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Abstract

Advanced technologies are commonly believed to be complementary to skills. Firms that adopt new technologies (for example, computer-aided design and computer networks) and at the same time invest in skills (for example, training in computer literacy and technical skills) are expected to realize greater productivity gains than those that do not. To validate this expectation, this paper first identifies the combinations of technologies and types of training that are commonly undertaken by firms, as part of their strategies to effectively utilize the adopted technologies and to improve their economic performance. This paper then estimates the relationship between these common technology-training combinations and productivity performance. It shows that these combinations are associated with higher productivity.

Key words: productivity, training, technology adoption

Résumé

On pense généralement que les technologies de pointe et les compétences sont complémentaires. On s’attend à ce que les entreprises qui adoptent de nouvelles technologies (pour la conception assistée par ordinateur et pour leurs réseaux informatiques, par exemple) réalisent des gains de productivité supérieurs à ceux des entreprises qui ne le font pas. Pour valider cette expectative, le présent document commence par inventorier les combinaisons de technologies et de types de formation auxquelles font généralement appel les entreprises, dans le cadre des stratégies qu’elles mettent en oeuvre pour utiliser efficacement les technologies adoptées et pour améliorer leur rendement économique. Le document présente ensuite une estimation des relations qui existent entre ces combinaisons courantes de technologies et de formation et la productivité. On y démontre que ces combinaisons sont associées à un accroissement de la productivité.

Mots clés : productivité, formation, adoption de technologies

1. Introduction

There is a growing literature showing that simply investing in new technologies is unlikely to provide a competitive advantage; and the full benefits of new technologies are only realized when these are used together with new workplace organizations including training.

Bresnahan, Brynjolfsson and Hitt (2002) view information technology (IT) as "embedded in a cluster of related innovations, notably organizational changes and product innovation, which taken together are the SBTC [skill-biased technical change] that calls for a higher-skilled labour mix". Using firm-level data, they show that "skilled labor is complementary with a cluster of three distinct changes at the firm level: information technology, new work organization, and new products and services". Brynjolfsson, Hitt and Yang (2002) find strong correlations between various organisational practices and IT measures and among the different types of organizational practices. They show that information technology, organizational practices and the interaction of these two measures all have positive effects on productivity. Black and Lynch (2004) use firm-level data to examine the effects of adoption of new workplace practices and computer use on productivity. They find that "changes in workplace practices, along with increasing diffusion of computers, may well have played a significant role in the recent rise in manufacturing productivity". Bartel, Ichniowski and Shaw (2005), in a study of the valve manufacturing industry, find that the adoption of new manufacturing technology is associated with increased skill requirements and changes in human resources practices.

This paper examines the complementarity between investments in technology and the change in workplace organizations. It provides Canadian evidence on the relation between technology adoption, training and productivity.[1] It uses the 1998 Survey of Advanced Technology in Canadian Manufacturing (SAT), which is linked to the Annual Survey of Manufacturing (ASM) of 1998. The SAT includes a range of indicators of technology use and skill investment. Productivity can be measured from output and employment indicators included in the ASM.

To some extent, this study is similar to Gera and Gu (2004) and Turcotte and Whewell Rennison (2004), both of which used the Workplace and Employee Survey (WES). WES links data on Canadian employers and employees from establishments covering the whole spectrum of the Canadian economy and poses a series of questions on human resources practices. Gera and Gu examine the relations between information and communications technology (ICT) use, human capital, organizational change and firm performance. They find that the adoption of ICTs along with organizational changes was perceived by firm managers to be positive for their performance. Turcotte and Whewell Rennison find that computer-related training provided to workers is associated with firms with high productivity levels. Moreover, the association is equally strong whether the worker is university-educated or not.

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[1] There have been several studies on the general impact of technology adoption on firm performance in the Canadian context. For instance, Baldwin and Sabourin (2001, 2004) for the manufacturing sector, and Baldwin and Gu (2004) with a focus on export orientation. None of these has examined possible complementarities between technology adoption and human resources practices in general or training in particular.

Relative to our data set, the WES is longitudinal, covers the whole economy and contains much richer information on firm human resource practices.[2] Thus we are unable to investigate the wide range of human resources practices considered by Gera and Gu (2004) and in the U.S. studies discussed above. The advantages of the data set we use are that it has a high degree of detail as to the type of technology adopted and allows much better measurement of productivity than does the WES.[3] We are only able to consider one kind of human resources practice—training related to technology adoption. Our data set does provide considerable detail as to the type of training provided, so that we are able to investigate possible complementarities between the type of technology adopted and the type of training provided.

This paper also departs from the above studies by first determining the association between the advanced technologies adopted by Canadian manufacturing firms and their corresponding training requirements. Specifically, we use a simple logit model to analyse the connection between six categories of advanced technologies adopted by firms and various types of training provided by firms. The types of training that show the most significant positive association with a category of technologies will be referred to as strategic training for that category of technologies.

Next, we test the hypothesis that strategic training for technology adoption is positively associated with productivity performance, with a control for the influence of other productivity-related characteristics. Our results provide support for this view.

2. Data

The primary source of data used in this paper was the 1998 Survey of Advanced Technology in Canadian Manufacturing (SAT). The survey was presented to the plant managers of a random stratified sample of 4,200 Canadian manufacturing establishments (hereafter referred to as "firms") taken from Statistics Canada's Business Register.[4] Food processing firms have been surveyed separately and were excluded from this survey. Firms with fewer than 10 employees were not surveyed because of cost constraints. The survey was conducted during a three-month period and the response rate was 98.5%.[5]

The SAT is linked to the Annual Survey of Manufacturers (1998) that contains additional information on firms' production activities, such as value added and employment. After the linkage, the database contains data on 2,273 manufacturing firms. An additional 165 in-sample firms with negative value added are considered to be outliers and excluded. Thus, the final

[2] A two-year panel of worker data is now available, which has allowed for dynamic effects that could not be analyzed at the time of the studies by Turcotte and Whewell-Rennison (2004) and Gera and Gu (2004).
[3] One shortcoming associated with WES is that output, and hence labour productivity, cannot be measured directly. Researchers have used various proxy measures to try to capture productivity effects in WES. Turcotte and Whewell Rennison (2004) measure value added as gross revenues less expenditure on materials (with expenditures on materials taken as gross operating expenditures net of expenses on payroll and non-wage benefits and training). In Gera and Gu (2004), the change in productivity is based on firm managers' perception.
[4] For a detailed description of the survey, see http://www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=4223&lang=en&db=IMDB&dbg=f&adm=8&dis=2
[5] Sabourin and Beckstead (1999)

sample for our analysis contains data on 2,108 in-sample firms. Each of the sampled firms carries a population weight that represents the number of firms with similar industry characteristics in the population. The final sample represents a subpopulation of 20,136 manufacturing firms, which equals the sum of population weights of all in-sample firms. These firms span 20 industries at the 3-digit NAICS level.

Among the subpopulation, 13.4% had their head office abroad. The highest proportion of foreign head offices was in chemical (33.7%) and plastics & rubber (27.2%), while furniture (2.2%) and printing (2.4%) showed the lowest percentage of firms with a head office abroad. Almost half of firms were exporting for manufacturing as a whole. The most export-oriented industries were primary metal (83.0%), petroleum & coal (79.6%), and computer & electronics (78.1%) while the least export-oriented industry was beverage & tobacco (9.1%).

2.1. Advanced Technologies

The SAT survey asks plant managers to indicate whether they are currently using some of 26 technologies -- most of them ICT based -- that fall under six functional areas:

a) Design and Engineering;
b) Processing, Fabrication and Assembly;
c) Automated Material Handling;
d) Inspection;
e) Network Communications; and
f) Integration and Control.

The number of technologies varies from one functional group to another. A list of the technologies is provided in Appendix A. If a firm adopted a specific technology, the indicator for the specific technology will be 1. Otherwise, it will be zero. Thus, a functional technology group is 3- to 9-point scale variable, depending on the number of specific technologies in the group.

Table 1 shows the average number of technologies used by firms in the 20 industries, weighted by population weight. The number in parentheses under the headings of each of the functional technology areas indicates the number of specific technologies contained in the functional technology area. For example, the Design and Engineering group comprises four technologies. Non-zero entries are reported in every cell meaning that all 20 industries adopted technologies from every one of the six functional groups. A boldface figure indicates that the average number of technologies adopted by an industry is higher than the manufacturing sector average (shown in the last row).

As one might expect, technologies associated with Design and Engineering, Processing, Fabrication, and Assembly, and Network Communications were commonly adopted by firms engaging in computer & electronics and transportation equipment manufacturing. On the other hand, technologies associated with Integration and Control were the most popular in transportation equipment and beverage and tobacco manufacturing firms, and technologies associated with Automated Material Handling were the most popular to petroleum, coal and paper manufacturing firms. Inspection technologies were mostly used by transportation equipment and beverage & tobacco manufacturing firms.

In sum, all functional technologies are used in each industry, but the degree of adoption is different across industries. Transportation equipment, computer & electronics, and paper industries are intensive technology adopters.

2.2. Training Pertaining to Technology Adoption

The SAT survey asks plant managers whether their employees received any training pertaining to the adoption of the advanced technologies in the following five areas:[6]

a) Basic Literacy/Numeracy (hereafter basic literacy);
b) Computer Literacy;
c) Technical Skills;
d) Quality Control Skills; and
e) Safety Skills.

The responses are binary variables. For instance, if a firm provided its employees any training in Computer Literacy, then the variable equals one; otherwise, it equals zero.

Table 2 shows, for each manufacturing industry, the weighted percentage of firms that provide certain types of training. Among the five types, Computer Literacy and Technical Skills were the most popular based on an average of 53% of firms providing that training for manufacturing as a whole. The least used training type was Basic Literacy (about 19% of firms providing such training).

The profile at the industry level varies significantly. A boldface figure indicates that the percentage of firms providing a specific training type in an industry is higher than the manufacturing sector average (last row). Transportation equipment was the leader in providing training in Basic Literacy and Safety Skills, while computer and electronics was the leader in providing training in Computer Literacy, Technical Skills and Quality Control Skills. In contrast, the petroleum and coal industry was the least involved in providing training in Basic Literacy and Computer Literacy. The apparel industry provided the least training in Technical Skills and Quality Control Skills and the leather industry was the least involved in training in Safety Skills.

2.3. Skill Shortage Related to Technology Adoption

The SAT survey asks plant managers to indicate whether in the operation of advanced technology, they are experiencing shortages in 20 specific skills that fall under four professional groups: [7]

[6] We exclude the sixth training area, "other", in this paper since only 2.6% of firms provided training in this area.
[7] We exclude the "other" group for the analysis in the paper since only about 3.4% of firms experienced such a type of shortage.

a) Professionals with University Degree;
b) Management;
c) Technicians/Technologists (hereafter technicians); and
g) Skilled Trades

Each of these professional groups contains three to seven specific skill shortages, which are listed in Appendix A. If a firm experienced a specific skill shortage, the indicator for the specific shortage will be 1. Otherwise, it will be zero. Thus, a professional group is 4- to 8-point scale variable, depending on the number of specific skill shortages being in the group.

Table 3 shows the average number of skill shortages experienced by firms in the 20 industries, weighted by population weight. For each profession group, the number of specific skill shortages appears in parentheses under the heading of the group. A boldface figure indicates that the average number of specific skill shortages experienced by firms in an industry is higher than the manufacturing sector average (shown in the last row).

The computer and electronics industry was the leader in experiencing shortages in Professionals with a University Degree and Technicians, while the paper industry was the leader in Management and the plastics and rubber industry lead in Skilled Trades shortages. In contrast, on average, beverage and tobacco firms experienced the least shortage in Professionals with a University Degree; petroleum and coal firms experienced the least shortage in Management and Skilled Trades, and textile product firms in Technicians.

In sum, all industries experienced some skill shortages, but the degree of shortage differed across industries.

3. Technology adoption and the likelihood of providing training

What types of training are associated with the adoption of a certain advanced technology? To answer this question, this paper starts with the correlation coefficient matrix between advanced technologies and training (Table 4). The matrix shows that each type of training is positively correlated with all technologies, but the degree of correlation is different. For instance, computer literacy is more strongly correlated with design and engineering while technical and quality control skills are more strongly correlated with integration and control. However, the correlation between a technology and a type of training is an uncontrolled relationship. It may be influenced by other factors. We will examine the relationship more formally in the model we present below.

As shown in Table 4, all types of training are positively and significantly correlated with large-sized firms, implying large-sized firms provide more training than small-sized firms. In addition, most types of training are significantly correlated with skill shortages.

To estimate the influence of technology adoption on the provision of each type of training while controlling for other factors, this paper employs a multivariate analysis. It tests whether or not the probability of a firm providing a type of training is significantly influenced by the adoption of certain technologies. To answer this, this paper uses a simple logit model in which the probability that firm *i* provides type *k* training is related to a set of factors. The specification is as follows:[8]

(1)
$$\ln\left[\frac{\text{Prob}(H_i = k)}{\text{Prob}(H_i = 0)}\right] = \alpha_{0,k} + \sum_{j=1}^{6}\alpha_{j,k}T_{j,i} + \alpha_{7,k}O_i + \alpha_{8,k}E_i + \sum_{j=1}^{4}\alpha_{j+8,k}U_{j,i} + \alpha_{13,k}G_i + \alpha_{14,k}S_i + \sum_{m=1}^{19}\alpha_{m+14,k}I_{m,i} + \varepsilon_{i,k}, \quad k = 1, 2, \dots, 6$$

where $\text{Prob}(H_i = k)$ denotes the probability of providing the k^{th} type of training;

T_i is the adoption of type *j* of advanced technology;

O_i is a dummy variable for the location of the head office of the controlling firm, taking the value one if the head office is foreign and zero otherwise;

E_i is a dummy variable for export outward orientation, taking the value one if the firm exports and zero otherwise;

U_i is an indicator for shortages in type *j* of professionals;

G_i is the share of salaried workers, a proxy for the general skill level;[9]

S_i is a firm size dummy based on employment, taking the value one for large firms and zero otherwise;

$I_{i,j}$ is the dummy for industry *j*; and,

ε_i is the error term.

The dependent variable in this model is the probability of providing one type of training over that of not providing the type of training. There are five not mutually exclusive types of training that a firm can choose to provide.

In the regression model above, we control for the effects of the location of head office and of export orientation, since these factors might have a direct influence on a firm's decision to provide training. In addition, we control for the effect of the general skill level of workers and skill shortages. These factors may be important for firms' decision to provide a certain type of training. Finally, we control for differences in firm size and industry characteristics that may be important for the supply of and need for training. As commonly explained in the literature, training decisions differ based on the supply of skilled labour and on technological and financial opportunities available to firms of different sizes and different industries. This can cause differences in training requirements that are not captured by the other independent variables.

[8] As is standard in logit models, the probability of providing a type of training is compared to the probability of not providing the training.

[9] Share of salaried workers is used as a proxy for the general skill level of a firm, as it is commonly used in the literature. We also tried to use labour compensation per worker as a proxy. It does not change the main results of the paper.

Firms are divided into two size groups: small (100 employees or less) and large (more than 100 employees). We control for industry heterogeneity by distinguishing between 20 industries based on 3-digit NAICS codes.[10]

We first estimate the model without controlling for any skill-related variables. Table 5a reports the derived elasticity of the odds ratio with respect to an independent variable, based on the estimation results from the logit model.[11] The larger the derived elasticity, the greater is the influence of an independent variable on the odds of a type of training being provided.

First we discuss the control variables. Training for Quality Control Skills and Safety Skills appears to be more important for firms facing foreign competition as the likelihood of both is positively associated with exporting and foreign head office. Exporting is also positively associated with training in Computer Literacy, but negatively with Basic Literacy. Large-sized firms tend to be more likely than small-sized firms to provide all types of training. However, the influence of all of these factors tends to be small.

At the core of the estimation are the results that link the technologies to the odds of providing training. Most technologies are found to be significant factors influencing the provision of a type of training. But, the driving forces for individual types of training are generally different. Based on the size of the derived elasticity, the technology with the greatest influence on the odds of the provision of Basic Literacy or Computer Literacy is Design and Engineering. For Technical Skills or Quality Control Skills, the most influential technology is Integration and Control. And for Safety Skills, it is Processing, Fabrication and Assembly. It is interesting to note that Integration and Control is also the second main force behind the provision of the other types of training.

Tables 5b and 5c report the results with an additional control for skill and skill shortages. Table 5c differs from table 5b by including the share of salaried workers as a control variable for the general skill level of a firm. Most of these additional control variables are statistically significant, but do not alter significantly the previous results.

It is interesting to note that shortages of Professionals are positively related to the provision of all types of training, especially Technical Skills, Quality Control Skills and Safety Skills. Management shortages are positively associated with Computer Literacy, Quality Control Skills and Safety Skills and negatively associated with Basic Literacy. The coefficient for Technician shortages is positive for Basis Literacy, Computer Literacy and Technical Skills and negative for Safety Skills. Skilled trade shortages are positive for Basic Literacy and negative or marginally significant for all other types of training. Finally, the share of salaried workers is positively associated with all types of training except Basic Literacy.

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[10] As mentioned earlier, the food industry was not covered by the Survey .

[11] The logit model is estimated using data weighted by the population weight, as discussed in section 2. The elasticity of the odds ratio, $\mathrm{Prob}(B_i = k) / \mathrm{Prob}(B_i = 0)$, with respect to a variable, say, x_i, is $\hat{\beta}_i \overline{x}_i$, implying that a change in x_i by one percent is associated with a change in the odds of using a business practice of $\hat{\beta}_i \overline{x}_i$ percent, where $\overline{x}_i$ represents the mean value of variable x_i across all manufacturing firms.

4. Strategic Training and Productivity Performance

The previous section demonstrates that certain technologies are driving the provision of training. Assuming that most firms know what they are doing and are providing necessary training to their employees in the event of adopting a technology, these efforts will translate into the effective use of technology and lead to high productivity performance. In other words, technology adopters with provision of necessary trainings to their workers will have higher productivity performance than others. This section is to see if the belief is consistent with the data. Note, however, that the data only allow us to establish a relationship and do not permit us to deal with causality.

4.1. Regression Model for Productivity Analysis

We divide firms into three groups: firms that are technology adopters with strategic training; firms that adopt technologies but with no strategic training; and firms that do not adopt any technology. Strategic training will be defined and discussed below. The linear regression model is as follows:

$$\ln(P_{i,98}) = \beta_0 + \beta_1 \ln(F_{i,98}) + \beta_2 Y_i + \beta_3 N_i + \beta_5 O_i + \beta_6 E_i + \beta_7 G_i + \beta_8 S_i + \sum_{j=1}^{19} \beta_{8+j} I_{i,j} + \varepsilon_i \,, \quad (2)$$

where $\ln(P_{i,98})$ is defined as value-added per worker in 1998 (in logarithm);

$\ln(F_{i,98})$ is fuel and power consumption per worker (in logarithm), a proxy for capital intensity;

Y_i is a dummy variable for firms that technology adopters with strategic training;

N_i is a dummy variable for firms that are technology adopters without strategic training;

O_i is a dummy variable for the location of the head office of the controlling firm, one if the head office is foreign and zero otherwise;

E_i is a dummy variable for exporting, one if the firm is exporting and zero otherwise;

G_i is the share of salaried workers, a proxy for the general skill level for firm *i*;

S_i is a firm size dummy based on employment in 1995, one for large-sized firms and zero otherwise;

$I_{i,j}$ is a binary industry dummy, 1 for firm *i* belonging to industry *j* and 0 otherwise; and

ε_i is the error term.

The regression model is an extension to the standard model that suggests that labour productivity is a function of capital intensity and multifactor productivity (the efficiency parameter). At the core of the regression are the two dummy variables associated with technology adoption and training. Besides the core variables, there are a number of control variables.

Capital intensity is an important variable for labour productivity, but there is no capital stock or investment data available in the dataset. To overcome the problem, this paper approximates capital intensity, defined as capital stock per worker, by the consumption of fuel and power per worker. This proxy is based on two observations: the working capital stock is highly correlated with fuel and power consumption; and industry differences in energy intensity are accounted for by industry dummies. The proxy has been successfully used by Globerman, Ries and Vertinsky (1994) and by Tang and Wang (2005).

The model also controls for the effect of the location of head office, a proxy for foreign control, since a number of studies show that foreign-controlled firms in Canada are more productive than domestic-controlled firms (Baldwin and Gu, 2005; Globerman, Ries and Vertinsky 1994, and Rao and Tang, 2002). In addition, it controls for exporting orientation, which has been found to be important for productivity (Baldwin and Gu, 2004). Furthermore, it controls for the general skill level since labour quality is important for productivity performance (Jorgenson, Ho and Stiroh, 2005; Tang and Wang, 2005). Finally, firm size and industry dummies are introduced to capture size-related and industry specific residuals. These effects result from differences in financial and technological opportunities and are not captured by other variables.

For the productivity analysis, in this paper, the strategic training types for a technology are defined as the types of training whose provision is mostly influenced by the technology, i.e., the technology with the largest elasticities for the probability of provision of the types of training.[12]

Five strategic training types are identified (those in boldface figures in table 5a): both training in basic literacy and in computer literacy are associated with design and engineering; both training in technical skills and in quality control skills are associated with integration and control; and training in safety skills is associated with processing, fabrication and assembly. Thus, the five types of training are associated with three specific technologies: design and engineering; processing, fabrication and assembly; and integration and control.

4.2. Empirical Results on Productivity Analysis

To gain insight on how strategic training is associated with productivity, this paper estimates several variants of model (2). As mentioned earlier, to estimate the degree to which technology adoption, training, or strategic training is associated with productivity performance, this paper divides firms into three groups. The first group consists of firms that are technology adopters providing at least one type of strategic training. The second group of firms are other technology adopters. The last group, those firms that do not adopt any technology, is used as a reference group in the estimation.

Model (2) is estimated using ordinary least square estimation, weighted by the population weight. The estimation shows that firms that adopted technologies are more productive than those that neither adopted technologies nor provided training, and that the most productive firms are those technology adopters with strategic training (column (1), table 6a). Indeed, the

[12] The cut-off line is arbitrary. But, with this cut-off line, the size of the group consisting of firms with at least one type of strategic training is relatively comparable to the sizes of the other groups. In particular, 55% of firms are technology adopters with strategic training, 23% of firms are other technology adopters and the remaining 22% are those firms that do not adopt any technology. The sizes of the two groups being comparable are important since it minimizes the potential bias of one group against the other in regressions (Lee and Tang, 2001). However, an alternative cutoff line, as shown later on, for defining strategic training does not change the overall results of the productivity analysis.

productivity effect was fifty percent larger for technology adopters with strategic training than for other technology adopters. This is an important result. It is consistent with the belief that technology adoption is associated with high productivity and that the effects of some technologies are reinforced by providing certain types of training. [13]

As expected, fuel and power consumption per employed person, as a proxy for capital intensity, is one of the most significant factors associated with labour productivity performance. This is consistent with the fact that the higher the capital intensity, the higher the level of labour productivity. In addition, the estimation shows that firms with their head office located abroad are on average more productive than others. The finding is consistent with the well-documented fact that foreign-controlled firms in Canada are more productive than domestic-controlled firms (for example, Globerman, Ries and Vertinsky 1994). Furthermore, it is found that firms with export orientation are more productive, which is consistent with the finding of Baldwin and Gu (2004). Finally, firm size matters for productivity. Large-sized firms tend to be more productive than small-sized firms. This finding is also consistent with the literature for Canadian manufacturing firms (for example, Baldwin, Jarmin and Tang, 2004).

The above results do not change significantly when share of salaried workers, a proxy for the skill level, is added to the regression (column (2), table 6a).

To check for the robustness of the results, we investigate if the result of Table 6a is driven by the fact that firms that adopted the three specific technologies that are associated with the strategic trainings are more productive than firms that adopted other technologies. To this end, we divide the firms into four groups: firms that adopted the three specific technologies with strategic training; firms that adopted the three specific technologies but without strategic training; firms that are not in the first two groups but adopted technologies; and firms with neither technology adoption nor training (which is used a reference group). The estimation results show that firms that adopted with the three specific technologies with strategic training are more productive than other groups (table 6b). Technology adopters in the other two groups are also more productive than non-technology adopters, and they tend to show equivalent productivity effects. Thus, the estimation results again is consistent with the belief that technology adoption is associated with high productivity and that the effects of some technologies are reinforced by providing certain types of training.

In addition, we redefine the strategic training types for a technology as the types of training whose provision is mostly or near mostly influenced by the technology, i.e., the technology with the largest or near-largest elasticity. Based on this definition and Table 5c, basic literacy and computer literacy are strategic training associated with design and engineering. Similarly, computer literacy and safety skills are strategic training for processing, fabrication and assembly, and all five types of training are the strategic trainings for integration and control. Consequently, we redefine technology adopters with strategic training as those firms that adopt at least one of

[13] Dufour, Nakamura and Tang (2006), using the same database, establish a link between business practices, advanced technologies and productivity. They find that firms bundling certain technologies and certain business practices are associated with higher productivity. Additional regression results, available from the corresponding author, show that the relationship is much stronger for firms bundling certain technologies and certain business practices and at the same time providing the strategic trainings to their workers.

the three technologies with the corresponding strategic training types. The regression results (Tables 7a and 7b) are similar to our earlier results.

4. Conclusions

It is commonly believed that firms that adopt technologies and at the same time invest in skills are expected to use the technologies more effectively and generate greater productivity gains than those that do not. Using the 1998 Survey of Advanced Technology in Canadian Manufacturing, which was linked to the Annual Survey of Manufacturers (1998), this paper investigated whether a strategic investment in training in combination with technology adoption is associated with high productivity. It is found that firms that adopt advanced technologies and provide strategic training are, on average, more productive than other technology adopters who, in turn, are more productive than those who do not use advanced technologies. Since strategic training for a technology is defined as those types of training whose provision is most influenced by the technology, the results indicate that the majority of firms providing strategic training are pursuing the right business strategies to use the adopted technologies to best effect, at least, in terms of productivity performance.

These findings, however, should be interpreted with the understanding that the analysis in this paper is based on one-time cross-sectional data which does not provide information as to when the technology was adopted. We therefore could not investigate whether there are lagged effects for some types of training that are considered as a strategic training.[14] Also, while our results support the view that there are productivity-enhancing complementarities between use of advanced technologies and human resources practices, we cannot test for a causal effect of technology-strategic training bundles on productivity.

[14] As discussed in Leung (2004), ICT may have a delayed effect due to adjustment cost. To capture such a delayed effect, time series data would be required.

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Appendix A: Selected Questions from Statistics Canada Survey of Advanced Technology in Canadian Manufacturing – 1998

Location of Head Office

Please indicate the geographic region of the head office of your controlling firm. (1: Canada, 2: US, 3: Europe, 4: Pacific Rim, and 5: Other foreign)

Export Orientation

Please indicate in which of the following markets your plant's primary product sold. (1: Canadian markets, 2: U.S. markets, 3: European markets, 4: Pacific Rim markets, and 5: Other foreign markets)

Advanced Technologies

Please indicate whether you are currently using the following advanced technologies in your plant. (1 indicates in use and 0 otherwise)

(1) <u>Design and Engineering</u>
- (a) Computer aided design/engineering (CAD/CAE)
- (b) Computer aided design/manufacturing (CAD/CAM)
- (c) Modelling or simulation technologies
- (d) Electronic exchange of CAD files

(2) <u>Processing, Fabrication, and Assembly</u>
- (a) Flexible manufacturing cells or systems (FMC/FMS)
- (b) Programmable Logic Control (PLC) machine(s) or process(es)
- (c) Lasers used in materials processing (including surface modification)
- (d) Robot(s) with sensing capabilities
- (e) Robot(s) without sensing capabilities
- (f) Rapid Prototyping Systems (RPS)
- (g) High speed machining
- (h) Near net shape technologies

(3) <u>Automated Material Handling</u>
- (a) Part identification for manufacturing automation (e.g. bar coding)
- (b) Automated Storage and Retrieval System (AS/RS)

(4) <u>Inspection</u>
- (a) Automated vision-based systems used for inspection/testing of inputs and/or final products
- (b) Other automated sensor-based systems used for inspection/testing of inputs and/or final products

(5) <u>Network Communications</u>

(a) Local Area Network (LAN) for engineering and/or production
(b) Company-wide computer networks (including Intranet and WAN)
(c) Inter-company computer networks (including Extranet and EDI)

(6) Integration and Control
(a) Manufacturing Resource Planning (MRP II)/Enterprise Resource Planning
(b) Computer(s) used for control on the factory floor
(c) Computer Integrated Manufacturing
(d) Supervisory Control and Data Acquisition (SCADA)
(e) Use of inspection data in manufacturing control
(f) Digital, remote controlled process plant control (e.g. Fieldbus)
(g) Knowledge-based software

Skill Requirements

Have your plant employees received any training pertaining to the adoption of advanced technology in the last three years? If yes, please indicate in which of the following areas training was provided (1 for yes and 0 for No). Please include both on-site and off-site training.

(a) Basic literacy/numeracy
(b) Computer literacy
(c) Technical skills
(d) Quality control skills
(e) Safety skills
(f) Other (please specify)

Skill Shortages

In the operation of advanced technology, for which types of skilled personnel have you experienced shortages at your plant during the past year? (1 for yes and 0 for No)

Professionals with University Degree

(a) Mechanical/aerospace
(b) Electronic/computer
(c) Chemical/chemical process
(d) Industrial/manufacturing process
(e) Science professionals
(f) Computer scientists

Management

(g) Production management
(h) Design management
(i) Human resources management

Technicians/Technologists (Community College/CEGEP)

(j) Electronics/computer hardware
(k) Science technicians
(l) Engineering science technicians
(m) Computer programmers
(n) Communications network administration
(o) Computer aided design
(p) Instrumentation

Skilled Trades

(q) Machinist (including tool, die mould)
(r) Machine operator
(s) Electrical equipment operator
(t) Process plant operator

Other

(u) Other (please specify)

Table 1
Average Number of Advanced Technologies Adopted By Firms

INDUSTRY	Design and engineering (4)	Processing, fabrication and assembly (8)	Automated material handling (2)	Inspection (2)	Network communications (3)	Integration and control (7)
Beverage and tobacco	0.81	**1.51**	**0.41**	**0.63**	**1.52**	**2.26**
Textile mills	0.53	0.70	**0.35**	**0.44**	0.95	**1.71**
Textile product	0.67	0.71	**0.27**	**0.29**	1.06	1.20
Apparel	0.56	0.43	0.16	0.07	0.56	0.92
Leather	0.40	0.43	**0.24**	0.08	0.61	0.66
Wood	0.61	1.12	**0.29**	**0.26**	0.90	1.32
Paper	**1.82**	**1.41**	**0.68**	**0.53**	**1.43**	**2.21**
Printing	0.89	0.99	0.23	0.21	1.11	1.46
Petroleum and coal	0.63	0.35	**0.72**	0.22	0.58	1.61
Chemical	0.84	0.76	**0.29**	**0.30**	**1.44**	1.58
Plastics and rubber	**1.38**	**1.35**	0.23	**0.29**	**1.20**	**1.78**
Non-metallic mineral	0.66	0.94	**0.25**	0.19	0.71	**1.63**
Primary metal	**1.64**	**1.22**	**0.25**	**0.40**	**1.46**	**1.94**
Fabricated metal	**1.30**	0.98	0.14	**0.26**	**1.31**	1.26
Machinery	**2.05**	**1.50**	0.12	0.21	**1.26**	1.57
Computer & electronics	**2.35**	**1.61**	0.16	**0.40**	**1.79**	**1.88**
Electrical equipment	**1.69**	**1.34**	**0.27**	0.10	**1.37**	**1.65**
Transportation equipment	**2.05**	**1.99**	**0.34**	**0.68**	**1.84**	**2.38**
Furniture	1.26	**1.32**	0.19	0.06	0.71	1.27
Miscellaneous manufacturing	1.15	0.82	0.17	0.09	0.80	1.05
Manufacturing Average	1.27	1.15	0.23	0.25	1.15	1.61

Note: The number in parentheses just below the title of a functional group is the number of technologies included in that group. A boldfaced figure indicates that the average number of technology adoption for an industry is above the manufacturing sector average.

Source: Tabulations done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 2
Percentage of Firms That Provided Training Pertaining to Technology Adoption

INDUSTRY	Basic literacy	Computer literacy	Technical skills	Quality control skills	Safety skills
Beverage and tobacco	**22.4**	49.9	51.2	**51.2**	**52.0**
Textile mills	**20.2**	49.0	39.8	41.7	39.6
Textile product	10.2	41.9	49.5	41.5	29.3
Apparel	13.3	34.0	24.9	20.7	25.4
Leather	10.1	25.1	28.4	22.8	19.1
Wood	**23.3**	**52.9**	50.3	**51.7**	**53.7**
Paper	13.7	**65.9**	**77.9**	**77.6**	**63.5**
Printing	12.1	**58.4**	**62.3**	**48.5**	48.2
Petroleum and coal	8.8	21.5	27.4	24.1	27.4
Chemical	**19.5**	**59.7**	**57.9**	**55.8**	**59.5**
Plastics and rubber	**29.1**	**61.0**	**60.5**	**61.7**	48.1
Non-metallic mineral	**20.0**	36.9	45.1	36.3	47.0
Primary metal	**29.2**	43.1	45.2	45.5	41.2
Fabricated metal	**19.7**	45.7	47.4	45.6	**63.5**
Machinery	13.7	**60.8**	**58.7**	44.8	41.7
Computer & electronics	18.4	**81.8**	**86.1**	**79.0**	**52.9**
Electrical equipment	**22.9**	52.5	**54.7**	**54.8**	**50.6**
Transportation equipment	**42.1**	**62.7**	**65.3**	**59.7**	**64.6**
Furniture	8.7	47.6	43.6	44.8	45.6
Miscellaneous manufacturing	14.2	48.4	42.0	30.9	44.1
Manufacturing Average	18.8	52.8	52.9	47.8	49.7

Note: A boldfaced figure indicates the percentage of firms providing training in an industry is above the manufacturing sector average.

Source: Tabulations done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 3
Average Number of Types of Skill Shortages Experienced by Firms

INDUSTRY	Professionals with a university degree (6)	Management (3)	Technicians (7)	Skilled trade (4)
Beverage and tobacco	0.12	0.22	0.15	0.42
Textile mills	0.49	0.31	**0.52**	0.32
Textile product	0.32	0.07	0.14	0.21
Apparel	0.14	0.15	0.22	0.31
Leather	0.17	0.16	0.15	0.17
Wood	0.35	0.33	**0.53**	0.49
Paper	**0.69**	**0.89**	**0.54**	**0.67**
Printing	0.40	0.36	0.42	0.48
Petroleum and coal	0.26	0.05	0.19	0.08
Chemical	**0.72**	0.23	**0.65**	0.29
Plastics and rubber	**0.70**	**0.71**	**0.69**	**0.91**
Non-metallic mineral	0.35	0.19	0.34	0.19
Primary metal	0.53	0.25	0.47	0.33
Fabricated metal	**0.77**	0.29	0.27	0.44
Machinery	**0.73**	**0.48**	0.47	**0.82**
Computer & electronics	**1.25**	0.35	**1.31**	0.22
Electrical equipment	**0.67**	**0.44**	**0.65**	0.26
Transportation equipment	**0.81**	**0.53**	**0.94**	0.46
Furniture	0.42	0.34	0.45	0.40
Miscellaneous manufacturing	0.46	0.21	0.31	0.14
Manufacturing Average	0.58	0.37	0.48	0.50

Note: The number in parenthesis just below the title of each type skill shortage is the number of specific skill shortages in that type of skill shortage. A boldfaced figure indicates the average number of shortages in an industry is above the manufacturing sector average.

Source: Tabulations done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 4
Correlation Coefficients Between Training, Technology Adoption and Other Variables

Variables	Basic literacy	Computer literacy	Technical skills	Quality control skills	Safety skills
Design and Engineering	0.21	0.47	0.40	0.35	0.32
Processing, Fabrication and Assembly	0.24	0.45	0.43	0.42	0.38
Automated Material Handling	0.14	0.22	0.22	0.25	0.23
Inspection	0.26	0.22	0.24	0.25	0.26
Network Communications	0.20	0.41	0.39	0.37	0.33
Integration and Control	0.24	0.42	0.45	0.48	0.37
Exporting	0.07	0.19	0.16	0.18	0.22
Foreign head office	0.06	0.09	0.02	0.13	0.14
Large firms	0.23	0.22	0.24	0.24	0.24
University Professional shortages	0.17	0.23	0.34	0.30	0.32
Management shortages	0.07	0.29	0.22	0.24	0.24
Technician shortages	0.21	0.24	0.27	0.21	0.18
Skilled trade shortages	0.13	0.16	0.18	0.13	0.17
Share of salaried workers (1995)	-0.10	-0.07	0.04	0.16	0.04

Source: Calculation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 5a
Derived Elasticities of the Odds of Providing a Type of Training with Respect to an Independent Variable

	Basic literacy	Computer literacy	Technical skills	Quality control skills	Safety skills
Design and Engineering	**0.24***** (11.1)	**0.69***** (31.4)	0.32*** (15.1)	0.24*** (11.4)	0.26*** (13.4)
Processing, Fabrication and Assembly	0.13*** (7.1)	0.61*** (26.5)	0.56*** (25.0)	0.40*** (20.2)	**0.41***** (21.3)
Automated Material Handling	-0.06*** (-5.8)	-0.05*** (-4.4)	-0.04** (-3.3)	0.04*** (3.3)	0.03*** (3.2)
Inspection	0.13*** (15.2)	-0.14*** (13.2)	-0.10*** (-9.6)	-0.09*** (-9.2)	0.03*** (3.5)
Network Communications	0.06** (2.4)	0.36*** (15.1)	0.36*** (15.4)	0.11*** (5.0)	0.03 (1.5)
Integration and Control	0.14*** (7.2)	0.54*** (24.8)	**0.68***** (30.1)	**0.77***** (35.8)	0.33*** (17.2)
Exporting	-0.07*** (-7.2)	0.03*** (3.6)	0.02* (1.8)	0.03*** (3.8)	0.09*** (11.6)
Foreign head office	-0.01** (-2.9)	-0.01* (-1.8)	-0.07*** (-17.4)	0.01*** (3.7)	0.02*** (5.7)
Large firm	0.09*** (15.5)	0.0 (0.3)	0.05*** (7.6)	0.03*** (5.0)	0.06*** (10.8)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Correct prediction (%)	66.5	76.4	77.2	72.9	75.5
LR test for slope coefficient being zero	Rejected***	Rejected***	Rejected***	Rejected***	Rejected***
Number of observations	2108	2108	2108	2108	2108

Note: The estimation is based on a Logit model. The elasticity with respect to a variable x_i is $\hat{\beta}_i \bar{x}_i$, where $\hat{\beta}_i$ and $\bar{x}_i$ represent the estimated coefficient and the mean value of variable x_i across the manufacturing firms, respectively.

t-value in parentheses and industry fixed effects are not reported.
***, **, and * indicate significance at the 1%, 5% and 10% level, respectively.
If the absolute value of the residual for a firm is less than 0.5, then the model has a correct prediction for the firm.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 5b
Derived Elasticities of the Odds of Providing a Type of Training with Respect to an Independent Variable (Controlling for Skill Shortages)

	Basic literacy	Computer literacy	Technical skills	Quality control skills	Safety skills
Design and Engineering	0.23*** (10.4)	0.64*** (28.5)	0.25*** (11.0)	0.19*** (8.8)	0.23*** (10.9)
Processing, Fabrication and Assembly	0.08*** (4.4)	0.60*** (25.4)	0.56*** (23.7)	0.40*** (19.2)	0.40*** (20.0)
Automated Material Handling	-0.05*** (-5.1)	-0.04*** (-3.2)	-0.02** (-2.0)	0.04*** (3.7)	0.03*** (2.9)
Inspection	0.13*** (13.9)	-0.12*** (-11.2)	-0.12*** (-10.5)	-0.09*** (-8.8)	0.03*** (3.2)
Network Communications	0.06** (2.2)	0.31*** (12.6)	0.25*** (10.2)	0.02 (0.6)	-0.05** (-2.1)
Integration and Control	0.18*** (8.7)	0.55*** (24.6)	0.78*** (33.4)	0.86*** (38.3)	0.40*** (20.2)
Exporting	-0.09*** (-8.3)	0.03*** (2.7)	-0.04*** (-4.0)	-0.04 (-0.49)	0.07*** (7.7)
Foreign head office	-0.01 (-1.4)	-0.01*** (-2.9)	-0.06*** (-14.8)	0.02*** (5.3)	0.03*** (6.8)
Large firm	0.07*** (11.2)	-0.01 (-1.39)	0.03*** (4.1)	0.01** (2.3)	0.05*** (8.8)
University Professional shortages	0.06*** (4.5)	0.03* (1.9)	0.40*** (26.9)	0.34*** (24.8)	0.37*** (24.5)
Management shortages	-0.10*** (-8.6)	0.25*** (20.1)	-0.01 (-1.0)	0.12*** (10.4)	0.16*** (14.0)
Technician shortages	0.12*** (11.2)	0.07*** (5.6)	0.10*** (7.6)	-0.02* (-1.7)	-0.13*** (-11.2)
Skilled trade shortages	0.10*** (9.3)	-0.10*** (-8.5)	0.02 (1.6)	-0.08*** (-7.7)	0.02 (1.6)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Correct prediction (%)	66.2	76.3	77.6	73.2	76.5
LR test for slope coefficient being zero	Rejected***	Rejected***	Rejected***	Rejected***	Rejected***
Number of observations	2108	2108	2108	2108	2108

Note: The estimation is based on a Logit model. The elasticity with respect to a variable x_i is $\hat{\beta}_i \bar{x}_i$, where $\hat{\beta}_i$ and $\bar{x}_i$ represent the estimated coefficient and the mean value of variable x_i across the manufacturing firms, respectively.
t-value in parentheses and industry fixed effects are not reported.
***, **, and * indicate significance at the 1%, 5% and 10% level, respectively.
If the absolute value of the residual for a firm is less than 0.5, then the model has a correct prediction for the firm.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 5c
Derived Elasticities of the Odds of Providing a Type of Training with Respect to an Independent Variable (Controlling for Skills and Skill Shortages)

	Basic literacy	Computer literacy	Technical skills	Quality control skills	Safety skills
Design and Engineering	0.21*** (9.5)	0.60*** (26.8)	0.26*** (11.4)	0.26*** (11.8)	0.24*** (11.3)
Processing, Fabrication and Assembly	0.09*** (4.6)	0.62*** (25.9)	0.56*** (23.5)	0.39*** (18.8)	0.40*** (20.0)
Automated Material Handling	-0.06*** (-5.3)	-0.04*** (-3.1)	-0.02* (-1.9)	0.05*** (4.0)	0.03*** (3.0)
Inspection	0.11*** (12.6)	-0.16*** (-13.9)	-0.11*** (-19.6)	-0.04*** (-4.3)	0.03*** (3.8)
Network Communications	0.06** (2.4)	0.32*** (13.2)	0.25*** (10.1)	0.01 (0.3)	-0.05** (-2.2)
Integration and Control	0.18*** (9.0)	0.59*** (25.8)	0.77*** (33.0)	0.83*** (36.9)	0.39*** (19.8)
Exporting	-0.09*** (-8.4)	0.02** (2.4)	-0.04*** (-3.9)	0.0 (0.3)	0.07*** (7.8)
Foreign Head Office	0.0 (1.4)	-0.01** (-2.2)	-0.06*** (-15.0)	0.01*** (3.7)	0.03*** (6.7)
Large Firm	0.06*** (10.4)	-0.02*** (-2.6)	0.03*** (4.4)	0.03** (4.0)	0.06*** (9.1)
Share of Salaried Workers (1995)	-0.25*** (-7.0)	0.47*** (14.5)	0.12*** (4.0)	0.71*** (23.0)	0.11*** (3.9)
University Professional Shortages	0.07*** (5.2)	0.06*** (3.8)	0.39*** (26.0)	0.30*** (21.3)	0.37*** (24.0)
Management Shortages	-0.09*** (-7.6)	0.28*** (21.7)	-0.02 (-1.4)	0.09*** (8.1)	0.15*** (13.5)
Technician Shortages	0.11*** (10.8)	0.06*** (4.5)	0.10*** (7.8)	0.0 (0.2)	-0.12*** (-10.9)
Skilled Trade Shortages	0.09*** (8.6)	-0.12*** (-10.4)	0.03** (2.1)	-0.05*** (-4.7)	0.02* (1.9)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Correct Prediction (%)	68.5	78.2	79.2	74.5	78.1
LR Test for Slope Coefficient Being Zero	Rejected***	Rejected***	Rejected***	Rejected***	Rejected***
Number of Observations	2108	2108	2108	2108	2108

Note: The estimation is based on a logit model. The elasticity with respect to a variable x_i is $\hat{\beta}_i \bar{x}_i$, where $\hat{\beta}_i$ and $\bar{x}_i$ represent the estimated coefficient and the mean value of variable x_i across the manufacturing firms, respectively.
t-value in parentheses and industry fixed effects are not reported.
***, **, and * indicate significance at the 1%, 5% and 10% level, respectively.
If the absolute value of the residual for a firm is less than 0.5, then the model has a correct prediction for the firm.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 6a

Productivity Performance of Two Groups of Technology Adopters

Independent Variables	Regression (1)	Regression (2)
Technology Adopters with Strategic Training	0.29 *** (8.8)	0.29 *** (8.7)
Other Technology Adopters (that do not belong to the first group)	0.18 *** (5.0)	0.18 *** (5.1)
Fuel and Power Consumption Per Worker	0.18 *** (12.9)	0.18 *** (13.0)
Foreign Head Office	0.45 *** (12.2)	0.45 *** (12.0)
Exporter	0.13 *** (5.2)	0.13 *** (5.2)
Large Sized Firm	0.12 *** (3.4)	0.12 *** (3.6)
Share of Salaried Workers (1995)		0.11 (1.5)
Industry Fixed Effects	Yes	Yes
Adjusted R-square	0.36	0.36
No of Observations	2108	2108

Note: The reference group for technology adopters with or without strategic training consists of firms that adopt no technology. The strategic trainings for a technology are defined as the types of training whose provision are mostly influenced by the technology, identified in Table 5a. Technology adopters with strategic training are those firms that adopt at least one of the three technologies (design and engineering; processing, fabrication and assembly) with the corresponding strategic trainings.

t-value in parentheses and industry fixed effects are not reported.
*** indicates significance at the 1%.

Test: "The coefficient on technology adopter with strategic training is larger for that on technology adopter without strategic training" is significant at the 1% level.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 6b

Productivity Performance of Three Groups of Technology Adopters

Independent Variables	Regression (1)	Regression (2)
Technology Adopters with Strategic Training	0.29 *** (8.8)	0.29*** (8.7)
Specific Technology Adopters without Strategic training	0.18*** (5.0)	0.18*** (5.0)
Other Technology adopters (that do not belong to the first two groups)	0.15 ** (2.5)	0.14 ** (2.4)
Fuel and Power Consumption Per Worker	0.18 *** (12.9)	0.18 *** (13.0)
Foreign Head Office	0.45*** (12.1)	0.44 *** (11.8)
Exporter	0.13 *** (5.2)	0.13 *** (5.2)
Large Sized Firm	0.12 *** (3.5)	0.12 *** (3.6)
Share of Salaried Workers (1995)		0.12 (1.5)
Industry Fixed Effects	Yes	Yes
Adjusted R-square	0.36	0.36
No of Observations	2108	2108

Note: The reference group for the three groups of technology adopters consists of firms that adopt no technology. The strategic trainings for a technology are defined as the types of training whose provision are mostly influenced by the technology, identified in Table 5a. Technology adopters with strategic training are those firms that adopt at least one of the three technologies (design and engineering; processing, fabrication and assembly) with the corresponding strategic trainings. Specific technology adopters without strategic training are those firms that adopt at least one of the three technologies without the corresponding strategic trainings.

t-value in parentheses and industry fixed effects are not reported.

*** and ** indicate significance at the 1% and 5% level, respectively.

Test1: “The coefficient on technology adopter with strategic training is larger for that on specific technology adopter without strategic training” is significant at the 1% level.

Test 2: “The coefficient on specific technology adopter without strategic training is larger for that on other technology adopters” is not rejected statistically.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 7a

Productivity Performance of Two Groups of Technology Adopters (An Alternative Definition of Strategic Training)

Independent Variables	Regression (1)	Regression (2)
Technology Adopters with Strategic Training	0.33 *** (9.4)	0.33 *** (9.5)
Other Technology Adopters (that do not belong to the first group)	0.18 *** (5.6)	0.18 *** (5.4)
Fuel and Power Consumption Per Worker	0.17 *** (12.6)	0.18 *** (12.8)
Foreign Head Office	0.44 *** (12.0)	0.43 *** (11.7)
Exporter	0.13 *** (5.1)	0.13 *** (5.1)
Large Sized Firm	0.10 *** (3.1)	0.11 *** (3.4)
Share of Salaried Workers (1995)		0.17** (2.3)
Industry Fixed Effects	Yes	Yes
Adjusted R-square	0.36	0.36
No of Observations	2108	2108

Note: The reference group for technology adopters with or without strategic training consists of firms that adopt no technology. The strategic trainings for a technology are defined as the types of training whose provision are mostly or near mostly influenced by the technology, identified in Table 5c. Technology adopters with strategic training are those firms that adopt at least one of the three technologies (design and engineering; processing, fabrication and assembly) with the corresponding strategic trainings.

t-value in parentheses and industry fixed effects are not reported.
*** and ** indicate significance at the 1% and 5% level, respectively.

Test: "The coefficient on technology adopter with strategic training is larger for that on technology adopter without strategic training" is significant at the 1% level.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.

Table 7b

Productivity Performance of Three Groups of Technology Adopters (An Alternative Definition of Strategic Training)

Independent Variables	Regression (1)	Regression (2)
Technology Adopters with Strategic Training	0.33 *** (9.4)	0.33*** (9.5)
Specific Technology Adopters without Strategic training	0.19*** (5.6)	0.18*** (5.5)
Other Technology adopters (that do not belong to the first two groups)	0.15 ** (2.5)	0.14 ** (2.4)
Fuel and Power Consumption Per Worker	0.17*** (12.6)	0.18 *** (12.8)
Foreign Head Office	0.44*** (11.8)	0.43 *** (11.5)
Exporter	0.13 *** (5.0)	0.13 *** (5.0)
Large Sized Firm	0.10 *** (3.1)	0.11 *** (3.3)
Share of Salaried Workers (1995)		0.17 (2.3)
Industry Fixed Effects	Yes	Yes
Adjusted R-square	0.36	0.36
No of Observations	2108	2108

Note: The reference group for the three groups of technology adopters consists of firms that adopt no technology. The strategic trainings for a technology are defined as the types of training whose provision are mostly or near mostly influenced by the technology, identified in Table 5c. Technology adopters with strategic training are those firms that adopt at least one of the three specific technologies (design and engineering; processing, fabrication and assembly) with the corresponding strategic trainings. Specific technology adopters without strategic training are those firms that adopt at least one of the three technologies without the corresponding strategic trainings.
t-value in parentheses and industry fixed effects are not reported
*** and ** indicate significance at the 1% and 5% level, respectively

Test1: "The coefficient on technology adopter with strategic training is larger for that on specific technology adopter without strategic training" is significant at the 1% level.

Test 2: "The coefficient on specific technology adopter without strategic training is larger for that on other technology adopters" is not rejected statistically.

Source: Estimation done by authors based on data from Statistics Canada, Linked Database of Advanced Technology in Canadian Manufacturing, 1998.