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How Do Information and Communication Technology Affect Delegation?

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Abstract

This paper investigates the distinct effects of the use of information technology and communication technology in firms on the degree of delegation of decision making. This paper contributes to the literature on organization design by showing empirically that these two types of technology have distinct effects on delegation at the level of analysis of delegation from manager to employees: delegation is more likely when database software is used and it is less likely when communication software is employed. We use a longitudinal and nationally representative dataset from Statistics Canada?s Workplace and Employee Survey to test the theory.

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***Keywords*: Decentralization; delegation of decision making, organization design,Information and Communication Technology; Workplace and Employee Survey**

INTRODUCTION

Delegation of decision authority is a key organizational mechanism through which firms pool the resources of authority and specialized knowledge for decision making (Aghion & Tirole, 1997). Delegation has been shown to be instrumental for speedy decision making (Lin & Germain, 2003; Patacconi, 2009), for firms' adaptation in dynamic environments (Bloom, Sadun, & Van Reenen, 2010; Mendelson, 2000), and for utilizing specialized knowledge that is embedded in multiple individuals in the firm (Jensen & Meckling, 1992). Prior research found that the design of delegation of authority over decisions is complementary to other organizational practices (Foss, Laursen, & Pedersen, 2011) and is facilitated by the application of Information and Communication Technologies (ICT). Most of prior empirical research on the relationship between ICT in the context of organization design aggregated ICT technologies together into one measure of ICT capital, computers per person, or implementation of network technology for sharing technical data (see e.g. Colombo & Delmastro, 2004). Recent research, both theoretical (Garicano, 2000) and empirical (Bloom, Garicano, Sadun, Reenen, & John, 2013), however, demonstrates that information technology (IT) and communication technology (CT) should be considered separately, as they have distinct effects on delegation.

This paper draws on a model of Garicano (2000) which implies that information technology, such as the use of database software or enterprise resource planning systems reduces the cost of information acquisition at lower organizational levels. Consequently, it acts as a decentralizing force, as it allows agents to make decisions based on easily available relevant knowledge. On the other hand, communication technology, such as the use of network systems, email or intranets, reduces the cost of communication between the manager and worker, therefore facilitates management by exception and is a centralizing force (Garicano, 2000; Bloom et al. 2013). To date one empirical study (Bloom et al. 2013) has documented these relationships

using a large dataset of about 1000 manufacturing firms across several countries by showing that these opposing effects are observed when headquarters delegate decision authority to business units. While that was the first empirical test of the theory developed by Garicano (2000), Bloom et al. have not found an empirical evidence of this mechanism at the level of delegation from divisional managers to employees. The present paper fills this gap.

The purpose of this paper is to provide further empirical evidence on the distinct effects of IT and CT on delegation of decision authority using the longitudinal workplace (establishment) level data from Statistics Canada's *Workplace and Employee Survey* (WES). Our regression sample contains 12,328 workplace-year observations in 1999, 2001, 2003, and 2005 from different manufacturing and non-manufacturing industries. Similar to the data set used by Bloom et al. (2014), WES contains detailed information on both the use of different types of ICT applications within a workplace and its decision structure. But on top of this, WES also contains longitudinal information on *both* organizational structure and ICT use, and it is representative of various sectors across Canada. Therefore, panel data regression analysis of this data set allows us to examine the distinct effect of information and communication technology at the level of analysis of delegation from manager to worker, therefore our findings are complementary to the results of Bloom et al. (2013) in a way that they corroborate the mechanisms at a more granular level of analysis.

Our contribution to the literature on delegation and organizational design is threefold. First, we join the very few studies that distinguish between IT and CT and their impact on organizational design. Second, we empirically demonstrate significant, distinct effects of these two types of ICT on delegation at the level of analysis of delegation from manager to workers. Third, we test this relationship on a dataset which is generalizable across industries and hasn't been used to test this relationship before.

This paper proceeds as follows. In the next section we explain the theory behind the distinct effects of IT and CM on delegation. Then we describe our data, report the results and robustness checks. Finally, we discuss or results and provide conclusions.

THEORY: THE DISTINCT EFFECTS OF ICT ON DELEGATION

Organizational design of allocation of decision authority between managers and workers is concerned with a tradeoff between the cost of decision makers acquiring decision-relevant knowledge (the cost of information acquisition), and communication cost between managers and workers (Garicano, 2000). Granting autonomy and decision authority to front line employees requires investments in their human capital e.g. through training (Lepak & Snell, 1999; Wang, He, & Mahoney, 2009) and facilitation of access to decision-relevant information. If acquiring decision-relevant knowledge is expensive, knowledge of frontline workers can be substituted for by the knowledge of their superiors, who typically have greater work experience, expertise and problem solving skills. While such centralized organizational solution reduces the cognitive burden of workers and reduces the cost of information acquisition by workers, it increases the intensity and cost of communication between workers and managers, as workers ask for managerial directions frequently. On the other hand, reduction in cost of vertical communication allows for "management by exception", in which case workers solve routine problems and make routine decisions, but when exceptions occur, they communicate the problem upwards where it is solved at higher levels, and the firm can economize on the cost of acquiring additional information at lower levels. In this way decentralized organizations trade off "knowing" by the workers vs. asking superiors for directions (Garicano, 2000; Bloom et al., 2013).

Reduction of information acquisition cost and delegation

The main benefits of decentralization arise from the ability to utilize distributed knowledge (Hayek, 1945; Jensen & Meckling, 1992) and reducing the need for information processing at the top of the hierarchy (Mintzberg, 1979). Reduction in the cost of accessing information at the lower hierarchy levels enables lower level workers to make qualified decisions independently, and thus increases workers' autonomy. This reduces the cognitive burden of managers, since workers don't need to ask for managers' directions. We are interested in the use of database software which provides workers with a wide range of real time, factual information about products, inventory levels, or other information relevant for performing task at hand, which allows employees to obtain accurate information, to solve wide range of problems and make informed decisions without asking the superior for help. Thus, the use of database software should increase the extent of delegation of decisions from managers to workers.

Hypothesis 1. Delegation is more likely when database software is used.

The effect of communication technology on delegation

When workers encounter non routine problems or lack sufficient knowledge for decision-making, they seek advice from the managers (Garicano, 2000). In the model of Garicano (2000), communication cost approximates such "helping cost" – the cost of a manager helping an employee to solve a problem. Communication cost is incurred per question asked. Communication technology, such as wired and wireless communications, e-mail, network technologies, or mobile devices, makes communication between the manager and worker easier, faster and less costly, thereby workers can refer unusual, non-routine problems upwards to their superiors at low cost.

Reduction a in the cost of communication increases the use of "management my exception", where untypical, non-routine problems are referred upwards to the managers. When workers rely more on managers for decision making, ask for directions and implement manager's suggestions, the extent of delegation is lower. Communication technology makes it cheaper for central manager to make decisions, and handle exceptions. Thereby cheaper communication is a centralizing force. In such case knowledge of frontline workers is substituted for by the knowledge of managers.

Hypothesis 2. Delegation is less likely when communication systems are used.

DATA

Workplace and Employee Survey

We use the data from Statistics Canada's *Workplace and Employee Survey* (WES) for empirical analysis. WES is a longitudinal linked employer-employee data set containing employer information (from the Workplace Survey) and employee information (from the Employee Survey).

WES has several unique features for examining the relationship between ICT use and decentralization. First, the workplaces in WES are drawn from a nationally representative sample from different industries allowing us to evaluate whether the observed empirical patterns reported in Bloom et al. (2013) are specific to a particular set of industries. Second, WES provides detailed information on the decision structure within the workplace, in particular, whether decision rights are decentralized from the top to the bottom. It also allows us to identify whether database and communication applications, among other types of ICT applications, are used within the workplace. Third, the data set contains other workplace-level measures which

can be used to control for other factors that may affect the decentralization decision of the workplace. Its longitudinal nature also allows me to control for the unobserved heterogeneity at the workplace level.

Nevertheless, since the unit of observation in the Workplace Survey is a workplace with a fixed address, a major limitation of WES is that we only observe the structure of a certain part of an organization (unless the sampled workplace is a single-location firm), and there is no direct information to infer whether two workplaces in the sample are within the same organization (such as two local branches of the same bank). As a result, we cannot study the interaction between different units of the same organization (such as the delegation of decision authority from the headquarters to the local plants, as in Bloom et al., 2013).

Definition of Variables

Dependent and independent variables.

Delegation. From the Workplace Survey, we can observe whether various work-related activities (such as daily or weekly planning of individual work, recruitment, and choice of production technology, etc.) can be decided by "Non-managerial employees," "Work group," "Work supervisor," "Senior manager," "Individual or group outside workplace," and "Business owner."[1] In the empirical analysis, we define "workers" as "Non-managerial employees" or "Work group," and "managers" as "Work supervisor," "Senior manager," or "Business owner." For each decision, we can observe the following three cases:

1. *Workers make decisions solely.*
2. *Workers and managers decisions jointly.*

[1] The information is obtained from Question 19 of the Workplace Survey which is reproduced in the Data Appendix.

3. *Managers make decisions solely.*

We restrict the attention to the decision of daily or weekly planning of individual work because it is directly related to the everyday work of the employees irrespective of the business nature of the *workplace*.[2] We characterize the level of delegation in the workplace with variable *delegate* , which equals to 1 when workers can normally plan their daily or weekly work and 0 otherwise. The major advantage of using this survey question to construct the outcome variables is that we can observe the allocation of decision rights between the managers and the workers: Workers have the highest level of decision authority when they can plan their own work and have the lowest level of decision authority when the work is planned by the managers, or decision authority is shared between managers and workers when they jointly make the work planning decision. Use of database software and communication system. From the Employee Survey, we can observe whether different types of ICT applications are used by the sampled employees.3 Using these information, we construct two dummy variables, denoted by Database and Communication respectively, to indicate whether database software (such as Access, dBase, Oracle, Excel, and FoxPro) and communication system (such as Compuserve, Netscape, Outlook, Email systems, and Internet) is used in the workplace. In WES, database software and communication systems are the closest counterparts available to Bloom et al. (2013)'s ERP system and network system. We use them to proxy for the reductions in learning cost and communication cost inside the workplace and examine how they are related to decentralization.

[2] Other activities specified in the survey question may be specific to certain types of workplaces. For example, recruitment decisions are usually made within the human resources department but rarely in a production plant.

[3] The information is from Question 22(c) of the Employee Questionnaire. The Employee Survey is used because the Workplace Survey only contains information on the aggregate state of technology use in the workplace (such as number of workers using computers and new investment in computer technology), while through the Employee Survey, we can observe whether different types of ICT applications are used within the workplace.

Control Variables.

In the regression analysis, we include several control variables which may affect the workplace's decision to decentralize. First, we use log of number of employees to control for the effect of workplace size (*Size*) since larger workplaces or firms tend to decentralize (e.g., Bloom et al., 2013). Second, we use the fraction of unionized workers (*Union*) to control for the potential effect of unions on productivity (e.g., DiNardo and Lee, 2004) which may subsequently affect decentralization of decisions.[4] Third, we include workplace's age (*Age*) and an index to measure the innovation introduced by the workplace (*ZInnovate*).[5] Acemoglu, Aghion, Lelarge, Van Reenen, and Zilibotti (2007) argue that decentralization is more likely when firms are younger or closer to the technological frontier (Mendelson, 2000). Fourth, we construct an index of Human Resource Management (HRM) practices implemented in the workplace (*ZHRM*).[6] This variable is used to control for the potential impact of incentives (Aghion and Tirole, 1997) and other HRM practices on decision structure.[7] Finally, we control for the intensity of competition faced by the workplace from local and international firms

[4] While productivity is not the outcome variable in my analysis, one may argue that productivity and decision authority are related. For example, since decision making takes up time which can otherwise be used for production, when the workers have high productivity, the managers may want to make the decision in order to save the precious production time.

[5] It is the sum of the standardized *z*-scores on the binary variables indicating the introduction of "new products or services," "improved products or services," "new processes" and "improved processes."

[6] It is the sum of the standardized *z*-scores on variables measuring the improvement in business operation, information sharing between the management and the employees, use of team work, and the provision of incentives within the workplace.

[7] Aghion and Tirole (1997) argue that delegating the decision rights to the agents is sometimes optimal because they will have the incentive to acquire information for the principal. Thus, delegation and incentive structure are complementary: when the agents are provided with incentives (through bonus system and profit sharing plan, etc.), they may exert more effort to acquire valuable information for production, so that it pays for the principal to delegate more decision rights to the agents. Besides, various empirical studies have found that the use of Human Resource Management (HRM) practices can affect workers' productivities (e.g., Ichniowski, Shaw, and Prennushi, 1997; Bloom and Van Reenen, 2007).

(*ZCompete*). Bloom, Sadun, and Van Reenen (2010) find that increased competition is associated with more decentralization of decision authority from the headquarters to the plants.[8]

Sample Selection

We only use a subset of the full WES data set for regression analysis. We start with a balanced panel of workplaces appearing throughout the sample period (1999 to 2006). The regression sample is chosen based on several sample selection criteria. First, we use observations in years 1999, 2001, 2003 and 2005 because the survey question for the outcome variable was not asked in other years. Second, we require that the decision of planning of individual work is made within the workplace, i.e., the decision is made by either the workers or the managers (or both). Thus, when the decision is made by someone external to the workplace,[9] or is neither decided internally nor externally, such a workplace is excluded. Excluding observations with missing information in the outcome variable and the other control variables, the regression sample consists of 12,328 workplace-year observations.

Unitary Analysis

Table 1reports the means (weighted by the sampling weights provided by Statistics Canada) and the standard deviations of the variables. Note that according to Statistics Canada's disclosure guidelines, the minimums and maximums of these variables cannot be reported. Focusing on the outcome variable Decentralize, we can see that in over half of the cases, workers can plan work for themselves. In fact, workers can have decision rights through joint decision with managers for about 39% of the time, and have decision rights through solo decision for about 14% of the

[8] In particular, Bloom, Sadun, and Van Reenen (2010) argue that plant managers (the agent) are usually more familiar with local market conditions than the CEO (the principal); as competition increases, the agent can respond more quickly and delegation enables them to make better use of their informational advantage.

[9] One possibility is that the workplace is a local plant, and the decision is made by the manager in the head office. Another possibility is that the decision is made by an external contractor. However, the survey question does not provide information to distinguish these two cases.

time. If we only consider the workplaces in the manufacturing industries, then workers can have decision rights for about 44% of the time: 38% of the time through joint decision with managers and 8% of the time through solo decision. The latter pattern is similar to that in the data set of Bloom et al. (2013) in which workers usually do not have full decision rights.

On the other hand, both ICT applications are commonly used by the workplaces in the sample: database software is in use in over 80% of the cases, and communication system over 70%. In contrast, the two ICT applications are less frequently used by the firms in the sample of Bloom et al. (2013): only about 36% of firms use database software (Enterprise Resource Planning system) and also about 36% of firms has communication system (presence of leased lines or frame relays). Among the workplaces in the manufacturing industries, database software and communication system are used in about 80% and 67% of the cases respectively. One possible reason for such a big difference in ICT adoption in WES and Bloom et al. (2013)'s data set is that, their ERP and NETWORK variables refer to a very specific type of application, whereas in my Database and Communication variables include a broader range of similar applications.

Table 1 also shows the correlations among the variables. We can see that the decentralization variable is positively related to both ICT use variables. But as will be discussed below, the (unconditional) positive correlation between the use of communication system and workers' decision rights becomes negative once unobserved workplace heterogeneity is controlled for in the regression.

[Insert Table 1 about here]

In Table 2, we compare the means of the variables by the adoption of the two ICT applications. Columns (1) and (3) show the means of the variables for the workplaces that use database software and those that do not; and Columns (6) and (8) show the means of the variables for the workplaces that use communication system and those that do not. This table shows that there are

significant differences between those workplaces using ICT and those not using: workplaces using database software or communication systems tend to (1) have more employees, (2) have a smaller fraction of unionized workers, (3) are "older," (4) have more innovations, (5) implement better HRM practices, and (6) face more competition. We can see that almost all of these differences are statistically significant. Thus one may be concerned about whether the workplaces using ICT and those not using ICT are systematically different along certain dimensions. In other words, endogeneity may exist in the two ICT use variables. If that is the case, then the regression results will be biased without proper control of the problem.

[Insert Table 2 about here]

EMPIRICAL ANALYSIS

Econometric Specification

To examine how delegation of decision rights is related to the use of database software and communication system, I estimate the following workplace-level linear probability model:

$$Decentralize_{it} = \alpha + \beta_1 Database_{it} + \beta_2 CommSys_{it} + X'_{it}\,\delta + \mu_i + \lambda_t + \varepsilon_{it}\,\eta$$

where i and t index workplace and year respectively, $Delegate_{it}$ is the dummy variable indicating whether workers can normally plan their own work, $Database_{it}$ and $Communication_{it}$ are the dummy variables indicating the use of database software and communication system respectively, X_{it} contains other control variables defined earlier, μ_i and λ_t are the workplace and year fixed-effects respectively, and ε_{it} is the error term. Based on the earlier discussion, we expect that decentralization is more likely when database software is used, and is less likely when communication system is used, i.e., $\beta_1>0$ and $\beta_2<0$.

Baseline Regression Results

Table 3 reports the regression results of the regression in (**Error! Reference source not found.**). In all the regressions, the observations are scaled by the sampling weights provided by Statistics Canada, and robust standard errors are reported. Model 1 in Table 3 reports a pooled cross-sectional, fixed effectsregression analysis by regressing the delegation dummy on the use of database software and communication system without any controls.

Our results show that delegation is positively associated with the use of database software but is negatively associated with the use of communication system. These results are consistent with our hypotheses.

As discussed earlier, there are other potentially important factors determining the extend of delegation in a firm . We include these factors in the baseline regression model as well to check whether the main results are driven by them. In Model 2, we include a measure of workplace size to control for the size effect. In Model 3, we include the fraction of unionized workers in the regression. In Model 4, we control for the workplace's age and the innovation introduced in the workplace. In Model 5, we include an index of the HRM practices in the regression. In Model 6, we control for the degree of product market competition faced by the workplace. Finally in Model 7, we include all the above covariates in the regression. In all these specifications, the coefficients of *Database* and *Communication* have the same signs as those in the baseline regression and are all statistically significant. Among the other control variables, the coefficients of the innovation index (*ZInnovate*) and the HRM practices index (*ZHRM*) are positive and statistically significant.

[Insert Table 3 about here.]

Focusing onModel 7 of Table 3, we can see that effects of the two ICT variables on workers' decision rights are also economically significant. The marginal effects of the two ICT variables

(calculated at the means of other variables) are as follows. When database software is used, the likelihood of decentralization increases by about 5.3%; when communication system is used, the likelihood decreases by about 4.2%. The two marginal effects are also similar in magitudes. In particular, the sum of the coefficients of *Database* and *Communication* are not statistically different from zero (with F-statistic = 0.37 and p-value = 0.553), suggesting that when both database software and communication system are used within the workplace, the two opposing effects on decentralization cancel out and the organizational design of delegation in the workplace does not change.

Robustness Checks

Endogeneity and reverse causality

In the baseline regression, the right hand side variables are assumed to be uncorrelated with the error term. However, endogeneity may exist because other factors not included in the regression may affect both the delegation in the workplace and the use of ICT applications or when ICT use depends on a particular organizational design of delegation. For example, when decision rights are delegated to the workers, the organization may require a communication system to facilitate the transmission of instructions from the top to the bottom. Part of the endogeneity problem is due to unobserved time-specific or workplace-specific factors which can be controlled for with a panel data set. Nevertheless, other time-varying factors may still exist and cause endogeneity. One common method to deal with the endogeneity problem is to rely on an Instrumental Variable (IV) which is correlated with the endogenous variable but is uncorrelated with the error term. In practice, it may be difficult to find a valid instrument. Instead of finding an instrument, we try to deal with the problem by the Control Function method developed by Heckman and Robb (1985). The basic idea of the Control Function method is to add a function in the

regression model to "control" for the correlation between the potential endogenous variables and the error term. Once the control function is included in the regression, the new error term will no longer be correlated with the endogenous variables.

The Control Function method can be implemented in two stages. In the first stage, we use the Probit model to regress the ICT use dummy (either *Database* or *Communication*) on an excluded variable (which is not included in the baseline regression) and other control variables. We then obtain the propensity score and construct the control function, denoted by CF_{it}, as a polynomial of the propensity score. In the second stage, I include the control function as an extra covariate, i.e., we estimate:

$$Decentralize_{it}=\alpha+\beta ICT_{it}+X_{it}'\delta+\mu_i+\lambda_t+CF_{it}+\varepsilon_{it}.$$

In this regression, the control function CF_{it} will control for the correlation between the potential endogenous variable (i.e., ICT_{it}) and the error term. The new error term ε_{it} will now be uncorrelated with ICT_{it}.

The excluded variable used in the Probit regression for the use of database software is the fraction of managerial and administrative workers in the workplace. The larger this fraction is, the workplace is more likely to be an administrative workplace (such as a head office or an accounting office) and use database software to store administrative records such as staff profile or financial information. The excluded variable used in the Probit regression for the use of communication system is the share of the workplace's sales in the international market. Presumably workplaces with more international businesses should have more clients or suppliers around the world so that communication system is more likely to be installed in these workplaces. In each case, we require that the excluded variable is not related to the unobserved

factors that affect decentralization when ICT is used and those unobserved factors that affect decentralization when ICT is not used.

Table 4 reports the regression results. Columns (1) and (2) in Panel (A) show the regression results from the first stage Probit regressions. As expected, the share of managerial workers in the workplace is positively related to the adoption of database software; and the share of sales in the international market is positively associated with the use of communication system. The second stage results are reported in Panel (B). For comparison, Columns (1) and (2) show the regression results from the baseline linear probability models. In Column (3), I include a quadratic polynomial of the propensity score obtained from the Probit regression in Column (1) of Panel (A); in Column (4), I include a quadratic polynomial of the propensity score obtained from the Probit regression in Column (2) of Panel (A).[10] Note that the standard errors of the control function regressions in Columns (3) and (4) are corrected by bootstrapping (250 times). In these two regressions, the coefficients of the two ICT variables are of expected signs and are still significant.

[Insert Table 4 about here.]

Other robustness checks

Alternative Specifications.The baseline regression is a linear probability model using a binary indicator of delegation as the dependent variable. We try two different specifications to check the robustness of the baseline results.

First, we estimate a panel data Probit model as an alternative regression model. Note that the estimation of this model is complicated by the "incidental parameters problem" in the sense that one cannot simply put in workplace fixed-effects in the Probit regression as in the linear

[10] We have tried higher-order polynomials as the control functions. The results are also similar.

probability model. To avoid this problem, we follow Wooldridge (2002) and impose additional identifying assumptions: we assume that the vector of the explanatory variables (including the unobserved year effects) is strictly exogenous conditional on the unobserved workplace effects which follow a Chamberlain-type (1980) conditional Normal distribution. These two assumptions essentially transform the original regression model by "differencing out" the unobserved workplace fixed-effects, so that the resulting regression no longer depends on them. In this case, the parameters can be consistently estimated by using a pooled Probit regression model of the outcome variable on a constant, the explanatory variables and their time averages. The regression results, reported in Column (1) of Table 4, show that the two ICT variables have the same signs as in the baseline regression model and are both statistically significant.

Second, we construct a slightly different outcome variable for regression analysis. Recall that in the raw data, we observe three different cases: (1) workers making decisions solely, (2) workers and managers making decisions jointly, and (3) managers making decisions solely. We define an ordinal variable to characterize the ranking of workers' decision rights: workers' level of decision rights is the highest when they make decisions solely and the lowest when managers make decisions solely. We use this 3-level categorical variable as the dependent variable and estimate a panel data ordered Probit model. Similar to the case for the panel data Probit model, the "incidental parameters problem" also exists in the panel data ordered Probit model estimation. We also follow Wooldridge (2002) and impose the same additional identifying assumptions to avoid the problem. The results of the panel data ordered Probit model, reported in Column (2) of Table 4, are similar to the baseline results and are statistically significant.[11]

[11] Note also that while the 3-level categorical variable defined above is used as an ordinal variable to rank the levels of workers' decision rights under different scenarios, it may also be treated as a cardinal variable. For example, we can assume that workers have 0% of the decision rights when managers make decisions solely, 50% of the decision rights when workers and managers make decisions jointly, and 100% of the decision rights when workers make decisions solely. Then we may also estimate a panel data fractional Probit model.

Subsample Regressions. We also estimate the baseline models with different subsamples. The results are reported in Models 3 to 6 of Table 5. The regression sample in Model 3 excludes not-for-profit workplaces, and that in Model 4 excludes the smaller workplaces (with fewer than 20 employees). The not-for-profit workplaces may have a different decision structure than that in profit-making workplaces, and the small workplaces may not have the same need to use ICT as in larger workplaces. The regression results, based on linear probability models, show similar results as in the baseline model. In Models 5 and 6, the regression samples include the workplaces in the manufacturing and non-manufacturing sectors respectively in the regression,[12] and these two regressions are panel data Probit model.[13] In all these regressions, we still find that decentralization is more likely when database software is used but is less likely when communication system is used. The results in Models 5 and 6 suggest that the baseline empirical patterns do not just appear in the manufacturing workplaces, but also in other types of workplaces.

[Insert Table 5 about here.]

DISCUSSION AND CONCLUSION

In this paper, we evaluate the distinct effects of Information and Communication Technology (ICT) on the delegation of decision rights within an organization. This paper privides empirical

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The estimation of a fractional Probit model is similar to that of a traditional Probit model except that the outcome variable is defined over the [0,1] interval rather than {0,1} only (see Papke and Wooldridge, 2008). The regression results, not reported here, are also very similar.

[12] The workplaces in the manufacturing sector are those in the "forestry, mining, oil, and gas extraction," "labour intensive tertiary manufacturing," "primary product manufacturing," "secondary product manufacturing," "capital intensive tertiary manufacturing," "construction," and "transportation, warehousing, wholesale" industries. The workplaces in the non-manufacturing sector are those in the "communication and other utilities," "retail trade and consumer services," "finance and insurance," "real estate, rental and leasing operations," "business services," "education and health services," and "information and cultural industries" industries.

[13] Results using the linear probability model have expected signs but are not statistical significant at the 10% level.

support to the theory developed by Garicano (2000) which predicts that to the extent that the cost of acquiring production knowledge can be reduced by the use of database software and the cost of communication can be reduced by the use of communication systems, delegation is more likely when the former ICT application is used but is less likely when the latter application is used.

We use the longitudinal and nationally representative data from Statistics Canada's *Workplace and Employee Survey* to test these predictions and find supportive evidence. These findings also complement the cross-sectional evidence documented in Bloom et al. (2013), who found an evidence for a similar theoretical argument at a different level of analysis. While Bloom et al. (2013) document the distinct effects of IT and CT on the delegation from headquarters to busienss units, we complement that evidence but showing that these relationships hold at the more granular level of delegation from manager to employee. An additional contribution arises from our robustness analysis which demonstrates that the mechanisms we test are present only only in manufacturing firms, but also in other types of workplaces in service industries. Overall, the empirical results reported in this paper advance our understanding on how the existing organizational theories apply in actual organizatons.

This paper not only complements the studies that investigate the distinct effects of IT and CM on delegation, but also contributes to the broader stream of liteature on organizational design. We add to the litature on antecedents of delegation and on organizational practices that facilitate delegation and employee autonomy.

We are aware that delegation involves other tradeoffs such as balancing access to specialized knowledge which is distributed among individuals in a firm and the agency problems which arises from loss of control over delegated decisions (Jensen and Meckling, 1992, Aghion and

Tirole, (1997) as well such as access to distributed knowledge vs. agency cost. Our findings are complementary to the focus on agency issues.

Data Appendix

Detailed Description of the Workplace and Employee Survey.

Statistics Canada's Workplace and Employee *is a longitudinal linked employer-employee data set. The unit of analysis in the Workplace Survey is a workplace (establishment) with a fixed physical location. The unit of analysis in the Employee Survey is an employee working in a workplace sampled in the Workplace Survey. The target population for the Workplace Survey is all business locations which operate in Canada (except those located in Yukon, Nunavut and the Northwest Territories and those in the agriculture, fishery and public administration industries) and have paid employees in March of the survey year. These workplaces are drawn from the Business Register of Statistics Canada. The target population for the Employee Survey is all employees who are working or on paid leave in the selected workplaces in March of the survey year.*

To form the workplace sample, the workplaces are selected by a stratified sample design based on different industries, workplace sizes, and geographical regions across Canada. Within each sampled workplace, employees are selected to form the Employee Survey: a maximum of 24 employees are sampled, and for workplaces with fewer than 4 employees, all of them are included. To ensure that the selected sample is representative of the national population, Statistics Canada has constructed different sets of sampling weights. These sampling weights will be used throughout the empirical analysis.

The sample period for the Workplace Survey is from 1999 to 2006, and that for the Employee Survey is from 1999 to 2005. Each workplace cross-section consists of around 6,000 observations and each employee cross-section around 16,000 to 24,000 observations. The workplaces sampled in 1999 are followed over time, with additions of new workplaces into the

sample in 2001, 2003, and 2005. However, the employees are followed for 2 years only, and new samples of employees are selected in 2001, 2003, and 2005. For further details about the WES, see Statistics Canada (2004).

Survey Question for the Decentralization Variable: Question 19 of Workplace Survey.[14]

7.25 pt7.25 pt 19. Who normally makes decisions with respect to the following activities? (Check all that apply.)

	Decision	*Non-managerial employee*	*Work group*	*Work supervisor*	*Senior manager*	*Individual or group outside workplace*	*Business owner*
A.	*Daily planning of individual work*	○	○	○	○	○	○
B.	*Weekly planning of individual work*	○	○	○	○	○	○
C.	*Follow-up of results*	○	○	○	○	○	○
D.	*Customer relations*	○	○	○	○	○	○
E.	*Quality control*	○	○	○	○	○	○
F.	*Purchase of necessary supplies*	○	○	○	○	○	○
G.	*Maintenance of machinery and equipment*	○	○	○	○	○	○
H.	*Setting staffing levels*	○	○	○	○	○	○
I.	*Filling vacancies*	○	○	○	○	○	○
J.	*Training*	○	○	○	○	○	○
K.	*Choice of production technology*	○	○	○	○	○	○
L.	*Product/ service development*	○	○	○	○	○	○

[14] The question number is based the 2005 version of the Workplace Survey.

References

Aghion, P., & Tirole, J. 1997. Formal and Real Authority in Organizations. ***Journal of Political Economy***, 105(1): 1–29.

Bloom, N., Garicano, L., Sadun, R., Reenen, V., & John. 2013. ***The Distinct Effects of Information Technology and Communication Technology on Firm Organization***. SSRN Scholarly Paper No. ID 2359541. http://papers.ssrn.com/abstract=2359541, January 12, 2015, Rochester, NY: Social Science Research Network.

Bloom, N., Sadun, R., & Van Reenen, J. 2010. Does Product Market Competition Lead Firms to Decentralize? ***American Economic Review***, 100: 434–438.

Bloom, N., & Van Reenen, J. 2007. Measuring and explaining management practices across firms and countries. ***Quarterly Journal of Economics***, 122(4): 1351–1408.

Chamberlain, G. 1980. Analysis of Variance with Qualitative Data. ***Review of Economic Studies***, 47: 225–238.

Colombo, M., & Delmastro, M. 2004. Delegation of Authority In Business Organizations: An Empirical Test. ***The Journal of Industrial Economics***, 52(1): 53–80.

DiNardo, J., & Lee, D. S. 2004. Economic impacts of new unionization on private sector employers: 1984-2001. ***Quarterly Journal of Economics***, 119(4): 1383–1441.

Dostie, B., & Jayaraman, R. 2012. Organizational Redesign, Information Technologies and Workplace Productivity. ***B E Journal of Economic Analysis & Policy***, 12(1): 4.

Foss, N. J., & Laursen, K. 2005. Performance pay, delegation and multitasking under uncertainty and innovativeness: An empirical investigation. ***Journal of Economic Behavior & Organization***, 58(2): 246–276.

Foss, N. J., Laursen, K., & Pedersen, T. 2011. Linking Customer Interaction and Innovation: The Mediating Role of New Organizational Practices. ***Organization Science***, 22(4): 980–999.

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

Hayek, F. A. 1945. The Use of Knowledge in Society. ***The American Economic Review***, 35(4): 519–530.

Heckman, J., & Navarro-Lozano, S. 2004. Using matching, instrumental variables, and control functions to estimate economic choice models. ***Review of Economics and Statistics***, 86(1): 30–57.

Heckman, J., & Robb, R. 1985. Alternative Methods for Evaluating the Impact of Interventions - an Overview. ***Journal of Econometrics***, 30(1-2): 239–267.

Ichniowski, C., Shaw, K., & Prennushi, G. 1997. The effects of human resource management practices on productivity: A study of steel finishing lines. ***American Economic Review***, 87(3): 291–313.

Jensen, M., & Meckling, W. 1992. Specific and general knowledge, and organizational structure. ***Contract Economics*** (Lars Werin and Hans Hijkander.): 251–274. Cambridge, MA,: Basil Blackwell.

Lepak, D. P., & Snell, S. A. 1999. The Human Resource Architecture: Toward a Theory of Human Capital Allocation and Development. ***The Academy of Management Review***, 24(1): 31–48.

Lin, X., & Germain, R. 2003. Organizational structure, context, customer orientation, and performance: lessons from Chinese state-owned enterprises. ***Strategic Management Journal***, 24(11): 1131–1151.

Mendelson, H. 2000. Organizational Architecture and Success in the Information Technology Industry. ***Management Science***, 46(4): 513–529.

Mintzberg, H. 1979. ***The Structuring of Organizations: A Synthesis of Research*** (1st ed.). Prentice Hall.

Papke, L. E., & Wooldridge, J. M. 2008. Panel data methods for fractional response variables with an application to test pass rates. ***Journal of Econometrics***, 145(1-2): 121–133.

Patacconi, A. 2009. Coordination and delay in hierarchies. ***The RAND Journal of Economics***, 40(1): 190–208.

Statistics Canada. 2004. Guide to the Analysis of the Workplace and Employee Surve.

Wang, H. C., He, J., & Mahoney, J. T. 2009. Firm-Specific Knowledge Resources and Competitive Advantage: The Roles. ***Strategic Management Journal***, 30(12): 1265–1285.

Westerman, G., & Cotteleer, M. 1999. ***Harvard Business School Case #***, 9-699-043.

Wooldridge, J. M. 2010. ***Econometric Analysis of Cross Section and Panel Data***. MIT Press.

Zoghi, C., & Mohr, R. D. 2011. The Decentralization of Decision Making and Employee Involvement within the Workplace: Evidence from Four Establishment Datasets. ***British Journal of Industrial Relations***, 49(4): 688–716.

Zoghi, C., Mohr, R. D., & Meyer, P. B. 2010. Workplace organization and innovation. ***Canadian Journal of Economics-Revue Canadienne D Economique***, 43(2): 622–639.

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TABLE 1

Summary statistics

	N	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Delegate	12328	0.527	0.499	1.000								
(2) Database	12328	0.815	0.388	0.187	1.000							
(3) Communication	12328	0.709	0.454	0.201	0.608	1.000						
(4) Size	12328	4.856	1.498	0.145	0.148	0.175	1.000					
(5) Union	12328	0.434	0.427	-0.019	-0.037	-0.024	0.394	1.000				
(6) Age	12328	28.779	25.490	0.018	0.025	0.041	0.294	0.297	1.000			
(7) ZInnovate	12328	0.646	3.451	0.128	0.122	0.122	0.218	-0.002	0.021	1.000		
(8) ZHRM	12328	1.139	3.007	0.180	0.177	0.154	0.374	0.115	0.152	0.409	1.000	
(9) ZCompete	12328	0.439	2.923	0.013	0.038	0.007	-0.016	-0.129	-0.021	0.144	0.216	1.000

TABLE 2

Differences of Variables by ICT Use. The table compares the means and standard deviations of the variables for workplaces with and without ICT

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Database = 1 N = 8561		Database = 0 N = 3767			Communication = 1 N = 7202		Communication = 0 N = 5126		
Variable	Mean	SD	Mean	SD	(1)-(3)	Mean	SD	Mean	SD	(6)-(8)
Size	4.961	1.486	4.391	1.465	0.571***	5.024	1.485	4.447	1.450	0.576***
Union	0.426	0.423	0.467	0.441	-0.041***	0.427	0.423	0.450	0.436	-0.023*
Age	29.087	25.871	27.423	23.692	1.664*	29.444	26.262	27.161	23.430	2.284***
ZInnovate	0.847	3.485	-0.240	3.146	1.087***	0.917	3.516	-0.012	3.194	0.929***
ZHRM	1.392	2.997	0.025	2.701	1.367***	1.436	2.960	0.416	3.001	1.020***
ZCompete	0.492	2.973	0.205	2.679	0.287***	0.453	3.016	0.406	2.683	0.047

.*p < 10%; **p < 5%; ***p < 1%.

TABLE 3

Effect of ICT Use on Decentralization. Specification: LMP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable				Delegate			
Database	0.055**	0.055**	0.055**	0.054**	0.054**	0.056**	0.053**
	(0.022)	(0.022)	(0.022)	(0.021)	(0.021)	(0.022)	(0.021)
Communication	-0.045**	-0.045**	-0.045**	-0.044**	-0.043**	-0.045**	-0.042**
	(0.018)	(0.018)	(0.018)	(0.017)	(0.018)	(0.018)	(0.016)
Size		-0.011					-0.023
		(0.015)					(0.017)
Union			-0.022				-0.028
			(0.057)				(0.057)
Age				0.001			0.001
				(0.001)			(0.001)
ZInnovate				0.009***			0.007***
				(0.002)			(0.002)
ZHRM					0.019***		0.018***
					(0.004)		(0.004)
ZCompete						0.003	0.000
						(0.007)	(0.007)
Constant	0.528***	0.580***	0.537***	0.496***	0.496***	0.527***	0.593***
	(0.020)	(0.070)	(0.038)	(0.041)	(0.024)	(0.021)	(0.068)
Workplace fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12328	12328	12328	12328	12328	12328	12328
Adjusted R2	0.348	0.348	0.348	0.351	0.354	0.348	0.356

Robust standard errors, clustered at the industry level, are in parentheses.
*p < 10%; **p < 5%; ***p < 1%.

TABLE 4

Robustness Check for Endogeneity Using the Control Function Approach.

Panel A: First stage results

	(1)	(2)
Dependent variable	Database	Communication
Specification	Probit	Probit
% managerial and admin. workers in the workplace	0.826***	
	(0.242)	
% sales in international market		0.004***
		(0.002)
Other controls	Yes	Yes
Workplace fixed-effects	Yes	Yes
Year fixed-effects	Yes	Yes
Observations	12328	12328
Log likelihood	-4973.075	-6665.724

Panel B: Second stage results

	(1)	(2)	(3)	(4)
Dependent variable	Delegate	Delegate	Delegate	Delegate
Specification	LPM	LMP	Control function	Control Function
Database	0.031*		0.027*	
	(0.017)		(0.015)	
Communication		-0.020		-0.023**
		(0.013)		(0.011)
\controls				
Workplace fixed-effects	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
Observations	12328	12328	12328	12328
Adjusted R2	0.355	0.355	0.362	0.361

Robust standard errors are in parentheses .*p < 10%; **p < 5%; ***p < 1%.

TABLE 5

Effect of ICT Use on Decentralization: Other Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. variable:	Delegate	Delegate (3-level)	Delegate	Delegate	Delegate	Delegate
Specification	Probit	Ordered probit	LPM	LPM	Probit	Probit
Database	0.143***	0.118***	0.047**	0.053**	0.118**	0.183**
	(0.047)	(0.037)	(0.021)	(0.024)	(0.054)	(0.082)
Communication	-0.111***	-0.076**	-0.041**	-0.041***	-0.076**	-0.172**
	(0.039)	(0.034)	(0.018)	(0.010)	(0.034)	(0.071)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Workplace fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12328	12328	12328	12328	12328	12328
Adjusted R2			0.365	0.360		
Log likelihood	-7817.171	-11697.519			-3760.872	-3851.934

Robust standard errors, clusteredat the industry level, are in parentheses. .*p < 10%; **p < 5%; ***p < 1%