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Workplace Organization and Innovation

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Abstract: This study uses data on Canadian establishments to test whether particular organizational structures are correlated with the likelihood of adopting process and product innovations, controlling for the endogeneity of the predictors. We find that establishments with decentralized decision-making, information-sharing programs, or incentive pay plans are significantly more likely to innovate than other establishments. Larger establishments and those with a high vacancy rate are also more likely to innovate. These findings are consistent with a model in which workers hold information about production inefficiencies or consumer demands that can lead to productive innovations and that workplace organization attributes facilitate the communication and implementation of those ideas.

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I. Introduction

This study tests whether establishments with decentralized decision-making, information-sharing programs, or incentive pay plans are significantly more likely to innovate than other establishments. There is reason to think this is the case. Workers who directly interact with customers have information about consumer preferences and constraints that managers do not have. This information may be important to spawning new product ideas. Similarly, workers who are part of the production process will know about the weaknesses and inefficiencies of the process; this information can generate innovative improvements to the process. If the worker with this private information also has the capacity to act on the information or to share the information with someone who has such capacity, subsequent innovations are more likely. There are costly tradeoffs however -- organizations that allow workers such authority will be subject to more internal uncertainty and surprises, and to more principal-agent problems.

Freeman and Lazear (1995), in their theory on works councils, point to information-sharing as a solution to this dilemma. Management and workers have different information sets and can therefore increase the organization's productive efficiency by adopting institutions that increase the transmission of information. The result may be that "management and labor together discover solutions to company problems that neither would have conceived separately" (p44). While information-sharing can be the right solution for some establishments, it can impose costs of setting up an information infrastructure and costs of delay while the information is transferred and interpreted. These costs can be severe if it is necessary to react quickly to the environment.

Under rapidly changing circumstances, transferring information from the worker to another decision-maker is more costly. This may encourage decentralization, giving workers more authority to act autonomously. For example, a firm may have to redefine its product frequently, change technologies in its design and production, or adapt its marketing to changing

circumstances. Partly for these reasons, high tech firms are thought to have more inclusive decision-making processes. Decentralization comes at a cost, however. If workers are given the authority to make decisions on the basis of private information, the organization will likely incur agency costs. As Jensen and Meckling (1995) describe, "[b]ecause they are ultimately self-interested, the agents to whom the CEO delegates authority have objective functions that diverge from his or her own" (p.17). This means that the establishment faces a trade-off between the agency costs it faces under decentralization, and the infrastructure and time costs of information sharing. Any combination of these two approaches could support product and process innovation.

The empirical literature on innovation presents some results consistent with these hypotheses. A number of studies show that various inclusive and interactive work processes increase productivity (see Black and Lynch, 2004; Bresnahan, Brynjolfsson and Hitt, 2002, or Ichniowski, Shaw, and Prennushi, 1997 for excellent examples). There are far fewer articles linking workplace organization to innovation. Typically, large nationally representative surveys lack either a direct measure of innovation or detailed information about work organization. Michie and Sheehan (1999) use two proxies for innovation to link human resources practices with innovation in a large data set of UK firms. Laursen and Foss (2003) show an association between a variety of human resource practices to innovation in data from 1,900 Danish firms, and Rogers (1999) uses a panel of 698 Australian workplaces to show that better employee-management communications systematically increase reported innovations. Therrien and Léonard (2003) use the first wave of the data set used here to show that particular forms of enrichment practices affect the innovative nature of the establishment.

The contributions of this paper differ from this prior literature on workplace and innovation. First, our data, which include over 19,000 observations spanning a period of four years, are more extensive than those used in prior research in this area. Second, much of the existing work follows Ichniowski, Shaw, and Prennushi (1997) in focusing on the

complementarities in human resource management techniques. One implication, supported by Michie and Sheehan (1999) and Therrien and Léonard (2003), is that the more types of workplace practices used, the greater the rate of innovation. Our approach presupposes a certain degree of complementarity, but also tries to identify tradeoffs in the sense that different groups of workplace practices imply different avenues through which firms can foster innovation. Finally, taking advantage of the panel aspect of our data, we control for the potential endogeneity of the workplace practices.

The remainder of this paper is divided into four sections. In Section II, a descriptive model highlights how either information sharing or decentralized decision rights might increase innovation. Section III describes the data, measures of decentralization and information-sharing and an empirical strategy. Section IV presents results, and section V concludes.

II. Theories of organization

We develop a descriptive model, inspired in part by the intuition of Jensen and Meckling (1995), to highlight how organizational structures might foster the use of workers' knowledge to make useful innovations. As Mookherjee (2006) points out, existing formal models do not provide a complete theory of decision rights that integrates information processing or communication costs with incentive considerations. This descriptive framework therefore provides intuition and insights into the trade-off between centralization and decentralization. Imagine that an establishment's founders choose its organizational structure to maximize future profits, taking into account a link between work organization and expected returns from innovations. Many factors, such as industry, uncertainty of the market, speed of market change, and the nature of inputs, affect whether such profitable innovations are likely in any particular establishment. The founder has *ex ante* estimates of the probabilities that workers and managers

possess private information relevant to conceiving of and implementing innovations, and the probability that innovations with positive expected returns will be found.

The model assumes that the risk-neutral founders have three choices available for increasing the expected benefits of innovation: decentralized decision making, information sharing, and the use of incentive pay. These three variables are summarized by nonnegative measures d, s and p. Decentralized decision making and information sharing enable the active use of more private information held by the establishment's workers. Incentive pay does not directly lead to the transfer of private information, but reduces the costs of decentralization or information sharing by aligning incentives. The expected number of future innovations is a nonnegative function $i(d,s)$ which is increasing in each of its arguments. Letting the average net expected benefit of each adopted innovation be b_i, the overall net expected benefits of innovation from these organizational choices are $b_i*i(d,s)$. Costs associated with innovation that are independent of workplace organization are subsumed in b_i.

We assume that decentralization has costs, $c_d(d,p)$, which include the possible losses from decisions with mutually inconsistent objectives, the costs of monitoring workers, and the opportunities lost because the establishment is less able to coordinate decisions at a higher level where information could be pooled. There are also costs to transferring information, which we denote $c_s(d,p)$. These include the costs of setting up and operating information infrastructure, including suggestion programs and problem-solving committees, and the indirect costs that are a function of the delay in transferring information. Incentive pay plays a special role in the model. It does not directly affect innovation, but instead mitigates the costs of the other two forms of work organization. Incentive pay encourages workers to make decisions consistent with the founders' goals, reducing c_d, and motivates workers to identify and share useful information, reducing c_s. We denote operational and other costs of incentive pay systems by $c_p(p)$. The

founders choose an organizational structure *(d, s, p)* to maximize the expected net benefits of future innovations:

$$\max_{d,s,p}: \quad b_i i(d,s) - c_d(d,p) - c_s(s,p) - c_p(p) \qquad (1)$$

Since the empirical section focuses on discrete measures of the three variables, corner solutions--where the founder chooses not to use some aspect of work organization--are particularly relevant. For example, if the benefits of both information sharing and decentralization are small (the first derivatives, i_s and i_d, are always close to zero) or the costs of these work organization practices are high, then the founder will choose a centralized workplace, where $d = s = 0$. Such a centralized workplace can nonetheless be consistent with innovation (if $b_i > 0$ and $i(d,s)$ has a positive intercept), or the presence of a centralized workplace might indicate that the founder does not pursue innovation (if $b_i < 0$).

The model also allows for the possibility that the founder chooses to use either d, or s, or both. One such case occurs when workers hold information that can lead to innovations, but the costs to communicating this information hierarchically exceed the agency costs of empowering workers. This could happen if the information were tacit (hard to communicate or identify) or if the economic environment were to require firms to react quickly.[1] In such situations, firms might optimally allocate decision making about technology and work processes to the workers. A second possibility is that workers have production-specific information that *can* quickly and easily be communicated. In this case the marginal impact of information sharing, i_s, might be relatively large. Here, labor-management committees and other formal programs that encourage information sharing, suggestions and feedback may support innovation. If complementarities

[1] Some examples illustrate the scenario. E-commerce has changing technologies and markets. Changing fashions can affect what the market wants. Difficulty or delay in computation or processing by decision makers introduces costs similar to difficulty or delay in communication; see Van Zandt (2003) for a model of this.

between d and s exist, the founder may choose to use both. The founder may offset some of the costs of these forms of work organization through the use of incentive pay.

This descriptive model allows us to classify combinations of work organization practices, highlights implicit assumptions, and points towards some hypotheses which provide a framework for prediction. For example, the model discounts reasons other than innovation that managers would decentralize or share information.[2] The model also assumes a direction of causality so that innovations depend on work organization; in the empirical section we test the alternative hypothesis that innovations predict structure.[3] In terms of providing a framework for prediction, the model suggests that decentralization and information-sharing should both be positively associated with innovations. While fully centralized firms may also innovate, they do so only if $b_i>0$, a more restrictive criteria than those faced by other firms. Thus, we expect that fully centralized firms should be negatively associated with innovations relative to decentralized ones.

Decentralization and information sharing can be either complements or substitutes. If information sharing improves the decision-making capacity of managers, it will reduce the benefits of decentralization. On the other hand, bottom-up information sharing makes monitoring easier and thus more closely aligns worker's objectives to the firm, reducing the agency costs of decentralization. Additionally, top-down information sharing allows decentralized workers to make better decisions. The empirical section will examine these paths by including interaction terms between the three types of workplace innovation.

While any result on the interaction terms between decentralization and information sharing might be consistent with the model, the model has clear predictions about the interaction between

[2] Mohr and Zoghi (2006) show that decentralized workplaces have higher worker satisfaction, so firms may use decentralization to motivate workers rather than specifically to foster innovation. Freeman and Lazear (1995) explore the hypothesis that information sharing is used to transmit bad news and thereby induce effort. Black and Lynch (2001) and others consider the possibility that decentralization affects productivity directly.

[3] Therrien and Léonard (2003) offer a nice counterexample of a firm that adopts a new machine that may temporarily slow production and cause the firm to operate at less than full capacity. Managers might introduce special human resource practices, such as training or problem-solving teams to minimize the delay.

incentive pay and the other two variables. It implies that incentive pay increases the effect of both decentralization and information sharing on innovation. In decentralized workplaces, incentive pay motivates workers to seek out profitable innovations. While information-sharing alone should result in innovation (since the decision-maker is assumed to have profit-maximizing objectives), we expect the effect to be strengthened if the bottom-up information sharing is accompanied by individual or group incentive pay, which motivates workers to identify and share useful information. Finally, the model suggests that incentive pay, absent information sharing or decentralization, should have little impact on innovation. Incentive pay at a centralized firm does not change the underlying problem: the worker might have the knowledge necessary to make improvements but not the authority to act on it, and vice versa.

III. Empirical strategy and data description

A probit model describes the hypothesized relationship between the organizational structure of the workplace and its innovativeness:

$$\text{Prob}(innov_{jt} = 1) = \Phi(\alpha + \beta_1 d_j + \beta_2 s_j + \beta_3 p_j + \beta_4 (d_j p_j) + \beta_5 (p_j s_j) + \beta_6 (d_j s_j) + \beta_7 (d_j p_j s_j) + \gamma Z_{jt} + \varepsilon_{jt}) \quad (2)$$

where $innov_{jt}$ is an indicator for whether establishment j introduced an innovation in year t, and d_j, s_j, and p_j are indicators for whether establishment j used decentralized decision-making, information-sharing, or incentive pay, respectively, in the initial year. The model includes interaction terms for the joint use of these organizational features. The descriptive model suggests that the coefficients on decentralization and information sharing (β_1 and β_2) will be positive, the coefficient on incentive pay alone (β_3) will be zero, the interactions between incentive pay and the other two forms of work organization (β_4 and β_5) will be positive, and that the remaining

interaction terms (β_6 and β_7) may be either positive or negative. Finally, Z_{jt} includes other variables that are likely to affect the innovativeness of an establishment.

This project uses data on 6,322 establishments drawn from the 1999-2003 Canadian Workplace and Employee Survey (WES). Establishments were first selected from all employers in Canada with paid employees, except for those in the Yukon, Nunavut, and Northwest Territories and those in farming, fishing and trapping, religious organizations and public administration. These establishments were then re-surveyed annually for five years, the first four of which are currently available for analysis. In 1999, 6322 workplaces were interviewed, with data collected through personal interviews.[4] In the succeeding years, responses were acquired from 6068, 6223, and 5818 of these establishments, using computer-assisted telephone interviews. Questions about workplace practices were asked only in 1999 and 2001 and only of establishments with more than 10 employees. Smaller establishments are dropped from our sample.

The survey asks respondents whether the workplace has introduced any of four specific types of innovations in the preceding year: 1) new goods or services, which "differ significantly in character or intended use from previously produced goods or services," 2) improved goods or services, which "are those whose performance has been significantly enhanced or upgraded," 3) new processes, which "include the adoption of new methods of goods production or service delivery," and 4) improved processes, which "are those whose performance has been significantly enhanced or upgraded." Table 1 shows the share of establishments that report introducing an innovation in the past year.[5] In three of the four years, the majority of establishments introduced some kind of innovation. Product innovations were more common than process innovations, and

[4] While the primary contact is typically a human resources person, in about 20% of the surveyed establishments, other respondents also answer some questions.

[5] All means reported here have been probability-weighted to adjust for the sampling framework and to protect the confidentiality of respondents.

more establishments reported improvements to existing products and processes than entirely new ones. Innovation rates of all kinds were highest in 1999 and lowest in 2002.

The survey also elicits detailed information about work organization, including the use of quality circles, teams, suggestion programs, feedback, self directed work and the use of incentive pay programs. It records who (workers, management or some combined team) participates in decisions over twelve different aspects of the production process, including planning of individual work, purchase of machinery, staffing levels, and new product development. The level of detail in the information about both innovation and work organization makes the WES data set unique.

Consistent with the theory explored in the previous section, we classify firms according to the allocation of decision authority, the use of information-sharing techniques, and incentive pay programs. We start with decision-making. We count the number of decisions that workers participate in making, and categorize those establishments that delegate two or more decisions (out of the twelve possible) as *decentralized* establishments.[6] Since these questions are asked twice of establishments, once in 1999 and again in 2001, an establishment could change organizational structure over time. In most estimations we include only an establishment's 1999 organizational structure. Using the 2001 structure or a combination yields similar results.

Apart from decision-making, flows of communication between workers and management can support innovation. The WES gathers information about three workplace characteristics that indicate such inclusiveness: 1) employee suggestion programs, including employee survey feedback, 2) information sharing programs, "for example with response to firm's performance, colleagues' wages, technological or organizational change, etc.", and 3) joint labor-management committees, which include "non-legislated joint labour-management committees and task teams that generally cover a broad range of issues, yet tend to be consultative in nature." These

[6] Thirty-five percent of establishments were decentralized by this definition, because they delegated two or more types of decisions to workers or workgroups. An alternative measure of decentralization would be how high in a hierarchy decision problems go to be resolved, as suggested by Clawson (1980, pp. 84-85).

workplace characteristics seek to transfer information and get employee input without necessarily ceding the decision rights. We define an establishment to employ *information-sharing* if it has at least two of these three programs existing on a formal basis in the workplace.

Finally, the survey includes indicators for the existence of an individual incentive pay plan, group incentive pay, or a profit-sharing plan for non-managerial employees at the workplace. We estimate the effects of each. When estimating interactions with the other two work organization variables, we use individual incentive pay.

Other factors that may affect the probability of innovation are included in Z_{jt}, and the means of these variables are listed in Table 2. The size of the establishment, measured by the natural log of the number of employees, should be positively related to innovation, since there may be more product lines and services that are open to efficiency and quality improvements. Establishment age may affect innovation in that older institutions may have already invested in determining their internal structure. Their core technologies and ways of organizing have survived a longer-term selection process, so they may therefore be less likely to innovate. A strong union presence can increase resistance to process changes or reduce the share of rents from innovation that are captured by the establishment. Both would reduce the incentive to innovate.[7] Employees in professional, technical, or managerial positions are more likely to possess valuable information that can be used to innovate. The model also includes a control variable for whether the establishment is part of a multi-plant firm, as well as industry and year indicators.

Two variables capture the volatility of the market: an indicator for whether the establishment experiences seasonal peaks in demand, and the vacancy rate (the number of vacancies as a fraction of total employment). Both may predict innovation. The establishment may innovate in response to fluctuations in either the input or output markets, and seasonal ebbs

[7] Hirsch and Link (1987) find that R&D spending is lower in unionized firms and Acs and Audretsch (1988) find that highly unionized industries produce fewer innovations.

may provide opportunities to focus on redesigning products or production processes. To measure competition, we include indicators for whether the establishment is a monopoly, whether it faces significant competition (more than twenty competitors), and if it has non-profit status. Aghion et al. (2005) and Parente and Prescott (1999) theorize that monopolies are less likely to innovate, but recognize Schumpeterian-type arguments going the other way. For example, some monopolies exist because the monopolist previously innovated, and may remain the type to innovate further. Monopolies may also be able to benefit uniquely from competence-enhancing innovations and therefore have a particular incentive to innovate (Tushman and Anderson, 1986).

Table 3a indicates how innovativeness varies across industry, measuring the share of establishments that had any of the four types of innovations in 1999. Establishments in finance and insurance and capital-intensive (often high tech) manufacturing reported innovations more often than establishments in other industries did. Also especially innovative were information and cultural industries, and labor-intensive tertiary manufacturing, which includes firms with many product lines, or firms that respond quickly to changes in consumer demand. A probit estimation of the probability of innovation on the industrial classification, shown in Appendix Table A2, confirms that these four industries are associated with the highest marginal increase in probability of innovation. Industries reporting the fewest innovations were forestry, mining, oil and gas extraction, education and health services, communications and other utilities.

Table 3b details innovativeness across values of the other explanatory variables in Z_{jt}. It suggests that the three workplace organization variables are correlated with higher innovation. Establishments that decentralize decision making, share information, or offer incentive pay plans innovate much more than those that do not do any of these.[8] Additionally, larger establishments, unionized establishments, those with seasonal demand peaks, and those with high vacancy rates,

[8] Appendix Table A1 shows innovation rates by the individual workplace practices that comprise these organizational types. No single component appears to dominate this result.

have higher innovation rates than the average establishment. Monopolies have a strikingly low rate of innovation. We now turn to our regression approach to determine whether these correlations persist when all effects are measured jointly.

IV. Results

The first three columns of Table 4 report marginal effects of the probit estimation described in equation (2), using three alternative measures of the dependent variable: whether the establishment introduced a new or improved product, whether it introduced a new or improved process, and whether it introduced any innovation in the past year. The fourth column uses a Tobit estimator to measure the effect of the independent variables on the number of these four innovation types an establishment introduced in the past year. We treat this count as a rough ranking of innovativeness. These show how the predictors affect the number of types of innovations—they are not comparable in magnitude, nor necessarily in sign, to the first three columns, which measure how the predictors affect the probability of having one or any innovation. All columns use the pooled 1999-2002 sample and standard errors are corrected both for sample design and for heteroskedasticity due to multiple observations per establishment.

Decentralized decision making and information sharing are both strongly correlated with innovation. Establishments that employ one of these forms of workplace organization are 14-22% more likely to have an innovation than the excluded group (centralized establishments without information-sharing or individual incentive pay programs). The use of incentive pay programs is also positively related to innovation, but the effect is small and statistically insignificant in three estimations. All of these results are consistent with the descriptive model, which predicts that information sharing and decentralization will both positively affect innovation, but that incentive pay will not foster innovation directly. The result that the marginal effect of information sharing is consistently larger than the marginal effect of decentralization is a significant new finding.

The negative coefficients on the interaction between decentralization and information sharing suggests that the two organizational structures are more likely substitutes than complements, although the effects are only statistically significant in the Tobit estimation. The consistently negative coefficient on the interaction between decision rights and incentive pay is contrary to the implications of our theory. The result may reflect a resistance by workers on some forms of incentive pay to implement change. Freeman and Kleiner (2005), studying production workers in shoe manufacturing who are paid on piece rates, argue that these workers might be particularly resistant to change. Innovation in technology or the production process may require workers to be assigned to new jobs, or learn new tasks. Such changes could cause a temporary decrease in the individual worker's output and therefore pay.[9]

Other establishment characteristics are also correlated with innovation. Larger establishments are more likely to innovate, presumably because they have more activities of any kind, including those which can be improved or leveraged to larger scale. Stronger union presence does not appear to be correlated with the probability of any particular innovation, although it is negatively related to the number of types of innovation an establishment reports. Nonprofit institutions are less likely to generate innovations than comparable for-profit institutions. A high vacancy rate is strongly correlated with innovation as predicted; these may be establishments in opportunistic, turbulent circumstances.

The findings in table 4 provide evidence that decentralization and information-sharing practices predict higher innovation rates. They may not *cause* the higher innovation rates, however. First, causality might go in the opposite direction -- innovation may spur workplace reorganization. Second, both outcomes may be caused by omitted variables. For example, it may be that college-educated managers spot potential innovations and that educated managers also

[9] Other plausible explanations might also account for these results, however. For example a survey instrument only captures the presence of formal programs. Information sharing in particular might often be done informally at establishments that decentralize decision rights. This would bias both the coefficient on information sharing and on the interaction term.

share information or grant decision rights. In this case, since manager education is unobserved, our results for the other variables would be biased relative to the structural relationship.

We investigate the first of these issues by testing for causality going the other direction. Table 5 reports the results of three probit estimations on the probability of an establishment granting decision rights, using information sharing programs or using an incentive pay scheme in 2001. We include most of the regressors in Table 4, along with measures of the number of innovations of any kind in each year of the sample. If past innovations are correlated with the workplace organization, but later ones are not, then we have evidence of a "reverse causality" problem. Results of this estimation do indicate the possibility that innovations lead to workplace organization, in particular for the adoption of information sharing and incentive pay plans, which are correlated with the one year lagged innovations. This is a short term phenomenon and difficult to pin down accurately since the observed annual variation depends on when an innovation is reported. For example, an establishment may commit to making a new product before the innovation is recognized by the survey respondent, or it may be recognized by the respondent before it is finished. The fact that there aren't correlations of the same kind at a two year lag suggests we do not have long term reverse causality.

We take additional steps to control for the potential endogeneity of the regressors. One way to remove some of this endogeneity is to restrict the analysis to the pooled 2000-2002 sample, and use the lagged 1999 variables as regressors. This specification gives up some information about the current year that might affect innovation outcomes in order to reduce short run endogeneity. Consider, for example, the vacancy rate. Innovative establishments are likely to expand by hiring, which implies that both the vacancy rate and the innovation rate is informative about the firm's type, but vacancy is not the cause of innovation. A lagged variable, like the previous vacancy rate is likely to tell us about the firm's type and its environment historically,

without being a short-run result of recent innovative outcomes. It is less endogenous than current-year vacancy rates.

Table 6 shows the results of these estimations. The results for the workplace organization variables are qualitatively similar to those in Table 4. Information-sharing programs and decentralized decision-making remain strongly correlated with reported innovations, and the magnitudes of these coefficients are largely unchanged. The effect of incentive pay is also similar to that found in the initial estimation, but the marginal effect is slightly larger and more significant. The interaction of decentralization and incentive pay remains strong and negative. Several other coefficients change in size and significance, suggesting that they were previously biased due to their relationship with the endogenous regressor. The size of the establishment is no longer significant at the 5% level in the three probit estimations, and even negatively affects the number of innovation types. Seasonal peaks become insignificant in this model. The vacancy rate is now significant only at the 10% level in the probit estimations.[10]

As a further step to eliminate potential endogeneity, we control for whether the establishment reported any of the four innovation types in 1999. Unobservable establishment characteristics that affect innovative behavior are approximately held fixed in the 1999 measures of innovation. Table 7 shows that year 1999 innovations strongly predict current innovations, especially those that are of the same type, i.e. product or process. The effects of work organization on innovation remain qualitatively the same. Information-sharing is the strongest positive predictor of innovations, although the size of the effect is somewhat smaller in this estimation. Decentralized decision making is also positive and statistically significant for both the number and types of innovations. The effects of most of the other predictors remain the same.

[10] Further concerns about the endogeneity of the vacancy rate led us to attempt a specification in which we replaced the establishment's own vacancy rate with an industry-averaged vacancy rate. This did not change the results significantly.

Finally, the longitudinal nature of the data enables us to test for endogeneity by including establishment fixed effects to the model in equation (2). Here, effects are identified for those establishments that change workplace organization between 1999 and 2001. This is a noisy source of variation, much of which probably comes from small differences in workplace practices, interpretation of the survey question, or reporting mistakes. Furthermore, changes in organizational practices would not usually immediately yield changes in innovative activity. Although this is not our preferred specification, we report the results nonetheless as one control for endogeneity.

Table 8 reports the results of this estimation. In the fixed effects logit models, establishments that adopt information-sharing techniques are much more likely to report innovations. Although this might be true by definition for process innovations if the respondent interprets changes in work organization as a process innovation, the result also holds up, and is even larger, in the product innovation specification. Although size and union presence were statistically insignificant in the pooled estimations, the effects are large and significant in this model. A given establishment is more likely to report innovations in periods when it is larger, and less likely to report innovations in periods when it has more union coverage. Those establishments whose demand becomes more volatile by becoming seasonal or by having an increased vacancy rate are more likely to innovate. The overall explanatory power of these estimations is quite low, confirming that our source of variation is noisy. Our aim here, however, is not to fully explain innovative behavior, but rather to confirm the relationship between organizational structure and innovation.

V. Conclusion

We use the Canadian WES data to identify whether an establishment is decentralized or centralized, based on the extent of worker participation in decision making in the establishment.

We further measure whether or not the establishment employs information-sharing techniques to transfer information to and from employees. We theorize that information-sharing and decentralization are two alternate methods of bridging the gap between information vital to innovative activity and the authority to act on such information. Our theory suggests that incentive pay would make either method more effective.

We test whether there is a relationship between decentralization, information-sharing, or incentive pay and innovation, controlling for a number of establishment characteristics like industry, establishment size, degree of competition, non-profit status, and demand volatility. Information-sharing is strongly and positively related to innovation. Decentralized decision making also has a positive, though weaker, relationship to innovation. Incentive pay is only weakly related to innovation and, surprisingly, the interaction of incentive pay with decision rights has a negative coefficient. While we cannot be certain that this relationship is causal, we have looked for evidence of reverse causality and used several different techniques to control for potential endogeneity. We find a consistently strong predictive effect of workplace organizational structure on innovation.

References

Acs, Zoltan J. and David B. Audretsch. 1988. "Innovation in Large and Small Firms: An Empirical Analysis" *The American Economic Review* 78: 4, 678-690.

Aghion, Philippe, Nicholas Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt. 2005. "Competition and Innovation: An Inverted U Relationship." *Quarterly Journal of Economics* (May) 701-728.

Black, Sandra E. and Lisa Lynch. 2004. "What's Driving the New Economy: The Benefits of Workplace Innovation." *The Economic Journal* 114 (Feb.) F97-F116.

Black, Sandra E., and Lisa M. Lynch. 2001. "How to Compete: The Impact of Workplace Practices and Information Technology on Productivity." *Review of Economics and Statistics* 83: 3 (Aug.) 434-445.

Bresnahan, Timothy F., Erik Brynjolfsson and Lorin M. Hitt. 2002. "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence." *Quarterly Journal of Economics* (Feb.) 339-376.

Clawson, Dan. 1980. *Bureaucracy and the Labor Process: The Transformation of U.S. Industry, 1860-1920.* New York: Monthly Review Press.

Freeman, Christopher and Edward Lazear. 1995. "An Economic Analysis of Works Councils," in (J. Rogers and W. Streeck, eds.), *Works Councils*, Chicago, IL: University of Chicago Press, 27-52,

Freeman, Richard and Morris M. Kleiner. 2005. "The Last American Shoe Manufacturers: Decreasing Productivity and Increasing Profits in the Shift from Piece Rates to Continuous Flow Production." *Industrial Relations* (April) 307-330.

Hirsch, Barry T. and Albert N. Link. 1987. "Labor Union Effects on Innovative Activity." *Journal of Labor Research* 8: 4, 323-332.

Ichniowski, Casey, Kathryn Shaw, and Giovanna Prennushi, 1997, "The Effects of Human Resources Management Practices on Productivity: A Study of Steel Finishing Lines." *American Economic Review* 87: 3, 291-313.

Jensen, Michael C. and William H. Meckling, 1995, "Specific and General Knowledge, and Organizational Structure." *Journal of Applied Corporate Finance*, vol. 8, no. 2.

Laursen, K. and N. J. Foss. 2003. "New Human Resource Management Practices, Complementarities, and the Impact on Innovation Performance." *Cambridge Journal of Economics* 27: 2, 243-63.

Michie, J. and M. Sheehan. 1999. "HRM Practices, R&D Expenditure and Innovative Investment: Evidence from the UK's 1990 Workplace Industrial Relations Survey." *Industrial and Corporate Change* 8, 211-34.

Mohr, Robert and Cindy Zoghi. 2006. “Is Job Enrichment Really Enriching?” Bureau of Labor Statistics Working Paper 389.

Mookherjee, Dilip. 2006. “Decentralization, Hierarchies, and Incentives: A Mechanism Design Perspective” *Journal of Economic Literature* 44:2, 367-390

Parente, Stephen L. and Edward C. Prescott. 1999. “Monopoly Rights: A Barrier to Riches.” *American Economic Review* 89:5, 1216-1233.

Rogers, Mark. 1999. “Innovation in Australian Workplaces: an Empirical Analysis.” *Australian Bulletin of Labour*, 24:4, 334-351.

Therrien, Pierre and André Léonard. 2003. *Empowering Employees: A Route to Innovation*, Statistics Canada: Ottawa. Catalogue no. 71-584-MIE.

Tushman, Michael L., and Philip Anderson. 1986. Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly* 31, 439-465.

Van Zandt, Timothy. 2003. “Real-Time Hierarchical Resource Allocation.” INSEAD working paper. http://faculty.insead.edu/vanzandt/research-orgs/papers/Resource1.pdf

Table 1. Percent of establishments in the WES reporting innovations

	1999	2000	2001	2002
New product or service	44.17	31.56	40.07	29.10
Improved product or service	53.29	43.61	46.00	33.52
New process	37.26	31.12	32.83	20.60
Improved process	45.55	37.76	37.39	28.14
Any innovation	63.0	54.1	57.3	45.3
Number of observations	4123	4021	4089	3940

Notes: All estimates are calculated using probability weights. Sample restricted to those establishments with more than 10 employees.

Table 2. Workplace characteristics in 1999 WES

	Mean
Organizational type:	
Decentralized decision rights	.420
Information sharing	.320
Individual incentive pay plan (yes = 1)	.422
Centralized, without incentive pay or information sharing	.279
Industry:	
Forestry, mining, oil and gas extraction	.015
Labor-intensive tertiary manufacturing	.049
Primary product manufacturing	.025
Secondary product manufacturing	.031
Capital-intensive tertiary manufacturing	.053
Construction	.051
Transportation, warehousing, wholesale trade	.133
Communication and other utilities	.021
Retail trade and consumer services	.288
Finance and insurance	.072
Real estate, rental and leasing operations	.015
Business services	.110
Education and health services	.105
Information and cultural industries	.031
Other vars:	
Ln (establishment size)	3.28
Union coverage rate	.131
Nonprofit institution (yes = 1)	.098
Part of multi-plant establishment	.328
Ln (establishment age)	2.19
Seasonal demand peaks (yes = 1)	.405
Vacancy rate	.037
Profit-sharing plan (yes = 1)	.151
Monopoly (yes = 1)	.081
More than twenty competitors (yes = 1)	.246

Notes: All estimates are calculated using probability weights. Sample restricted to those establishments with more than 10 employees.

Table 3a. Share of establishments innovating, by industry

	Percent innovating
Full sample	63.0
Industry:	
Forestry, mining, oil and gas extraction	45.0
Labor-intensive tertiary manufacturing	66.5
Primary product manufacturing	62.2
Secondary product manufacturing	71.4
Capital-intensive tertiary manufacturing	82.8
Construction	54.0
Transportation, warehousing, wholesale trade	70.1
Communication and other utilities	52.6
Retail trade and consumer services	59.6
Finance and insurance	73.3
Real estate, rental and leasing operations	64.9
Business services	62.3
Education and health services	50.1
Information and cultural industries	68.4

Notes: All estimates are calculated using probability weights. Sample restricted to those establishments with more than 10 employees.

Table 3b. Share of establishments innovating, by workplace characteristics

	Percent innovating
Full sample	**63.0**
Decentralized decision rights	69.4
Information sharing	75.2
Individual incentive pay plan (yes = 1)	70.3.
Centralized, without incentive pay or information sharing	49.8
Less than 50 employees	62.0
50 – 99 employees	67.5
100 – 249 employees	64.7
At least 250 employees	74.8
Unionized	64.7
Non-unionized	62.6
Nonprofit institution	47.9
For-profit institution	64.6
Establishment part of multi-plant firm	66.4
Stand-alone establishment	61.3
Establishment age less than five years	62.2
Establishment age 5 – 14 years	64.6
Establishment age at least 15 years	62.2
Seasonal demand peaks	63.6
No seasonal demand peaks	62.6
Vacancy rate = 0	60.2
Vacancy rate less than .03	73.8
Vacancy rate at least .03	68.6
Profit-sharing plan	71.3
No profit-sharing plan	61.5
Monopoly	57.0
Not monopoly	63.5
More than twenty competitors	64.4
Under twenty competitors	62.5

Notes: All estimates are calculated using probability weights. Sample restricted to those establishments with more than 10 employees.

Table 4. Effect of 1999 organizational structure and establishment characteristics on the probability of innovation in 1999-2002 WES

	Product Innovation	Process Innovation	Either Innovation	Number of Innovation Types
1999: Decentralized	.1537***	.1579***	.1354***	.6914***
(yes = 1)	(.044)	(.050)	(.045)	(.087)
1999: Info-sharing	.2147***	.2234***	.1812***	1.1653***
(yes = 1)	(.056)	(.053)	(.055)	(.103)
1999: Incentive Pay Plan	.0765*	.0362	.0694	.3249***
(yes = 1)	(.043)	(.046)	(.042)	(.091)
Decentralization *	-.1162*	-.1343**	-.1221*	-.5397***
Individual Incentive Pay	(.062)	(.062)	(.064)	(.142)
Information-sharing *	-.0757	.0292	.0019	-.0822
Individual Incentive Pay	(.080)	(.076)	(.078)	(.174)
Decentralization *	-.1245	-.1076	-.0921	-.6061***
Information-sharing	(.081)	(.076)	(.084)	(.148)
Decentralization *				
Individual Incentive Pay	.0382	-.0269	-.0001	.2442
* Information-sharing	(.113)	(.108)	(.110)	(.250)
Ln (establishment size)	.0295**	.0382***	.0373***	.0566
	(.013)	(.013)	(.013)	(.036)
Union coverage rate	-.0023	.0130	.0079	-.3591***
	(.045)	(.046)	(.043)	(.097)
Nonprofit institution	-.1650***	-.1083*	-.1546**	-.8157***
(yes = 1)	(.057)	(.058)	(.060)	(.137)
Profit-sharing plan	-.0133	-.0062	.0067	-.1329
	(.034)	(.039)	(.036)	(.090)
Group incentive pay	.0083	.0417	.0183	.2144**
	(.038)	(.034)	(.039)	(.089)
Part of multi-plant firm	.0296	.0664**	.0427	.2566***
(yes = 1)	(.033)	(.033)	(.032)	(.065)
Ln (establishment age)	-.0093	-.0025	-.0036	-.0694***
	(.014)	(.013)	(.013)	(.025)
Seasonal peaks (yes = 1)	.0499*	.0285	.0287	.2538***
	(.028)	(.030)	(.029)	(.060)
Vacancy rate	.2208***	.1397**	.2226***	1.0027***
	(.073)	(.063)	(.078)	(.229)
Monopoly (yes = 1)	-.0362	.0133	-.0401	-.1461
	(.041)	(.046)	(.040)	(.104)
20+ competitors	-.0043	.0097	-.0025	.0045
(yes = 1)	(.036)	(.034)	(.036)	(.067)
Percent professional,	.0593	.0262	.0527	.2942***
technical, managerial	(.049)	(.044)	(.048)	(.107)
Pseudo-R^2	.064	.083	.064	.024

Notes: Cols. 1-3 are marginal effects of probit regressions. Col. 4 are Tobit effects. All are adjusted with probability weights and to control for clustering due to multiple observations in the same establishment, one for each year. * = p-value<.1, ** = p<.05, *** = p<.01. Each regression also includes a full set of 13 industry and year indicators. N = 14,594

Table 5. Predictive effect of innovations on workplace organization; a test of reverse causality

	Dependent variable: 2001 workplace organization type:		
	Decentralized decision rights	**Information sharing**	**Individual incentive pay plan**
1999: any innovation	-.0294	-.0329	-.0133
	(.047)	(.042)	(.048)
2000: any innovation	-.0268	.1573***	.1349***
	(.046)	(.041)	(.047)
2001: any innovation	.0819*	.0289	.0514
	(.048)	(.043)	(.052)
2002: any innovation	.0275	.0913**	-.0446
	(.045)	(.042)	(.050)
1999: Decentralized (yes = 1)	.2104***		
	(.043)		
1999: Info-sharing (yes = 1)		.1809***	
		(.045)	
1999: Incentive Pay Plan (yes = 1)			.2676***
			(.046)
Ln (establishment size)	.0528***	.0531***	.0536**
	(.019)	(.016)	(.023)
Union coverage rate	-.0335	.0712	-.2971***
	(.067)	(.053)	(.076)
Nonprofit institution (yes = 1)	-.0346	.1514	-.2448***
	(.076)	(.100)	(.052)
Profit-sharing plan	.1238*	-.0113	.0898
	(.071)	(.048)	(.067)
Group incentive pay	-.0067	.1539***	.2130***
	(.060)	(.060)	(.073)
Part of multi-plant firm (yes = 1)	-.0885*	.0653	.1394***
	(.050)	(.046)	(.054)
Ln (establishment age)	-.0185	-.0032	-.0080
	(.022)	(.019)	(.019)
Seasonal peaks (yes = 1)	.0776	-.0020	.0021
	(.054)	(.043)	(.052)
Vacancy rate	-.3605	-.3422	.6905
	(.605)	(.565)	(.568)
Monopoly (yes = 1)	-.2470***	.0047	-.0997
	(.046)	(.099)	(.094)
20+ competitors (yes = 1)	.0723	.075	-.0263
	(.061)	(.052)	(.048)
Percent professional, technical, managerial	.0206	-.0324	.0767
	(.074)	(.064)	(.072)
Number of observations	3570	3501	3570
Pseudo R-squared	.17	.19	.25

Coefficients shown are marginal effects of probit estimation. Each regression also includes a full set of 13 industry and year indicators. * = p-value<.1, ** = p<.05, *** = p<.01. All are adjusted with probability weights and to control for clustering due to multiple observations in the same establishment, one for each year

Table 6. Effect of 1999 organizational structure and 1999 establishment characteristics on the probability of future innovation in 2000-2002 WES

1999 value of :	**Product Innovation**	**Process Innovation**	**Either Innovation**	**Number of Innovation Types**
1999: Decentralized	.1583***	.1606***	.1281**	.6849***
(yes = 1)	(.050)	(.059)	(.055)	(.104)
1999: Info-sharing	.2248***	.2315***	.1870**	1.1403***
(yes = 1)	(.075)	(.068)	(.073)	(.124)
1999: Incentive Pay Plan	.0874*	.0609	.0881*	.3415***
(yes = 1)	(.049)	(.051)	(.049)	(.113)
Decentralization *	-.1478**	-.1793**	-.1668**	-.6429***
Individual Incentive Pay	(.069)	(.066)	(.074)	(.171)
Information-sharing *	-.0955	-.0313	-.0470	-.1587
Individual Incentive Pay	(.101)	(.087)	(.104)	(.217)
Decentralization *	-.1117	-.1128	-.0658	-.5548***
Information-sharing	(.090)	(.082)	(.097)	(.179)
Decentralization *				
Individual Incentive Pay *	.0877	.0179	.0846	.3672
Information-sharing	(.129)	(.125)	(.128)	(.301)
Ln (establishment size)	.0216	.0364*	.0243	-.0990**
	(.015)	(.015)	(.015)	(.044)
Union coverage rate	.0262	.0128	.0198	-.0934
	(.060)	(.060)	(.060)	(.128)
Nonprofit institution	-.1324*	-.0953	-.1131	-.7183***
(yes = 1)	(.067)	(.066)	(.073)	(.166)
Profit-sharing plan	.0135	.0272	.0460	.0435
	(.039)	(.043)	(.040)	(.110)
Group incentive pay	.0359	.0679*	.0446	.3832***
	(.044)	(.041)	(.043)	(.109)
Part of multi-plant firm	.0185	.0533*	.0434	.1913**
(yes = 1)	(.038)	(.037)	(.038)	(.079)
Ln (establishment age)	-.0098	-.0164	-.0111	-.1141***
	(.013)	(.014)	(.013)	(.030)
Seasonal peaks (yes = 1)	-.0230	-.0220	-.0415	-.1513*
	(.033)	(.033)	(.034)	(.071)
Vacancy rate	.2157*	.4795*	.4033*	1.9315***
	(.125)	(.244)	(.216)	(.298)
Monopoly (yes = 1)	.0873	.0551	.0670	.1562
	(.065)	(.073)	(.063)	(.128)
20+ competitors	-.0093	-.0185	-.0047	-.0779*
(yes = 1)	(.041)	(.038)	(.041)	(.080)
Percent professional,	.0442	.0189	.0255	.3516***
technical, managerial	(.058)	(.060)	(.063)	(.134)
Pseudo-R^2	.056	.082	.059	.021

Notes: Cols. 1-3 are marginal effects of probit regressions. Col. 4 are Tobit effects. All are adjusted with probability weights and to control for clustering due to multiple observations in the same establishment, one for each year. * = p-value<.1, ** = p<.05, *** = p<.01. Each regression also includes a full set of 13 industry and year indicators. N = 10,409

Table 7. Effect of 1999 organizational structure and 1999 establishment characteristics on the probability of future innovation in 2000-2002 WES, with controls for 1999 innovations

1999 value of :	Product Innovation	Process Innovation	Either Innovation	Number of Innov. Types
Decentralized (yes = 1)	.1265**	.1260**	.0968*	.4547***
	(.051)	(.064)	(.057)	(.102)
Info-sharing (yes = 1)	.1771**	.1785**	.1416*	.7646***
	(.080)	(.070)	(.077)	(.123)
Incentive Pay Plan (yes = 1)	.0776*	.0537	.0835*	.2938***
	(.046)	(.050)	(.048)	(.111)
Decentralization * Individual Incentive Pay	-.1576**	-.1770**	-.1726**	-.6720***
	(.068)	(.067)	(.076)	(.167)
Information-sharing * Individual Incentive Pay	-.1401	-.0668	-.0920	-.4497**
	(.102)	(.084)	(.108)	(.211)
Decentralization * Information-sharing	-.1168	-.1124	-.0682	-.5845***
	(.093)	(.084)	(.101)	(.175)
Decent * Individual Incentive Pay * Info-sharing	.1886	.0923	.1699	1.0068***
	(.125)	(.130)	(.124)	(.294)
New product	.1309***	.0607	.1277***	.6385***
	(.037)	(.039)	(.037)	(.083)
New process	.0545	.1022**	.0909**	.5325***
	(.044)	(.044)	(.043)	(.097)
Improved product	.0984**	.0148	.0477	.4753***
	(.045)	(.042)	(.047)	(.095)
Improved process	.0067	.0915**	.0133	.2405**
	(.050)	(.046)	(.050)	(.103)
Ln (establishment size)	.0159	.0316**	.0189	-.1261***
	(.015)	(.015)	(.015)	(.042)
Union coverage rate	.0439	.0331	.0414	.0283
	(.056)	(.055)	(.056)	(.125)
Nonprofit institution (yes = 1)	-.1062	-.0964	-.0969	-.5872***
	(.065)	(.064)	(.070)	(.162)
Profit-sharing plan	.0156	.0331	.0485	.0579
	(.040)	(.044)	(.039)	(.107)
Group incentive pay	.0510	.0756*	.0572	.4620***
	(.046)	(.044)	(.043)	(.106)
Part of multi-plant firm (yes = 1)	.0199	.0458	.0381	.1686**
	(.038)	(.039)	(.038)	(.078)
Ln (establishment age)	-.0056	-.0153	-.0072	-.0910***
	(.013)	(.014)	(.013)	(.029)
Seasonal peaks (yes = 1)	-.0458	-.0425	-.0670*	-.2911***
	(.034)	(.034)	(.035)	(.070)
Vacancy rate	.1570	.4781*	.3736*	1.6489***
	(.121)	(.247)	(.206)	(.289)
Monopoly (yes = 1)	.0900	.0602	.0703	.1644
	(.072)	(.083)	(.070)	(.124)
20+ competitors (yes = 1)	-.0340	-.0472	-.0299	-.2676***
	(.040)	(.037)	(.040)	(.079)
Percent professional, technical, managerial	.0194	-.0059	-.0038	.1544
	(.059)	(.062)	(.064)	(.132)
Pseudo-R^2	.090	.115	.090	.035

Notes: Cols. 1-3 are marginal effects of probit regressions. Col. 4 are Tobit effects. All are adjusted with probability weights and to control for clustering due to multiple observations in the same establishment, one for each year. * = p-value<.1, ** = p<.05, *** = p<.01. Each regression also includes a full set of 13 industry and year indicators. N = 10,409

Table 8. Effect of organizational structure and establishment characteristics on the innovations in 1999-2002 WES, with establishment fixed effects included

	Product Innovation	Process Innovation	Either Innovation	Number of Innovation Types
Decentralized (yes = 1)	.1797	.1004	.1154	.1353***
	(.112)	(.115)	(.112)	(.045)
Info-sharing (yes = 1)	.4972***	.1330	.3547***	.3476***
	(.120)	(.119)	(.118)	(.049)
Incentive Pay Plan (yes = 1)	.2247**	.0380	.1880	.1922***
	(.118)	(.120)	(.116)	(.047)
Decentralization * Individual	-.0481	-.0130	-.1077	-.0044
Incentive Pay	(.166)	(.167)	(.164)	(.069)
Information-sharing *	-.1958	.2564	-.0911	.0179
Individual Incentive Pay	(.180)	(.181)	(.182)	(.076)
Decentralization *	-.0408	.1413	.0737	.0585
Information-sharing	(.163)	(.162)	(.163)	(.068)
Decent * Individual	.1144	.0231	.1995	.0292
Incentive Pay * Info-sharing	(.249)	(.249)	(.253)	(.105)
Ln (establishment size)	.1577*	.2533***	.3031***	.1350***
	(.087)	(.083)	(.084)	(.013)
Union coverage rate	-.1841	-.2297*	-.2652**	-.2060***
	(.128)	(.126)	(.127)	(.042)
Profit-sharing plan	-.0747	.0468	-.0268	.0118
(yes = 1)	(.108)	(.106)	(.107)	(.038)
Group incentive pay	.1037	.0766	.1182	.1153***
plan (yes = 1)	(.092)	(.092)	(.095)	(.037)
Seasonal peaks (yes = 1)	.2028***	.2376***	.2413***	.1487***
	(.078)	(.077)	(.078)	(.029)
Vacancy rate	.5112*	.9449**	1.1475***	.0204
	(.324)	(.422)	(.478)	(.038)
Monopoly	-.2414*	.0231	-.0618	-.1625***
	(.136)	(.140)	(.137)	(.052)
Percent professional,	-.0612	-.1708	-.0874	.0181
technical, managerial	(.127)	(.130)	(.129)	(.049)
Pseudo-R^2	.008	.008	.010	.023
Number of observations	8623	8642	8617	14594

Notes: Cols. 1-3 are effects of fixed effects logit regressions. Col. 4 are linear fixed effects. * = p-value<.1, ** = p<.05, *** = p<.01. Each regression also includes a full set of 13 industry and indicators. N = 10,409

Table A1. Workplace organization and components in 1999 WES, by whether or not innovating

	Fraction innovating
Decentralized decision-making	
Decide on daily planning of individual work	.625
Decide on weekly planning of individual work	.629
Decide on follow-up of results	.697
Decide on customer relations	.680
Decide on quality control	.688
Decide on purchase of necessary supplies	.680
Decide on machine/equipment maintenance	.662
Decide on setting staffing levels	.512
Decide on filling vacancies	.851
Decide on training	.667
Decide on choice of production technology	.727
Decide on product/service development	.708
Information –sharing	
Suggest	.774
Info-sharing	.763
Committee	.755

Notes: All estimates are calculated using probability weights. Sample restricted to those establishments with more than 10 employees.

Table A2. Effect of industry on the probability of innovations

	New Product	New Process	Improved Product	Improved Process
Finance and insurance	**0.44**	**0.31**	**0.38**	**0.26**
Capital-intensive tertiary manufacturing (printing, machinery manufacturing, computer and electronics, lighting, transportation equipment)	**0.37**	**0.20**	**0.33**	**0.22**
Labor-intensive tertiary manufacturing (food, beverage, tobacco, textile, apparel, leather, furniture, and miscellaneous manufacturing)	**0.37**	**0.15**	**0.28**	**0.15**
Information and culture	**0.32**	**0.14**	**0.29**	**0.15**
Secondary product manufacturing (chemicals; plastic, rubber, and fabricated metal products)	**0.34**	**0.14**	**0.23**	**0.15**
Primary product manufacturing (wood, paper, petroleum, coal, metal, and nonmetallic mineral products)	**0.21**	**0.09**	**0.22**	**0.15**
Retail trade and consumer services	**0.33**	**0.07**	**0.25**	0.02
Transportation, storage and wholesale trade	**0.28**	**0.08**	**0.21**	**0.04**
Business services	**0.23**	**0.07**	**0.19**	**0.07**
Communication and other utilities	**0.23**	**0.09**	**0.16**	**0.07**
Education and health services	**0.20**	**0.06**	**0.14**	0.01
Real estate, rental, and leasing operations	**0.14**	-0.01	**0.12**	-0.03
Construction	0.02	**-0.07**	0.01	**-0.09**
year 2000	**-0.05**	**-0.04**	**-0.06**	**-0.05**
year 2001	**-0.02**	**-0.04**	**-0.02**	**-0.05**
year 2002	**-0.10**	**-0.11**	**-0.13**	**-0.11**

Notes: estimates shown are marginal effects of probit regressions, which are adjusted with probability weights and to control for clustering due to multiple observations in the same establishment, one for each year. The omitted reference industry is extraction industries (forestry, mining, oil) and the omitted reference year is 1999.
Figures in bold are statistically significant at $p<.05$.