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The Evolving Workplace Series

Empowering employees: A route to innovation

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Empowering employees: A route to innovation

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Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

Table of contents

Foreword

This document provides data from the new Workplace and Employee Survey (WES) conducted by Statistics Canada with the support of Human Resources Development Canada. The survey consists of two components: (1) a workplace survey on the adoption of technologies, organizational change, training and other human resource practices, business strategies, and labour turnover in workplaces; and (2) a survey of employees within these same workplaces covering wages, hours of work, job type, human capital, use of technologies and training. The result is a rich new source of linked information on workplaces and their employees.

Why have a linked workplace and employee survey?

Advanced economies are constantly evolving. There is a general sense that the pace of change has accelerated in recent years, and that we are moving in new directions. This evolution is captured in phrases such as "the knowledge-based economy" or "the learning organization". Central to these notions is the role of technology, particularly information technology. The implementation of these technologies is thought to have substantial impact on both firms and their workers. Likely related to these technological and environmental changes, many firms have undertaken significant organizational changes and have implemented new human resource practices. Globalization and increasing international competition also contribute to the sense of change.

In this environment, greater attention is being paid to the management and development of human resources within firms. Education and training are increasingly seen as an important investment for improved prosperity—both for firms and individual workers.

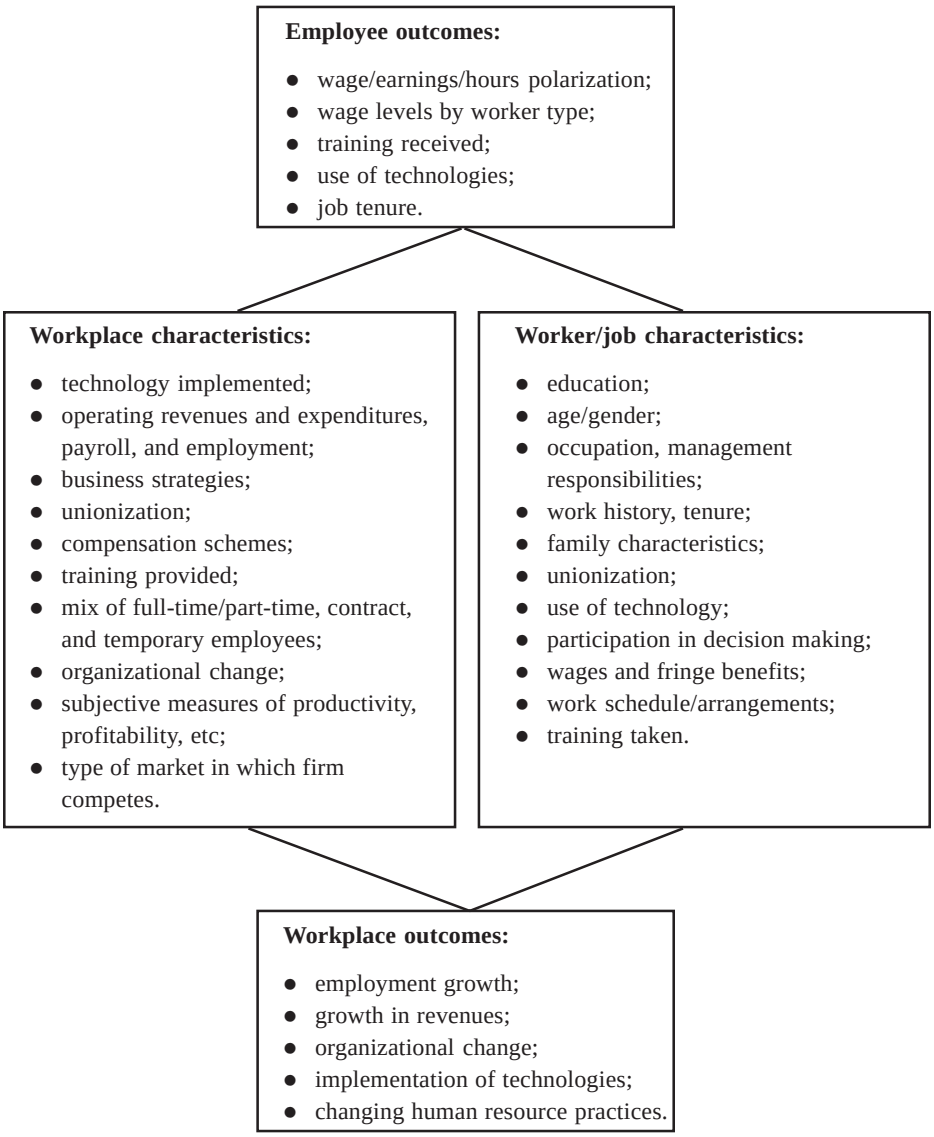
Thanks to earlier surveys, researchers have a good understanding of workers' outcomes regarding wages and wage inequality, job stability and layoffs, training, job creation, and unemployment. What is missing on the employees' side is the ability to link these changes to events taking place in firms. Such a connection is necessary if we hope to understand the association between labour market changes and pressures stemming from global competition, technological change, and the drive to improve human capital. Thus, one primary goal of WES is to establish a link between events occurring in workplaces and the outcomes for workers. The advantage of a linked survey is depicted in the figure which displays the main content blocks in the two surveys.

The second goal of the survey is to develop a better understanding of what is indeed occurring in companies in an era of substantial change. Just how many companies have implemented new information technologies? On what scale? What kind of training is associated with these events? What type of organizational change is occurring in firms? These are the kinds of issues addressed in the WES.

This report aims to give those interested in innovation and human resource management practices some useful insights from the initial survey, as well as stimulating their interest in the possibilities provided by these new data.

Those interested in the methodology should go to our website at http://www.statcan.ca/english/survey/business/workplace/workplace.htm.

Link between the workplace survey content, employee survey content, and outcomes



1. Introduction

Knowledge accumulation is, according to the economic literature, one of the most important characteristics of innovation (Rosenberg, 1994, Nelson and Winter, 1982). The accumulation of knowledge comes from complex and dynamic interactions between the firms' own internal innovation capacity and external expertise. A firm's knowledge is largely embodied in its workforce. For example, engineers and scientific workers have scientific and technical knowledge, production workers have pragmatic knowledge, and managers, in addition to their knowledge of internal operations, have access to knowledge through their networks with external partners, such as clients, suppliers and researchers. All of these types of knowledge enhance the firm's internal innovation capacities. Therefore, retaining workers as well as keeping them highly motivated are critical factors to assure continuity in the knowledge accumulation process leading to innovation.

To retain its workers and keep them motivated, a firm may use financial incentives, such as compensation pay, as well as non-financial benefits, such as employee involvement practices and training. These methods are known as human resource management (HRM) practices, and although a growing literature has studied the impact of such practices on firms' productivity, only a few studies have looked at their impacts on innovation performance.

This paper investigates the relationship between such workplace practices and the innovative performance of Canadian firms. In Section 2, we review relevant literature on this issue and present the hypotheses to

be tested in this paper. In Section 3, we discuss our methodology and data used, while in Section 4, we discuss our results. Finally, in the final section, we discuss the policy implications of our findings and identify issues for further research.

2. Literature review and hypotheses to be tested

There is a growing amount of literature studying the effect of HRM on several aspects of economic life, such as productivity, employee loyalty and, more recently, innovation. These HRM practices consist of new work arrangements directed at managing human resources towards the achievement of superior organizational performance. Following incentive contract theory, a firm's productivity may be improved by using compensation practices such as profit sharing, stock options or line incentives. However, HRM practices are not limited to financial benefits. Other practices, such as teamwork, quality circles, information sharing with employees, and self-managed workgroups, are also designed to get employees more involved in their jobs. Together, incentive pay, employee involvement, and training initiatives are the core of HRM practices.

Based on the economic literature, Ichniowski, Shaw and Prennushi (1997) document the complementarity of these human resource practices. Combining compensation pay with employment involvement practices suggests that, in order to improve productivity, employees must benefit financially from their contribution. This assumption is clearly stated in a more recent paper, (Boning, Ichniowski and Shaw, 2001): "Good (performance-improving) decisions do not just happen spontaneously. Jobs must be designed to put decision-making authority in the right hands, and employees must be motivated to exercise that authority in a productive manner." Therefore, it is not sufficient just to give workers the opportunity to improve the production process; they must have incentives that motivate

good decisions. Testing the latter assumption with their own database on U.S. steel mini mills, the authors found that the adoption of problem-solving teams (an employee involvement practice) or group-based incentive pay each increases a firm's productivity, but not as much as when these two practices are used together.

This leads to a more general statement about the complementarity of HRM practices. In essence, complementarity between a set of practices implies that the adoption of one practice has externalities for decisions regarding the adoption of other practices (Athey and Stern, 1998).[1] Applied to the HRM practices perspective, Ichniowski et al. (1997) argued that "firms benefit little from making marginal decisions about one HRM practice at a time, but instead realize the largest benefit (productivity increase) by making discrete jumps in the use of clusters of practices." Using several HRM practices contributes to overcoming potential problems that only one HRM practice could not prevent on its own (for example, the free riding problem when individual effort is difficult to measure).

However, one must combine individual practices into a coherent HRM system to have the predicted gain. Ichniowski et al. (1997) regrouped individual practices into seven HRM policy areas: incentive pay, recruiting, teamwork, employment security, job flexibility, training, and labour-management communication. The authors defined a HRM system with four categories: firms in the first category (most sophisticated) are engaged in the seven HRM policy areas, while firms in the fourth category (least sophisticated) are not engaged in any of these HRM policy areas. Ichniowski et al. found a striking difference in the economic performance

[1] Complementarity would arise when "[…] doing more from one thing increases the return of doing (more of) the others" (Milgrom and Roberts from Laursen and Foss, 2003).

of firms using the most and least sophisticated HRM systems. "These results imply that a more carefully crafted system of HRM policies makes it possible for employees in manufacturing establishments to produce significantly higher levels of high-quality output," (Ichniowski et al., 1997).

Freeman, Kleiner, and Ostroff (2000), using a U.S. firm-based dataset (HRM survey), looked at the hierarchical ordering in the use of eight employee involvement (EI) practices. They found that firms using more advanced HRM practices also use, on average, a greater number of HRM practices. This suggests that firms must first implement less advanced practices before introducing more advanced ones.[2] More specifically, Freeman et al. (2000) report that while basic EI practices such as information sharing and suggestion/complaint systems are very prevalent (used by more than 92% of firms), enhanced practices such as self-managed teams and design labour teams are less prevalent (used by 61% and 68% of firms). Consistent with the literature, the authors also found that the incidence (proportion of firms using a practice) and intensity (proportion of employees involved and frequency of use by employees) were lower for self-managed teams, the most advanced EI practice in terms of "decision-power" given to employees.[3] Firms using employee involvement practices are also more likely to have profit-sharing or other forms of compensation practices. "The complementarity between sharing decision-making and sharing financial rewards lends support to agency models of the development of 'shares capitalist' institution" (Freeman et al., 2000).

[2] Having information about the time a firm introduced a practice, they found that less advanced practices (information sharing, suggestion/complaint systems) have longer years in use than more advanced practices (self-directed work group).

[3] Self-managed teams involve responsibility for decisions, assigning work and determining work methods.

From productivity to innovation: Theory and implications

So far, the papers reviewed studied the relationship between HRM practices and productivity. It is worthwhile extending the analysis to innovation. Several studies (Crépon, Duguet and Mairesse, 1998; Gu, Sawchuk and Whewell, 2001) have already highlighted the positive relationship between productivity and innovation, but a more direct association between HRM practices and innovation is still needed.

The innovation literature has, for a long time, recognized the highly complex process leading to innovation and the importance of having the right set of skills to successfully bring a new product/process into the market. The chain-link model of innovation (introduced by Kline and Rosenberg, 1986) argues that the accumulation of knowledge necessary for innovation comes from complex and dynamic interactions. Research and development (R&D) knowledge remains important in the innovation process, but must be integrated with knowledge from other actors, such as the product testing and development team, the marketing department, and the production staff. The model states that innovation can be initiated by any actor (R&D staff, production workers, etc.) and tends to be circular (with back and forth interactions between these actors) rather than linear (a discovery made by the R&D staff, then developed by the design team, to finally go to the market). Therefore, an attempt to capture, in a formal way, the interactions between these actors as a way to build a strong internal innovation capacity would certainly be in line with the theory of the chain-link model.

Including HRM practices, such as task teams or labour-management committees, in an analysis of a firm's innovation activities provides insights on the interactions between different occupations (or actors along the chain-link model) within the firm. The rationale behind the use of HRM practices

in the innovation process rests on the assumption that they give the right incentive to the right person to make significant improvements in the production mix (process innovation) or in the product itself (product innovation). As already noted, the chain-link model of innovation states that any actor may initiate innovation, at any stage. Therefore, it is important to leave enough room for people to bring new ideas (through problem-solving teams and employee suggestion programs), and allow them to play an important role in the decision-making process (self-managed work teams), whatever their occupation and their place in the production process. Other employee involvement practices, such as flexible job assignments (job rotations or flexible schedules), will provide employees with a better overview of the production process and will give them more opportunities to improve it. Training will give employees a better understanding of the techniques used and potentially increase their capacity to improve the way they use machinery and equipment. Finally, incentive pay (such as line incentives, profit sharing, and productivity bonuses) is a necessary tool to reward their actions.

However, the direction of causality between the introduction of HRM practices and innovation is not as clear as it seems. Innovation, or any technological change, might give rise to the introduction of HRM practices. For instance, with the introduction of new machinery or other innovations in the production process, managers might foresee a delay in the time required to use the new machinery at full capacity. To minimize that delay, managers could introduce problem-solving teams and training. Ichniowski et al. (1997) made an interesting point saying that only establishments with a highly complex production line would see any improvement in productivity using HRM practices. Simple commodity producing plants would be better off using standard operating procedures (no HRM) because of the high transaction costs (workers investing in new skills and forging

new communication relationships) requested by the introduction of such practices. Therefore, a firm would introduce HRM practices to complement the introduction of new products/processes leading to a complex production procedure.

The economic literature on innovation already incorporates some HRM practices–through training–as innovation activities. However, due to data constraints, the link between HRM practices as a system to build the firm's innovation capacity and the innovation performance has been the subject of only a few studies. Michie and Sheehan (1999), who made one of the first empirical attempts to link innovation and HRM practices, noted that little is known about this relationship because most databases with information on innovation do not contain information on the characteristics of the labour forces within firms nor about HRM practices.

That being said, Michie and Sheehan use firm-level data from the 1990 Workplace Industrial Relations Survey fielded in the United Kingdom to examine firm-level characteristics associated with innovation. They created a proxy for innovation by using two different variables: R&D performer and the introduction of advanced technical change.[4] Because neither R&D nor advanced technical change is an exact measure of innovation, the author used both variables together as proxies for the likelihood that a firm introduces innovation. To explain innovation, they used conventional firm-related variables such as: size, industrial sector, and some variables about CEOs' perceptions of the financial performance of their firms. Finally, they built a HRM taxonomy derived from Ichniowski's. They found that firms which incorporate at least one

[4] Advanced technical change is defined as the introduction of "[…] new plant, machinery or equipment that includes the use of new micro-electronics technologies" (Michie and Sheehan, 1999).

component from each of the HRM policy areas (which stand as the most innovative HRM system according to Ichnioswki) are also more likely to engage in R&D and to use new technology.

Laursen and Foss (2003) also looked at the link between HRM practices and innovation. Borrowing arguments from several literatures (e.g. evolutionary economics, management strategy, industrial organization), they offered a theoretical link between the complementarity of HRM practices and innovation performance. They argued that HRM practices would lead to innovation because many practices have the common characteristic of increasing "delegation." For example, problem-solving teams are assigned to the shop floor where the knowledge is highly tacit. When used in conjunction with the right incentives, increased delegation in such contexts can foster innovation through improvements in processes and also minor product improvements. Moreover, teams often "bring together knowledge that hitherto existed separately, potentially resulting in non-trivial process improvements […] or 'new combinations' that lead to novel products […]" (Laursen and Foss, 2003). Finally, they also stressed that these HRM practices should be most conducive to innovation performance when adopted as a system of mutually reinforcing practices instead of in isolation.

Using a Danish firm-level database, they tested their assumptions about the effect of HRM practices on firms' innovation performance. Using the novelty of innovation as the innovation performance measure, that is, whether the firm is a world-first, country-first, firm-first innovator or non-innovator, they found that two different HRM systems were conducive to innovation. The first HRM system encompassed all HRM variables (à-la-Ichnioswki) while the second one was dominated by training and incentive

pay.[5] Moreover, they found that results differed whether the firm was in the manufacturing sector or in the service sector. Manufacturing firms reacted positively to the first HRM system while firms in services industries reacted to the second HRM system.

Using these papers as a theoretical basis, this paper examines the relationship between HRM practices and innovation performance in a Canadian context. As already stated, most databases do not have the information on both innovation activities and HRM practices. Due to data constraints, Michie and Sheehan (1999) had to use general firm characteristics (except HRM practices) such as firm size, industrial sector, and financial performance to explain innovation. While these variables are important determinants of innovation, they fail to capture the firm's internal processes leading to innovation. Laursen and Foss (2003) also used general firm characteristics but the Danish database allowed them to use a variable associated with firm's behavior toward innovation—the link with knowledge institution.[6]

Using data from the Workplace and Employee Survey (WES), this paper examines the role of HRM practices and other activities (R&D activities, collaboration) aimed at developing a strong internal innovation capability leading to innovation. Moreover, the role of HRM practices in the firm's performance will be separated from the other usual determinants of innovation.

[5] They used principal component analysis to sort out six different HRM systems.
[6] This variable depicts whether the firm has increased its interaction with knowledge institutions, including technical support institutions, consultancies or universities.

This paper will test these hypotheses:

- Are establishments using compensation practices and/or other HRM practices more likely to be innovative?
- Is the relationship between HRM practices and innovation stronger when establishments use clusters of HRM practices (i.e. the complementarity effect of HRM practices)?

3. Data and econometric model

3.1 Data

The Workplace and Employee Survey (WES) is a linked employer-employee survey. A first questionnaire was completed by the employer, and includes questions on topics such as workplace practices, training, innovation, organizational change, and the introduction of new technology. A second questionnaire was completed by up to twelve employees of each surveyed establishment. The reference period for the first round of the WES was the 12-month period ending in March 1999.

In this paper, we use only variables from the employer survey. Due to survey design, workplaces with ten employees or less were not asked the questions on HRM practices and are excluded from our analysis.[7] Non-profit operation workplaces are also excluded because they were thought to behave differently from other workplaces regarding innovation and HRM practices.[8] Therefore, from the original 6,322 respondents, our final sample consists of 3,545 establishments.[9]

[7] See p.17 of the questionnaire. The questionnaire can be found at the following address: www.statcan.ca/english/concepts/wes2.pdf

[8] Q28 of the questionnaire (p.26) directly asks whether the establishment is a non-profit operation organization or not.

[9] See Statistics Canada, www.statcan.ca/english/ips/data/71-584-MIE2001001.htm no. 1, for a comprehensive description of the coverage of the survey.

Table 1

Sample distribution, by industry and size

	Number of observations (unweighted)	Number of observations (weighted)[1]	Percentage (weighted)[1]
Industry [2]			
Primary	178	2,468	**2**
Manufacturing	964	24,806	**16**
Secondary	1,070	34,351	**23**
Services	1,333	90,212	**59**
Size			
11 – 19 employees	544	71,818	**47**
20 – 49 employees	854	54,088	**36**
50 – 99 employees	715	15,341	**10**
100 and more employees	1,432	10,589	**7**
Multi-location firms	*1,827*	*50,912*	***34***
Total	**3,545**	**151,836**	**100**

Source: Authors' compilation from Statistics Canada's WES, 1999.
[1] Establishment-based weight.
[2] Industries are defined in Appendix B.

Table 1 provides information on the basic characteristics of our sample. Two things stand out from this table: first, 59% of establishments belong to the services industry—with 32% from the Retail trade and Consumer services alone (not shown in the table). The other striking characteristic of our sample is that it includes a large proportion of small establishments (47% have from 11 to 19 employees, 83% have from 11 to 49 employees). Finally, one might note that WES surveyed establishments, not firms. Table 1 shows that 34% of our sample is comprised of multi-location firms, meaning that one establishment out of three is part of a firm encompassing more than one establishment.[10]

[10] However, we do not have information on other establishments of the same firm. Tests were performed to take into account the multi-location status of the firm but results were generally similar with or without the inclusion of such a variable in the model presented later in this section. From this point forward, unless otherwise specified, we will use the terms firm, employer and establishment interchangeably, even though the concept of reference is the establishment.

3.2 Econometric model

In this paper, we analyse the relationship between human resource practices and the establishment's innovation performance. The innovation performance can be measured by several variables—sales from product innovations, number of patents, novelty of innovation, etc.—each of which has its shortcomings.[11] Using a variable such as the novelty of the innovation allows us to rank innovators as real creators of technology (world-first innovators), early adopters of technology (Canada-first and local-first), and technology-users.

Using Novelty* as the dependent variable, the econometric model can be written as:

$$Novelty_i^* = \beta X_i + \beta^c H_i^c + \varepsilon_i$$

Where: *Novelty** indicates whether the establishment (subscript *i*) is a first-to-the-market innovator, a technology-user or a non-innovator.

X refers to a set of independent variables.

H^c is a dummy indicating if an establishment uses human resource practices.

ε is a vector of error term.

[11] See for instance, Freeman and Soete, the Economics of Industrial Innovation (1997) for a comprehensive review of advantages and limits of these innovation indicators.

Using WES, novelty of innovation is measured by five categories: world-first, Canada-first, first in the local market, technology-user, and non-innovator.[12] For the purpose of this paper, we aggregate the first three categories into the "first-to-the-market innovator" category. This new category comprises creators of technology as well as "early-adopters" of technology.[13] Technology-users (introduced a new or improved process or product but not a first-to-the-market innovation) are establishments that use new technologies when these are already widely available on the market. Non-innovators are establishments that have not introduced a new or significantly improved product or process into the market in the last year.

[12] Innovative establishments are those which introduced a new or improved product or process between April 1, 1998 and March 31, 1999. One might note that this definition is similar to the internationally accepted Oslo definition (OECD's Oslo Manual, 1997) except that the Oslo definition requires a three-year period of time, as opposed to only one year in the WES. This narrower period of time to introduce an innovation might lead to an under-estimation of the real proportion of innovators in Canada. However, the incidence of innovation in the 1999 Survey of Innovation (which uses the three-year period of time) is similar to that of the WES database when numbers are adjusted to reflect the same target population. To qualify the innovation, the WES questionnaire asked whether the most important innovation (the one which cost the most to implement) was a world-first, a Canada-first, or a first in the local market.

[13] We are aware that being a world-first innovator or an early adopter may imply different behaviors. We regrouped them for two main reasons: the first is that depending on the firm size, the perception of an innovation's importance can be biased (larger firms are expected to devote more resources for strategic intelligence than smaller firms and, therefore will be more informed on the true importance of their own innovation). The second reason lies in the very small sample of world-first innovators (less than 3%). Thus, we regrouped these two categories as first-to-the-market innovators, which is in line with the definition used in European innovation surveys (such as Community Innovation Surveys).

Working with discrete dependent variables requires a specific econometric method. The appropriate econometric technique to use is the ordered logit or probit model depending on the assumption about the distribution of the error term. The ordered probit is modelled as follows:

$$\Phi^{-1}(p_1) = \alpha_1 + \beta' x$$
$$\Phi^{-1}(p_1 + p_2) = \alpha_2 + \beta' x$$
$$and \;\; p_1 + p_2 + p_3 = 1$$

where p_1 is the probability of event 1 (first-to-the-market innovator),
p_2 is the probability of event 2 (technology-user),
p_3 is the probability of event 3 (non-innovator),
x is a set of explanatory variables, and
Φ is the cumulative standard normal distribution function

One can note that the β's are assumed to be constant for all categories.[14] A positive and significant β means a positive correlation between the variable estimated and the likelihood of innovation.

3.3 Explanatory variables

The potential explanatory variables (X) are discussed below and are listed in Box 1.

[14] Estimates from the ordered probit will be analyzed in the result section. However, the reader can find in Appendix A two sets of estimates where the assumption of proportionality (of β's) is relaxed. The first set (Model A) estimates the link between the explanatory variables and innovation at large (first-to-the-market innovator or technology-user), while the second set (Model B) estimates the impact of the same explanatory variables on first-to-the-market innovator (vs. all other establishments).

Box 1. Summary of dependent and explanatory variables

	DEPENDENT VARIABLE
Innovator (novelty)	
First-to-the-market innovator	=1 if World-1st, Canada-1st, or local-1st innovator
Technology-user	=1 if establishment-1st innovator
Non-innovator	=1 if establishment is non-innovator
	EXPLANATORY VARIABLES
Establishment characteristics	
Log (empl)	= Log (number of employees)
Foreign	= 1 if more than 50% of the assets of the establishment are held by foreign interests
Union	= Percent of unionized employees
Industries	Industry dummies (14 industries)
HRM PRACTICES	
Employee involvement (EI)	1- Employee suggestion 2- Information sharing 3- Problem solving teams 4- Flexible job design 5- Labour-management committees 6- Self-directed work groups
Compensation pay (CP)	1- Individual incentives (bonuses, piece-rate, etc. or merit pay) 2- Collective incentives (productivity/quality gain-sharing or profit-sharing)
Training (Tr)	1- Formal training 2- Informal training
HRM SYSTEM	
HRM_n	System based on the sum of practices
HRM_n_7+	= 1 if n=7-10, n = Σ EI, Tr, CP
HRM_n_4-6	= 1 if n=4-6
HRM_n_1-3	= 1 if n=1-3
HRM_n_0	= 1 if n=0
Innovation capacity	
Prof	= Percent of professionals in the establishment workforce
RD_tax-grnt	= 1 if establishment uses R&D tax credit or grants
RD_collab	= 1 if establishment is engaged in R&D partnerships
Competition measures	
INT_comp	= 1 if indirect competition with international owned firms

Size of the establishment[15]

Size matters to innovation. On the one hand, larger firms can more easily fund research (with larger financial and human capacities) giving them a long established advantage over smaller firms in bringing an innovation into the market. On the other hand, the greater flexibility of smaller firms allows them to adjust more quickly than larger firms to market requirements. This ability to adjust more quickly, combined with the ICT revolution, which has reduced barriers to innovation (Pavitt, 1992), means that small firms can now theoretically be as innovative, or even more innovative, than larger firms. The log of the number of employees will be used to capture the effect associated with establishment size.

Industrial sectors

The technological environment influences firms' innovation performance. Even though the capability to transform technological opportunities into successful innovations is intrinsic to the firm, it is well understood that each firm in a specific industry faces a similar environment in terms of opportunities (technological advance) and appropriability of innovation rewards (Dosi, 1988). Therefore, differences between industries will be taken into account by introducing industrial dummies to the model.

Foreign/national status of the establishment

The literature shows that foreign ownership matters in terms of innovation behaviour (Baldwin, Hanel and Sabourin, 2000). Usually, firms will develop their research expertise for the most part inside their home

[15] As stated earlier, the concept of reference of the WES is the establishment, not the firm. Most studies use firm-level data. However, we will make the assumption that expected results are generally the same whether using establishment or firm-level data.

country (usually close to the headquarters–see Baptista and Swann (1998) for a good review of literature). Therefore, domestic and foreign firms will show different innovation behaviour. A dummy variable is added to the model and set to one when at least 50% of the assets of the establishment are held by foreign interest.

Competition and market

Theoretical views on the impact of competition on innovation are mixed. Competition can deter innovation and technological progress because of market uncertainty and financial pressure. Monopolistic firms would innovate more because they would not be facing a hostile environment and would be wealthier than firms operating under conditions of strong competition. However, one could also predict that competition would compel firms to innovate to survive.

In a paper reviewing theoretical and empirical findings on this issue, Ahn (2002) states that, "the claim that market concentration is conducive to innovation does not appear to be supported by recent empirical findings. Motivated by Schumpeter's conjecture that large firms in concentrated markets have the advantage in innovation, many empirical studies have investigated the relationship between market concentration and innovation. However, on the whole, there is little empirical support for the view that large firm size or high concentration is strongly associated with a higher level of innovative activity." Several dummy variables were included in the model to capture the kind of competition an establishment faces, the main market in which it operates and the fact that it is monopolistic or not. However, results convinced us to use only one competition variable, namely international competition.

Professional occupations

Is a skilled workforce important for innovation? This question alone is worth a separate study. Depending on the nature of the technology and its rate of change, different categories of workers may be more closely related than others to a given technology (Lavoie and Therrien, 1999). Goldin and Katz (1996) showed that technological change in the last few decades has been biased toward skilled workers. Therefore, a greater proportion of professional workers in the establishment would positively affect the innovation capability and the innovation performance of the establishment. We add to the model a variable taking into account the share of the establishment's workforce that is comprised of professional employees.[16]

Union

Union support of innovation and HRM practices would vary depending on whether their representatives see these activities as a threat or as an opportunity to increase their influence (Kizilos and Reshef, 1997). Union representatives might see HRM practices as a means for managers to decrease the union's influence on workers. With such practices, union representatives would no longer be the sole channel by which workers can grieve or solve problems with management. Moreover, because technical change can be perceived as capital-biased instead of worker-biased, union representatives may deter innovation to protect workers' jobs (Hirsch and Link, 1987).

[16] The survey defines professionals as "employees whose duties would normally require at least an undergraduate university degree or the equivalent." See the 1999 Workplace and Employee Survey questionnaire for more details.

However, union representatives might also see innovation and/or HRM practices as having a positive impact on the firm's future as well as for their workers and therefore would want to take an active part to implement them. Moreover, a strong union would be the best protection for workers against massive layoffs due to a hypothetical capital-biased technological change. Therefore, unions would increase job security for workers and it would be easier to introduce HRM practices as a means to innovate or improve productivity. According to Kizilos and Reshef (1997), the negative influence of unions regarding innovation (and related activities) would most likely occur in workplaces with lower levels of unionization. The share of unionized workers in the establishment is added to the model to capture the effect of unions on the innovation performance.

Participation in R&D partnership

Because of the increasing complexity of technologies and the need for speed to market, collaboration (R&D partnership) is becoming an essential part of the firm's strategy for innovation. Few firms can, by themselves, master all specific fields required to bring a radical innovation into the market. Therefore, firms must collaborate to capture "missing" knowledge that is embodied in other workers, firms, or organizations (Therrien and Chang, 2002). Bayona, Garcia-Marco, and Huerta (2001) found that complexity of technology and the fact that innovation is costly and uncertain make firms seek R&D alliances.[17] A dummy indicating whether the establishment participated in such R&D partnerships is added to the model.

[17] See Bayona et al. (2001) for a good summary of why firms want to do R&D partnership.

Use of R&D tax credit or R&D grant[18]

Even though R&D is not the sole channel leading to innovation, it remains apparent that performing R&D is an important innovation activity. Cohen and Levinthal (1989) underlined the dual role of R&D–creation of new knowledge and capacity to assimilate and exploit externally available information. Ernst (1998) reviewed some of the principal functions that can be performed by research. He mentions a better understanding of presently used techniques, transferring technologies from external sources into the firm, facilitating personnel acquisition, strengthening information exchange and establishing (international) research co-operation. Therefore, performing R&D should increase the probability of innovating as well as launching a radical innovation into the market as shown in Hanel (2001) using Canadian data. Thus, we will use a dichotomous variable to proxy the use of R&D, set to one if the establishment received a R&D grant or tax credit.

Human resource management variables

The research literature shows that HRM practices are most efficient when used in combination. From Ichniowski, we borrow the notion of the important HRM areas, such as incentive pay, communication, teamwork, job rotation, and training. From the WES database, we define ten HRM practices. Of these ten practices, six are related to the employee involvement (EI) area—employee suggestion, information sharing, problem-solving teams, flexible job design, labour-management committees and, finally self-directed groups. The compensation pay (CP)

[18] It is well known that some firms will not use R&D tax credits even though they are R&D performers. As the questionnaire did not ask directly whether the establishment is an R&D performer or not, we use the R&D tax credit/grant as a proxy for performing R&D.

area is composed of two distinct practices: individual incentives such as bonuses, piece-rate, or merit pay; and collective incentives such as productivity or quality gain sharing, and profit-sharing. Finally, there are two different kinds of training (Tr): formal (classroom job-related training) and informal (on-the-job training).

HRM system

Using these ten HRM practices, one can build a taxonomy describing the composition of HRM practices within the establishment. This taxonomy (HRM_n) deals with the notion of complementarity of HRM practices but without any coherent system considerations (such as in Ichniowski et al., 1997). Establishments which do not use any of the ten HRM practices (Cat.4 or HRM_n_0) are considered the baseline.[19] At the other extreme, establishments using more than six HRM practices (Cat.1 or HRM_n_7+) are considered as the most involved regarding the use of human resource practices. Establishments using four to six HRM practices are part of the second category (HRM_n_4-6), while those using one to three HRM practices compose the third category (HRM_n_1-3).

Alternate models will also be tested using other HRM taxonomies and their impact on innovation performance will be assessed. Regressions by industrial sectors will also be performed.

[19] We will consider these establishments as having no HRM. Obviously, we are referring to the ten practices that we defined. These establishments still have a type of human resource management ("traditional" payment of employees and management of employees).

Table 2

Proportion of establishments with specific HRM practices within the four categories

	HRM_n			
	Cat.1 (7+)	Cat.2 (4-6)	Cat.3 (1-3)	Cat.4 (0)
Compensation pay	**0.98**	**0.71**	**0.48**	**0.00**
Individual	0.84	0.64	0.46	–
Individual incentives	0.66	0.55	0.38	–
Merit pay	0.55	0.39	0.20	–
Collective	0.70	0.35	0.08	–
Gain sharing	0.43	0.23	0.04	–
Profit sharing	0.45	0.21	0.05	–
Employee involvement	**1.00**	**0.90**	**0.35**	**0.00**
Employee suggestion	0.81	0.39	0.09	–
Information sharing	0.94	0.70	0.19	–
Flexible job design	0.69	0.45	0.07	–
Problem-solving teams	0.80	0.28	0.05	–
Labour-management committees	0.60	0.21	0.05	–
Self-directed work groups	0.41	0.10	0.01	–
Training	**0.97**	**0.98**	**0.82**	**0.00**
Formal	0.89	0.68	0.42	–
Informal	0.95	0.90	0.63	–

Source: Authors' compilation from Statistics Canada's WES, 1999

Table 2 summarizes the characteristics of the HRM taxonomy described above (HRM_n). Almost all establishments in the first category (HRM_n_7+) use practices in all the major areas (98% use compensation pay, 100% use EI practices, and 97% use training practices). Moreover, they have a higher incidence for every practice than those in category 2 (HRM_n_4-6), which in turn have a higher incidence than those in category 3 (HRM_n_1-3). By definition, establishments in the fourth category (HRM_n_0) use no HRM practice.

Looking at the incidence of compensation pay, Table 2 shows that individual incentives are more widely used than collective ones. This is particularly true for the establishments in the third category: only 5% of them use profit sharing practices and 4% use gain sharing practices.

For all categories of establishments, information sharing and employee suggestion practices are the most widely used EI practices, the only exception comes from establishments in category 2, where slightly more establishments use flexible job design (45%) than employee suggestion practices (39%). Very few establishments in category 3 use practices such as problem-solving teams, labour-management committees and self-directed groups.

Finally, for the incidence of training, establishments in categories 1 and 2 are very similar, with respectively 97% and 98% of these establishments using training, while 82% of the establishments in category 3 train at least one of their employees.

4. Results

4.1 Descriptive statistics

Before turning to the multivariate analysis, we will look at the distribution of the explanatory variables by the dependent variable, novelty of innovation. Table 3 shows that 35% of establishments are non-innovators, 48% are technology-users, and 17% are first-to-the-market innovators. On average, establishments are made up of 43 employees and size of establishment increases with the novelty of innovation. As mentioned earlier, the services sector is the largest industrial sector with almost 60% of weighted observations. These establishments are less likely to be first-to-the-market innovators: they only represent 50% of the establishments in this category, which is well under the sample average. However, establishments in the manufacturing sector, which represent 16% of the whole sample, account for a larger proportion of the innovators categories (20% of the first-to-the-market and 18% of the technology-users), as compared to only 13% of non-innovators.

The average proportion of unionized workers is similar among establishments of the three categories of innovators. It is only slightly higher for first-to-the-market innovators (15%) as compared to the whole sample (12%). The proportion of first-to-the-market innovators that are owned by foreign interests (10%) is greater than the overall sample average (6%) while the proportion of non-innovators owned by foreign interest (3%) is less than the overall average.

First-to-the-market innovators are more likely to face international competition than others, as 55% of them do so, well over the overall sample average (43%). The same can be said about the three variables grouped under innovation capacity (share of professional employees, use of R&D tax credit or grant, and R&D collaboration), even though only a very small percentage of establishments are engaged in R&D collaboration.

Regarding human resource practices, Table 3 shows that 13% of establishments are in the first category of the HRM system (HRM_n_7+), while respectively 43% and 38% of establishments are in the second (HRM_n_4-6) and third categories (HRM_n_1-3) of the HRM system. Finally, 7% of establishments use none of the HRM practices (HRM_n_0). Establishments using more HRM practices are more likely to be first-to-the-market innovators. For example, the proportion of first-to-the-market innovators in the HRM_n_7+ category (25%) is well above the overall sample average (13%). Looking now at particular HRM practices, we can see that the frequency of using each practice increases with the novelty of innovation. While there are always large differences between non-innovators and innovators, differences within innovators first-to-the-market innovators and technology-users are sometimes important (problem-solving teams, self-directed work group, collective compensation practices) and sometimes very tiny (formal training, flexible-job design, labour-management committee).

Table 3

Composition of establishments, by selected characteristics and novelty of innovation

Variables	Non-innovator	Technology-user	First-innovator	Total
Establishment characteristics				
Number of employees (mean)	37	44	50	43
Primary	3%	1%	1%	2%
Manufacturing	13%	18%	20%	16%
Secondary	23%	20%	29%	23%
Services	61%	62%	50%	59%
Union (% unionized)	12%	11%	15%	12%
Foreign firm	3%	7%	10%	6%
Competition measures				
INT_comp	32%	46%	55%	43%
Innovation capacity				
Prof (% in the workforce)	7%	6%	9%	7%
RD_tax-grnt	3%	5%	15%	6%
RD_collab	0.4%	0.6%	1.5%	0.7%
HRM variables				
Training	79%	88%	89%	85%
Formal	42%	64%	65%	56%
Informal	67%	78%	80%	74%
Compensation practices	52%	65%	70%	61%
Individual	30%	59%	65%	56%
Collective	23%	27%	34%	27%
EI practices	**47%**	**72%**	**81%**	**65%**
Employee suggestion	19%	35%	45%	31%
Information sharing	33%	58%	59%	49%
Flexible job design	21%	35%	39%	31%
Problem-solving teams	11%	29%	40%	25%
Labour-management committees	13%	22%	21%	18%
Self-directed work groups	6%	9%	20%	10%
HRM system				
HRM_n_7+	5%	15%	25%	13%
HRM_n_4-6	35%	48%	43%	43%
HRM_n_1-3	49%	31%	32%	38%
HRM_n_0	12%	5%	1%	7%
Total	**35%**	**48%**	**17%**	**100%**

Source: Authors' compilation from Statistics Canada WES, 1999

Table 4

Results of ordered probit regressions

	(1) All establishments		(2) Manufacturing only	
Intercept 1	0.47	(0.34)	0.28	(0.41)
Intercept 2	1.91**	(0.33)	1.85**	(0.43)
Establishment characteristics				
Industrial dummies	Yes		Yes	
Log (empl)	-0.01	(0.06)	-0.03	(0.07)
Union	-1.62	(0.99)	1.08	(0.86)
Union²	2.15*	(1.13)	-1.48	(1.06)
Foreign	0.28*	(0.16)	-0.28	(0.19)
Competition measure				
INT_comp	0.16	(0.13)	0.34**	(0.15)
Innovation capacity				
Prof	-1.55	(1.17)	2.96*	(1.71)
Prof²	2.36	(1.67)	-1.85	(2.04)
RD_tax-grnt	0.68**	(0.16)	0.24	(0.19)
RD_collab	-0.02	(0.31)	-0.05	(0.39)
HRM system				
HRM_n_7+	1.29**	(0.28)	1.30**	(0.39)
HRM_n_4-6	0.85**	(0.26)	1.02**	(0.38)
HRM_n_1-3	0.52**	(0.26)	0.49	(0.37)
HRM_n_0	Benchmark		Benchmark	
Wald test				
Prob. > Chi²	0.0000		0.0000	
Number of observations	3,545		964	

*Significant at 10%, ** significant at 5%. Standard deviation in parenthesis.

4.2 Multivariate analysis

Table 4 presents estimates from the ordered probit model.[20] In regression 1, the whole sample is used, while in regression 2, it is limited to the sub-sample of manufacturing establishments.[21]

[20] As already mentioned in footnote 14, results allowing different coefficients depending on whether the dependent variable is innovation at large (first-to-the-market innovators and technology-users vs. non-innovators) or only first-to-the-market innovators (vs. other establishments) are presented in Appendix A. Note that other studies using the novelty of innovation (Laursen and Foss, 2003 and Vinding, 2001) report only results from the ordered probit.

[21] As the manufacturing sector is an important user and producer of new technology, we want to have a clearer view about the determinants of innovation for that particular sector. Moreover, establishments from the service sector account for almost 60% of our sample (see Table 1) and therefore, the behaviour of those establishments would have a significant impact on the results of the model dealing with all establishments.

A first look at Table 4 shows that only a few factors have a statistically significant relationship with the novelty of innovation and, indeed, these factors change depending on the sample used (all establishments or the manufacturing sector only). In regression 1, only the foreign status of the establishment, R&D tax credit or grant, and the square of the share of unionized workers are positively linked to the probability of being an innovator. The positive relationship between the foreign status and innovation means that establishments owned by foreign interests are more likely to have introduced new technology or introduced a first-to-the-market innovation than domestic establishments (shown more explicitly in Table 5). The positive relationship between the square of the share of unionized workers (while the share in itself is negative but not significant) means that only establishments with large percentage of unionized workers react positively to innovation.[22] One can interpret this result as the need for union representatives to secure jobs (as well as securing their own influence) first and then, as the proportion of workers unionized reach a specific level, union representatives, becoming stronger and more confident, can play a positive role in the innovation process.[23] None of these relationships hold when dealing exclusively with manufacturing establishments (regression 2).

[22] It must be noted that a large percentage of establishments (81%) has no unionized workers while half of the remaining establishments (9%) have more than 75% of unionized workers.

[23] For example, a strong union can better pressure management to give the necessary training associated with the introduction of a new technology.

Size of the establishment is not significant whatever the sample used.[24] This result is not very surprising as recent literature shows that, even though size plays a significant role when estimating a model on innovation input (such as R&D), the relationship between size and innovation output is often non-significant or negative (see for instance, Mohnen and Therrien, 2002; Lööf and Heshmati: 2001 and Crépon, Duguet and Mairesse, 1998).

International competition has a positive and significant relationship with innovation in the manufacturing sector, but not when the sample includes all industrial sectors (estimate still positive but not significant). These results suggest that competition cannot be viewed as an impediment to innovation, but instead is conducive to innovation. They might also show that (international) competition in services sectors, for instance, is not as critical as in manufacturing sectors because several services are still not easily tradable internationally.

Factors determining the establishment innovation capacity have, again, different impacts in regression 1 and regression 2. While manufacturing establishments using more professional workers are more likely to innovate, there is no significant association between the share of professionals and innovation when dealing with all industrial sectors. One can be surprised by the lack of consistency regarding the effect of professionals on innovation among industrial sectors. However, these results might only show that professionals in the manufacturing sectors

[24] We also performed regressions using only small firms (11-19 and 11-49 employees) to see whether determinants of innovation change with the size of the establishment. Core results (related to HRM practices) remain similar to those reported later in this section for small establishments (11-49), while HRM practices are positively correlated with innovation for very small establishments (11-19) only when those establishments use more than six HRM practices.

are more likely to be involved directly in the innovation process (engineers, scientific workers) than in other sectors (e.g. accountants and professionals in social sciences and humanities in the service sectors).[25]

Establishments using R&D tax credit or grant have a greater probability to innovate in regression 1, but surprisingly, the effect is not significant in regression 2.[26] And finally, being engaged in R&D collaboration agreements has no significant impact either in regression 1 or 2. This result is startling because evidence from other Canadian studies as well as reports from other countries usually show a positive relationship between R&D collaboration and innovation (see for instance, "Understanding Innovation in Canadian Industry" (Therrien and Chang, 2002) edited by Industry Canada for Canadian studies and Mohnen and Therrien (2002) for papers using European data).[27]

Turning to the analysis of the relationship between HRM practices and innovation, Table 4 shows that establishments using HRM practices are more innovative than those not using any of the human resource

[25] One has to keep in mind that professionals are defined as employees whose duties require at least a university degree (see footnote 16). A finer disaggregation of occupations would allow a better understanding of the relationship between skills and innovation.

[26] We suspected that, in the manufacturing sector, performing R&D would be correlated to first-to-the-market innovators but not necessarily with technology users. We then performed a test using first-to-the-market innovators (vs. all others) as the dependent variable for the manufacturing sector only. The coefficient associated with performing R&D ended up being positive and statistically significant at a level of 11% (not shown in tables).

[27] As shown in Table 3, there is a surprisingly low percentage of establishments (1%) using collaboration agreements in the WES sample. Questionnaire design might explain that low percentage as this question is located at the very end (question 51, page 40) of the long questionnaire in the "Other" category. That particular question was clearly not the core objective of the survey and the respondents might have noticeably understood this.

management practices. It also shows that whatever the category (from HRM_n_7+ to HRM_n_1-3), HRM practices have a positive and significant impact on both regression 1 and 2 (with the sole exception of HRN_n_1-3 for manufacturing establishments where its effect is not different from the baseline, HRM_n_0). Moreover, each HRM coefficient is statistically different from the others (e.g. coefficient of HRM_n_7+ different from HRM_n_4-6, etc.) meaning that the correlation between innovation and the number of HRM practices differs whether establishments use several or just a few practices.[28]

Table 5 reports the predicted probabilities at different values of specific explanatory variables, other variables being set at their mean values. Overall, regression 1 predicts a probability of being a first-to-the-market innovator of 15%, while regression 2 estimates that probability to be 18%.[29] Focusing now on the effect of HRM practices on the probability of being an innovator, a typical establishment using no HRM practice has a probability of being a first-to-the-market innovator of only 4% but a probability of 62% to be a non-innovator (regression 1). The probability of being a first-to-the-market innovator (non-innovator) increases (decreases) up to 32% (16%) when that typical establishment uses more than seven HRM practices. Facing international competition, being owned by foreign interests and using R&D tax credits or grants also increase the probability of being first-to-the-market innovator (compared to the predicted mean value, in both regressions). A low percentage (e.g. 30%)

[28] We also performed a test using a continuous variable to define HRM practices where NHRM equals the sum of HRM practices used in the establishment. The coefficient is positive and significant (coefficient = 0.22 with standard deviation = 0.08), while the coefficient of the square of that variable is not (coefficient = -0.008 with standard deviation = 0.09).

[29] Note that the real frequencies of first-to-the-market innovators are respectively 17% and 21% for regression 1 and regression 2.

Table 5

Predicted probabilities from ordered probit regressions

	(1) All establishments			(2) Manufacturing only		
	Non-innovator	Technology-user	First-innovator	Non-innovator	Technology-user	First-innovator
At the mean	**34%**	**51%**	**15%**	**26%**	**56%**	**18%**
HRM system:						
HRM_n_7+	16%	51%	32%	12%	53%	35%
HRM_n_4-6	32%	52%	18%	19%	57%	25%
HRM_n_1-3	42%	47%	11%	36%	53%	11%
HRM_n_0	62%	34%	4%	55%	40%	4%
INT_Comp =1	31%	52%	17%	22%	57%	21%
Foreign =1	25%	53%	22%	35%	53%	12%
RD_tax-grnt =1	15%	51%	35%	20%	57%	23%
Percentage of professionals:						
= 10%	37%	50%	13%	20%	57%	23%
= 30%	42%	47%	11%	10%	51%	39%
= 50%	39%	49%	12%	6%	44%	50%
= 70%	30%	52%	18%	4%	40%	56%
= 90%	17%	51%	32%	4%	40%	56%
Percentage of unionized workers:						
= 10%	39%	49%	12%	23%	57%	21%
= 30%	45%	45%	9%	20%	57%	24%
= 50%	44%	46%	10%	20%	57%	23%
= 70%	37%	50%	13%	24%	57%	19%
= 90%	24%	53%	23%	33%	54%	13%

of unionized workers decreases the probability of being a first-to-the-market innovator (estimated probability of 9%), while a high percentage (e.g. 90% of unionized workers) increases the estimated probability of being a first-to-the-market innovator to 23% (regression 1).

So far, results show a positive relationship between the clustering HRM practices and innovation. However, additional tests must be done to ensure the complementarity effect between these HRM practices. First, we estimated the ordered probit using the same variables as before, but instead of using the HRM systems, we used the HRM practices alone to see whether those HRM practices are significantly related to innovation.

Table 6 shows that each of these HRM practices (with the sole exception of collective compensation pay) has a positive and significant coefficient. However, if we add these HRM practices together with the HRM system variables, coefficients for the HRM systems remain significant (and almost identical), while the effects of HRM practices on innovation vanish for almost all variables (except for problem-solving teams). Therefore, this latter result shows that even though HRM practices alone are conducive to innovation, there are also interactions between HRM practices that can be taken into account using the clustering of these HRM practices. This corroborates the hypothesis of complementarity of HRM practices as seen in the literature.

Results using an alternate HRM taxonomy

As the previous findings showed, there is a positive relationship between the introduction of HRM practices and innovation. Grouping these HRM practices together makes that relationship even stronger. Therefore, one might want to go a step further and assess whether or not regrouping these HRM practices into a coherent system would make the relationship even stronger.

Using the concept developed in Freeman et al. (2000), we test another HRM taxonomy taking into account the hierarchical order of the employee involvement practices. Therefore, practices providing decision-making powers to workers such as "self directed work group" and to a lesser extent "problem-solving team" are treated as high employee involvement practices (Hi_EI).[30]

[30] Problem-solving teams are defined as teams whose responsibilities are limited to specific areas such as quality or work flows. These teams share the same objective as self-directed work groups but with narrower range of responsibilities. That is why we grouped them together. Initially, we had included "labour-management teams" but tests convinced us to withdraw this practice from the enhanced ones.

Table 6

Results of ordered probit regressions using individual HRM practices, with or without an HRM system

		Ordered probit (all establishments)								
		With HRM system								
HRM_n_7+	1.16	1.08	1.17	1.02	1.37	1.24	1.28	1.47	1.27	1.36
HRM_n_4-6	0.76	0.69	0.77	0.75	0.87	0.84	0.84	0.94	0.83	0.91
HRM_n_1-3	0.50	0.48	0.50	0.51	0.53	0.53	0.51	0.55	0.51	0.56
Individual HRM practices	Employee suggestion	Info sharing	Flexible job design	Problem solving teams	Labour-management committees	Self-directed work groups	Individual compensation	Collective compensation	Formal training	Informal training
Coefficient	0.24	0.23	0.15	0.34	-0.14	0.15	0.02	-0.27	0.03	-0.06
Standard error	(0.16)	(0.15)	(0.15)	(0.13)	(0.15)	(0.23)	(0.13)	(0.14)	(0.17)	(0.15)
		Without HRM system								
Coefficient	0.49	0.49	0.44	0.59	0.22	0.48	0.23	0.08	0.32	0.29
Standard error	(0.13)	(0.11)	(0.13)	(0.11)	(0.13)	(0.21)	(0.12)	(0.13)	(0.14)	(0.13)

Note: These regressions include the same independent variables as in Table 4. All regressions have prob. > Chi² = 0.0000 (Wald test).

Practices that do not give a direct decision-making power to employees are part of the second group, namely "Basic_EI." However, these practices are nonetheless important as "flexible job design" increases the employee's knowledge of the production process and "labour-management committees," "employee suggestion programs," and "information sharing with employees" focus on good communication between employees and managers.[31]

Regarding compensation practices, we created two new categories whether establishments have compensation practices (individual or collective) for all their employees or not. Because all employees could initiate innovation (as seen with the chain-link model), it is also important that all employees could benefit from their ideas improving the production process. Therefore, Hi_comp refers to establishments that have compensation practices for all their employees, while Basic_comp refers to establishments using compensation practices but not necessarily for all employees.[32] In the same manner, variables regarding training are also disaggregated into two categories: Hi_train if the share of trained workers is above the industrial average for both categories of training, and Basic_train if the establishment uses training as an HRM practice but is not a "high trainer."

[31] Classification of EI practices into a hierarchical order is somewhat arbitrary. We tried to follow the main idea from Freeman et al. (2000). In their paper, they classified self-managed groups, involving employees in the evaluation and compensation systems and total management quality as the most sophisticated practices. Practices such as opinion surveys and committees of employees which examine quality and productivity problems were ranked lower than the first two practices. Finally, suggestion/complaints systems and information sharing were viewed as the least sophisticated EI practices.

[32] It should be noted that 10% of establishments using compensation practices offer them to managers only.

As already stated, a complete HRM system is expected to lead to better outcomes. Firms which ask for active involvement and give more responsibility to employees (through EI practices) should also give them the tools (by training) and compensation to make sure that they use these tools in a valuable manner.

With all these considerations in mind, we use an alternate HRM system (see Box 2) in which establishments in the first category (HRM_h_1) are those using a complete system of HRM areas (that is, EI, compensation, and training) and that are highly dedicated in at least two areas. Establishments are defined as "highly dedicated" when they use practices previously defined as high in a specific area (Hi_train or Hi_comp or Hi_EI). Establishments that are engaged in an incomplete HRM system and are highly dedicated in at least one HRM area constitute the second category (HRM_h_2). The third category includes establishments using a complete HRM system, but which are highly dedicated on less than two practices.[33] Establishments that use some HRM practices but not as a complete system or that are not highly dedicated on any practice comprise the fourth category (HRM_h_4). And finally, establishments which use no HRM practices comprise the fifth category (HRM_h_5).

[33] The third category is constituted of 21% of the total observations. While 15% use a complete system and uses one high practice, the remaining (6%) also use a complete system but are not involved in any high HRM practice. We choose to aggregate them because of the small percentage of the latter sub-category.

Box 2. Alternate HRM system

	EXPLANATORY VARIABLES
HRM areas	
Employee involvement (EI)	
Hi_EI	= 1 if uses self-directed work groups or problem-solving teams
Basic_EI	= 1 if uses Labour-management committees or Employee suggestion or Information sharing or Flexible job design
Training (Tr)	
Hi_train	= 1 if percentage of workers trained is above the industrial average for both categories (formal and informal)
Basic_train	= 1 if not Hi_train but engaged in some training
Compensation pay (CP)	
Hi_comp	= 1 if offers compensation pay to all employees
Basic_comp	= 1 if not Hi_comp but uses compensation pay
Highly Devoted (HD)	= Σ Hi_EI, Hi_train, Hi_comp
HRM_h	
HRM_h_1	= 1 if establishment uses all HRM areas and HD = 2 or 3
HRM_h_2	= 1 if uses some HRM areas and HD ≠ 0
HRM_h_3	= 1 if uses all HRM areas and HD ≤ 1
HRM_h_4	= 1 if uses some HRM areas and HD = 0
HRM_h_5	= 1 if does not use any HRM practices

*significant at 10%, ** significant at 5%. Standard deviation in parenthesis.

Table 7 shows a positive relationship between each HRM category and innovation. As expected, establishments using the most sophisticated HRM system (complete and highly dedicated in at least two HRM areas) also have the highest probability to be first-to-the-market innovators (predicted probability of 28%). From our results, establishments engaged in a complete system with very few highly dedicated practices or no highly dedicated practices (HRM_h_3) have a greater predicted probability (20%) of being a first-to-the-market innovator than those that lack a complete HRM system (16% if they have high HRM practices and 8% if not). These results tell us that establishments gain from being engaged in the most sophisticated HRM system. However, it seems preferable to build a coherent system (presence in three HRM areas) rather than focus on only one or two HRM areas, even if using practices of a high-level in those areas.

Table 7

Results of ordered probit regressions and predicted probabilities using an alternate HRM system, all establishments

	Ordered probit (All establishments)		Predicted probability	
			Non-innovator	First-to-the-market
Alternate HRM system:				
Hrm_h_1	1.20**	(0.27)	19%	28%
Hrm_h_2	0.77**	(0.26)	33%	16%
Hrm_h_3	0.94**	(0.27)	26%	20%
Hrm_h_4	0.38	(0.28)	48%	8%
Hrm_h_5	Baseline		63%	4%

Note: These regressions include the same independent variables as in Table 4. Regression has prob. > Chi^2 = 0.0000.
*Significant at 10%, ** significant at 5%. Standard deviation in parenthesis.

5. Conclusion

The objective of this paper is to assess whether establishments using HRM practices are more likely to innovate. Using econometrics, we differentiated the role (relationship) of such HRM practices on the firm's innovation performance from other factors aimed at developing a strong internal innovation capacity.

Estimates from a model that includes establishments from all industries are considerably different from a model that includes establishments in the manufacturing sector alone. For instance, when establishments across all industries are considered, we find that establishments owned by foreign interest are more likely than others to be innovative. However, this relationship vanishes when dealing with the manufacturing sector only. In the same manner, international competition has a positive and significant relationship with the probability to innovate in the manufacturing sector; this relationship is not significant when considering all establishments. Because most establishments that are not in the manufacturing sector are in the services sector, one could conclude that international competition is not as important in the services sector as in the manufacturing sector because most services, even today, are not easily tradable internationally.

HRM practices play a positive and significant role in the innovation performance. This relationship holds when dealing with all industrial sectors as well as with the manufacturing sector only. Moreover, using more HRM practices makes the relationship with innovation stronger. For instance, the predicted probability of being a first-to-the-market innovator

is 35% when using more than six HRM practices, 11% when using three or fewer practices, and only 4% if none of these HRM practices are adopted.

Starting from the previous result, we investigated whether regrouping these HRM practices into a more structured (other than the sum of all HRM practices) taxonomy would reveal some important patterns. By classifying the ten HRM practices into three broad areas (training, compensation pay and employee involvement) and selecting highly dedicated practices within each area, we find that establishments involved in all HRM areas (coherent system) and highly dedicated (having high practices) in at least two of these areas have the highest probability of being a first-to-the-market innovator. Our results also show that the probability of being a first-to-the-market innovator is higher for establishments engaged in a coherent HRM system than those that lack a coherent HRM system (with few or no high HRM practices), even those highly dedicated in some HRM areas. The latter result might be of interest for firms (e.g. small firms) that want to integrate some HRM practices but don't have the resources to use the most sophisticated HRM system.

It is important to note that these findings raise some questions as to the role of HRM practices on the firms' innovation performance. For instance, one must exercise caution regarding the direction of causality between adoption of HRM practices and innovation. One could argue that increasing the range of employees' decisions, giving them a voice in the decision-making process, and offering financial incentives will encourage an internally dynamic environment leading to innovation. Others would say that it is the introduction of new processes or products that lead management to introduce new HRM practices to facilitate the introduction of these innovations. Either way, these changes can occur only if management is willing to give more responsibility and, the essential

counterpart of it—more incentives to its workers. However, future research could make use of the longitudinal aspect of the WES database (when at least three years of data will be available), to look more closely at the causality link between HRM practices and innovation. Therefore, it will be possible to examine empirically whether the introduction of innovation and HRM practices occurs at the same time and, if not, which sequence would lead to better results.

It must also be noted that the positive relationship between innovation and HRM practices does not mean that each and every establishment must implement those practices at any price: A one-size-fits-all policy regarding HRM practices and innovation would not be optimal. As already mentioned, such practices may not lead to productivity gains for some establishments. For instance, manufacturing establishments with a simple production process would expect negative net return from the implementation of such practices. Very small establishments would not need to implement formal HRM practices as the knowledge shared by each worker can flow more easily in such establishments than in larger ones. Therefore, drawing up the boundaries and setting up empirically the limitations of the present paper results would certainly be a valuable issue for further research.

A final question is to what extent is the introduction of HRM practices important compared to all other organizational changes? Of course, simultaneous changes can occur in a firm and focusing on only a few of them can lead to erroneous conclusions. However, we think that these HRM practices are an important part in building a positive and innovative environment inside firms, helping them to introduce—and keep introducing—new processes and products into the market. The results of this paper show a link between such workplace practices and innovation,

but more must be done to better understand the existing dynamics between organizational change and innovation.

Appendix A: results of probit regressions, all establishments

	Model (A) Innovator		Model (B) First-to-the-market innovator	
Intercept	-0.45	(0.42)	-2.36**	(0.38)
Establishment characteristics				
Industrial dummies	Yes		Yes	
Log (empl)	0.02	(0.08)	-0.05	(0.07)
Union	-1.71	(1.15)	-1.15	(1.07)
Union²	2.11	(1.29)	1.83	(1.27)
Foreign	0.43**	(0.19)	0.14	(0.24)
Competition measure				
INT_comp	0.17	(0.16)	0.15	(0.16)
Innovation capacity				
Prof -1.54	(1.37)	-1.09	(1.28)	
Prof²1.71	(1.80)	2.26	(1.68)	
RD_tax-grnt	0.47**	(0.18)	0.78**	(0.17)
RD_collab	0.14	(0.28)	-0.09	(0.41)
HRM practices				
HRM_n_7+	1.35**	(0.33)	1.67**	(0.36)
HRM_n_4-6	0.81**	(0.30)	1.26**	(0.33)
HRM_n_1-3	0.36	(0.30)	1.13**	(0.33)
HRM_n_0	Benchmark		Benchmark	
Number of observations	3,545		3,545	

Model (A): dependant variable is whether establishment is innovator or non-innovator.
Model (B): dependant variable is whether establishment is first-to-the-market innovator or not
*significant at 10%, ** significant at 5%. Standard deviation in parenthesis.

Appendix B: industry definitions

Grouped	WES definition	2 or 3 digit NAICS definition
Primary	Forestry, Mining, Oil and Gas Extraction	Forestry and Logging, Support Activities for Agriculture and Forestry, Mining, Oil and Gas Extraction
Manufacturing	Labour Intensive Tertiary	Food, Beverage and Tobacco Product Manufacturing, Textile and Textile Product Mills, Clothing, Leather and Allied Product, Furniture and Related Product, Miscellaneous Manufacturing
	Primary Product	Wood Product, Paper, Petroleum and Coal Products, Non-Metallic Mineral Product and Primary Metal Manufacturing
	Secondary Product	Chemical, Plastic, Rubber Products and Fabricated Metal Product Manufacturing
	Capital Intensive Tertiary	Printing and Related Support Activities, Machinery, Computer and Electronic Product, Transportation Equipment Manufacturing
Secondary	Construction Transportation, Storage, Wholesale Trade	Prime Contracting, Trade Contracting Wholesaler/Distributors, Wholesale Agents and Brokers, Transportation, Warehousing and Storage
	Communication and Other Utilities	Utilities, Postal Service, Couriers and Messengers, Waste Management and Remediation Services
Services	Retail Trade and Commercial Services	Retail Trade, Amusement, Gambling and Recreation Industries, Accommodation and Food Services, Repair and Maintenance, Personal and Laundry Services
	Finance and Insurance	Monetary Authorities - Central Bank, Credit Intermediation and Related Activities, Securities, Commodity Contracts and Other Financial Investment and Related Activities, Insurance Carriers and Related Activities, Funds and Other Financial Vehicles

Appendix B: industry definitions – Concluded

Grouped	WES definition	2 or 3 digit NAICS definition
Services	Real Estate, Rental, Leasing Operations	Real Estate, Rental and Leasing Services
	Business Services	Lessors of Non-Financial Intangible Assets (Except Copyrighted Works), Professional, Scientific and Technical Services, Management of Companies and Enterprises, Administrative and Support Services
	Educational and Health Care	Educational Services, Health Care Services, Social Assistance, Religious, Grant-Making, Civic, Professional and Similar Organizations
	Information and Cultural Industries	Information and Cultural Industries, Performing Arts, Spectator Sports and Related Industries, Heritage Institutions

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