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Offshoring and Productivity: A Micro-data Analysis

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Abstract

Offshoring has become increasingly important for businesses, especially manufacturing firms, to compete in increasingly competitive domestic and international markets. This paper empirically studies the association between offshoring, productivity and plant characteristics by focusing on the geographical dimension of plants' business activities. Using Statistics Canada's Survey of Innovation 2005, which linked to Annual Surveys of Manufacturers, it demonstrates that material offshoring was highly associated with firms' outward-oriented business activities including foreign operation, investing in foreign M&E, and exporting, after controlling for offshoring and operating locations advantages and industry-specific effects. For R&D offshoring, it is found that it was mainly associated with investment in foreign M&E. In addition, this paper shows that material offshoring is positively associated with productivity and that the association is significantly larger for material offshoring to non-U.S. countries than for material offshoring to the U.S. after controlling for the effects of being multinationals, the education level of workers, and plant size.

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1. Introduction

Offshoring has become increasingly important for Canadian businesses, especially Canadian manufacturing firms, to compete in domestic and international markets (do Livramento and Tang 2007). The development is mainly facilitated by the revolutionary advances in transportation and communications technology, combined with trade liberalization, reduction in FDI restrictions, abundant cheap skilled labour in emerging economies, and the increased ability of those countries to supply high quality products and services.

However, this does not mean that every firm will equally participate in offshoring, pursue same offshoring business models, and benefit from engaging in this activity. Firm-specific business strategy may be important. Based on micro data, this paper is an empirical study of the relationship between offshoring and productivity.

In this paper, offshoring specifically refers to purchasing raw materials, semi-products, or services as intermediate inputs for production by firms from foreign affiliates or independent firms abroad.

There are two main factors that influence the offshoring decision. First, offshoring depends on transaction costs. It requires relationship-specific investments, it faces contractual incompleteness, it involves searching for reliable and quality suppliers, and it incurs transportation, coordination and communication costs. Transaction costs are closely associated with the complexity of inter- and infra-firm transactions. Goods and services that can be codified and packaged are more likely to have a lower transaction cost since they are relatively easier to manage. Firms that have established business activities (e.g., affiliates through FDI or exporting) in a country are more likely to offshoring to this country because of low transaction costs and established supply networks. Second, offshoring also depends on the market conditions of suppliers. Trade liberalization, reduction in FDI restrictions, the availability of cheap skilled labour (for operating affiliates for producing intermediate inputs), and the ability to produce and supply high quality products and services are all important conditions.

For those firms engaging in offshoring, they may pursue different business models. They may simply replace expensive domestic suppliers by cheap foreign suppliers to reduce production costs, they may offshore low productive and low value added components to foreign firms or affiliates to focus on high value added components and core competences, they may invest in foreign technologies (machinery and equipment) which require specific accessories and services to operate effectively, or they may want to access foreign expertise (e.g. R&D services) and high-tech components for designing quality products to move ahead of competition.

The choice of business model may be largely influenced by the expertise and know-how of potential suppliers. For instance, a Canadian firm is more likely to engage a Chinese firm to supply low-value added components (e.g. computer tower case), which aims to reduce production costs, than an American firm because of China's low cost production in manufacturing low-value added components. On the other hand, a Canadian firm is less likely to engage a Chinese firm to supply high-value added components (e.g., CPUs) for introducing quality products than an American firm because of superior technologies in the U.S.

Different business models may generate different levels of productivity dividend. Firms that offshore by simply replacing expensive domestic suppliers with cheap foreign suppliers are not expected to have a directly impact on their productivity, although profitability of these firms may increase. On the other hand, if firms offshore to move up the value chain (focusing on high value added components and moving ahead of competition by introducing quality products) and specialize and obtain economy of scale (concentrating in core competency of the firm), then offshoring may directly affect productivity.[1] In addition, offshoring potentially promotes firms to innovation by exposing firms that engage in such activity to intense international competition and to the world technology frontier and best management practices. "Vigorous global competition against the best-practice companies not only spurs allocative efficiency, it can also force structural change in industries and encourage the adoption of more efficient product and process designs" Baily and Gersbach (1995).

Thus, offshoring has the potential to generate the composition effect by helping firms move up the value chain and specialize and obtain economy of scale. In addition, offshoring may generate the innovation effect by encouraging firms to engage in workplace innovation. These potential effects, if realized, will show up in productivity. However, the extent of the effects is expected to be different across different geographical locations of offshoring because of the differences in market conditions of those locations that may appeal to different offshoring business models.

Using Statistics Canada's Survey of Innovation 2005, which linked to Annual Surveys of Manufacturers, this paper aims to provide some Canadian micro evidence for a better understanding of firms' offshoring behavior and the linkage between offshoring and productivity. It focuses on geographical locations of offshoring with a distinction between material offshoring and R&D offshoring. This paper specifically seeks to addresses following two questions.

(1) What are the factors that are associated with material or R&D offshoring?

(2) Is material or R&D offshoring associated with plants' productivity? Does the geographical location of offshoring matter for the association?

[1] A shift away from one phase of production to another may require a change in organizational structure. For instance, it may require an increase in the skill level of its workers if a firm moves up the value chain and focus on high value added components of a product by offshoring low value added components. The productivity change due to a change in skill level may be controlled by a skill level variable.

In an earlier work, do Livramento and Tang (2007) estimate the linkage between offshoring and productivity using industry level data.[2] Industry-level studies are important, but they cannot capture variation at the micro level. There are many reasons that micro-level analysis is desirable. Not all firms will offshore. For those engaging in offshoring, they may pursue different offshoring business models and offshore to different geographical locations and may obtain different levels of productivity dividend. At the industry level, all these important variation may be averaged out.

In addition, the Survey of Innovation 2005 provides, for the first time, a direct estimate of offshoring intensity with geographical location information for Canadian manufacturing plants. In previous studies for Canada on offshoring and demand for skills (e.g., Yan 2006) or on offshoring and productivity (e.g., do Livramento and Tang 2007), offshoring is imputed from information on total imports by assuming that an imported good or service is proportionally to be used as either intermediate inputs or final demand (consumption and investment).[3] The direct measure of offshoring in the Survey will certainly address the potential problem with the imputation. The survey data, however, are one-time cross-sectional, which limits our analysis.

This paper shows that more than three-fourth of Canadian manufacturing plants engaged in material offshoring and on average 29 percent of materials were offshored in 2004. U.S. was the dominant location for material offshoring for all industries except apparel[4], accounting for about 70 percent of material offshoring. On the other hand, less than three percent of manufacturing plants engaged in R&D offshoring, which excludes R&D done by foreign affiliates in 2004, representing one percent of R&D expenditures. Again, U.S. was the dominated location for R&D offshoring. In addition, the paper shows that material offshoring is highly associated with outward-oriented business activities (having foreign affiliates, investing in foreign M&E and exporting) and that R&D offshoring is only associated with investing in foreign M&E and exporting. Furthermore, this paper shows that material offshoring to non-U.S. countries was associated with higher productivity performance than material offshoring to the U.S. after controlling for the effects of being multinationals, the skill level of workers, and plant size.

The rest of the paper is organized as follows. Section 2 describes the micro data and provides descriptive statistics on variables that are important for this study. Then, using econometrical analysis, Section 3 relates outward-oriented business activities to offshoring and Section 4 links offshoring to productivity. The last section, Section 5, provides with concluding remarks.

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[2] They find that material offshoring in Canada over the period of 1987-2000 contributed significantly to the productivity growth in the manufacturing sector but they find no evidence that service offshoring had such impact.

[3] Note that offshoring is also imputed using this assumption for most U.S. studies on offshoring (e.g., Feenstra and Hanson 1996 and Amiti and Wei 2006).

[4] For apparel, about 44 percent of material offshoring went to Asia Pacific compared to 25 percent for U.S.

2. Data and Sample Profile

The data used in the study are from Statistics Canada's 2005 *Survey of Innovation* (SI). The survey covers plants with at least 20 employees and $250,000 in revenues from the logging and manufacturing industries.[5] The one-time cross sectional data contain innovation-related information (for the period 2002-2004) on the plant's operations; plant success factors; product and process innovation; ongoing or abandoned product and/or process innovations; innovation activities; sources of information and co-operation for innovation; impact of innovation; problems and obstacles to innovation; intellectual property protection and acquisition of technology; market and supply chain; and funding and support. However, information on almost all variables used for this study is for the year of 2004. The overall response rate for the survey was 71.9%, for a total of 6,143 completed questionnaires.

The SI was linked to production data from the 2002 and 2004 *Annual Survey of Manufacturers* (ASM). With this linkage, the SI incorporates additional information on firms' production activities such as value added and employment in these two years. The linked SI database contains data on 6,109 in-sample manufacturing plants. Each plant carries a weight. The weight given to each in-sample plant allows that firm to represent other plants in the population having similar characteristics. Thus, if the weight given to plant X is 5, plant X represents five plants in the population. The total population is made out of 17,367 manufacturing plants, which is equal to the sum of population weights of the in-sample plants.

For the purpose of this study, however, in-sample plants that are considered to be outliers (e.g., with value added being non-positive) are excluded. The final sample (by restricting value added in 2004 being non-negative) for the productivity analysis in this study contains data on 5,653 in-sample manufacturing plants, representing a sub-population of 15,733 manufacturing plants. For the offshoring analysis, the final sample (by restricting value added in 2002 being non-negative) is on 5073 in-sample plants, representing a sub-population of 14,101 manufacturing plants.

In the remaining of this section, this paper provides descriptive statistics on variables that are the main variables being used to explain offshoring and productivity. These variables include offshoring and other outward-oriented business activities. The descriptive statistics are produced based on the unlinked database according to Statistics Canada's standards.[6]

Plant general characteristics

[5] Data was collected through respondent completed questionnaires in paper format (mail or fax). All establishments were "pre-contacted" to determine the name and correct mailing address for the respondent, the Chief Executive Officer (CEO) or senior manager at the location. Questionnaires were mailed out with mail, telephone and fax follow ups carried out for to elicit a response from non-respondents. In some cases, respondents completed the questionnaire over the phone with responses entered on a paper questionnaire by the interviewer.

[6] The standards include variation of responses, the imputation rate, and confindentiality.

About two-thirds of plants are single plants and their operations are not part of larger firms in the manufacturing sector (Table 1). The industries with the largest presence of single plants are apparel and leather (86%), while the industries with the lowest presence of single plants are petroleum and coal (22%) and chemical (37%).

For the manufacturing sector as a whole, the plant average percentage of workers with university was 8.7% in 2004. The average ranged from 3.3% in wood to 28.0% in computer and electronics.

Multinationals

A plant is affiliated with a multinational if the plant's operation is part of the multinational that has other plants and operations outside of Canada. About 22% of plants in the Canadian manufacturing sector are affiliated with multinationals (Table 2). Majority of those multinationals have operations in the United States. In contrast, about half of them have operations in Europe and less one-third in each other locations: Asia Pacific, Mexico and other countries. At the industry dimension, almost half of plants in chemical and paper were affiliated with multinationals. In contrast, only about 7% of plants in apparel and leather are affiliated with multinationals.

Importing Foreign Machinery and Equipment (M&E)

The SI also asked each plant for the percentage of its expenditures on new M&E that is supplied from different geographical locations in 2004.

For the manufacturing sector as a whole, about 40% of plants imported new M&E in 2004 (Table 3). The incidence of importing varies from 18% in apparel and leather to 52% in plastics and rubber.

On average, about 24% of expenditures on new M&E in manufacturing were on imported M&E. Most of the importing in manufacturing was from the U.S., accounting for 16 percentage points, while importing from other regions were small, accounting for less than 5.3 percentage points each. At the industry level, the printing industry had the highest averaged percentage (34%), followed by computer and electronics (33%) and plastics and rubber (32%). This compared to only 11% in wood and 13% in apparel and leather. It is interesting to note that most of the imported new M&E in textile mills and apparel was from Europe.

Exporting

The SI asked each plant for the percentage of its total revenue that came from sale of products (goods or services) to clients in different geographical markets in 2004. As in offshoring, this paper has four foreign locations associated with exporting: United States, Europe, Asia Pacific, and other countries.

For the manufacturing sector as a whole, 73% of plants engaged in exporting (Table 4).

The incidence of exporting varies from 55% in non-metallic mineral to 90% in computer and electronics.

On average, about 30% of revenue in manufacturing was from exporting. Most exporting revenue was from the U.S., accounting for 25.1 percentage points, while exporting revenue from other regions were small, accounting for less than 2 percentage points each. At the industry level, more than half of revenue in computer and electronic and transportation equipment was from exporting. This compared to only 11% in printing and 17% in petroleum and coal.

Material offshoring

Material offshoring refers to imported raw materials and components (materials hereafter) used as intermediate inputs for production. It includes the materials that are supplied by foreign affiliates. For each plant, the SI identifies the percentage of total expenditures on materials in 2004 that were supplied from the different geographical locations: United States, Europe, Asia Pacific, Mexico and all other countries.

For the manufacturing sector as a whole, majority of plants (76%) engaged in material offshoring in 2004 (Table 5). The industries with the highest proportion of plants that engaged in material offshoring were computer and electronics (94%) and electrical equipment (93%). As expected, the industries with the lowest proportion of plants that engaged in offshoring were wood (41%) and petroleum and coal (64%).

On average, about 29% of materials were offshored for the manufacturing sector as a whole. But, at the industry level, the offshoring intensity varies significantly, from 11% in wood to 53% in textile mills and textile product. For the computer and electronics industry that had the highest incidence of offshoring, the offshoring percentage was 50%.

Most material offshoring was from the United States, representing 20.5% of total expenditures on raw materials and components. This is followed by Asia Pacific (3.7%). Europe, Mexico and other countries accounted for the remaining proportion, 2.8%, 0.4% and 1.7%, respectively. The pattern is similar at the industry level. Except apparel and leather in which most material offshoring was from Asia Pacific, for all other industries, most material offshoring was from the United States.

R&D offshoring

R&D offshoring refers to R&D services that are carried out on a plant's behalf by independent foreign firms. Unlike material offshoring, R&D offshoring for a plant does not include R&D services carried out by its foreign affiliates. For each plant, the SI asked the respondent to estimate the percentage of the plant's expenditures on R&D services that were supplied from the different geographical locations: United States, Europe, Asia Pacific and all other countries.

For the manufacturing sector as a whole, only a small portion of plants (3%) engaged in

R&D offshoring in 2004 (Table 6). The industries with the highest proportion of plants that engaged in R&D offshoring were petroleum and coal (13%), primary metal (9%), and computer and electronics (9%). On the other hand, only 0.3% of plants in wood engaged in R&D offshoring. The other industry with the lowest proportion of plants that engaged in R&D offshoring was non-metallic mineral (0.8%).

On average, about 1% of R&D services were offshored for the manufacturing sector as a whole. But, at the industry level, the offshoring intensity varies significantly. It was 6% in petroleum and coal. For the computer and electronics industry that had the third highest incidence of R&D offshoring, the offshoring percentage was 5%, the second highest among the industries with data avaiable.

Like material offshoring, most R&D offshoring was from the United States, representing 0.8% of total R&D. This is followed by Europe (0.2%). The pattern is similar at the industry level.

3. Firm Characteristics and Offshoring

Plants could offshore raw materials and components to different locations: United States, Europe, Asia Pacific, and other countries. What factors are influencing or associated with the choice of location for offshoring? This section addressed this question.

Potential factors

As discussed in introduction, offshoring is generally influenced by transaction costs (e.g. searching costs for reliable and quality suppliers, transportation and communication costs) and the market conditions of suppliers (e.g. trade liberalization, FDI restrictions, cheap and skilled labour, and the quality of products). Some of those factors are economy-wide or industry-specific conditions that may explain why some locations are more popular than others in offshoring, but they cannot explain firm variation in offshoring in a particular industry.

This paper hypothesizes that the variation in offshoring across plants is associated with outward-oriented business strategies of firms' operation after control for plant-specific factors. This paper considers three outward-oriented business strategies: establishing foreign operation, investing in foreign M&E, and exporting.

It is likely that the objective of some firms becoming multinationals by establishing operation through FDI in a foreign country is to take the low cost advantage of the country in producing certain parts or components for a product. This is evidenced by the fact that intra-firm trade accounted for 47 percent of U.S. total imports in 2005 (Grossman and Rossi-Hansberg, 2006). Most of the intra-firm transaction is associated with intermediate inputs. In other words, transactions with foreign affiliates are significant part of offshoring. Thus, being part of multinationals and whether having an affiliate in a foreign location are important for the plant to offshore to the location.

Offshoring may also be necessary when a plant is adopting foreign technologies through investment in foreign machinery and equipment. Imported M&E from a foreign firm may require specific materials or accessories from the firm to operate effectively (e.g., a printer requires a specifically-designed cartridge). They may also require the manufacturers' expertise (R&D services) to ensure them being tailored into the plant's special needs and to make sure the overall operation of the M&E in the plant being successful.

Although exporting, which is associated with market of final products, may not be directly linked to offshoring, it may indirectly influence offshoring and the choice of its location. There are two main reasons. First, exporting exposes a firm to international competition which may force the firm to improve its cost-competitiveness by reorganizing its business and production structure. Offshoring may be part of the reorganization. Second, exporting will allow firms to understand local markets (including potential suppliers) better and to reduce transaction costs associated with offshoring. Thus, exporting to a location may influence a plant to offshore to the location. To capture the influence, this paper uses export intensity, which is indicated by the percentage of total revenue that came from a geographical location in 2004.[7]

Besides the association with the outward-oriented factors, offshoring may also influenced by other plant-specific factors. These factors can be productivity level, skill level, and plant size.

Offshoring is often considered to be endogenous to productivity, that is, whether or where to offshore may depend on productivity level (Amiti and Wei (2006)). Based on a theoretical framework for studying global sourcing strategies, Antràs and Helpman (2004) show that high-productivity firms more likely engage in offshoring activities than low-productivity firms. In this paper, we use labour productivity performance in 2002 to indicate a plant's productivity level before offshoring in 2004.[8]

The skill level of workers may also be an important factor for offshoring. In essence, offshoring is about reducing production costs and generating the composition effect by moving up the value chain and specializing. However, the success of offshoring depends on firms' ability to coordinate the complexity involved in offshoring, which requires knowledge and skills (Gereffi, Humphrey and Sturgeon, 2005). Deloitte (2005) finds that manufactures that master the complexity of managing global value chains are the ones enjoying greater competitive advantage, improved operating profits, and higher shareholder value. In addition, firms need skilled workers to specify R&D projects for offshoring and absorptive capacity to benefit from R&D offshoring. This paper uses the percentage of workers in a plant with a university degree in 2004 as a proxy for the average skill level of the plant.

[7] There is no data available for previous years.
[8] Note that the innovation survey is only linked to 2002 and 2004 annual survey of manufactures that contain production data.

Finally, large firms are generally perceived to be more likely to engage in offshoring than small firms because large firms are more capable of financing offshoring projects and stand to gain more from their investments.[9] This paper classifies a plant to be large if the plant had more than 250 employees in 2002.

Offshoring and its associated factors

To establish the relationship between offshoring and each of the above discussed potential factors, this paper starts with the simple correlation between offshoring and its potential factors. The correlation coefficient matrix shows that both material and R&D offshoring are positively correlated with all these variables in general and the correlations are statistically significant (Tables 7 and 8). But the degree of correlation is different across different geographical locations. For instance, material offshoring to the U.S. is significantly correlated with being multinationals with U.S. operations, imported new M&E from the U.S., and exporting to the U.S., but material offshoring to Asia Pacific is not significantly correlated with importing new M&E from this region nor is correlated with exporting to this region.

However, the correlations are uncontrolled relationships. They may be influenced by many factors that are complementary to each other. In the remaining of this section, this paper will examine the relationship more formally in the model presented below.

To identify potential underlying factors for the geographical location of offshoring, this paper conducts an econometric analysis to link outward-oriented business strategies to offshoring at different geographical locations, controlling for plant specific factors. The general econometric model for offshoring (materials or R&D) by plant *i* is specified as:

$$
\begin{aligned}
(1) \qquad O_{i,04} = {} & \alpha_0 + \alpha_1 M_i + \alpha_2 T_{i,04} + \alpha_3 E_{i,04} + \alpha_4 P_{i,02} + \alpha_5 U_{i,04} + \alpha_6 S_{i,02} \\
& + \sum_{j=1}^{3} \alpha_{6+j} D_{i,j} + \sum_{k=1}^{6} \alpha_{9+k} L_{i,k} + \sum_{m=1}^{20} \alpha_{15+m} I_{i,m} + \varepsilon_i \, ,
\end{aligned}
$$

where $O_{i,04}$ is the percentage of materials or R&D services in 2004 that are offshored;

M_i is a dummy variable for plant *i* to be part of a multinational that has operation in foreign location;

$T_{i,04}$ is the percentage of plant *i*'s total expenditures on new M&E in 2004 that is supplied from overseas;

$E_{i,04}$ is the percentage of plant *i*'s total revenue in 2004 that come from abroad;

[9] There are three main reasons for this perception. First, the cost of financing is lower for large firms than for small firms because of higher risk of failure and lack of collateral associated with small firms. Large firms are also more capable of funding offshoring internally, which is cheaper than external financing because of asymmetrical information. Second, large firms are able to benefit from economies of scale by averaging the fixed costs of offshoring over a higher level of output. Finally, they are more likely to benefit from its large scope and reduced risk of offshoring activities (i.e. if an established offshoring facility does not work well for one production line, it may be used for another production line).

$P_{i,02}$ is defined as value-added per worker in 2002;

$Q_{i,04}$ is a variable for skills, indicated by the percentage of workers with a university education in 2004;

$S_{i,02}$ is a firm size dummy based on employment in 2002, taking the value one for large firms and zero otherwise;

$D_{i,j}$ is a binary offshoring location dummy, taking the value one if plant *i* is offshoring to a foreign country/region *j* and zero otherwise;

$L_{i,k}$ is a binary operating location dummy, taking the value one if plant *i* is located *k* in Canada and zero otherwise;

$I_{i,m}$ is a binary industry dummy, taking the value one if plant *i* belongs to industry *m* and zero otherwise; and

ε_i^j is the error term that is associated with geographical location *j*.

Offshoring location dummies are introduced to capture the effects of market conditions of foreign suppliers in different geographical locations. It is expected that U.S. be the main offshoring location given the closeness between the two countries.[10] On the other hand, Asia Pacific countries may also be attractive for offshoring due to their low-cost production. For this study, there are four geographical locations for offshoring: U.S., Europe, Asia Pacific and all other countries.[11] The last group is used as a reference in regression.

Operating location dummies are to capture the effects of the local business environment where plants are operating. Local business environment may be important for offshoring since provinces may differ in closeness to offshoring markets in term of physical distance, spoken language, infrastructure, and marketplace framework including business taxation and regulations. This study introduces six operating location dummies representing six provinces: Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia. The other provinces and territories are used as reference.

Industry dummies are introduced to capture industry-related specific effects resulting from differences in financial and technological opportunities that are not captured by other variables. There are 21 industries based on 3-digit NAICS codes.

Empirical results for material offshoring

As a starting point, this paper first estimates regression model (1) for material offshoring without offshoring and operating location dummies. To reflect the total subpopulation represented by the sample, the regressions are weighted by the population weight. The

[10] Besides being a neighbor, U.S. and Canada are alike in many aspects. These include similar levels of social and economic development; a shared language (mostly) and historical tradition; similar emphases on the rule of law and democratic principles; and long-term alliances and partnerships in most regional and global matters.

[11] Mexico is grouped with other countries since it is not an important offshoring location for Canadian firms.

regression shows that all outward-oriented business activities variables are positive and significant for material offshoring (Column (1), Table 9). In other words, being a multinational, investing in foreign M&E, and exporting are all positively associated with material offshoring. According to t-statistics, the most significant factor is investment in foreign M&E. For the control variables, only the share of university educated workers is positive and significant.

In the second regression (Column (2), Table 9), this paper controls for offshoring and operating location specific effects. After controlling these location effects, the three outward-oriented business activities variables are still positive and highly significant, although the magnitude (both estimated coefficient and significance) for each variable is reduced. Among the three variables, the most significant one is still investment in foreign M&E. Besides productivity and size variables, the share of university educated workers become insignificant.

As expected, U.S., Europe and Asia Pacific are more significant offshoring locations for Canadian manufacturing plants than all other countries as a group. The most popular offshoring location is U.S., followed by Asia Pacific.

The regression also shows that plants in Ontario and British Columbia are more likely engaging in offshoring than plants in Alberta and Saskatchewan. This may be due to the fact that the first two provinces are physically close to international markets.

Empirical results for R&D offshoring

This paper also runs the same regressions for R&D offshoring as for material offshoring. The regression shows that only a very small variation of R&D offshoring can be explained without control for specific effects due to offshoring and operating locations (Column (1), Table 11). For the regression, all variables are positive and significant for R&D offshoring except for previous productivity level and being multinationals. The insignificance of being multinationals is expected, given that R&D offshoring here does not include R&D carried out by foreign affiliates.

However, after control for specific effects related to offshoring and operating locations, only investing in foreign M&E remains positive and significant (marginally) (Column (2)). The share of university educated workers become negative and significant. Like material offshoring, Europe and Asia Pacific are more significant R&D offshoring locations for Canadian manufacturing plants than all other countries as a group. The most popular offshoring location is U.S., followed by Asia Pacific.

The regression shows that plants in Ontario, Alberta, British Columbia, and to a less extent Quebec are for some reasons less likely engaging in R&D offshoring than plants in other provinces or territories.

4. Offshoring and Productivity

As discussed in the introduction section, offshoring has the potential to generate the composition effect and innovation effect. These potential effects, if realized, will show up in productivity. In this section, this paper examines whether offshoring to different geographical locations has different association with productivity. It is important to note that because it is based on cross-section data, the analysis is about association not about causality.

Regression model for the linkage between offshoring and productivity

The regression model is based on the Cobb-Douglas production function that relates productivity to offshoring to different geographical locations and other control variables.[12]

$$\begin{aligned} \ln(P_{i,04}) = \beta_0 + \beta_1 \ln(F_{i,04}) + \beta_2 O^{US}_{i,04} + \beta_3 O^{EU}_{i,04} + \beta_4 O^{AP}_{i,04} + \beta_5 O^{OT}_{i,04} + \beta_6 R_{i,04} \\ + \beta_7 M_i + \beta_8 Q_{i,04} + \beta_9 S_{i,02} + \sum_{k=1}^{6} \beta_{9+k} L_{i,k} + \sum_{m=1}^{20} \beta_{15+m} I_{i,m} + \varepsilon_i , \end{aligned} \tag{2}$$

where $\ln(P_{i,04})$ is defined as value-added per worker in 2004;

$\ln(F_{i,04})$ is fuel and power consumption per worker in 2004, a proxy for capital intensity;

$O^{US}_{i,04}$ is the percentage of total expenditure on materials that imported from the U.S. in 2004;

$O^{EU}_{i,04}$ is the percentage of total expenditure on materials that imported from Europe in 2004;

$O^{AP}_{i,04}$ is the percentage of total expenditure on materials that were supplied from Asia Pacific in 2004;

$O^{OT}_{i,04}$ is the percentage of total expenditure on materials that were supplied from the rest of countries including Mexico in 2004;

$R_{i,04}$ is the percentage of total expenditure on R&D services that were supplied from overseas in 2004;[13]

M_i is a dummy variable for being a plant of a multinational, taking the value one if the plant is part of a multinational and zero otherwise;

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[12] This paper has also considered the impact of innovation, indicated by the percentage of workers who were involved in R&D activities, on productivity. However, this variable is always insignificant whenever the variable the percentage of workers with a university education, a proxy for the average skill level of workers, is present. Because of this high correlation between these two variables, this paper excludes the innovation intensity proxy from the analysis. Gu and Tang (2004) show that the average skill level of workers is a reliable indicator of innovation for all industries, after controlling for industry-specific characteristics.

[13] This regression model does not distinguishes the geographical locations of R&D services because only 2.7 percent of manufacturing plants engaged in R&D offshoring and the variable is not statistically significant in either case.

$Q_{i,04}$ is a variable for skills, indicated by the percentage of workers with a university education in 2004;

$S_{i,04}$ is a plant size dummy based on employment in 2002, taking the value one for large firms and zero otherwise (from ASM);

$L_{i,k}$ is a binary operating location dummy, taking the value one if plant *i* is located *k* in Canada and zero otherwise;

$I_{i,m}$ is a binary industry dummy, taking the value one if firm *i* belongs to industry *m* and zero otherwise; and

ε_i is the error term.

Labour productivity is a function of capital intensity (capital stock per worker), but there is no capital stock or investment data available in the linked dataset. To account for this factor, this paper uses fuel and power consumption per worker as a proxy for capital intensity. The proxy is based on the observation that the working capital stock is highly correlated with fuel and power consumption, and that industry differences in energy intensity are accounted for by industry dummies. The proxy has been commonly used in the literature (e.g., Globerman, Ries and Vertinsky (1994) and Tang and Wang (2005)).

Besides the control for capital intensity, this paper also controls for the effects of being multinationals, the average skill level of workers, plant size, operating location, and industry-specific characteristics. Each of them is directly or indirectly linked to productivity performance, although they often complement and interact with each other to contribute to productivity improvements.

It has been found that multinationals are more productive than non-multinationals because of their scale, scope, diversified markets, unique technology, and superior business organizations (Baldwin and Gellatly, 2007).

It has been well established that labour quality or composition is important for productivity performance (Jorgenson, Ho and Stiroh, 2005). Skills are important for technology adoption and innovation. They are required to form business organizations and develop systems associated with sophisticated products or production processes, and to manage the organizations and operate the systems effectively (Tang and Wang, 2005). In this paper, skills are indicated by the percentage of workers with university education in total employees.

Finally, plant size, operating location and industry dummies are introduced to capture specific effects from differences in local business environment, financial and technological opportunities across different size groups, operating locations and industries. As before, large-sized plants are those with at least 250 employees (small-sized plants, which have 250 employees or less, are the reference group). There are six operating location dummies, representing for Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia (the other provinces and territories are used as reference).

For industry fixed effects, this paper divide the manufacturing sector into 21 industries based on 3-digit NAICS codes.

Empirical results for the linkage between offshoring and productivity

This paper first runs regressions to establish the general link between offshoring and productivity without control for variables other than the proxy for capital intensity. To reflect the total subpopulation represented by the sample, the regressions are weighted by the population weight.[14] The most interesting results for this paper are related to offshoring. The regression shows that both material and R&D offshoring are positively, significantly associated with productivity (Column (1), Table 11). In addition, as expected, fuel and power consumption per employee, as a proxy for capital intensity, is found to be the most significant factors associated with labour productivity performance. This is in ling with the fact that capital is a primary factor for production and that the workers with more machines at their control tend to produce more output.

In the second regression, material offshoring is distinguished by its geographical location: U.S., Europe, Asia Pacific, and other countries. This is to test whether offshoring to different geographical locations has different associations with productivity. The regression (Column (2), Table 11) shows that estimated coefficients on material offshoring to non-U.S. locations are significantly larger than the estimated coefficient on material offshoring to the U.S. This suggests that offshoring materials to non-U.S. locations tends to be associated with larger productivity gain than offshoring materials to the U.S.

After controlling for being multinationals, the share of university educated workers and plant size, however, the estimated coefficients on offshoring variables become less significant (Column (3), Table 11). In particular, material offshoring to the U.S. becomes marginally (at the 10% level) significant and R&D offshoring becomes insignificant. This is because these control variables are to a different extent associated with material and R&D offshoring. Thus, after controlling for these variables, the offshoring variables capture only the association above what is linked to these control variables.

The estimation shows that multinationals are on average more productive than others. The finding is consistent with the well-documented fact that multinationals (foreign- or domestically-owned) in Canada are more productive than domestic-controlled non-multinationals (Baldwin and Gellatly, 2007). The estimation also shows that the share of university educated workers is positive and highly significant, indicating the importance of skills for productivity. The importance may be directly linked to high level of innovation or a better organization (e.g., Gu and Tang, 2004 and Tang and Wang 2005). Finally, plant size is also found to matter for productivity. Large-sized plants tend to be more productive than small-sized plants. This finding is also consistent with the literature for Canadian manufacturing plants (for example, Baldwin, Jarmin and Tang, 2004).

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[14] Note that the results generally hold if only single plants, which are Canada-based non-multinationals, in the sample are used for regressions.

After control for operating location specific effects, the previous estimation results generally hold except that material offshoring to the U.S. is insignificant although it is still positive (Columns (4) and (5)). The new regression shows that plants located outside of maritime provinces and territories tend to be more productive.

5. Concluding remarks

Why do some firms offshore materials in a particular location and others don't? This paper hypothesizes that offshoring is a part of a firm's overall business operation and is associated with plant-specific factors and outward-oriented business strategies.

Using Statistics Canada's Survey of Innovation 2005, which linked to Annual Surveys of Manufacturers, this paper indeed shows that material offshoring was significantly associated with foreign affiliates, investment in foreign M&E, and exporting. For R&D offshoring, which excludes R&D services carried out by foreign affiliates, however, it is found that only investment in foreign M&E is marginally significant.

In addition, this paper finds that material offshoring to non-U.S. countries tend to be associated with larger productivity gains than material offshoring to the U.S. after controlling for the effects of being multinationals, the education level of workers, and plant size.

These findings generally hold when plants whose operations are part of larger firms are excluded from the sample (results are not reported).[15] However, the results should be interpreted with the understanding that the analysis in this paper is based on one-time cross-sectional data which only allows for contemporary correlation analyses. This paper, therefore, could not investigate whether there are lagged effects of business strategy on offshoring or offshoring on productivity.

Also, while the results support the view that offshoring is part of firms' outward-oriented business strategy and offshoring enhances productivity, this paper cannot test for a causal effect of either a specific outward-oriented business strategy on offshoring or offshoring on productivity. For instance, although it is a reasonable conjecture, this paper cannot conclude that investing in foreign M&E, which is found to be significantly correlated with offshoring, causes offshoring. It is possible that importing foreign M&E is just a good indictor for pursuing outward-oriented business strategy and that it is the latter not the former causing offshoring.

Finally, it should be noted that the result that material offshoring to non-U.S. countries tends to be associated with larger productivity gains than material offshoring to the U.S may be justified by higher transaction cost associated with material offshoring to those regions. This conjecture merits further research.

[15] This is expected given that about two-thirds of plants in the sample are single unit plants.

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Table 1
An Industry Profile of Canadian Manufacturing

NAICS	Industry Name	Percentage of plants being single plant	Average percentage of workers with university education
311-312	Food and beverage and tobacco	56.3	12.5[E]
313-314	Textile mills and textile product	65.9	6.5
315-316	Apparel and leather	86.3	6.1
321	Wood	62.5	3.3
322	Paper	40.8	6.9
323	Printing	75.2	7.1
324	Petroleum and coal	22.4	11.6
325	Chemical	36.5	17.4
326	Plastics and rubber	57.2	6.5
327	Non-metallic mineral	54.3	5.9
331	Primary metal	46.2	7.4
332	Fabricated metal	77.1	5.2
333	Machinery	73.6	8.6
334	Computer & electronics	62.1	28.0
335	Electrical equipment	58.0	12.7
336	Transportation equipment	57.6	8.2
337	Furniture	80.0	5.7
339	Misce. manufacturing	82.8	10.3
Total Manufacturing		65.3	8.7

Note: The quality of all estimates have been assessed and are of "very good" or "good" reliability except for those that are marked by "E" that should be used with caution.
Source: Statistics Canada, Survey of Innovation 2005

Table 2
An Industry Profile of Multinationals in Canadian Manufacturing
(Percentage of Plants Having Foreign Affiliates)

NAICS	*Industry Name*	*In All Foreign countries*	*In U.S.*	*In Europe*	*In Asia Pacific*	*In Mexico*	*In all other countries*
311-312	Food and beverage and tobacco	19.7	17.7	8.3	6.3	5.6	7.1
313-314	Textile mills and textile product	21.1	19.9	13.2	10.8	8.3	5.9
315-316	Apparel and leather	7.4	6.2	1.8	11.7	0.7	0.4
321	Wood	22.0	21.1	10.7	2.7	4.3	1.5
322	Paper	48.5	46.1	23.5	11.5	10.7	6.1
323	Printing	11.7	11.5	3.9	3.5	5.6	2.2
324	Petroleum and coal	44.0	36.1	27.1	19.5	9.2	20.6
325	Chemical	47.4	40.9	22.0	12.8	8.4	15.8
326	Plastics and rubber	25.8	23.0	15.8	13.0	10.0	8.7
327	Non-metallic mineral	29.9	28.6	17.2	12.0	7.5	10.7
331	Primary metal	43.9	36.6	20.4	17.7	11.9	14.7
332	Fabricated metal	12.1	11.2	6.0	4.1	3.7	2.2
333	Machinery	16.2	13.0	8.1	3.9	1.0	5.5
334	Computer & electronics	31.5	28.5	19.6	13.8	7.4	7.0
335	Electrical equipment	30.8	27.2	15.9	15.6	13.8	9.5
336	Transportation equipment	33.9	33.0	23.3	16.9	20.1	6.2
337	Furniture	12.9	12.9^E	6.2^E	2.9	0.9	1.5
339	Misce. manufacturing	7.7	6.7	3.3	2.1	1.6	1.5
Total manufacturing		21.6	19.7	11.1	7.3	6.0	5.4

Note: The quality of all estimates have been assessed and are of "very good" or "good" reliability except for those that are marked by "E" that should be used with caution.
Source: Statistics Canada, Survey of Innovation 2005

Table 3

An Industry Profile of Investment in Machinery and Equipment in Canadian Manufacturing

(Incidence of Adopting Foreign M&E and Average Percentage of Investment in M&E supplied from Foreign Countries**)**

NAICS	*Industry Name*	*Incidence of Adopting Foreign M&E (%)*	*Average Percentage of Investment in M&E Supplied from Overseas*	*Average Percentage of Investment in M&E from Different Foreign Geographical Locations*				
				U.S.	*Europe*	*Asia Pacific*	*Mexico*	*Others*
311-312	Food and beverage and tobacco	51.9	27.1	18.3	7.0^E	F	0.0	F
313-314	Textile mills and textile product	33.6	25.6	12.3	12.2	F	0.0	0.0
315-316	Apparel and leather	18.1	12.5	5.6^E	3.6	F	0.0	F
321	Wood	21.4	10.7	7.3^E	3.1^E	F	F	F
322	Paper	49.2	30.1	19.2	10.0^E	0.4	0.0	F
323	Printing	45.8	33.5	21.6	5.7^E	F	F	F
324	Petroleum and coal	48.6	19.6	17.2	F	F	0.0	F
325	Chemical	41.3	20.2	15.4	3.3^E	F	0.0	F
326	Plastics and rubber	52.4	32.4	22.4	7.4^E	F	0.0	F
327	Non-metallic mineral	43.1	26.0	16.5	7.9^E	F	F	F
331	Primary metal	50.7	27.3	20.3	6.5^E	F	0.0	F
332	Fabricated metal	33.1	22.4	14.8	3.2^E	F	F	F
333	Machinery	36.1	23.2	17.2	3.6	F	F	F
334	Computer & electronics	48.8	32.7	27.0	2.9	2.7	F	F
335	Electrical equipment	35.7	20.5	15.5	3.4^E	1.3^E	F	F
336	Transportation equipment	41.2	23.2	16.5	3.7^E	2.9	F	0.1
337	Furniture	34.7	24.3	10.3^E	9.8^E	F	0.0	F
339	Misc. manufacturing	34.8	22.8	15.7	4.7^E	F	0.0	F
Total manufacturing		38.9	23.8	16.0	5.3	2.0	0.0	0.6^E

Note: The quality of all estimates have been assessed and are of "very good" or "good" reliability except for those that are marked by "E" that should be used with caution. Estimates that are too unreliable to be published are indicated by "F".

Source: Statistics Canada, Survey of Innovation 2005

Table 4
An Industry Profile of Exporting in Canadian Manufacturing
(Incidence of Exporting and Average Percentage of Revenue from Exporting)

NAICS	*Industry Name*	*Incidence of Exporting (%)*	*Average Percentage of Revenue from Exporting*	*Average Percentage of Revenue from Exporting to Different Geographical Locations*				
				U.S.	*Europe*	*Asia Pacific*	*Mexico*	*Others*
311-312	Food and beverage and tobacco	62.9	24.6	16.4	1.9^E	4.3^E	F	1.5^E
313-314	Textile mills and textile product	77.1	33.5	28.4	1.8	1.3^E	F	1.0^E
315-316	Apparel and leather	67.7	24.9	22.2	1.1^E	F	F	0.5^E
321	Wood	64.7	31.6	28.7	F	F	0.0^E	0.3^E
322	Paper	78.1	34.9	28.0	2.6^E	3.0^E	0.3^E	1.1^E
323	Printing	65.3	11.4	10.5	F	F	0.1^E	F
324	Petroleum and coal	55.6	16.5	13.8	1.5^E	0.3^E	0.2^E	0.7^E
325	Chemical	84.6	36.9	30.0	2.8^E	1.6^E	0.7^E	1.8^E
326	Plastics and rubber	84.3	33.7	30.9	F	F	0.5	1.0
327	Non-metallic mineral	55.2	19.9	18.3	0.6	0.5	0.1	0.5
331	Primary metal	89.7	41.6	37.5	1.0	1.3	0.7	F
332	Fabricated metal	65.7	18.8	16.7	0.8	F	0.3	F
333	Machinery	85.9	38.5	31.2	1.9	1.2	0.9	3.2
334	Computer & electronics	90.6	56.1	38.4	8.2	5.6	0.8	3.2
335	Electrical equipment	87.6	39.8	32.3	2.5^E	1.7^E	1.8^E	1.4^E
336	Transportation equipment	86.0	50.7	44.5	2.4^E	F	1.2^E	F
337	Furniture	72.5	27.6	26.6	F	F	F	0.4^E
339	Misce. manufacturing	61.6	23.0	18.5	2.2	1.1^E	0.3^E	0.9^E
Total manufacturing		72.9	29.9	25.1	1.8	1.4	0.5	1.2

Note: The quality of all estimates have been assessed and are of "very good" or "good" reliability except for those that are marked by "E" that should be used with caution. Estimates that are too unreliable to be published are indicated by "F".

Source: Statistics Canada, Survey of Innovation 2005

Table 5
An Industry Profile of Material Offshoring in Canadian Manufacturing
(Incidence of Material Offshoring and Average Percentage of Materials Offshored)

NAICS	*Industry Name*	*Incidence of Offshoring (%)*	*Average Percentage of Materials Offshored*	*Average Percentage of Materials Offshored to Different Geographical Locations*				
				U.S.	*Europe*	*Asia Pacific*	*Mexico*	*Others*
311-312	Food and beverage and tobacco	59.4	16.4	10.2	1.3	0.9^{E}	F	3.9^{E}
313-314	Textile mills and textile product	87.4	53.3	32.6	3.8	12.8	1.0^{E}	3.1
315-316	Apparel and leather	76.1	43.6	12.2	8.8	17.9	1.2^{E}	3.4^{E}
321	Wood	41.3	10.8	9.9	0.1^{E}	0.3^{E}	F	0.5^{E}
322	Paper	81.3	31.6	27.9	2.1^{E}	0.5^{E}	F	F
323	Printing	71.3	25.6	18.1	2.4^{E}	4.1^{E}	F	0.9^{E}
324	Petroleum and coal	63.5	24.0	17.5	3.1^{E}	F	F	F
325	Chemical	88.7	39.7	28.8	3.9	4.2	0.3^{E}	2.5^{E}
326	Plastics and rubber	92.0	42.7	36.6	1.9^{E}	3.3^{E}	F	0.6^{E}
327	Non-metallic mineral	60.8	22.6	14.0	2.9^{E}	F	F	F
331	Primary metal	85.4	30.3	24.3	2.5^{E}	1.2^{E}	F	2.1^{E}
332	Fabricated metal	80.9	24.0	18.2	2.6^{E}	2.0^{E}	F	0.9^{E}
333	Machinery	87.6	31.8	22.5	3.9^{E}	3.1^{E}	F	F
334	Computer & electronics	93.9	49.9	33.9	4.0	10.0	0.4	1.7^{E}
335	Electrical equipment	93.0	42.2	26.0	4.6^{E}	8.6	1.1^{E}	2.0^{E}
336	Transportation equipment	89.7	42.6	34.9	3.5^{E}	2.8^{E}	F	0.7^{E}
337	Furniture	72.2	17.8	10.4	2.9^{E}	3.6^{E}	F	0.7^{E}
339	Misc. manufacturing	78.5	30.9	21.2	2.8	5.0	F	1.3^{E}
Total manufacturing		76.1	29.0	20.5	2.8	3.7	0.4	1.7

Note: The quality of all estimates have been assessed and are of "very good" or "good" reliability except for those that are marked by "E" that should be used with caution. Estimates that are too unreliable to be published or have been suppressed for confidentiality reasons are indicated by "F".
Source: Statistics Canada, Survey of Innovation 2005

Table 6
An Industry Profile of R&D Offshoring in Canadian Manufacturing
(Incidence of R&D Offshoring and Average Percentage of R&D Services Offshored)

NAICS	*Industry Name*	*Incidence of R&D Offshoring (%)*	*Average Percentage of R&D Offshored*	*Average Percentage of R&D Offshored to Different Geographical Locations*				
				U.S.	*Europe*	*Asia Pacific*	*Mexico*	*Others*
311-312	Food and beverage and tobacco	3.6	1.2^{E}	F	0.5^{E}	0.0	0.0	F
313-314	Textile mills and textile product	3.3	F	F	F	0.0	0.0	0.0
315-316	Apparel and leather	1.7	1.1^{E}	F	0.0	F	0.0	0.0
321	Wood	0.3	F	F	F	0.0	0.0	0.0
322	Paper	5.1	2.2^{E}	F	0.8^{E}	F	0.0	F
323	Printing	1.5	F	F	F	F	0.0	F
324	Petroleum and coal	12.5	6.2	5.1^{E}	0.1	0.0	0.0	F
325	Chemical	5.7	3.1	1.8^{E}	0.5	F	0.0	0.0
326	Plastics and rubber	1.6	F	F	0.0	F	0.0	0.0
327	Non-metallic mineral	0.8	F	F	F	0.0	0.0	0.0
331	Primary metal	8.8	3.0^{E}	F	F	F	0.0	0.0
332	Fabricated metal	1.2	F	F	F	0.0	0.0	F
333	Machinery	3.3	F	F	F	0.0	0.0	F
334	Computer & electronics	8.8	4.5	2.5	0.7^{E}	F	0.0	F
335	Electrical equipment	5.2	F	F	F	F	0.0	0.0
336	Transportation equipment	3.2	F	F	0.0	F	0.0	0.0
337	Furniture	2.6	F	F	0.0	0.0	0.0	0.0
339	Misc. manufacturing	1.7	F	F	F	F	0.0	0.0
Total manufacturing		2.8	1.2	0.8	0.2^{E}	0.1^{E}	0.0	F

Note: The quality of all estimates have been assessed and are of "very good" or "good" reliability except for those that are marked by "E" that should be used with caution. Estimates that are too unreliable to be published or have been suppressed for confidentiality reasons are indicated by "F".
Source: Statistics Canada, Survey of Innovation 2005

Table 7
Correlation between Material Offshoring and Firm Characteristics

	Total material offshoring	Material offshoring to U.S.	Material offshoring to Europe	Material offshoring to Asia Pacific	Material offshoring to other countries
Multinationals	0.159***	0.168***	0.069***	-0.006	0.014
with U.S. operation	0.142***	0.165***	0.044***	-0.009	-0.004
with Europe operation	0.133***	0.137***	0.069***	-0.010	0.019
with Asia Pacific operation	0.170***	0.168***	0.049***	0.030**	0.026*
with operation in other countries	0.141***	0.137***	0.050***	0.003	0.048***
Percentage of investment in Foreign M&E	0.246***	0.216***	0.076***	0.064***	0.078***
from U.S.	0.200***	0.210***	0.004	0.042	0.047***
from Europe	0.112***	0.075***	0.135	0.011	0.013
from Asia Pacific	0.056***	0.015	0.051	0.078	0.021
from other countries	0.034**	0.004	-0.015	-0.013	0.146***
Exporters	0.239***	0.230***	0.120***	0.041***	-0.001
to U.S.	0.223***	0.228***	0.095***	0.027**	-0.006
to Europe	0.090***	0.071***	0.063***	0.029**	0.003
to Asia Pacific	0.012	-0.000	0.020	0.020	-0.006
to other countries	0.098***	0.055***	0.096***	0.036**	0.028**
Previous labour productivity	0.031**	0.033**	0.030**	-0.028**	0.021
Share of uni. education workers	0.118***	0.081***	0.055***	0.084***	0.005
Dummy: large-sized firms	0.098***	0.091***	-0.004	0.033**	0.046***

Note: "*", "**", and "***" denote significance at 10%, 5% and 1%, respectively.

Table 8
Correlation between R&D Offshoring and Firm Characteristics

	Total R&D offshoring	R&D offshoring to U.S.	R&D offshoring to Europe	R&D offshoring to Asia Pacific	R&D offshoring to other countries
Multinationals	0.059***	0.054***	0.018	0.015	0.031
with U.S. operation	0.051***	0.049***	0.008	0.018	0.033
with Europe operation	0.060***	0.050***	0.028**	0.013	0.041
with Asia Pacific operation	0.063***	0.052***	0.029**	0.021	0.024*
with operation in other countries	0.033**	0.029**	-0.001	0.013	0.051***
Percentage of investment in Foreign M&E	0.087***	0.077***	0.041***	0.023*	0.012
from U.S.	0.083***	0.088***	0.023*	0.012	0.003
from Europe	0.023*	0.012	0.036***	-0.002	-0.006
from Asia Pacific	0.019	-0.002	0.014	0.042***	-0.002
from other countries	0.002	-0.005	-0.006	0.000	0.075***
Percentage of revenue from exporting	0.118***	0.107***	0.052***	0.041***	-0.016
from U.S.	0.088***	0.093***	0.023*	0.026*	-0.019
from Europe	0.057***	0.019	0.056***	0.048***	0.011
from Asia Pacific	0.078***	0.061***	0.052***	0.028**	-0.005
from other countries	0.057***	0.044***	0.044***	0.013	-0.001
Previous labour productivity	0.041***	0.037***	0.013	0.010	0.029
Share of uni. education workers	0.150***	0.135***	0.062***	0.051***	0.014
Dummy: large-sized firms	0.059***	0.046***	0.021	0.032**	0.024*

Note: “*”, “**”, and “***” denote significance at 10%, 5% and 1%, respectively.

Table 9
Material Offshoring and the Associated Factors

Variable	(1)	(2)	(3)	(4)	(5)
Multinationals	5.873*** (5.7)	4.126*** (4.6)		4.525*** (5.0)	5.053*** (5.7)
Percentage of investment in foreign M&E in 2004	0.168*** (15.6)	0.103*** (10.9)	0.105*** (11.1)		0.105*** (11.0)
Share of revenue from exports in 2004	0.138*** (10.9)	0.071*** (6.3)	0.079*** (7.1)	0.074*** (6.5)	
Productivity in 2002	-1.449 (-0.6)	-2.289 (-1.1)	-0.798 (-0.4)	-2.780 (-1.3)	-2.086 (-1.0)
Share of uni. educated workers	0.112*** (3.4)	0.036 (1.2)	0.040 (1.4)	0.039 (1.3)	0.053* (1.9)
Dummy: large-sized plant	0.891 (0.6)	-0.593 (-0.5)	0.565 (0.4)	0.796 (0.6)	0.391 (0.3)
Dummy: material offshoring to U.S.		22.044*** (26.9)	22.156*** (27.0)	22.926*** (27.8)	22.554*** (27.6)
Dummy: material offshoring to Europe		11.886*** (12.5)	12.142*** (12.8)	12.637*** (13.2)	12.464*** (13.1)
Dummy: material offshoring to Asia Pacific		15.974*** (16.8)	15.911*** (16.7)	16.755*** (17.5)	16.066*** (16.9)
Dummy: plant located in Quebec		1.023 (0.7)	1.268 (0.8)	1.035 (0.7)	0.013 (0.0)
Dummy: plant located in Ontario		2.485 (1.6)	2.821* (1.9)	2.794 (1.8)	1.547 (1.0)
Dummy: plant located in Manitoba		1.025 (0.5)	0.844 (0.4)	1.381 (0.6)	0.357 (0.2)
Dummy: plant located in Saskatchewan		-0.462 (-0.2)	-0.314 (-0.1)	-0.130 (-0.1)	-1.272 (-0.5)
Dummy: plant located in Alberta		-2.568 (-1.4)	-2.013 (-1.1)	-1.433 (-0.8)	-3.896** (-2.1)
Dummy: plant located in British Columbia		1.711 (1.0)	2.039 (1.2)	2.456 (1.4)	1.280 (0.7)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squares	0.22	0.41	0.41	0.40	0.40
Number of observations	5073	5073	5073	5073	5073

Note: t-statistics are in parenthesis. "*", "**", and "***" denote significance at 10%, 5% and 1%, respectively.

Table 10
R&D Offshoring and the Associated Factors

Variable	(1)	(2)
Multinationals	-0.085 (-0.3)	-0.104 (-0.6)
Percentage of investment in foreign M&E in 2004	0.014*** (4.7)	0.003* (1.8)
Share of revenue from exports in 2004	0.018*** (5.1)	0.002 (0.9)
Productivity in 2002	0.382 (0.6)	0.141 (0.3)
Share of uni. educated workers	0.067*** (7.3)	-0.013** (-2.2)
Dummy: large-sized plant	1.057** (2.5)	0.133 (0.5)
Dummy: R&D offshoring to U.S.		32.159*** (58.0)
Dummy: R&D offshoring to Europe		24.675*** (29.3)
Dummy: R&D offshoring to Asia Pacific		30.864*** (28.9)
Dummy: plant located in Quebec		-0.536* (-1.7)
Dummy: plant located in Ontario		-0.828*** (-2.7)
Dummy: plant located in Manitoba		-0.067 (-0.1)
Dummy: plant located in Saskatchewan		-0.815 (-1.5)
Dummy: plant located in Alberta		-0.787** (-2.1)
Dummy: plant located in British Columbia		-0.722** (-2.1)
Industry fixed effects	Yes	Yes
Adjusted R-squares	0.04	0.62
Number of observations	5073	5073

Note: t-statistics are in parenthesis. "*", "**", and "***" denote significance at 10%, 5% and 1%, respectively.

Table 11
Offshoring and Productivity Performance

Variable	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)
Fuel and power consumption per worker	0.285*** (40.0)	0.286*** (40.0)	0.275*** (38.2)	0.270*** (37.5)	0.269*** (37.4)
Material offshoring	0.155*** (7.1)				0.080*** (3.7)
to U.S.		0.151*** (4.2)	0.051* (1.9)	0.039 (1.5)	
to Europe		0.243*** (3.8)	0.153** (2.4)	0.169*** (2.7)	
to Asia Pacific		0.219*** (4.1)	0.153*** (2.9)	0.132** (2.5)	
to other countries		0.204*** (2.8)	0.195*** (2.7)	0.157** (2.2)	
R&D offshoring	0.159** (2.1)	0.157** (2.1)	0.031 (0.4)	0.053 (0.7)	0.054 (0.7)
Multinationals			0.158*** (9.5)	0.150*** (9.1)	0.149*** (9.1)
Share of university educated workers			0.484*** (9.9)	0.467*** (9.6)	0.470*** (9.7)
Dummy: large-sized firms			0.058** (2.3)	0.066*** (2.7)	0.066*** (2.6)
Dummy: plant located in Quebec				0.224*** (7.6)	0.225*** (7.6)
Dummy: plant located in Ontario				0.277*** (9.7)	0.275*** (9.6)
Dummy: plant located in Manitoba				0.174*** (4.1)	0.171*** (4.1)
Dummy: plant located in Saskatchewan				0.226*** (4.5)	0.221*** (4.4)
Dummy: plant located in Alberta				0.302*** (8.7)	0.302*** (8.7)
Dummy: plant located in British Columbia				0.314*** (9.7)	0.315*** (9.7)
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squares	0.36	0.37	0.39	0.40	0.40
Number of observations	5653	5653	5653	5653	5653

Note: t-statistics are in parenthesis. "*", "**", and "***" denote significance at 10%, 5% and 1%, respectively.