Performance Effects of Aligning Information Technology with Organization and Product Market Strategy

Ferdinand Mahr

Institute for Communication Economics, Munich School of Management, LMU Munich

Schackstrasse 4/III, 80539 Munich, Germany, f.mahr@lmu.de

Tobias Kretschmer

Institute for Communication Economics, Munich School of Management, LMU Munich

Schackstrasse 4/III, 80539 Munich, Germany, t.kretschmer@lmu.de

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ABSTRACT

The returns from information technology (IT) use have been studied in some detail in recent years. The consensus in various disciplines is that there are complementarities between firm organization and IT and that the combination of decentralization and IT appear to work best, although there are also some functions of IT which favour centralization. In this paper, we propose that the complementarities between organization and IT depend on a third factor, a firm's strategy or learning mode. Using a novel dataset on almost 260 German manufacturing firms, we find that IT use and decentralization are complements in firms exploring new products and markets, while IT and centralization are complementary in firms exploiting cost advantages in established product-market domains.

Keywords: Information Technology, Organizational Design, Complementarities, Fit, Contingency Factors, Exploration, Exploitation.

JEL Codes: L23, M15, L60.

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INTRODUCTION

The returns to information technology (IT) adoption have been studied in some detail in recent years (Barua & Mukhopadhyay, 2000; Chan, 2000; Dedrick et al, 2003; Dehning & Richardson, 2002; Kohli & Davaraj, 2003; Melville et al., 2004). While most scholars agree that there appears to be a positive relationship between IT adoption and firm performance, the literature is also united in their finding that firms differ significantly in their ability to appropriate performance gains from IT (e.g., Brynjolfsson & Hitt, 1995; Loveman, 1994). One explanation is that firms are not equally successful in exploiting complementarities that exist between IT and the internal organization and management of firms (Brynjolfsson & Hitt, 1998; 2000).

For example, in some large-scale empirical studies IT was found to be especially fruitful if combined with the decentralization of decision rights to lower-level employees and human resource management (HRM) practices that support decentralized decisions through the provision of the proper motivation, qualification and information to make high-quality decisions (Bresnahan et al., 2002; Brynjolfsson & Hitt, 1998; 2000; Brynjolfsson & Mendelson, 1993; Brynjolfsson et al., 2002; Colombo et al., 2007; Hitt & Brynjolfsson, 1997). These findings have important implications for (technology) managers, as they provide guidance on how to unlock IT's full potential for performance increases by aligning it with organization and management.

Nevertheless, it appears unrealistic that there is one best way to align IT with a firm's organization and management. Indeed, the theoretical literature and case studies have also supposed the opposite view as to which combining IT with a centralized organization and management may be beneficial (e.g., Bolton & Dewatripont, 1994; Garicano, 2000; Gurbaxani & Whang, 1991; Leavitt & Whistler, 1958). But to date, large-sample studies have not supported this view. The lack of such findings may result from the fact that existing empirical studies on firm characteristics complementary to IT "say little about which factors are important in which settings" (Melville et al., 2004, p. 302).

In this study, a contingency theoretic framework is developed to explain that both possible forms of complementarities between IT and organization/HRM practices (i.e., IT/decentralization and IT/centralization) may be beneficial, dependent on a firm's model of organizational learning as a contingency factor. A firm's strategic direction may afford the continuous exploration of new products and markets or the constant improvement in existing product-market domains (March, 1991). As both learning models, exploration and exploitation, are best realized through different organizational designs (Benner & Tushman,

2003; Roberts, 2007; Stieglitz & Heine, 2007), the complementarities between IT and organization/HRM practices may take a different form under an explorational and an exploitational learning model.

Using a unique sample of German manufacturing firms, it is found that the learning model indeed affects the sign of the interaction between IT adoption and the degree of (de-)centralization. Specifically, under an explorational learning model a decentralized organization and IT are found to be complementary, while firms with an exploitational learning model appear to benefit from coupling IT with a centralized organization.

These results present a departure from existing empirical findings that IT adoption and decentralization would be the only combination worth pursuing, but support theoretical and case base studies that have supposed complementarities between IT and centralization. The findings also offer new insights for practitioners on how to align IT with organization/HRM practices given a firm's individual strategic orientation. This is highly managerially-relevant, as it appears very realistic that a firm will only be able to exploit IT's full potential for performance increases if the firm's efforts to align IT with organization and management are fitted to the firm's context.

The study is organized as follows: In the following section, a short review of the previous literature in this field is given, followed by a conceptual framework of the learning model's role for the alignment of IT and organization/HRM practices. Then, the empirical approach to test this theoretical framework is presented. In the following two sections, the data, the data collection process and the variables used in the multivariate analysis are described. A summary of the results is followed by concluding remarks.

THEORETICAL FRAMEWORK

An information processing view of IT's role in contingency theory

The basic tenet of contingency theory is that many elements inside and outside an organization like a firm's structure, technology and strategy have to fit to create a superadditive relationship among them. That is, aligning these elements creates more value than the added value of the elements taken in isolation. From the perspective of a single element, the efficiency of this individual element is contingent on other elements (Van de Ven & Drazin, 1985; Zott & Amit, 2008). In economic terms, the need to achieve "fit" resembles a complementarity between elements (Milgrom & Roberts, 1990; 1995). Organizational elements X and Z are complementary if using X increases the marginal benefit of using Z, i.e.

the marginal return from Z rises in the level of X and the other way around (Stieglitz & Heine, 2007).[1]

Indeed, organizations have to align the elements of its organizational design like structure and HRM practices ("horizontal" fit) and to match this internally consistent organizational design with contingency factors faced by the organization like strategy, environment or culture ("vertical" fit). Horizontal or vertical fit in isolation should not be enough to achieve high firm performance (Becker & Huselid, 1998; Burton & Obel, 2004a; Delery & Doty, 1996; Drazin & Van de Ven, 1985; Huselid, 1995; Miles & Snow, 1978; Mintzberg, 1979; Venkatraman, 1989).

The need to achieve vertical fit can be explained by the functional demand that is imposed on an organization by its contingency factors, which are typically assumed to be "unchangeable" in the short- and middle-term or at least more difficult to change than the organizational design. This functional demand has to be answered by a consistent organizational design that can offer this set of functions (Gresov & Drazin, 1997; Anderson & Jonsson, 2006).

IT has a direct impact on one very important function of an organization, i.e. to cope with the flow of information that is imposed on the organization by its contingency variables and which may have different forms under different contingencies like different strategic orientations and thus different models of organizational learning. IT increases the information available to individual employees, enabling them to improve the quality and quantity of their work. Further, information exchange between employee groups is facilitated, enabling them to better coordinate their (team) work (Garicano, 2000; Dewett & Jones, 2001).

From this simple conceptualization of using information processing theory as a linking mechanism between IT, other (horizontal) elements inside the organizational design on the one hand and (vertical) contingency factors on the other hand, a framework can be derived of how IT has to be aligned with organizational structures, HRM practices and a firm's model of organizational learning (see Figure 1):

INSERT FIGURE 1 ABOUT HERE

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[1] In mathematical terms: $\frac{\partial^2 y(x,z)}{\partial x \partial z} \geq 0$.

Organizational structure, HRM practices and IT affect the quantity and quality of information that can be handled by a firm. Thus, certain organizational structures and HRM practices increase the benefits from IT. In turn, IT increases the benefits from particular organizational structures and HRM practices. IT and its horizontal complements have to be aligned to exploit the complementarities between them and thus to achieve the best possible amount and quality of information handling capability. For example, if a firm's structure forces two plant managers to exchange production data on a daily basis, the benefits of an EDI system are increased and in turn, installing an EDI system will increase the returns from organizational structures which afford plant managers to regularly exchange information.

Vertical IT complements are all contingency factors that impose certain requirements concerning the quantity and the quality of information which has to be handled by an organization. Very similarly to horizontal complements, these contingencies increase the benefits from certain organizational designs, whereas certain organizational designs increase a firm's benefits to operate under certain vertical constraints. Consequently, vertical complements and organizational design have to be aligned to achieve high firm performance. This study focuses on a firm's learning model as a contingency factor, as it is the direct consequence of a firm's strategic direction which is often seen as the most important contingency variable in contingency theory (Roberts, 2007; Saloner, Shepard, & Podolny, 2001).

This framework does not make explicit assumptions regarding the sequence used by firms to achieve vertical fit, i.e. if they first choose a learning model and then implement the organizational design needed to pursue it or if it is more likely that "function follows form". Also, no specific sequence is assumed concerning the emergence of horizontal fit, i.e. regarding the adoption of IT, organizational structures and HRM practices. Empirically, the goal of this study is to find combinations of learning models and elements of organizational designs that are more beneficial than other combinations at a certain point in time, independently of how they have emerged in the past.

Previous literature on IT, organizational structure, HRM practices and contingency factors

This section discusses which parts of the above described theoretical framework have been analyzed by prior literature and which additional parts this study aims to shed light on.[2]

[2] This is not meant to be an exhaustive review, but more to show the main studies in this field and thus to motivate the research question. For a more detailed review see Mahr (2008).

The dimension of horizontal fit has mainly been debated in terms of the right combination of IT with a certain degree of (de-)centralized structures and HRM practices. The degree of (de-)centralization refers to the extent to which decision authority is allocated high in the hierarchy (centralization) or low in the hierarchy (decentralization). Typically, lower-level employees have better local information about supplier and customer needs, competitor behavior and production conditions as they have direct contact to a firm's stakeholders. Top-level employees in turn have more detailed information about firm-wide resources, needs and problems (Anand & Mendelson, 1997; Roberts, 2007). As stated above, IT increases the information exchange between employees and the information endowment of individual employees. This is true for top-level decision makers as well as for lower-level employees.

Scholars proposing complementarities and thus the need to achieve horizontal fit between IT and decentralization argue that concentrating local information at the top management level will not lead to better decision making due to the restricted human information processing capability (Hitt & Brynjolfsson, 1997; Roberts, 2007). Given that parts of the implicit local information will always remain with lower-level workers and that IT endows these employees with more explicit firm-wide information while helping them to coordinate their actions with employees on the same hierarchical level, the co-location of decision authority and residual implicit knowledge, i.e. giving frontline personnel more decision rights, is favored (Brynjolfsson & Mendelson, 1993; Hitt & Brynjolfsson, 1997). Thus, IT is believed to enable lower-level workers to make autonomous decisions in line with the firm's central goals (Brynjolfsson & Mendelson, 1993; Dewett & Jones, 2001; Hitt & Brynjolfsson, 1997; Huber, 1990). As mentioned, this notion is indeed supported by empirical analyses where decentralization is found to be complementary with different IT measures as well as certain incentive and human capital structures (Bresnahan et al., 2002; Brynjolfsson & Hitt, 1998; Brynjolfsson et al., 2002; Hitt & Brynjolfsson, 1997).

In these empirical studies, decentralization has been defined as dispersing decision rights over the pace and the methods of the own work to lower-level employees ("individual decentralization"), the increased use of work practices like self-managed teams, employee involvement groups, and broad job specifications ("structural decentralization"), as well as the increased use of additional HRM practices like promotions based on team performance, team-building mechanisms, and intensive pre-employment screening and training of employees. These practices ensure that employees with extended decision rights are also adequately motivated and qualified to make high-quality decisions (Bresnahan et al., 2002; Brynjolfsson & Hitt, 1998; 2000; Brynjolfsson & Mendelson, 1993; Brynjolfsson et al., 2002; Hitt &

Brynjolfsson, 1997). In this context, one can distinguish between formal decentralization – if only decision rights are given to lower-level employees – and actual decentralization if employees are also provided supporting HRM practices to qualify and motivate them to make good decisions on their own. In this study, it is tested empirically if horizontal fit between IT and a certain degree of (de-)centralization can be achieved by the suitable allocation of decision rights only or if supporting HRM practices are also needed.

There are other scholars which argue that IT enables a higher degree of centralization. According to this interpretation, endowing both lower-level workers and top-level employees with more and better information leads to frontline employees working more autonomously, which releases top-level employees from getting involved in the day-to-day business. This enables top-level workers to increase their span of control (Bolton & Dewatripont, 1994; Garicano, 2000; Gurbaxani & Whang, 1991; Leavitt & Whistler, 1958). IT may be used to support centralization if the advantages from better informed central decisions are more valuable than the advantages from using tacit knowledge which remains with lower-level workers (Anand & Mendelson, 1997; Wyner & Malone, 1996). The advantage of dispersed decision making may further be diminished by lower-level workers' suboptimal coordination among themselves or with company-wide goals due to a lack of experience or incentives (Nault, 1998; Roberts, 2007). Here, IT can be used as additional monitoring mechanism for objective performance measures (Hitt & Brynjolfsson, 1997). Hence, the IT-facilitated information flow may also be exploited by endowing top-level employees with more information and thus by centralizing. To the author's knowledge, no large-scale empirical studies exist which support this view.

In summary, linking IT with decentralization and aligning IT with centralization may both be effective ways to design organizational structures and HRM practices around IT. Or, the other way around, using IT may become more beneficial with both increasing decentralization and increasing centralization. That is, both combinations (IT/decentralization, IT/centralization) may be suitable ways to achieve horizontal fit. This calls into question the studies suggesting that it is only the "IT/decentralization" bundle that can create value. At the very least, the alternative combination can be beneficial under some circumstances, i.e. given a certain strategic orientation and learning model.[3]

[3] March (1991) states that firms have to choose between exploration and exploitation in their "decisions about […] competitive strategies" (March, 1991: 71), i.e. a firm's strategy determines its learning model. Indeed, well-known strategy typologies like Porter's (1985) differentiation/cost leadership or Miles & Snow's (1978) prospector/defender typologies are close to the exploration/exploitation dichotomy (Burton & Obel, 2004) and have empirically been measured in a similar way (Campbell-Hunt, 2000; Delery & Doty, 1996; Dess & Davis, 1984; He & Wong, 2004; Lubatkin et al., 2006).

March (1991) proposed "exploration" and "exploitation" as two types of organizational learning, where exploration resorts to a continuous search for new products and markets whereas exploitation means learning by the ongoing advancement in existing product-market domains. Both exploration and exploitation are best pursued with different organizational designs. An explorer will allow his employees to experiment and innovate, i.e. he will decentralize decision authority to a higher degree. An exploiter will focus on execution, efficiency, rationalization, incremental innovation and the elimination of slack resources, which is best realized with a higher degree of centralization (Benner & Tushman, 2003; Roberts, 2007; Stieglitz & Heine, 2007). This suggests that firms following one learning type will prefer a different organizational structure and consequently benefit from adopting IT differently than firms following the other learning model. Specifically, in terms of the theoretical framework, firms with an explorational learning model face an information flow that should be best coped with a decentralized IT-enabled organizational design. In turn, an exploitational learning model demands a more centralized IT-enabled design.

The main contribution of this study is to analyze the horizontal alignment of IT with organization and HRM practices as well as the vertical alignment of the organizational design with a firm's learning model in conjunction, finding that opposite combinations of IT with horizontal and vertical complements may be equally beneficial. Past studies have focused on horizontal fit or on vertical fit in isolation[4] which should – in line with the theoretical framework presented above – not be enough to gain high firm performance. Summarizing section 2, two hypotheses are proposed which are to be tested empirically in the following:

> *Hypothesis 1. The form of complementarities between IT and organization/HRM practices depends on a firm's model of organizational learning.*
>
> *1a. Under an explorational learning model, IT and decentralization are complementary.*

[4] There are some empirical studies that have analyzed the impact of aligning IT with firm strategy and indicate that aligning IT with a strategy that focuses on new product-market domains may be especially beneficial (Croteau & Bergeron, 2001; Li & Yee, 1999). Thus, similar to the case of horizontal alignment, for vertical IT alignment only one combination of IT and strategy/learning model has been found beneficial, neglecting that combining IT with the opposite strategy/learning model may also be beneficial if the suitable (horizontally consistent) organizational design is in place.
There are also a few empirical studies that have analyzed both horizontal and vertical IT complements. Nevertheless, these studies mostly do not analyze both types of IT complements at the same time and lack further drawbacks. See Mahr (2008) for more details.

1b. Under an exploitational learning model, IT and centralization are complementary.

Hypothesis 2. The relationships proposed in hypothesis 1 are stronger for actual (de-)centralization than for formal (de-)centralization.

EMPIRICAL APPROACH

To test these hypotheses, the impact of IT, organization/HRM practices and learning model on firm performance are analyzed by estimating different specifications of a Cobb-Douglas production function, relating firm j's value added (VA) at time t to the three input factors IT capital (IT), non-IT Capital (C) and labor (L), which is a common approach to empirically test the relationship between IT and firm performance in the more economically oriented literature (Bresnahan et al., 2002; Brynjolfsson & Hitt, 1995; 1998; Lichtenberg, 1995).

$$VA = A(j,t)IT^{\beta_{IT}} C^{\beta_C} L^{\beta_L}$$

In the regression equation to test this production function, j and t denote firm j in period t, X^i denotes a set of i control variables and ε a stochastic error term. Quantitative input factors appear in natural logarithms (see equation 1).

$$(1) \qquad \ln VA_{jt} = \alpha + \beta_{IT} \ln IT_{jt} + \beta_C \ln C_{jt} + \beta_L \ln L_{jt} + \sum_i X^i_{jt} + \varepsilon_{jt}$$

An interaction term between IT and organization/HRM practices (ORG) captures the notion of complementarities between IT and ORG if δ>0 (see equation 2). Interaction terms have been used in many studies to analyze complementarities (e.g., Bloom et al., 2007; Bresnahan et al., 2002; Colombo et al., 2006; Crespi et al., 2006), although a justified criticism of this approach is that there may exist alternative explanations for the covariation of IT, ORG and VA. Examples are unobserved third factors that are correlated with IT, ORG and VA like for instance managerial decisions (Athey & Stern, 2003; Bloom et al., 2007, Bresnahan et al., 2002). In absence of a plausible natural experiment to differentiate between complementarity and alternative explanations, the evidence presented here must "be considered suggestive conditional correlations rather than causal" (Bloom et al., 2007, p. 17).

$$(2)\qquad \ln VA_{jt} = \alpha + \beta_{IT} \ln IT_{jt} + \beta_C \ln C_{jt} + \beta_L \ln L_{jt} + \beta_{ORG} ORG_{jt} + \delta(\ln IT_{jt} * ORG_{jt}) + \sum_i X^i_{jt} + \varepsilon_{jt}$$

To test if the form of complementarities between IT and organization/HRM practices differs with the model of organizational learning, it is tested if the slope of the interaction term IT*ORG for firms with an explorational model differs from the slope for those firms with an exploitational model. To do so, a three-way interaction term consisting of IT, ORG and a group dummy variable indicating a firm's learning model (MODEL1) is included. MODEL1 takes the value 1 for learning model 1 (e.g., exploration) and value 0 for model 2 (e.g., exploitation). In equation 3, δ_3 indicates the existence and form of complementarities between IT and ORG for firms with learning model 2 and δ_4 represents the slope difference to the other learning model, i.e. the difference between IT*ORG's coefficient under learning model 1 and under model 2 (Greene, 2008; Wooldridge, 2006). Thus, summing up δ_3 and δ_4 gives the coefficient of IT*ORG for firms with learning model 1 and indicates the existence and direction of complementarities between IT and ORG under this learning model. The correct specification of a linear regression equation with a three-way interaction includes all linear terms and all possible two-way interactions consisting of the three-way interaction's components.

$$(3)\qquad \ln VA_{jt} = \alpha + \beta_{IT} \ln IT_{jt} + \beta_C \ln C_{jt} + \beta_L \ln L_{jt} + \beta_{ORG} ORG_{jt} + \beta_{MODEL1} MODEL1_{jt} + \delta_1(ORG_{jt} * MODEL1_{jt}) + \delta_2(\ln IT_{jt} * MODEL1_{jt}) + \delta_3(\ln IT_{jt} * ORG_{jt}) + \delta_4((\ln IT_{jt} * ORG_{jt}) * MODEL1_{jt}) + \sum_i X^i_{jt} + \varepsilon_{jt}$$

Although allowing only the variable of interest (and the intercept) to vary between groups is a common procedure, this may bias results as IT*ORG*MODEL1 is possibly forced to explain more inter-group variation than it really does. Thus, in a more flexible specification not only the two-way interaction IT*ORG but all independent variables including the control variables are allowed to vary between groups. That is, all independent variables occur once in their original form as in equation 2 and once interacted with MODEL1. This test for structural breaks between groups is known as Chow test (Greene, 2008; Wooldridge, 2006).

For further robustness tests, different return ratios (RATIO) which are more common in management research on factors affecting firm performance serve as dependent variables. As

these regressions are no production function regressions, it is only controlled for the number of firm employees (EMPL) and not for other "input factors". Additionally, IT and EMPL do not appear in their logarithmized form (equation 3').

$$(3') \quad RATIO_{jt} = \alpha + \beta_{IT} IT_{jt} + \beta_{EMPL} EMPL_{jt} + \beta_{ORG} ORG_{jt} + \beta_{MODEL1} MODEL1_{jt}$$
$$+ \delta_1 (ORG_{jt} * MODEL1_{jt}) + \delta_2 (IT_{jt} * MODEL1_{jt}) + \delta_3 (IT_{jt} * ORG_{jt})$$
$$+ \delta_4 ((IT_{jt} * ORG_{jt}) * MODEL1_{jt}) + \sum_i X^i_{jt} + \varepsilon_{jt}$$

To test hypothesis 2, all regression equations are first run with a measure of actual decentralization used to represent ORG and then using a measure of formal decentralization.

DATA

To estimate these equations, three independent datasets on the IT, on the organization, HRM practices and learning model as well as on the firm performance of German manufacturing firms are matched. As the dependent variable (firm performance) and the most important independent variables (IT, organization/HRM practices, learning model) are drawn from three independent sources, common method variance from single source bias, i.e. the „variance that is attributable to the measurement method rather than to the constructs the measures represent" (Podsakoff et al., 2003, p. 879), is minimized.

Firm performance

Firm performance information comes from Bureau Van Dijk's AMADEUS database which has been used for many prior studies on firm performance. AMADEUS covers almost the entire population of European firms, including small and medium enterprises (SME). Bureau Van Dijk can provide these information as it is a legal requirement for all firms in the European Union to report balance sheets and profit and loss statements. Nevertheless, many firms only provide basic financial information, leading to many missing values.[5]

Information technology

Data on the IT adopted by German manufacturing firms come from the CI Technology database, constructed by the private company Harte-Hanks. Harte-Hanks collects very

[5] Experiments with filling in additional performance data from other versions of AMADEUS as well as other databases like OSIRIS, ORBIS and Hoppenstedt showed unsolvable problems to bring into line these different sources.

detailed information on the hardware, IT employees, interconnecting technologies and software adopted by firms in the United States and Europe. For hardware, interconnecting technologies and software the data are partly were detailed, including information on the manufacturers, product names and product versions. Information are gathered on the site level, i.e. Harte-Hanks surveys one or more establishments of a company on the IT used by this or these establishments.[6] High data quality is implied, as the data are primarily sold to large IT producers and suppliers for the purpose of sales and market research. This information has been collected by annual telephone surveys since the 1990s and has also been used by prior studies on IT, organization/HRM practices and firm performance (e.g., Bresnahan et al., 2002; Bloom et al., 2007).

Organization, HRM practices and learning model

As no information on the organizational structures/HRM practices and learning models of German firms are publicly available, a survey on these topics was conducted. Like prior studies on the impact of IT and/or high-performance work practices (e.g., Bresnahan et al., 2002) only manufacturing firms[7] were surveyed to be able to focus on a single questionnaire and to avoid the problems of interpreting the output of service firms when estimating production functions.

For this survey, the sampling frame of 600 German manufacturing firms resulted from those firms for which the above mentioned firm performance and IT information were available. Due to limited database access at the time of the sampling frame construction, it consisted of those firms for which at least 2004 IT data and 2004 or 2005 firm performance data were available.[8] These firms formed the sampling frame for a telephone survey which took place in March 2008 and was conducted by six student interviewers and two supervising PhD students which were located at a specially equipped telephone studio. The interviewers targeted the firm's switching boards, asking for the production manager or an employee in a similar position. These persons were approached as they typically are in the upper middle of a firm's hierarchy, thus having a good overview of both firm-wide issues like the firm's learning model as well as of more lower-level issues like actual organizational structures and HRM

[6] "Establishment" and "site" are used synonymously. "Company" and "firm" also serve as synonyms.

[7] Manufacturing firms are represented by the US Standard Industrial Classification (SIC) codes 20 to 39.

[8] Selection effects do not appear to be an issue if comparing the average size of the companies (measured in terms of employees, operating revenue and tangible fixed assets) in the sampling frame with the average size of the other companies in the CI Technology database. This is based on a t-test of group mean differences, assuming equal variances and using conventional significance levels. Nevertheless, note that Harte-Hanks does not strictly randomly choose the firms to be surveyed for the CI Technology database.

practices. By concentrating on such a narrow set of potential interviewees, measurement error from single informant bias was held relatively constant.

An important factor was to convince the switching board as well as the potential interviewees (and sometimes their assistants) to take part in the survey. To ensure a high response rate, several steps were undertaken:[9] (1) The interviewers explicitly introduced the survey as a "scientific research project" rather than a "survey" which would often lead to the immediate rejection by switching boards, assistants or potential interviewees. (2) Interviewers assured potential interviewees that they would not ask for financial or any other clearly confidential information. (3) Potential interviewees were offered a free summary of the research results. (4) An e-mail with a written description of the research project as well as an endorsement letter of the chairman of Deutsche Telekom Foundation and former German Foreign Secretary, Klaus Kinkel, was sent to all potential interviewees who wished so. (5) To further underline the respectability of the project, individual e-mail-addresses for interviewers and a website with information on the project, the interviewers and supervisors were set up. (6) As soon as an interview appointment had been made, interviewees were sent an approval of this appointment and a reminder 24 hours prior to the appointment. (7) To minimize interview abruptions, the interview started with rather neutral questions (e.g., number of firm employees), with more critical questions (e.g., owner of the firm) only occurring at the end of the interview. (8) The main part of an interviewer's pay was based on the number of interviews conducted by her or him. Additionally, team boni were paid to all interviewees as soon as the whole team had conducted certain overall amounts of interviews. The performance of each interviewer and of the whole team was monitored on a daily basis and made public to the whole team at the end of each week. Together, this lead to strong incentives for each individual interviewer to continuously reassess her or his procedure in making interview appointments and conducting interviews as well as to team incentives to exchange best practices between interviewers. (9) More formally, best practices were also discussed during regular and irregular team meetings moderated by the supervisors.

Information on the organization/HRM practices and learning model were partly gathered with classic verbalized Likert scale questions, and partly by an innovative survey method introduced by Bloom and Van Reenen (2007). This method allows (1) to get a very detailed insight into the HRM practices of a firm which might not have been possible with a (limited) number of Likert scale questions and (2) to avoid the problem of social desirability which is

[9] Experience in approaching potential interviewees was drawn from a pretest in course of a seminar at the Institute for Communication Economics, Munich School of Management, LMU Munich and from Bloom and Van Reenen's (2007) detailed description of their similar survey.

particularly a problem if asking for HRM practices that support decentralization which are generally seen as "good". Some interviewees may for example claim that their firm's frontline personnel had more chances to participate in decision making than it actually has, if directly asked for. Instead of asking closed questions, i.e. for example asking interviewees to score a statement about their firm from 1 ("I fully disagree") to 5 ("I fully agree"), interviewees were asked open questions about HRM practices. Their answers were then scored from 1 to 5 by the interviewers. Interviewees did not know that their open answers were scored, assuring that the problem of social desirability did not occur.[10]

The interviewers were provided with prepared questions to ask. The aim of one example question used for this study is to find out if lower-level employees do participate in decision making processes of their supervisors (see Table 1). The interviewers were provided with "anchor" descriptions of the scores 1, 3 and 5 and could also score 2 and 4 for intermediate cases. They began with an open and quite general question on the decision making process ("How do you make decisions …?") and invited the interviewees to answer freely. To make the interviewees' explanations more concrete, they later asked more detailed questions ("When do you inform your staff …?", "What kind of influence … do your staff members have?"). The interviewers were encouraged to deviate from these prepared questions if needed or suitable and to ask own questions as well as for examples ("Can you describe the last/a typical decision making process for me?") as much as possible. Thus, a conversation led by the interviewer developed for each question which was ended by the interviewer only as soon as he had a full picture of the HRM practice in question and was able to give a score from 1 to 5. Due to this detailed insight into the interviewed firms' HRM practices, even a single item measuring one HRM practice should at least perform as well as a scale from multiple Likert scale items used to measure the same practice. As interviews lasted 45 minutes on average (the maximum interview duration was 78 minutes), an in-depth insight into the firms was given.

INSERT TABLE 1 ABOUT HERE

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[10] This survey method has been passed by the Human Subjects Committee of Stanford University for the study of Bloom and Van Reenen (2007). The interviewees' unawareness of being scored was seen acceptable because it is (1) necessary to reduce the problem of social desirability, it is (2) not risky for the interviewees or their firms as the data are held confidential, and it is (3) temporary as the interviewees were debriefed after the end of the project (Bloom & Van Reenen, 2007). All persons interviewed for this study will also receive a debriefing package.

As this data gathering method strongly relies on the interviewers' capabilities, several steps were undertaken to ensure high interview quality. The six student interviewers came from management, economics and sociology and were chosen in a two step assessment procedure from almost 80 applicants. Selection criteria were prior experience with the topics of the survey and data gathering in general as well as performance in a simulated interview situation. The interviewers were intensively trained in the survey background, method, questions and software during a two day training period before the start of the survey period. Several simulated interviews were done during this training. Interview quality was further enhanced through regular team meetings and through interview monitoring by the two supervisors. The supervisors listened to 55 interviews (i.e. 21.4% of all interviews) and assigned scores to the interviewees' answers independently from the interviewers.[11] In the first week of the project, supervisors and student interviewers discussed possible differences between the interviewers' and the supervisors' scores to enhance interview quality.

Additionally, these supervisors' "double scorings" can be used as a test of the inter-rater reliability of the innovative survey method used for this study. To analyze if two raters would give similar scores to the same interviewee using this interview method, the correlation of the interviewers' and the supervisors' scores for those questions/scales which were using the innovative interview method and which were used in the regressions was calculated. The partial correlation coefficients (controlling for interviewer and supervisor fixed effects) for a single-item measure on a firm's learning model[12] and a scale of items on HRM practices[13] are very high in magnitude and significance (see Table 2), indicating that the interview method leads to relatively homogenous results, even if different interviewers score the same interview. [14]

INSERT TABLE 2 ABOUT HERE

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[11] In the regressions, only interview scorings from interviewers were used.

[12] This item is part of a scale described below.

[13] This scale is used in the empirical analysis and further described below.

[14] Correlation coefficients are calculated using those double scorings made in the last two weeks of the survey period only. This gives a more conservative indication of inter-rater reliability, as in the first week (and to a much smaller extent in the second week) the discussions between interviewers and supervisors after double scored interviews could in some cases result in the adaptation of individual scorings by the interviewer.

The 600 firms from the sampling frame were randomly assigned to the six interviewers in two slices at the beginning and in the middle of the project time. On average, interviewers had to contact a firm eight times to obtain an interview and were able to interview 257 firms successfully, resulting in an acceptable response rate of 42.8%.[15] Only 17.5% of the firms explicitly refused to take part in the survey. All other firms have not been contacted during the survey period, were "in queue" at the end of the project[16], did not exist anymore or do not produce in Germany contrary to the information at the time of sampling frame construction. Each interviewer conducted on average 2.7 interviews a day and on average 42.8 interviews throughout the survey period.

The combined dataset

The full dataset comprises information on 259 companies.[17] Due to extended database access after the end of the survey, firm performance and IT data for these firms are available for the period from 1999 to 2008, though many firms are covered only for parts of the entire period by the AMADEUS and/or CI Technology databases. Two issues will be treated in more detail in section 5:

First, the full dataset combines establishment level data on IT and organization/HRM practices/learning model with company-level data on firm performance. Despite the potential bias from this, the combined data are valid (1) as establishment level information are extrapolated to create firm level measures, (2) as the representativeness of these measures is controlled for and (3) as these estimates should be reliable in face of relatively small and thus homogenous companies with on average 3,385 employees in the largest common sample used in the empirical analysis. 53% of the observations in this sample are from firms with a maximum of 500 employees and 78% of the observations from firms with up to of 1,000 employees. Thus, the companies are relatively small in comparison to other studies, where Fortune 1000 firms with on average more than 13,000 employees were analyzed (Bresnahan et al., 2002).

[15] Response bias does not appear to be an issue if comparing the average size of the interviewed companies (measured in terms of employees, operating revenue and tangible fixed assets) with the average size of the other companies in the sampling frame. This is based on a t-test of group mean differences, assuming equal variances and using conventional significance levels.

[16] As described above, interviewers made about eight firm contacts per interview, i.e. for the firms „in queue" the interviewers were still in the process of trying to make an interview appointment at the end of the project time or had already made an appointment which was then postponed.

[17] Two firms that were originally only interviewed for training purposes could be matched with firm performance and IT data ex-post, leading to a potential sample of 259 firms for the multivariate analysis

Second, panel data on firm performance and IT (1999-2007) area combined with cross-section information on organization/HRM practices and learning models (2008). Although some measurement error is undeniable, (1) this is justifiable by the fact that a firm's organization and HRM practices as well as its learning model are much harder and slower to change than investments in IT and firm performance, i.e. organization/HRM practices and learning model can be regarded as quasi-fixed in the short- and middle-term (e.g., Bloom et al., 2007; Bresnahan et al., 2002). (2) Second, a measure for potential changes in organization, management and learning model is included as a control variable in all analyses. (3) Additionally, the measures of organization/HRM practices and learning models can at least be interpreted as changes toward the final situation measured in 2008 (Bresnahan et al., 2002). As the existence of complementarities does not indicate a certain sequence of adopting IT and specific types of organization/HRM practices (see above), this does not essentially affect the findings. Finding those firms that first adopt IT and then switch to certain organizational structures and HRM practices to have higher firm performance would still be evidence for complementarities between IT and these forms of organization structures/HRM practices.

VARIABLES

Firm performance

As described above, firm performance is measured in terms of (1) value added when estimating production functions and in terms of (2) different return ratios in robustness tests.

In the production function estimations, value added (VA) is defined as operating revenue less material costs. The input factor capital (C) is measured by total assets[18], the factor labor (L) by the number of firm employees.

The three return ratios are return on sales (ROS), return on assets (ROA) and return on capital employed (ROCE), a figure similar to return on investment (ROI). These measures are defined as shown in Table 3.

INSERT TABLE 3 ABOUT HERE

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[18] Note that C should indicate non-IT capital only, but that the data available for this study do not allow calculate a measure of capital less IT capital.

All four dependent variables are obtained directly from the AMADEUS database and relate to the firm level.[19] Total assets are obtained from the AMADEUS database, whereas the number of firm employees is obtained from the CI Technology database due to many missing values in the AMADEUS database.[20] As AMADEUS includes unconsolidated as well as consolidated accounts, a control variable for the account type is included in all regressions.[21]

Information technology

In a first step, the total number of personal computers (PCs) in a firm is used as a proxy for a firm's IT adoption intensity (IT). The CI Technology database offers more detailed information on the hardware and software used by the interviewed sites, but similar measures have been used in those empirical studies on IT and organization/HRM practices which this study aims to enrich (e.g., Bloom et al., 2007; Bresnahan et al., 2002). As mentioned above, IT information are on the site level, i.e. the number of PCs per establishment employee is known. To make this ratio comparable to the firm level and thus the performance measures, the number of PCs per site employee is multiplied by the number of firm employees, resulting in an estimate of the total number of PCs per company (IT):

$$IT = \frac{\text{number of site PCs}}{\text{number of site employees}} * \text{number of firm employees}$$

To control for the fact that site level IT information is used to estimate firm level IT intensity, two efforts are undertaken. First, for several firms in the sample, the CI Technology database includes information on multiple sites of these firms. In this case, the number of PCs per site employee is aggregated across establishments to generate more reliable firm level estimates.[22] Second, a control variable for CI Technology database's coverage of firm employees is included, showing on which percentage of firm employees the estimate of firm level IT is

[19] The three return ratios obtained from AMADEUS have successfully been cross-checked by calculating them manually.

[20] The correlation coefficient for the number of firm employees from the AMADEUS database and from the CI Technology database is 0.98 ($p<0.000$).

[21] 75% of the firm performance observations in the largest common sample used below come from unconsolidated accounts.

[22] For example, in the case of two observed sites, IT is defined as:

$$IT = \frac{\text{PCs on site 1} + \text{PCs on site 2}}{\text{employees on site 1} + \text{employees on site 2}} * \text{number of firm employees}$$

based on.[23] The mean coverage ratio of the largest common sample used in the multivariate analysis is as high as 82%, indicating that the estimate of firm level IT is relatively accurate. Indeed, 58% of the IT observations in the largest common sample are based on a coverage ratio of 1, i.e. the firm level IT measure is no estimate in these cases, but gives the actual total number of PCs in these companies.

Organization and HRM practices

As described above, a distinction between formal and actual decentralization can be drawn, where the allocation of decision rights to lower-level employees per se represents formal decentralization and the combination of decision rights with supporting HRM practices represents actual decentralization.

To measure formal decentralization, an index of six five-point Likert scale items that are derived and adapted from Bresnahan et al. (2002) and Brynjolfsson and Hitt (1998) is built. These items represent production related decisions, where production managers were asked to indicate for each decision if it normally is made by "managers exclusively" (score 1), "managers mainly", "managers and workers", "workers mainly" or "workers exclusively" (score 5). Production managers were asked who was responsible for the decision on the delivery time and priority of orders (DEC1), the development of production plans (DEC2), the distribution of work among production workers (DEC3), the decision on how exactly work is done (e.g., pace and order) (DEC4), the decision on which machines and tools are used (DEC5) and the coordination between different areas of the production process (DEC6).[24] Formal decentralization (FDEC) is thus defined as the simple average of six standardized items:

$$\text{FDEC} = \frac{\text{DEC1} + \text{DEC2} + \text{DEC3} + \text{DEC4} + \text{DEC5} + \text{DEC6}}{6}$$

FDEC is defined as a reflective index, i.e. DEC1 to DEC6 are interpreted as being caused by the construct "formal decentralization". Thus, changes in formal decentralization should lead to changes in DEC1 to DEC6 which should therefore be correlated (Diamantopoulos &

[23] The coverage ratio is defined as follows. Coverage ratio values exceeding 1 due to data errors are transformed to 1.

$$\text{coverage ratio} = \frac{\text{number of site employees}}{\text{number of firm employees}}$$

[24] For the questionnaire see Appendix A.

Winklhofer, 2001; Jarvis et al., 2003). For FDEC, the most common measure for internal consistency reliability, Cronbach's alpha, is acceptable (α=0.68). Analyses were also run with FDEC', where DEC1 to DEC6 were weighted with their factor loadings obtained from a principal components analysis.

Additionally, a measure of HRM practices which support formal decentralization (HRM) was constructed. HRM is defined as the simple average of nine standardized HRM practices. Two practices complement formal decision rights, i.e. the possibility to participate in the decision making process of superiors' (HR1) as well as the possibility to criticize superiors' decisions (HR2). As decentralizing formal decision rights is useless unless workers have the opportunity to make independent decisions, two further items measure HRM practices which allow for such discrete decision making, i.e. (self-managed) teamwork (HR3) and a certain variety of the daily work (HR4). The remaining HRM practices included in the scale endow workers with the proper information, qualification and motivation to make use of formal decision rights effectively, i.e. the amount and quality of information given to lower-level workers (HR5), the amount and contents of training given to them (HR6), pay components based on individual performance (HR7), pay components based on establishment or firm performance (HR8) and promotion criteria coupled with capabilities that enable lower-level workers to make their own decisions (HR9).[25]

The measure of actual decentralization (ADEC) is defined as the simple average of the standardized values of FDEC and HRM.

Both, HRM and ADEC are defined as formative measures. The components of a formative measure are believed to cause the latent variable and not to be a result of the latent variable like in the case of reflective measures. Thus, as one explicitly assumes that the correlation between a formative measure's components "may be positive, negative or zero" (Diamantopoulus et al., 2008, p. 1215), testing reliability in terms of internal consistency is not appropriate for formative measures (Diamantopoulus et al., 2008; Nunally & Bernstein, 1994; Rossiter, 2002).

As described above, establishment level information on organization/HRM practices which are gathered by one interviewer who speaks to one interviewee are used as an estimate of firm level organization/HRM practices. Similar to the case of the IT measure, the representativeness of the interviewed site for the whole firm is controlled for by the share of the whole firm's employees that work in the interviewed site. As also described above, organization/HRM practices and learning model are assumed to be quasi-fixed in the short

[25] For the questionnaire see Appendix B.

run. Nevertheless, to control for potential changes, a dummy variable which indicates if a firm's owner has changed in the last five years, is included in all analyses. Change of ownership can be interpreted as a major reason for significant changes of organization/HRM practices or learning model. Only 18% of the observations in the largest common sample used below are from firms with a change of ownership in the last years. As interviewers ran between 32 and 54 interviews, effectively controlling for interviewer fixed effects like systematically better or worse scorings through certain interviewers is possible by including a set of interviewer dummies in all regressions. Possible interviewee effects like for example a different point of view through a different position in the firm's hierarchy or different amounts of knowledge on the firm due to different tenure are controlled for by the interviewee's relative position in the firm's hierarchy[26] as well as the interviewee's tenure. To control for general interview quality, the interview duration is included as a control in all analyses.

Learning model

March's (1991) different models of organizational learning, i.e. exploration and exploitation, are measured by a scale consisting of (1) classical Likert scale items scored by the interviewee, (2) dummy variables scored by the interviewee and by (3) one item scored by the interviewer using the described in-depth interview method. These items measure if the interviewed site as well as the firm as a whole have concentrated on exploring new markets and customer groups as well as on introducing new products in the last years or if the main focus was on existing markets and customer groups as well as on the continuous improvement of existing products and processes. The scale representing a firm's learning model (LEARN) is constructed by the simple average of six standardized items.[27]

LEARN is defined as a formative measure, as a firm's decision to focus on new products and/or markets affords an explorational learning model.

The median of LEARN is used to split the sample in two groups of nearly equal size, i.e. in one group with what is considered as an explorational learning model and another group with an exploitational learning model. The group dummy for exploration (XPLOR) takes the value

[26] The interviewee's relative hierarchical position is calculated as follows:

$$\text{relative hierarchical position} = \frac{\text{interviewiee's hierarchical level}}{\text{number of the firm's hierarchical levels}}$$

[27] For the questionnaire see Appendix C.

1 for LEARN≥median(LEARN) and 0 otherwise. The dummy for an exploitational learning model (XPLOIT) takes the value 1 for LEARN<median(LEARN) and 0 otherwise.

This procedure to distinguish between both learning models will also define those firms as a member of one of both groups which are relatively close to the median of LEARN and thus may follow a mixed or "ambidextrous" learning model. A dummy marking those firms that lie between the 25th and the 75th percentile of LEARN is included to control for this fact. This dummy takes the value 1 for 39% of the observations in the largest common sample used below.

Further control variables

Control variables that are included in all regressions but have not been described so far include dummies representing the 70 different industry sectors in which the firms in the largest common sample are engaged in. To determine a firm's industry sector, the very detailed three-digit level of the US SIC codes is used. As panel data are used, all regressions contain a full set of year dummies. Control variables for robustness tests (to be described in more detail below) include one year lagged firm performance measures, the percentage of site employees with a degree, as well as the denominators of the return ratios presented above.

Descriptive statistics for the largest common sample

The largest sample for which all data that are needed for the multivariate analysis are available comprises 295 observations of 152 companies in the period from 2000 to 2007.[28] Descriptive statistics on the main variables are summarized in Table 4.[29]

INSERT TABLE 4 ABOUT HERE

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[28] Selection effects do not appear to be an issue if comparing the average size of the companies in the largest common sample (measured in terms of employees, operating revenue and tangible fixed assets) and the average size of the other companies in the CI Technology database and in the sampling frame. This is based on a t-test of group mean differences, assuming equal variances and using conventional significance levels. This "largest common sample 1" is used in the main analyses. For robustness tests with return ratios as dependent variable, a larger sample is used.

[29] Before calculating the descriptive statistics shown in Table 4, all variables have been averaged across all years for which a firm is observed.

RESULTS

Hypothesis 1: Main analyses

Colum 1 in Table 5 shows the results for the basic production function regression with the three input factors IT, capital and labor (see equation 1 above). As expected in a production function regression, capital and labor have a significantly positive impact on value added. In line with the theoretical framework, IT does not appear to significantly influence firm performance if not aligned with organization/HRM practices.

Column 2 shows the results for regression equation 2 where IT is interacted with actual decentralization (ADEC). The interaction term IT*ADEC[30] is not significant, supporting hypothesis 1 as to which there is no general form of complementarities between IT and ADEC that applies to all firms.

INSERT TABLE 5 ABOUT HERE

This result contradicts prior findings of complementarities between IT and decentralization (Bresnahan et al., 2000).[31] This may be due to differences in the composition of firms in the samples used for their study and for this study. Specifically, in their ten years older sample from the late 1980s to the mid 1990s, heavy IT adopters are early IT adopters. It would be intuitive to assume that these firms were also pioneers in other fields than IT, i.e. these firms may have also been early adopters of decentralized organizational structures and HRM practices and may have had above-average firm performance due to first-mover advantages in the adoption of these technological and organizational innovations. This would result in a strong estimated complementarity effect driven by successful pioneering firms. In the meantime, IT as well as decentralized structures and HRM practices are much more widespread among firms, leading to a greater variety of combinations of IT use, organization and HRM practices. Thus, a positive correlation of high performance with certain combinations of IT and organization/HRM practices should indicate complementarities between the elements of these combinations instead of first-mover advantages in the more recent sample of firms used in this study.

[30] Logarithms are dropped for convenience in the description of the results.

[31] The interaction term in Bresnahan et al. (2002) is only significant at the 10% level of significance and in the maximum sample.

To test hypotheses 1a and 1b, several specifications of regression equation 3 are run in Table 6. In a first step, only IT*ADEC is allowed to vary between those firms with an explorational and those with an exploitational learning model by interacting IT*ADEC with a group dummy. In column 1, IT*ADEC is interacted with the dummy variable XPLT which takes the value 1 if a firm follows an exploitational learning model.[32] As a consequence, the coefficient of the interaction term IT*ADEC shows the effect of IT*ADEC for the other group, i.e. for those firms with an explorational learning model. This "other" group is termed "base" group in this study and indicated at the top of all tables below the dependent variable. In line with hypothesis 1a, the positive and significant coefficient of IT*ADEC in column 1 (0.1283**) indicates the existence of complementarities between IT and actual decentralization for firms with an explorational learning model.

INSERT TABLE 6 ABOUT HERE

Additionally, in column 1 the impact of IT*ADEC on the performance of explorers is found to be significantly different from the impact of IT*ADEC on the performance of exploiters. More specifically, the impact of IT*ADEC is significantly lower for exploiters, which can be derived from the coefficient of the three-way interaction IT*ADEC*XPLT (-0.2738***). Thus, the performance impact of IT*ADEC should be negative for exploiters, which can be calculated by summing up the coefficients of IT*ADEC and IT*ADEC*XPLT (0.1283-0.2738=-0.1455).

This can easily be approved by switching the base groups, what is done in column 2. Here, IT*ADEC is interacted with the dummy XPLR, making exploiters the base group. Indeed, the performance impact of IT*ADEC is found to be negative (-0.1455**). More important than approving the magnitude of the coefficient for IT*ADEC under an exploitational learning model is that from column 2 one can additionally derive that this coefficient is significant at the 5% level. The significantly negative performance impact of IT*ADEC for exploiters supports hypothesis 1b, as ADEC is a continuous variable and thus not only a measure for decentralization, but at the same time a (reverse coded) measure of centralization. Therefore, the negative performance effect of IT*ADEC for exploiters can be rephrased as a positive performance impact of combining IT and centralization under an exploitational learning

[32] The most important rows in Table 7 are marked with grew colour.

model. Thus, it is an indication for the existence of complementarities between IT and centralization for exploiters.

As expected, the difference between both groups (IT*ADEC*XPLR) in column 2 has the same magnitude and significance as in column 1 but with the opposite sign (0.2738***).

In summary, hypothesis 1 is supported. The existence of complementarities between IT and decentralization for all companies is not supported. Instead, the results show that the performance effects of combining IT and (de-)centralization differ significantly with learning models. Specifically, support is found for complementarities between IT and decentralization under an explorational learning model and for complementarities between IT and centralization under an exploitational learning model.

Hypothesis 1: Robustness tests

In the following, a number of further tests of hypothesis 1 are undertaken. Together, these tests will give astonishingly robust support for this hypothesis.

A first robustness test is the inclusion of a lagged performance variable as further control in columns 3 and 4 of Table 6. Including a lagged dependent variable has been suggested to account for reverse causality, i.e. for the possibility that better performing firms tend to adopt consistent clusters of IT, organization/HRM practices and learning model. More generally, lagged dependent variables have been suggested as a control for historical factors that cause current differences in the dependent variable, i.e. for any form of bias from omitted control variables (Burton et al., 2002; 2004b; Dezső & Ross, 2007; Wooldridge, 2006). One would expect the significance of IT*ADEC to entirely vanish if the results in columns 1 and 2 were only driven by the fact that "better" firms adopt more consistent clusters of IT, organization/HRM practices and learning model or solely by another omitted variable. Instead, although the lagged performance variable enters highly significant, the results for IT*ADEC under both learning models and for the three-way-interactions that indicate IT*ADEC's slope difference between groups (IT*ADEC*XPLT and IT*ADEC*XPLR) largely hold in magnitude and significance.

There is a significant literature on the so-called skill-biased technical change (SBTC), i.e. the finding that new technologies are complementary with higher skilled workers (e.g., Autor et al., 1998). Additionally, other authors find complementarities between skills and organizational change (Caroli & Van Reenen, 2001). Thus, the results obtained so far could be driven by unobserved correlations between firm performance, organization/HRM practices, learning model and the level of skills in the observed firms. To exclude this possibility, a

control for the proportion of employees in the interviewed establishments who have earned a degree is included in columns 5 and 6 of Table 6. The known results hold.

The results also largely hold in Table 7, where all regressions from Table 8 are re-run, but - as described above - all coefficients are allowed to vary between groups. The only exception is the coefficient of IT*ADEC in column 2, which holds in magnitude but not significance. Of special interest are columns 5 and 6 which represent the toughest robustness test and fully support the prior findings.

INSERT TABLE 7 ABOUT HERE

A final robustness test is undertaken in Table 8, where three return ratios are used as dependent variables. One concern when using (return) ratios as dependent variables that is seldom approached is the possibility that results are mainly driven by the ratios' denominators. Thus, the denominators of ROS, ROA and ROCE are included as controls in Table 8. Whereas high R^2 are not unusual in the case of multi-factor productivity regressions (see Table 5 to Table 7), R^2 naturally decreases in Table 8 Table 8 shows that if allowing IT*ADEC to vary between both groups, the known results for IT*ADEC and the group differences largely hold in magnitude and significance. Exceptions are the results for IT*ADEC under an explorational learning model in columns 3 and 5, which are not significant. IT*ADEC in column 5 additionally changes its sign, although the coefficient is very small.

INSERT TABLE 8 ABOUT HERE

Hypothesis 2

Finally, hypothesis 2 is tested, as to which the relationships proposed in hypothesis 1 are stronger for actual than for formal decentralization. All regressions from Table 5 to Table 8 are repeated, replacing ADEC by the measure of formal decentralization (FDEC).[33] The overall finding is that - with some exceptions - most of the results found for ADEC hold in

[33] Results are available from the authors.

magnitude and significance if using FDEC instead of ADEC. There is no general tendency according to which the coefficients of IT*ADEC or IT*FDEC would be systematically larger or smaller, i.e. according to which the complementarities between IT and (de-)centralization would be stronger or weaker for actual or formal decentralization. The fact that only a few results do not hold if using FDEC instead of ADEC in the regressions indicates that even dispersing formal decision rights to lower-level employees without putting in place supporting HRM practices is sufficient to make at least partly use of the complementarities between IT, organization/HRM practices and learning model. Nevertheless, as some results do not hold, the use of actual decentralization may still help to better exploit these complementarities. This result does not change if FDEC' (DEC1 to DEC6 weighted with factor loadings) is used instead of the FDEC (simple average of DEC1 to DEC6).

CONCLUSION AND POTENTIALS FOR FUTURE RESEARCH

In summary, this study supports prior findings as to which there are complementarities between IT adoption and appropriate organizational structures/HRM practices. Nevertheless, this study suggests that there is no general type of complementarity between IT and organization/HRM practices (e.g., between IT and decentralization) which applies to all firms. Instead, the analysis of German manufacturing firms suggests that IT, organization/HRM practices and learning model are interrelated in such a way that the complementarities between IT and organization/HRM practices have a different direction under different learning models. Specifically, in firms that continuously explore new products and markets, IT and decentralized organizational structures/ HRM practices appear to be complementary, whereas in firms which mainly exploit existing products and markets, IT is found to be complementary with centralized structures and HRM practices.

Additionally, HRM practices that support the (de-)centralization of decision rights are found to play only a minor role in exploiting complementarities between IT and the degree of (de-) centralization. These complementarities appear to be already partly exploited by aligning IT with formal decision rights. These results, which are summarized in Table 9, are obtained by estimating production functions and hold several robustness tests.

INSERT TABLE 9 ABOUT HERE

The results appear to contradict existing empirical studies who predominantly found support for complementarities between IT adoption and decentralized decision rights which are supported by proper HRM practices. These one-sided findings may be a result of the time in which these studies were conducted. A decade ago, firms adopting IT were more likely to be pioneers in many aspects of their business. One explanation would be that heavy IT adopters at this time were also early adopters of then innovative decentralized structures and HRM practices. An extension of this explanation is that IT and decentralization seemed to be the only beneficial combination, because explorers – whose learning model was unobserved in prior studies – were much more likely to have adopted IT and decentralized organizational structures/HRM practices than exploiters, as it is the very characteristic of an explorer to fastly adopt new technological and organizational innovations. However, with IT having spread throughout the economy, the heterogeneity in learning models across IT-adopting firms should be much bigger today, i.e. many exploiters now also have adopted IT. Thus, the existence of complementarities between IT and centralization can now be confirmed empirically, if a firm's learning model is taken into account.

The finding that HRM practices play only a small role in the exploitation of complementarities between IT and organization adds to the literature as prior studies have not (empirically) distinguished between formal and actual decentralization.

The findings have important implications for (technology) managers and consultants as they stress the need to align IT with a firm's organization and management to be able to unlock IT's full potential for performance increases. More important, the findings show that IT cannot be integrated with a firm's structures and management practices in a general way that is suitable for all firms. Instead, a thorough analysis of a firm's strategic orientation and learning behavior is a necessary condition to implement and exploit IT successfully. It is also important for managers to recognize the meaning of complementarities between IT, organization/HRM practices and learning models in situations of organizational change. Changes in one of the three complements afford changes in the other parts to become effective. That is, the introduction of new IT may strengthen existing types of organization/HRM practices and learning models or serve as an incubator to launch changes in a firm's organization/HRM practices or strategic direction.

To offer more detailed guidelines for management practice, complementarities between IT, organization/HRM practices and learning models will have to be analyzed on a more detailed level in future research, i.e. specific types of hardware and software and their potentially different complementarities with organization/HRM practices and learning models will have

to be taken into account. Another very interesting topic would be to analyze the role of other contingency factors for the optimal combination of IT with organization/HRM practices. Prominent examples for such contingencies are a firm's environment or culture. Another interesting point suggested by the results is to analyze in more detail the relationship between technology and HRM practices, i.e. for example the question if HRM practices supporting a certain degree of (de-)centralization are complements or substitutes to technologies which also support a certain degree of (de-)centralization. Further, to test the robustness of the results, the use of alternative methods that have been suggested to capture the notion of complementarities or "fit" in economics and management research should be assessed (e.g., Bergeron et al., 2004; Burton et al., 2002; Cassiman & Veugelers, 2006; Meilich, 2006; Miravete & Pernías, 2006; Mohnen & Röller, 2005).

Nevertheless, this study is an important step in the direction of a more nuanced assessment of IT's impact on firm performance. Recognizing a firm's strategic direction and learning model as an important determinant of the interactions between IT adoption and organization/HRM practices is an important aspect that holds significant potential for future research and management practice.

BIBLIOGRAPHY

Anand, K. S., & Mendelson, H. 1997. Information and Organization for Horizontal Multimarket Coordination. ***Management Science*****:** 43(12): 1609–1627.

Andersen, J. A., & Jonsson, P. 2006. Does Organization Structure Matter? On the Relationship Between the Structure, Functioning and Effectiveness. ***International Journal of Innovation and Technology Management:*** 3(3): 237-263.

Athey, S., & Stern, S. 2003. ***An empirical framework for testing theories about complementarity in organizational design.*** Working Paper, NBER.

Barua, A., & Mukhopadhyay, T. 2000. Information Technology and Business Performance: Past, Present and Future. In Zmud, R. W. (Ed.), ***Framing the Domains of IT Management: Projecting the Future Through the Past:*** 65–84. Cincinnati: Pinnaflex Educational Resources.

Becker, B. E., & Huselid, M. A. 1998. High performance work systems and firm performance: A synthesis of research and managerial implications. ***Research in Personnel and Human Resource Management:*** 16: 53–101.

Benner, M. J., & Tushman, M. L. 2003. Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited. ***Academy of Management Review*****:** 28(2): 238–256.

Bergeron, F., Raymond, L., & Rivard, S. 2004. Ideal patterns of strategic alignment and business performance. ***Information & Management*****:** 41: 1003-1020.

Bloom, N., & Van Reenen, J. 2007. Measuring and explaining management practices across firms and countries. ***Quarterly Journal of Economics*****:** CXXII(4): 1351-1408.

Bolton, P., & Dewatripont, M. 1994. The firm as a communication network. ***Quarterly Journal of Economics*****:** 109: 809–839.

Bresnahan, T. F., Brynjolfsson, E., & Hitt, L. M. 2002. Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm level Evidence. ***Quarterly Journal of Economics*****:** 117: 339–376.

Brynjolfsson, E., & Hitt, L. M. 1995. Information Technolny as a Factor of Production: The Role of Differences Among Firms. ***Economics of Innovation and New Technology*****:** 3: 183–199.

Brynjolfsson, E., & Hitt, L. M. 1998. ***Information Technology and Organizational Design: Evidence from Micro Data.*** Working Paper, MIT.

Brynjolfsson, E., & Hitt, L. M. 2000. Beyond Computation: Information Technology, Organizational Transformation and Business Performance. ***Journal of Economic Perspectives*****:** 14(4): 23–48.

Brynjolfsson, E., Hitt, L. M., & Yang, S. 2002. Intangible Assets: Computers and Organizational Capital. ***Brookings Papers on Economic Activity: Macroeconomics*****:** 1: 137–199.

Brynjolfsson, E., & Mendelson, H. 1993. Information Systems and the Organization of Modern Enterprise. ***Journal of Organizational Computing & Electronic Commerce*****:** 3(3): 245–255.

Burton, R. M., Lauridsen, J., & Obel, B. 2002. Return on Assets Loss from Situational and Contingency Misfits. ***Management Science:*** 48(11): 1461-1485.

Burton, R. M., & Obel, B. 2004a. ***Strategic Organizational Diagnosis and Design*****.** New York: Springer.

Burton, R. M., Lauridsen, J., & Obel, B. 2004b. The impact of organizational climate and strategic fit on firm performance. ***Human Resource Management:*** 43(1): 67-82.

Campbell-Hunt, C. 2000. What have we learned about generic competitive strategy? A meta-analysis. ***Strategic Management Journal:*** 21: 127-154.

Caroli, E., & Van Reenen, J. 2001. Skill-Biased Organizational Change? Evidence from a Panel of British and French Establishments. ***Quarterly Journal of Economics:*** 116(4): 1449-1492.

Cassiman, B., & Veugelers, R. 2006. In Search of Complementarity in Innovation Strategy: Internal R&D and External Knowledge Acquisition. ***Management Science:*** 52(1): 68-82.

Chan, Y. E. 2000. IT Value: The Great Divide Between Qualitative and Quantitative and Individual and Organizational Measures. ***Journal of Management Information Systems*****:** 16(4): 225–261.

Colombo, M. G., Delmastro, M., & Rabbiosi, L. 2007. "High performance" work practices, decentralization, and profitability: evidence from panel data. ***Industrial and Corporate Change*****:** 16(6): 1037-1067.

Crespi, G. & Criscuolo, C. 2006. ***Information Technology, Organisational Change and Productivity Growth: Evidence from UK Firms.*** Working Paper, CEP, LSE.

Croteau, A.-M., & Bergeron, F. 2001. An information technology trilogy: business strategy, technological deployment and organizational performance. ***Journal of Strategic Information Systems*****:** 10: 77-99.

Dedrick, J., Gurbaxani, V., & Kraemer, K. L. 2003. Information Technology and Economic Performance: A Critical Review of the Empirical Evidence. ***ACM Computing Surveys*****:** 35(1): 1–28.

Dehning, B., & Richardson, V. J. 2002. Returns on Investments in Information Technology: A Research Synthesis. ***Journal of Information Systems Management*****:** 16(1): 7–30.

Delery, J. E., & Doty, D. H. 1996. Mode of Theorizing in Strategic Human Resource Management: Tests of Universalistic, Contingency, and Configurational Performance Predictions. ***Academy of Management Journal*****:** 39(4): 802–835.

Dess, G.G., & Davis, P.S. 1984. Porter's (1980) generic strategies as determinants of strategic group membership and organizational performance. ***Academy of Management Journal:*** 27(3): 467-488.

Deszö, C. & Ross, D. G. 2007. ***"Girl Power": Female Participation in Top Management and Firm Performance.*** Working Paper, University of Maryland/Columbia Business School.

Dewett, T., & Jones, G. R. 2001. The role of information technology in the organization: a review, model, and assessment. ***Journal of Management*****:** 27(3): 313–346.

Diamantopoulos, A., & Winklhofer, H. M. 2001. Index Construction with Formative Indicators: An Alternative to Scale Development. ***Journal of Marketing Research:*** 39(May): 269-277.

Diamantopoulos, A., Riefler, P., & Roth, K. P. 2008. Advancing formative measurement models***. Journal of Business Research:*** 61(12): 1203-1218.

Drazin, R., & Van de Ven, Robert. 1985. Alternative Forms of Fit in Contingency Theory. ***Administrative Science Quarterly*****:** 30: 514-539.

Garicano, L. 2000. Hierarchies and the Organization of Knowledge in Production. ***Journal of Political Economy*****:** 108(5): 874–904.

Grant, R. 2008. ***Contemporary Strategy Analysis.*** Oxford: Blackwell Publishing, 6th edition.

Gresov, C., & Drazin, R. 1997. Equifinality: Functional Equivalence in Organization Design. ***Academy of Management Review*****:** 22(2): 403-428.

Greene, W. H. 2008. ***Econometric Analysis.*** London: Pearson Education, 6th edition.

Gurbaxani, V., & Whang, S. 1991. The Impact of Information Systems on Organizations and Markets. ***Communications of the ACM*****:** 34(1): 59–73.

He, Z.L., & Wong, P.-K. 2004. Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. ***Organization Science***: 15: 481-531.

Hitt, L. M., & Brynjolfsson, E. 1997. Information technology and internal firm organization: an exploratory analysis. ***Journal of Management Information Systems*****:** 14(2): 81–101.

Huber, G. P. 1990. A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making. ***Academy of Management Review*****:** 15(1): 47–71.

Huselid, M. A. 1995. The Impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance. ***Academy of Management Journal*****:** 38(3): 635–672.

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. 2003. A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research. ***Journal of Consumer Research:*** 30: 199-218.

Kohli, R., & Devaraj, S. 2003. Measuring Information Technology Payoff: A Meta-Analysis of Structural Variables in Firm level Empirical Research. ***Information Systems Research*****:** 14(2): 127–145.

Leavitt, H. J., & Whistler T. L 1958. Management in the 1980s. ***Harvard Business Review*****:** November-December: 41–48.

Li, M., & Ye, L. R. 1999. Information technology and firm performance: Linking with environmental, strategic and managerial contexts. ***Information & Management*****:** 35: 43-51.

Lichtenberg, F. R. 1995. The Output Contributions of Computer Equipment And Personnel: A Firml-Level Analysis. ***Economics of Innovation and New Technology:*** 3(3&4): 201-218.

Loveman, G. W. 1994. An Assessment of the Productivity Impact of Information Technologies. In Allen, T. J., & Morton, S. M. S. (Eds.), ***Information Technology and the Corporation of the 1990s: Research Studies:*** 84-110. Oxford: Oxford University Press.

Lubatkin, M.H., Simsek, Z., Ling, Y., & Veiga, J.F. 2006. Ambidexterity and Performance in Small-to Medium-Sized Firms: The Pivotal Role of Top Management Team Behavioral Integration. ***Journal of Management:*** 32(5): 646-672

Mahr, F. 2008. ***An Integrative Framework for Identifying Horizontal and Vertical Complements to ICT Types.*** Working Paper, ICE, LMU.

March, J. G. 1991. Exploration and exploitation in organizational learning. ***Organization Science*****:** 2: 71–87

Meilich, O. 2006. Bivariate Models of Fit in Contingency Theory. ***Organizational Research Methods:*** 9(2): 161-193.

Melville, N., Kraemer, K. L., & Gurbaxani, V. 2004. Review: Information Technolny and Organizational Performance: An Integrative Model of IT Business Value. ***MIS Quarterly*****:** 28(2): 283–322.

Miles, R., & Snow, C. C. 1978. ***Organizational strategy, structure, and process***. New York: McGraw-Hill Book Co.

Milgrom, P., & Roberts, J. 1990. The Economics of Modern Manufacturing: Technology, Strategy, and Organization. ***The American Economic Review*****:** 80(3): 511–528.

Milgrom, P., & Roberts, J. 1995. Complementarities and fit strategy, structure, and organizational change in manufacturing. ***Journal of Accounting and Economics*****:** 19(2-3): 179–208.

Mintzberg, H. 1979. ***The structuring of organizations: A synthesis of the research.*** New York: Prentice-Hall.

Miravete, E. J., & Pernías, J. C. 2006. Innovation complementarity and scale of production. ***Journal of Industrial Economics:*** LIV(1): 1-29.

Mohnen, P., & Röller, L.-H. 2005. Complementarities in innovation policy. ***European Economic Review:*** 49: 131-1450.

Nault, B. R. 1998. Information Technology and Organization Design: Locating Decisions and Information. ***Management Science*****:** 44(10): 1321–1335.

Nunally, J. C., & Bernstein, I. H. 1994: ***Psychonometric Theory:*** McGraw-Hill, 4th edition.

Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. 2003. Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. ***Journal of Applied Psychology:*** 88(5): 879-903.

Porter, M. E. 1985. ***Competitive Advantage.*** New York: Free Press.

Porter, M. E. 1996. What Is Strategy? ***Harvard Business Review*****:** November-December: 61–78.

Roberts, J. 2007. ***The modern firm: Organizational design for performance and growth.*** New York: Oxford University Press.

Rossiter, J. 2002. The C-OAR-SE procedure of scale development in marketing. ***International Journal of Research in Marketing:*** 29: 305-335.

Saloner, G., Shepard, A., & Podolny, J. 2001. ***Strategic Management.*** New York: John Wiley & Sons Inc.

Stieglitz, N., & Heine, K. 2007. Innovations and the role of complementarities in a strategic theory of the firm. ***Strategic Management Journal***: 28(1):1-15.

Van de Ven, A. H., & Drazin, R. 1985. The Concept of Fit in Contingency Theory. ***Research in Organizational Behavior***: 1985: 333–365.

Venkatraman, N. 1989. The Concept of Fit in Strategy Research: Toward Verbal and Statistical Correspondence. ***Academy of Management Review*****:** 14(3): 423-444.

Wooldridge, J. M. 2006. ***Introductory Econometrics***. Mason: Thomson South-Western.

Wyner, G. M., & Malone, T. W. 1996. ***Cowboys or Commanders: Does Information Technology Lead to Decentralization.*** Manuscript.

Zott, C. & Amit, R. 2008. The fit between product market strategy and business model: implications for firm performance. ***Strategic Management Journal:*** 29(1): 1-26.

APPENDIX A

QUESTIONNAIRE FOR FORMAL DECENTRALIZATION (FDEC)

(DEC1) "Who decides on delivery time and priority of orders?"

(DEC2) "Who issues production plans?"

(DEC3) "Who distributes work among workers?"

(DEC4) "Who decides on how work is done (e.g., pace and order)?"

(DEC5) "Who decides which machines and tools are used?"

(DEC6) "Who coordinates different production steps?"

(1 = exclusively managers, 2 = mainly managers, 3 = workers and managers, 4 = mainly workers, 5 = exclusively workers)

Scored by the interviewee who chose from a predefined set of possible answers.

APPENDIX B

QUESTIONNAIRE FOR HRM PRACTICES SUPPORTING FORMAL DECENTRALIZATION (HRM)

General format:

▪ Prepared question 1? ▪ Prepared question 2? ▪ ...		
1	3	5
Example answer for score 1 ...	Example answer for score 3 ...	Example answer for score 5 ...

(HR1) Participation in superiors' decision making[a]

▪ How do you make decisions which impact the work of your personnel? ▪ When do you inform your staff about your decisions? ▪ What kind of influence on your decisions do your staff members have?		
1	3	5
These decisions are made by the management exclusively. After the decision has been made, staff members are informed.	We actively ask for the positions and information of personnel or workers' representatives. Decisions are made by the management exclusively, staff members are informed afterwards.	A discussion with workers or their representatives takes place. Decisions are made by management and workers/their representatives together.

(HR2) Criticize superiors' decisions[a]

▪ What do you expect from a lower-level employee who thinks that one of your decisions was wrong? ▪ How do you react on this worker's opinion?		
1	3	5
Criticism is seen as an attack and not welcome. Everybody should focus on his responsibilities.	Well-grounded criticism is possible without fear of consequences. Nevertheless, the original decision has to be accepted.	Criticism is welcome at all times. Decisions are reconsidered (possibly together with the worker). The result of this reconsideration is explained to the worker.

(HR3) Intensity of (self-managed) teamwork[a]

▪ Could you describe the tasks that are fulfilled by teams of workers? ▪ Are teams used routinely or irregularly? ▪ How much discretion do teams have in their daily work? ▪ Which role do managers play for worker teams?		
1	3	5
Teams are only used irregularly or if required.	Teams are used routinely. These teams have no discretion as their work is regulated by managers or otherwise.	Teams are used routinely. These teams are self-managed. Managers play a rather supportive role.

(HR4) Variety of daily work[a]

▪ Could you describe for how many different tasks workers are qualified for commonly? ▪ How much do these tasks differ from each other? ▪ For which reasons do workers rotate between these tasks? ▪ How often do workers switch between these tasks?		
1	3	5
Workers are only qualified for one task and pursue this task only.	Workers are qualified for slightly different tasks within one step of the production process. They switch between these tasks from time to time or if required.	Workers are qualified for clearly different tasks and switch between them in regular time intervals.

(HR5) Amount and quality of information[a]

▪ Which are the topics for which you make sure that workers are always informed on? ▪ Why should workers be informed on these topics? ▪ How and where do workers receive these information? ▪ How often do workers receive these information?		
1	3	5
Workers do not receive information from the firm or the firm does not actively, regularly and/or in a well accessible way inform workers.	Worker receive information actively, regularly and in a well accessible way. These information are needed for the functioning of the workers' own job (e.g. quantity and quality produced in the own production step).	In addition to what is described for score 3, workers actively, regularly and accessibly receive information on other sections of the establishment or firm to be able to coordinate with these sections.

(HR6) Training intensity and variety[a]

▪ Could you describe the training programs workers are involved in? ▪ What are the contents of these training programs? ▪ What are the goals of these training programs? ▪ How often do these training programs take place?		
1	3	5
Workers do not participate in regular training programs which upgrade/expand their capabilities. No trainings or only trainings mandatory by law (e.g. job safety) take place.	Worker participate in regular training programs which are directed on upgrading/expanding existing capabilities needed for workers' own job.	Worker participate in regular training programs which are – in addition to what is described for score 3 – directed on acquiring additional capabilities from other areas or general capabilities like leadership capabilities or „soft skills".

(HR7) Individual performance review and pay[a]

▪ Could you describe how worker's individual performance (or the performance of their workspace/team) is reviewed? ▪ How often is performance reviewed? ▪ Which consequences do performance reviews have on workers' pay?		
1	3	5
Individual/workspace/team performance is not reviewed regularly. Workers receive a fixed pay.	Individual/workspace/team performance is reviewed regularly. Performance reviews do not impact pay.	Individual/workspace/team performance is reviewed regularly. Performance reviews strongly influence pay.

(HR8) Individual performance review and pay[b]

"Do lower-level employees receive a bonus which depends on the whole establishment's and/or firm's performance and if yes, is there a formal rule for this bonus?"

(0=no bonus, 1=irregular bonus, 2=formal bonus rule)

(HR9) Promotion criteria[a]

▪ Imagine, a higher position is free and one of two candidates for the position is working for the company five more years than the other candidate. Who will be promoted? ▪ Aside from leadership skills: Which kind of knowledge and background is needed for higher positions in your company?		
1	3	5
Employees are exclusively promoted on the basis of tenure/age.	Employees are promoted on the basis of special knowledge and experience in the area they are promoted to.	Employees are mainly promoted on the basis of heterogeneous knowledge and experiences (e.g. different areas of expertise, departments, functions, establishments, etc.).

[a] Scored by the interviewer following the above described innovative interview method.

[b] Scored by the interviewee who chose from a predefined set of possible answers.

APPENDIX C

QUESTIONNAIRE FOR LEARNING MODEL (LEARN)

(MSITE)[a]

„Has your establishment concentrated on existing customer groups and markets as well as their needs in the last five years or more on opening up new customer groups and markets?“

(1 = existing markets, 2 = mainly existing markets, 3 = existing and new markets, 4 = mainly new markets, 5 = new markets)

(MFIRM)[a]

„Has the rest of your firm concentrated on existing customer groups and markets as well as their needs in the last five years or more on opening up new customer groups and markets?“

(1 = existing markets, 2 = mainly existing markets, 3 = existing and new markets, 4 = mainly new markets, 5 = new markets)

(PSITE)[a]

„Has your establishment concentrated on upgrading existing products and production processes in the last five years or more on introducing new products?“

(1 = existing products, 2 = mainly existing products, 3 = existing and new products, 4 = mainly new products, 5 = new products)

(PFIRM1)[a]

„Has the rest of your firm concentrated on upgrading existing products and production processes in the last five years or more on introducing new products?“

(1 = existing products, 2 = mainly existing products, 3 = existing and new products, 4 = mainly new products, 5 = new products)

(XPLORSITE)[b]

▪ How many new products, product variants, or product generations have been introduced by your establishment during the last five years? ▪ Why have you introduced them? ▪ Where has the idea for the new products originated from? ▪ (Did the idea originate from customers or competitors or did it originate from your establishment, e.g. from market research or research and development?)		
1	3	5
New products have not been introduced.	New products have been introduced because of customer pressures/ideas or because of competitors' pressures (reactive).	New products which have been actively searched for (e.g. ideas from employees, market research, research and development) have been introduced.

(PFIRM2)[a]

"Have new products, product variants or product generations been introduced during the last five years in the rest of your company, i.e. outside your establishment?"

(0 = no, 1=yes, 2=n/a)

[a] Scored by the interviewee who chose from a predefined set of possible answers.

[b] Scored by the interviewer following the above described innovative interview method.

FIGURE 1

HORIZONTAL AND VERTICAL IT ALIGNMENT

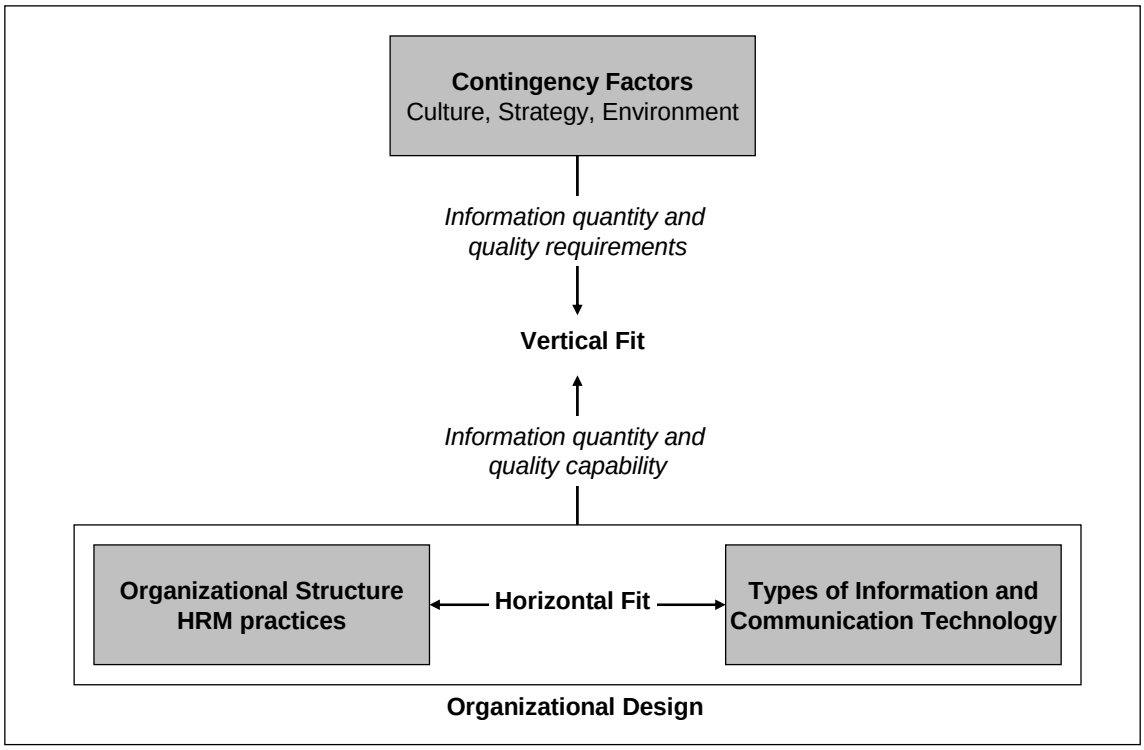

TABLE 1

EXAMPLE QUESTION: PARTICIPATION IN DECISION MAKING

Prepared open questions		
▪ How do you make decisions which impact the work of your personnel? ▪ When do you inform your staff about your decisions? ▪ What kind of influence on your decisions do your staff members have?		
Example answers as anchor for …		
... score 1:	**... score 3:**	**... score 5:**
These decisions are made by the management exclusively. After the decision has been made, staff members are informed.	We actively ask for the positions and information of personnel or workers' representatives. Decisions are made by the management exclusively, staff members are informed afterwards.	A discussion with workers or their representatives takes place. Decisions are made by management and workers/their representatives together.

TABLE 2

CORRELATION OF INTERVIEWERS' AND SUPERVISORS' SCORES FOR SAME INTERVIEW DURING THE SECOND HALF OF THE PROJECT

Variable/scale	Partial correlation[a]	p-value	Observations
Exploration of site	0.844	0.000	34
HRM practices (scale)	0.815	0.000	35

[a] Controlling for interviewer and supervisor fixed effects.

TABLE 3

RETURN RATIOS USED IN ROBUSTNESS TESTS

Measure	Variable	Definition
Return on sales	ROS	$\frac{\text{profit/loss before tax}}{\text{operating revenue}}$
Return on assets	ROA	$\frac{\text{profit/loss before tax}}{\text{total assets}}$
Return on capital employed	ROCE	$\frac{\text{profit/loss before tax + interest paid}}{\text{shareholders' funds + noncurrent liabilities}}$

TABLE 4

DESCRIPTIVE STATISTICS OF MAIN VARIABLES

Variable	Description	Obs.	Mean	Std. dev.	Min.	Max.
VA	Value added (million €)	152	341	2,923	0.643	35,800
L	Number of firm employees	152	3,385	24,972	24	305,163
C	Total assets (million €)	152	894	9,388	0.740	116,000
IT	Number of PCs in firm	152	1,157	5,533	12	61,018
FDEC	Formal decentralization	152	0.0314	0.5995	-0.8822	1.7131
HRM	Human resource management	152	0.0030	0.3605	-1.1602	1.2373
ADEC	Actual decentralization	152	0.0367	0.7691	-1.7648	2.4647
LEARN	Learning model	152	0.0336	0.7263	-2.2973	1.5353
Variable	**Description**	**Obs.**	**Var.=1**	**Var.=0**	**Min.**	**Max.**
XPLT	Exploitational model	152	74	78	0	1
XPLR	Explorational model	152	78	74	0	1

TABLE 5

THE PERFORMANCE IMPACT OF NOT OR NOT FULLY ALIGNING IT WITH BOTH ORGANIZATION AND LEARNING MODEL

	(1)	(2)
Dependent variable	**ln(VA)**	**ln(VA)**
ln(IT)	-0.0279	0.0018
Information technology	(0.0425)	(0.0471)
ln(C)	0.7584***	0.7387***
Capital	(0.0863)	(0.0846)
ln(L)	0.1849**	0.1782**
Labor	(0.0801)	(0.0795)
ADEC	-	0.1103
(De-)centralization		(0.4872)
ln(IT)*ADEC	-	-0.0254
		(0.0949)
Observations	295	295
R^2	0.96	0.96

Controls: Column (1): Year dummies, 3-digit SIC code dummies, employee coverage ratio (IT survey), accounts type dummy. Further controls in column (2): Employee coverage ratio (organization survey), interviewer dummies, interview duration, interviewee tenure, interviewee's relative hierarchical position, recent change of ownership.

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 2000-2007. The estimation method in all columns is OLS. Standard errors in brackets under coefficient are clustered by firm, i.e. Huber-White robust to heteroskedasticity and autocorrelation of unknown form. Largest common sample 1 used. Results are similar if the maximal sample is used in each regression.

TABLE 6

THE PERFORMANCE IMPACT OF ALIGNING IT WITH ACTUAL (DE-)CENTRALIZATION AND LEARNING MODEL

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	**ln(VA)**	**ln(VA)**	**ln(VA)**	**ln(VA)**	**ln(VA)**	**ln(VA)**
Control for	-	-	VA_{t-1}	VA_{t-1}	VA_{t-1} SBTC	VA_{t-1} SBTC
Base group…	explores	exploits	explores	exploits	explores	exploits
ln(IT) *Information technology*	0.0478 (0.0617)	0.0115 (0.0448)	0.0228 (0.0403)	0.0085 (0.0332)	0.0222 (0.0394)	0.0120 (0.0330)
ln(C) *Capital*	0.6930*** (0.0615)	0.6930*** (0.0615)	0.2261*** (0.0721)	0.2261*** (0.0721)	0.2326*** (0.0729)	0.2326*** (0.0729)
ln(L) *Labor*	0.1931*** (0.0629)	0.1931*** (0.0629)	0.0341 (0.0423)	0.0341 (0.0423)	0.0326 (0.0421)	0.0326 (0.0421)
ADEC *Actual (de-)centralization*	-0.6611** (0.3074)	0.7193* (0.3993)	-0.7910** (0.3518)	0.4739 (0.2909)	-0.7574** (0.3494)	0.4766 (0.2936)
ln(IT)*ADEC *Base group*	0.1283** (0.0554)	-0.1455** (0.0715)	0.1453** (0.0673)	-0.0863* (0.0485)	0.1421** (0.0667)	-0.0863* (0.0488)
XPLT *Exploitation dummy*	0.2100 (0.2840)	-	0.1150 (0.1670)	-	0.0794 (0.1771)	-
ln(IT)*XPLT	-0.0362 (0.0493)	-	-0.0144 (0.0293)	-	-0.0103 (0.0300)	-
ADEC*XPLT	1.3803*** (0.4692)	-	1.2649*** (0.4160)	-	1.2340*** (0.4157)	-
ln(IT)*ADEC*XPLT *Difference to exploiters*	-0.2738*** (0.0824)	-	-0.2315*** (0.0755)	-	-0.2284*** (0.0755)	-
XPLR *Exploration dummy*	-	-0.2100 (0.2840)	-	-0.1150 (0.1670)	-	-0.0794 (0.1771)
ln(IT)*XPLR	-	0.0362 (0.0493)	-	0.0144 (0.0293)	-	0.0103 (0.0300)
ADEC*XPLR	-	-1.3803*** (0.4692)	-	-1.2649*** (0.4160)	-	-1.2340*** (0.4157)
ln(IT)*ADEC*XPLR *Difference to explorers*	-	0.2738*** (0.0824)	-	0.2315*** (0.0755)	-	0.2284*** (0.0755)
$ln(VA)_{t-1}$ *One year lagged VA*	-	-	0.6879*** (0.0781)	0.6879*** (0.0781)	0.6791*** (0.0775)	0.6791*** (0.0775)
ln(degree) *% employees w. degree*	-	-	-	-	-0.0245 (0.0307)	-0.0245 (0.0307)
Observations	295	295	295	295	295	295
R^2	0.97	0.97	0.98	0.98	0.98	0.98

Controls: Year dummies, 3-digit SIC code dummies, employee coverage ratio (IT survey), accounts type dummy, employee coverage ratio (organization survey), interviewer dummies, interview duration, interviewee tenure, interviewee's relative hierarchical position, recent change of ownership, ambidextrous learning model.

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 2000-2007. The estimation method in all columns is OLS. Standard errors in brackets under coefficient are clustered by firm, i.e. Huber-White robust to heteroskedasticity and autocorrelation of unknown form. Largest common sample 1 used. Results are similar if the maximal sample is used in each regression.

TABLE 7

ROBUSTNESS TEST 1: ALLOWING ALL COEFFICIENTS TO VARY BETWEEN GROUPS

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	**ln(VA)**	**ln(VA)**	**ln(VA)**	**ln(VA)**	**ln(VA)**	**ln(VA)**
Control for	-	-	VA_{t-1}	VA_{t-1}	VA_{t-1} SBTC	VA_{t-1} SBTC
Base group…	explores	exploits	explores	exploits	explores	exploits
ln(IT) *Information technology*	0.1241 (0.0935)	0.0676 (0.0808)	0.1117** (0.0518)	0.0042 (0.0800)	0.1040** (0.0514)	-0.0351 (0.0972)
ln(C) *Capital*	0.7032*** (0.1043)	0.6387*** (0.1178)	0.2065** (0.1018)	0.2371 (0.1489)	0.2385** (0.0988)	0.2561* (0.1518)
ln(L) *Labor*	0.0386 (0.1284)	0.0564 (0.1234)	-0.0819 (0.0763)	-0.0143 (0.1065)	-0.0796 (0.0745)	0.0108 (0.1070)
ADEC *Actual (de-)centralization*	-0.8890** (0.3788)	0.6592 (0.4310)	-0.9360*** (0.2537)	0.6266** (0.3050)	-0.7698*** (0.2231)	0.5879* (0.3015)
ln(IT)*ADEC *Base group*	0.1918*** (0.0616)	-0.1119 (0.0806)	0.1884*** (0.0440)	-0.1078* (0.0547)	0.1714*** (0.0393)	-0.1125** (0.0540)
XPLT *Exploitation dummy*	0.9281 (2.4617)	-	1.5726 (2.0762)	-	1.5942 (1.9955)	-
ln(IT)*XPLT	-0.0565 (0.1236)	-	-0.1075 (0.0953)	-	-0.1390 (0.1099)	-
ADEC*XPLT	1.5482*** (0.5738)	-	1.5626*** (0.3967)	-	1.3577*** (0.3750)	-
ln(IT)*ADEC*XPLT *Difference to exploiters*	-0.3037*** (0.1015)	-	-0.2962*** (0.0702)	-	-0.2839*** (0.0668)	-
XPLR *Exploration dummy*	-	-0.9281 (2.4617)	-	-1.5726 (2.0762)	-	-1.5942 (1.9955)
ln(IT)*XPLR	-	0.0565 (0.1236)	-	0.1075 (0.0953)	-	0.1390 (0.1099)
ADEC*XPLR	-	-1.5482*** (0.5738)	-	-1.5626*** (0.3967)	-	-1.3577*** (0.3750)
ln(IT)*ADEC*XPLR *Difference to explorers*	-	0.3037*** (0.1015)	-	0.2962*** (0.0702)	-	0.2839*** (0.0668)
$ln(VA)_{t-1}$ *One year lagged VA*	-	-	0.7260*** (0.1006)	0.6042*** (0.1112)	0.6786*** (0.1047)	0.6047*** (0.1115)
ln(degree) *% employees w. degree*	-	-	-	-	-0.0895** (0.0367)	-0.1286 (0.1110)
Observations	295	295	295	295	295	295
R^2	0.98	0.98	0.98	0.98	0.98	0.98

Controls: Columns (1) and (2): Ln(C), ln(L), year dummies, 3-digit SIC code dummies, employee coverage ratio (IT survey), accounts type dummy, employee coverage ratio (organization survey), interviewer dummies, interview duration, interviewee tenure, interviewee's relative hierarchical position, recent change of ownership, ambidextrous learning model. All these controls are included a second time, interacted with XPLT or XPLR respectively. Additional controls in columns (3) and (4): $Ln(VA)_{t-1}$ and $ln(VA)_{t-1}$ interacted with XPLT or XPLR respectively. Additional controls in columns (4) and (5): Ln(degree) and ln(degree) interacted with XPLT or XPLR respectively.

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 2000-2007. The estimation method in all columns is OLS. Standard errors in brackets under coefficient are clustered by firm, i.e. Huber-White robust to heteroskedasticity and autocorrelation of unknown form. Largest common sample 1 used. Results are similar if the maximal sample is used in each regression. Only the interactions of IT*ADEC with XPLT and XPLR are shown. In the regressions, all independent variables including all control variables were included a second time, interacted with XPLT or XPLR respectively

TABLE 8

ROBUSTNESS TEST 2: RETURN RATIOS AS DEPENDENT VARIABLES

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	**ROS**	**ROS**	**ROA**	**ROA**	**ROCE**	**ROCE**
Base group…	explores	exploits	explores	exploits	explores	exploits
IT *Information technology*	-0.0000 (0.0001)	0.0008* (0.0005)	-0.0001 (0.0001)	0.0007 (0.0005)	-0.0001 (0.0002)	0.0008 (0.0008)
ADEC *Actual (de-)centralization*	-0.3148 (0.9403)	0.2412 (1.1674)	-0.2520 (1.1784)	-0.0115 (1.3677)	-0.2602 (2.1900)	1.3519 (2.4143)
IT*ADEC *Base group*	0.0004*** (0.0001)	-0.0018*** (0.0006)	0.0002 (0.0001)	-0.0020*** (0.0007)	-0.0000 (0.0003)	-0.0026*** (0.0009)
XPLT *Exploitation dummy*	0.1119 (1.3097)	-	-0.2235 (1.6387)	-	-2.1948 (2.7984)	-
IT*XPLT	0.0008* (0.0005)	-	0.0007 (0.0005)	-	0.0008 (0.0008)	-
ADEC*XPLT	0.5560 (1.4324)	-	0.2404 (1.5975)	-	1.6121 (2.9031)	-
IT*ADEC*XPLT *Difference to exploiters*	-0.0022*** (0.0006)	-	-0.0022*** (0.0008)	-	-0.0026** (0.0010)	-
XPLR *Exploration dummy*	-	-0.1119 (1.3097)	-	0.2235 (1.6387)	-	2.1948 (2.7984)
IT*XPLR	-	-0.0008* (0.0005)	-	-0.0007 (0.0005)	-	-0.0008 (0.0008)
ADEC*XPLR	-	-0.5560 (1.4324)	-	-0.2404 (1.5975)	-	-1.6121 (2.9031)
IT*ADEC*XPLR *Difference to explorers*	-	0.0022*** (0.0006)	-	0.0022*** (0.0008)	-	0.0026** (0.0010)
EMPL *Number of employees*	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Operating revenue	0.0000 (0.0000)	0.0000 (0.0000)	-	-	-	-
Total assets	-	-	0.0000 (0.0000)	0.0000 (0.0000)	-	-
Capital employed *Shareholders' funds + noncurrent liabilities*	-	-	-	-	0.0000 (0.0000)	0.0000 (0.0000)
Observations	575	575	575	575	575	575
R^2	0.41	0.41	0.43	0.43	0.43	0.43

Controls: Year dummies, 3-digit SIC code dummies, employee coverage ratio (IT survey), accounts type dummy, employee coverage ratio (organization survey), interviewer dummies, interview duration, interviewee tenure, interviewee's relative hierarchical position, recent change of ownership, ambidextrous learning model.

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. The time period is 1999-2007. The estimation method in all columns is OLS. Standard errors in brackets under coefficient are clustered by firm, i.e. Huber-White robust to heteroskedasticity and autocorrelation of unknown form. Largest common sample 2 used. Results are similar if the maximal sample is used in each regression.

TABLE 9

SUMMARY OF HYPOTHESES AND EMPIRICAL RESULTS

Hypotheses		Results	
1a	Complementarities between IT and decentralization for explorers	✔	Strong support
1b	Complementarities between IT and centralization for exploiters	✔	Strong support
2	1a and 1b work better with actual than with formal decentralization	✘	Weak support