvements had taken place within the 1.5 years between the surveys. This is especially true concerning receiving goods, with units reporting problems occurring at least weekly declining from 45 % to 27 % (statistically significant at the 5% level.) Again, the results from the sales personnel survey are consistent with the 2006 manager survey. These findings help to illuminate the reasons behind the econometric evidence reported earlier on the observed turnaround in performance.

TABLE 5 AROUND HERE

Organizational changes and the employee experience

The introduction of the ERP system often implies significant organizational changes (e.g. Brynjolfsson and Hitt 2000.) Our interviews and the free format responses in questionnaires clearly indicated that the work employees performed changed quite significantly. Whereas prior to the introduction of the ERP system, most employees had never used a computer in their work, afterwards

most employees had to use a computer. Some employees reacted enthusiastically and saw it as an opportunity to develop their work skills. But other employees, who were not given the opportunity to use ERP, complained. At the same time there were some employees who did not wish to use computers but who were forced to do so. In interviews, sales personnel also reported that they had to be more conscientious in their work since mistakes would affect the work of others much more than prior to the introduction of ERP. Some sales persons also reported that the use of time had become tied to the use of computers, and that there was less flexibility in designing the job tasks. Many interviewees reported that they spent from one to two hours daily at their computer. While computerization had replaced some other job-related tasks, due to the learning process that was still on-going, most interviewees reported in early 2005 that the net effect of the ERP implementation had been an increased work load.

In sum, our interviews created a sense that the effects of the introduction of ERP for overall employee welfare were rather mixed. Some employees resented the intensification of work that took place after the introduction of the system and felt that discretion at work had diminished. On the other hand, some other employees welcomed the new job tasks and increased responsibility in work. In addition we would expect that some of the variables (especially the amount of work) would change over time as employees learned to use the program in more efficient ways.

We attempted to capture the nature and extent of these changes in employee attitudes more precisely in our survey instrument(s). Questions were asked both in 2005 and in 2006 on the changes in the work organization that had taken place after the introduction of the ERP system (though not necessarily because of the ERP) using a 1-5 Likert scale. Table 5, Panel C presents the means and standard errors of these responses. Column 1 reports the responses to the 2005 manager survey. We test the null hypothesis that the mean does not change (i.e. equals 3). For 2005, all means are significantly different from 3, at least at the 5% level. Pronounced increases in job difficulty, responsibility, amount of work and multi-tasking are observed, while teamwork increases to a lesser extent. In the department managers' assessment, job discretion and employee motivations have decreased. These results corroborate earlier findings that i) standardization of work processes lead to decreased discretion for employees (e.g. Hall, 2005); ii) that introduction of new responsibilities for front line employees lead to increased complexity of work (Robey et al., 2002), increased perceived responsibility and work intensification (Hall, 2005).

Column 2 shows the results from the 2006 department manager survey, and column 3 shows the difference in the responses between 2006 and 2005. While many variables remain relatively stable, there are some interesting changes. In the 2006 survey, managers report that employee motivation has increased, rather than decreased, after the introduction of the ERP system. Also, in the 2006 survey there is no observed change in job discretion. Column 3 shows that the differences in the responses in the two

consecutive surveys are statistically significantly different concerning job discretion and employee motivation. There is also a statistically significant difference concerning job amount (with the 2006 responses indicating a smaller increase than in the 2005 responses, although the change compared to the pre-ERP situation is still positive and significant). These results are consistent with the view that, at the outset, when large scale inputting of data takes place and new work processes need to be learned (Robey et al. 2002), the adverse impact on employees is the greatest. The permanent increase in responsibility, multi-tasking and job difficulty is probably due to new tasks introduced with the ERP. However, eventually (in this case, by 2006), the perceived decreases in discretion and motivation observed at the start have been offset and the extra work that sales personnel experienced in 2005 has settled at a more moderate level. Thus the results partly support hypothesis 5. In turn, these findings suggest that the impact on ERP on employee welfare in ambiguous and that potentially employee welfare improves after a time.

Finally, in column 4 we present the means from sales personnel survey. They are consistent with the interpretation that the managerial concerns of reduced discretion and motivation were misplaced, although sales personnel responses indicate even sharper increase in the amount of work. These changes were also reflected in the free format responses to the questionnaire. In the first department manager questionnaire and the employee questionnaire respondents complained about the increased amount of work and were frustrated when the system was not operating properly. On the other hand, the more systematic approach to work and planning ahead were generally appreciated. The responses in 2006 were markedly more positive than in 2005 and clearly suggest a larger decrease in problems being experienced with the ERP over time.

VII Discussion and Conclusions

By using diverse kinds of data for a retail chain we study the impact of ERP adoption on firm and employee outcomes. Our key data are monthly financial and performance information for over six years and they allow us to estimate the time profile of the impact on performance. Importantly, our estimates are not affected as much as were earlier studies by issues surrounding reverse causality and we are also able to employ more controls than is often the case in earlier work, notably for management quality.

Our first hypothesis is that the initial impact of ERP implementation is negative and recovery will take several months. While this kind of time profile for the impact of IT adoption has been identified in the literature as early as the 1980s, the scarcity of reliable quantitative estimates of the magnitude of the dip and recovery time has been noted (e.g., McAfee 2002.) In general, our findings provide good support for this hypothesis and representative findings (depending on specification) are that sales and inventory turnover initially drop by 7 %, and recover in 6-12 months. Moreover, for several reasons our results

concerning the observed performance pattern as quite robust -- the effects are quite strong and immediate, they are found for quite different performance measures and concerns over endogeneity are not acute.

The second hypothesis on firm outcomes is that the impact of the ERP depends on the wave of the adoption so that the later adopters learn from early adopters and are more likely to experience more favorable outcomes. And we do find that establishments adopting the ERP system in later waves reap the benefits, in terms of increased inventory turnover, more quickly. However, in other respects support is not as strong. Thus we do not find much impact in terms of our productivity variables, nor do we find that the wave of adoption affects the initial drop in performance. However, overall our findings provide a clearer picture than contained in earlier studies of the nature and importance of learning (e.g. Ross and Vitale, 2000.)

The critical importance of the effectiveness of employee training to the successful adoption of ERP has been argued by many (e.g. Peslak et al., 2007.) In our empirical analysis we investigate the effectiveness of various dimensions of employee training. We find that the impact of ERP on performance depends on the way the system is used and that different aspects of use matter for different performance variables. The larger the share of employees initially participating in ERP training, the smaller is the dip in value added and the quicker was the recovery in sales. Also, the more the department heads used the reporting features of the systems, the quicker value added recovered. The recovery of sales from the initial drop was also quickened by a larger share of employees using the system for ordering goods. Overall this evidence on employee training provides a more comprehensive picture of different facets of employee training than was contained in prior work (e.g. Nah et al, 2004.)

The importance of the link between workplace reorganization and ICT has long been recognized (e.g. Brynjolfsson and Hitt, 2003.) However, evidence for specific technologies such as ERP, and links with HRM practices, such as the extent of employee participation and information sharing, are extremely scarce. Our empirical analysis provides little support for the hypothesis of the importance of HRM for successful ERP adaptation. Using an index of employee participation and information sharing, we find that HRM itself improves performance outcomes, though it does not have any significant interactions with the ERP variable. Our failure to find strong econometric evidence of a link between the HRM environment and performance may reflect enhanced measurement error in our measure of the HRM environment after the introduction of ERP.

Interview and survey evidence clarifies further the reasons behind the observed performance patterns. The survey evidence indicates that a key mechanism behind the observed initial drop in performance was poor and uneven training. There were significant network benefits from adoption of the ERP system in a narrow time frame but limited training resources. Therefore, the time each store could use in preparing for the ERP adoption was relatively limited. The received training was perceived to be

insufficient. Many employees did not use IT previously in their work and they had to adopt job tasks they did not perform before. Against this background it is natural that there were a lot of problems in the early stage of ERP use. Also employees felt that the amount of work had increased. Interestingly this observation corresponds to the dip in performance that was experienced. However, over time the survey evidence strongly suggests that problems were gradually solved, with improved training and more sharing of knowledge showing up in our data alongside the performance recovery. Employees became more appreciative about the more systematic way of working and broadened responsibilities, and the initial adverse effects on motivation were overcome.

The main focus of our study has been to provide evidence on firm outcomes after the introduction of ERP, However, and most unusually for a single study, we also provide evidence on employee outcomes. Specifically we use the interview and evidence from the new surveys to investigate whether the implementation of the ERP has implications for outcomes such as employee workload and how these might change over time. Consistent with the fifth hypothesis, we find that the employee workload initially increased, but the impact of the new technology was perceived to become less burdensome over time. In turn, these findings suggest that the impact on ERP on employee welfare in ambiguous and that potentially employee welfare improves after a time.

Our results also give support to the idea that the broad-based use of ERP and intensive use of reporting features do not harm performance and quite possibly lead into better performance outcomes. This indicates that the ERP adoption should be done in conjunction with sweeping organizational changes where the job tasks of employees are broadened. Against this, it is somewhat surprising that we do not find evidence that HRM environment matters for the effectiveness of ERP implementation. These questions should be addressed more fully in future research.

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TABLE 1
Descriptive statistics

Variable	Description	Obs	Mean	S.d.	Min	Max
Inputs and Outputs						
Sales	Log sales	3386	8.924	0.423	7.661	10.55
Gross proceeds	Log gross proceeds	3388	7.689	0.469	3.662	9.277
Inventory turnover	Log inventory turnover	3013	1.304	0.208	0.288	1.959
Hours	Log Hours	3384	8.795	0.317	8.015	10.2
Space	Log Space (m2)	3388	8.306	0.285	7.471	8.909
HRM						
Participation	"I can participate in planning and development of my job"	3388	0.004	0.497	-1.698	1.047
Information sharing	"I get enough information to manage my job"	3388	-0.007	0.497	-1.962	1.206
HRM Environment	Scale based on the two items above	3388	-0.002	0.499	-1.839	1.247

Table 2
ERP and Performance

	Sales	Value added	Inventory turnover	Sales	Value added	Inventory turnover
Log Hours	0.491***	0.486***	0.067*	0.487***	0.475***	0.049
	[7.46]	[7.71]	[1.98]	[7.49]	[7.55]	[1.46]
Log Space	0.361*	0.100**	-0.007	0.360*	0.082*	-0.045
	[1.83]	[2.40]	[-0.084]	[1.78]	[1.87]	[-0.48]
ERP	-0.073***	-0.038***	-0.071***	-0.069***	-0.066***	-0.094***
	[-3.61]	[-2.78]	[-5.34]	[-3.04]	[-3.47]	[-4.68]
ERP*t	0.006***	-0.002	0.011***	0.007**	0	0.008***
	[2.85]	[-1.22]	[7.26]	[2.62]	[0.13]	[5.28]
ERP*Second Wave				0.033	0.036	0.023
				[0.90]	[1.00]	[0.62]
ERP*Third Wave				-0.041	0.047	-0.004
				[-0.97]	[1.42]	[-0.100]
ERP*Fourth Wave				-0.032	0.071***	0.021
				[-0.76]	[3.08]	[0.80]
ERP*t* Second Wave				-0.001	-0.002	0.005**
				[-0.67]	[-0.95]	[2.45]
ERP*t*Third Wave				-0.001	-0.003	0.006***
				[-0.54]	[-1.42]	[2.77]
ERP*t* Fourth Wave				0.001	-0.001	0.008***
				[0.36]	[-0.32]	[4.82]
Manager dummies	YES	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES	YES
Recovery	11.59	-24.79	6.23	10.43	291.6	11.46
	1.681	0.98	4.658	1.8	0.127	3.564
Observations	3333	3335	2964	3333	3335	2964
N	49	49	49	49	49	49
R-squared	0.755	0.71	0.48	0.756	0.711	0.496

Notes: 1) Coefficients are reported in the table and t-statistics in brackets. 2) Significance of the varibles is indicated as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. 3) The t-statistics are robust to heteroscedasticity and autocorrelation within each establishment. 5) R-squared is the unadjusted within R-squared. 6) All regressions include an industry-wide sales index.

Table 3
ERP and Performance: Interactions with ERP training, use, and reporting

	Sales	Value Added	Inventory turnover
Log Hours	0.466***	0.456***	0.044
	[7.22]	[8.26]	[1.34]
Log Space	0.392*	0.131**	0.017
	[1.90]	[2.28]	[0.19]
ERP	-0.069***	-0.030*	-0.069***
	[-3.30]	[-1.92]	[-4.64]
ERP*t	0.006***	-0.002*	0.011***
	[2.70]	[-1.71]	[7.07]
Initial training*ERP	0.174	0.278*	0.193
	[0.94]	[1.97]	[1.43]
Initial training*ERP*t	0.006*	0.006	0.001
	[1.93]	[1.41]	[0.28]
Receiving*ERP	-0.04	-0.084	-0.111
	[-0.32]	[-0.81]	[-1.15]
Receiving*ERP*t	-0.001	0.003	0.001
	[-0.36]	[1.24]	[0.53]
Ordering*ERP	-0.248*	-0.17	-0.054
	[-1.88]	[-1.60]	[-0.53]
Ordering*ERP*t	0.007**	0.004	0.004
	[2.22]	[1.18]	[1.57]
Inventory*ERP	0.019	0.004	0.055
	[0.21]	[0.045]	[0.63]
Inventory*ERP*t	0	-0.003	-0.002
	[-0.069]	[-1.44]	[-1.20]
Reporting*ERP	-0.015	-0.027	-0.027
	[-0.56]	[-0.65]	[-0.83]
Reporting*ERP*t	0	0.002*	0
	[0.34]	[1.75]	[0.18]
Manager dummies	YES	YES	YES
Month dummies	YES	YES	YES
Observations	3274	3276	2868
N	49	49	49
R-squared	0.756	0.714	0.496

Notes: 1) Coefficients are reported in the table and t-statistics in brackets. 2) Significance of the varibles is indicated as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. 3)The t-statistics are robust to heteroscedasticity and autocorrelation within each establishment. 5) R-squared is the unadjusted within R-squared. 6) All regressions include an industry-wide sales index.

Table 4
ERP and Performance: Interactions with HRM variables

	Sales	Value added	Inventory turnover
Log Hours	0.492***	0.488***	0.071**
	[7.45]	[7.77]	[2.17]
Log Space	0.352*	0.07	-0.024
	[1.76]	[1.66]	[-0.26]
ERP	-0.077***	-0.047***	-0.079***
	[-3.68]	[-3.26]	[-5.88]
ERP*t	0.006***	-0.002	0.011***
	[2.94]	[-1.33]	[6.62]
HRM environment	0.011	0.028*	0.039**
	[0.50]	[1.83]	[2.21]
HRM environment*ERP	-0.017	-0.017	-0.037
	[-0.66]	[-0.73]	[-1.31]
HRM environment*ERP*t	0.002	0.003	0.002
	[0.95]	[1.32]	[1.16]
Manager dummies	YES	YES	YES
Month dummies	YES	YES	YES
Observations	3333	3335	2927
N	49	49	49
R-squared	0.755	0.712	0.49

Notes: 1) Coefficients are reported in the table and t-statistics in brackets. 2) Significance of the varibles is indicated as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. 3)The t-statistics are robust to heteroscedasticity and autocorrelation within each establishment. 5) R-squared is the unadjusted within R-squared. 6) All regressions include an industry-wide sales index.

Table 5
The Effect of ERP: Evidence from Surveys

	May 2005 department managers	October 2006 department managers	Difference (2006-2005)	October 2005 sales personnel
Panel A: The Use of ERP				
Ordering	0.68***	0.80***	0.12***	0.74***
	(0.02)	(0.03)	(0.03)	(0.02)
Receiving	0.62***	0.71***	0.09*	0.68***
	(0.03)	(0.04)	(0.05)	(0.03)
Inventory	0.57***	0.62***	0.05	0.047***
	(0.04)	(0.04)	(0.05)	(0.04)
Department managers using reporting features at least monthly	0.35***	0.47***	0.11*	-
	(0.06)	(0.06)	(0.07)	-
Panel B: The Problems with ERP				
Problems with …				
Ordering	0.19***	0.20***	0.01	0.13***
	(0.04)	(0.05)	(0.06)	(0.02)
Receiving	0.45***	0.27***	-0.18**	0.28***
	(0.06)	(0.05)	(0.07)	(0.03)
Inventory	0.12***	0.06*	-0.06	0.07***
	(0.04)	(0.03)	(0.05)	(0.02)
Technical issues	0.20***	0.16***	-0.04	0.14
	(0.05)	(0.04)	(0.06)	(0.02)
Panel C: Impact of ERP on organization				
Teamwork	3.45***	3.29**	-0.17	3.22***
	(0.08)	(0.11)	(0.13)	(0.05)
Job difficulty	4.04***	4.13***	0.09	3.84***
	(0.09)	(0.08)	(0.12)	(0.04)
Job discretion	2.77**	3.03	0.27*	3.11**
	(0.11)	(0.11)	(0.15)	(0.04)
Responsibility	4.07***	4.20***	0.13	3.68***
	(0.10)	(0.08)	(0.13)	(0.04)
Amount of work	4.02***	3.66***	-0.36**	4.20***
	(0.10)	(0.10)	(0.14)	(0.04)
Multi-tasking	3.89***	3.90***	0.01	3.86***
	(0.08)	(0.08)	(0.11)	(0.04)
Employee motivation	2.78**	3.18**	0.40***	2.98
	(0.10)	(0.09)	(0.13)	(0.05)

Notes: i) significance levels: *** 1%; **5%; *10%, ii) standard errors in parenthesis iii) in Panel A, the percentages are store-level means of the use of ERP for different surveys, iii) in Panel B, the percentages are store-level means of respondent experiencing problems with ERP at least weekly, iv) in Panel C, the means reported in columns 1, 2 and 4 are store-level average responses to the question whether the variable has increased or decreased in a 1-5 Likert scale, where 1- substantial decrease, 2- some decrease, 3- no change, 4- some increase, 5- substantial increase. In columns 1, 2 and 4 we report results from t-tests for the null hypothesis mean=3. In column 3 the null is mean=0

Appendix

Table A1
ERP and Performance without PRP dummy

	Sales	Value added	Inventory turnover
Log Hours	0.491***	0.482***	0.060*
	[7.48]	[7.59]	[1.73]
Log Space	0.361*	0.107**	0.001
	[1.83]	[2.61]	[0.015]
	-	-	-
ERP	0.073***	0.073***	0.108***
	[-3.29]	[-6.25]	[-7.83]
ERP*t	0.006***	0.003***	0.017***
	[3.42]	[4.06]	[13.7]
Manager dummies	3.684	3.040***	2.107**
Month dummies	[1.60]	[3.96]	[2.37]
Recovery	11.58	21.85	6.457
	1.741	3.519	6.804
Observations	3333	3335	2964
N	49	49	49
R-squared	0.755	0.708	0.468

Notes: 1) Coefficients are reported in the table and t-statistics in brackets. 2) Significance of the varibles is indicated as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. 3) The t-statistics are robust to heteroscedasticity and autocorrelation within each establishment. 5) R-squared is the unadjusted within R-squared. 6) All regressions include an industry-wide sales index.

Table A2
ERP and Performance: Interactions with ERP Use Variables

	Sales	Inventory turnover	Sales	Inventory turnover	Sales	Inventory turnover	Sales	Inventory turnover	Sales	Inventory turnover
Initial training*ERP	0.049	0.163								
	[0.54]	[1.22]								
Initial training*ERP*t	0.005**	-0.001								
	[2.08]	[-0.26]								
Ordering*ERP			-0.130*	-0.004						
			[-2.00]	[-0.039]						
Ordering*ERP*t			0.006**	0.003						
			[2.25]	[1.13]						
Receiving*ERP					-0.003	-0.021				
					[-0.035]	[-0.29]				
Receiving*ERP*t					0.001	0.001				
					[0.47]	[0.61]				
Inventory*ERP							0.061	0.089		
							[0.62]	[1.06]		
Inventory*ERP*t							0.002	0		
							[1.03]	[-0.25]		
Reporting*ERP									-0.005	0.018
									[-0.17]	[0.50]
Reporting*ERP*t									0.001	0
									[0.43]	[-0.37]
Manager dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3333	2964	3274	2905	3274	2905	3274	2905	3333	2964
N	49	49	49	49	49	49	49	49	49	49
R-squared	0.755	0.484	0.753	0.483	0.752	0.482	0.752	0.484	0.755	0.48

Notes: 1) Coefficients are reported in the table and t-statistics in brackets. 2) Significance of the varibles is indicated as follows: * significant at 10%; ** significant at 5%; *** significant at 1%. 3)The t-statistics are robust to heteroscedasticity and autocorrelation within each establishment. 5) R-squared is the unadjusted within R-squared. 6) All regressions include an industry-wide sales index.