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OFFSHORING AND PRODUCTIVITY: A MICRO-DATA ANALYSIS

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Offshoring has become increasingly important for businesses, especially manufacturing firms, to compete in 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 data from Statistics Canada's Survey of Innovation 2005 and Annual Surveys of Manufacturers, we show that material offshoring is strongly associated with firms' outward-oriented business activities (including foreign operation, investing in foreign M&E, and exporting), even after controlling for geographic advantages and industry- and plant-specific effects. For R&D offshoring, we find that it is 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 Asia Pacific countries than for material offshoring to the U.S. and other locations.

1. INTRODUCTION

Offshoring has become increasingly important for Canadian businesses, especially Canadian manufacturing firms, to compete in domestic and international markets.[1] This is mainly facilitated by the revolutionary advances in transportation and communications technology, combined with trade liberalization, the reduction in FDI restrictions, the abundance of cheap skilled labor 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 the same offshoring business models, and benefit to the same extent from engaging in such activities. Firm-specific business strategy may be important.

In this paper, we use micro-economic data to analyze the relationship between offshoring and productivity, as well as their linkages to firm-specific factors.

It should be noted that in this paper the term "offshoring" specifically refers to purchasing raw materials, unfinished/intermediate-products, or R&D services as intermediate inputs for production by firms from foreign affiliates or independent firms abroad.

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[1]Offshoring intensity, which is defined as the share of imputed imported intermediate inputs in total intermediate inputs, in the Canadian manufacturing sector increased from 21 percent in 1983 to almost 40 percent in 1999 before it declined to 32 percent in 2003 (do Livramento and Tang, 2007).

There are two main factors that influence the offshoring decision. First, offshoring depends on transaction costs.[2] For instance, it requires relationship-specific investments; it faces contractual incompleteness; it needs to search 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 in a particular country (e.g., affiliates through FDI or exporting) are more likely to engage in offshoring in 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 labor (for operating affiliates for producing intermediate inputs), and the ability to produce and supply high quality products and services are all important conditions.

For firms that choose to engage in offshoring, they have a variety of possible business models to pursue. For example, firms may simply replace expensive domestic suppliers by cheap foreign suppliers to reduce production costs; they may offshore low value-added components to foreign firms or affiliates in order 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 higher quality products, in order to gain an advantage over competitors.

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) than an American firm because of China's relatively low production costs 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) 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 (all else being equal) are not expected to increase their productivity, although profitability 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 the competition by introducing higher quality products) and achieve economies of scale through specialization (concentrating on core competencies), then offshoring may directly affect productivity.[3] In addition, offshoring

[2]Hanson *et al.* (2005) find that demand for imported inputs depends on trade costs, wages for less-skilled labor, and host-country policies and characteristics.

[3]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 focuses 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.

potentially encourages firms to innovate by exposing firms to intense international competition, the world technology frontier, and the 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). Amiti and Konings (2007) also suggest that imported inputs can raise productivity through learning, variety, and quality effects.

Thus, offshoring has the potential to help firms move up the value chain, specialize, and increase economies of scale (i.e., the "composition effect"). In addition, offshoring may encourage firms to engage in workplace innovation (i.e., the "innovation effect"). These potential effects, if realized, will be reflected in productivity.[4] The magnitudes of these effects are expected to vary geographically because of differences in market conditions across the world.

Using Statistics Canada's Survey of Innovation 2005, which has been linked to the Annual Surveys of Manufacturers, this paper presents Canadian micro evidence on firms' offshoring behaviors 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 address the following two questions.

(1) What are the factors that are associated with material and R&D offshoring?
(2) Are material and R&D offshoring associated with a plant's productivity? Is the geographical location of offshoring relevant?

In an earlier work, do Livramento and Tang (2007) estimate the linkage between offshoring and productivity using industry-level data for Canada.[5] 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; those engaging in offshoring may pursue different offshoring business models and offshore to different geographical locations, and may obtain different levels of productivity dividend. At the industry level, this heterogeneity in the data may be averaged out.

In addition, the Survey of Innovation 2005 provides, for the first time, a direct estimate of offshoring intensity alongside geographical location information for Canadian manufacturing plants. In previous Canadian studies 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 imported goods and services are proportionally used for intermediate inputs and final demand (consumption and investment).[6] The direct measure of offshoring in the Survey will certainly address the potential problem

[4]Offshoring may also bring in other real economic impacts. For instance, López (2006) finds that importing intermediate inputs increases the probability of plant survival. Such an impact is not discussed in this paper.

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

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

with the imputation. The survey data, however, are one-time cross-sectional, which limits our analysis to contemporary correlation.

This paper shows that more than three-quarters of Canadian manufacturing plants engaged in material offshoring and on average 29 percent of materials were offshored in 2004. The U.S. was the dominant location for material offshoring for all industries except apparel and leather,[7] accounting for about 70 percent of material offshoring. On the other hand, less than 3 percent of manufacturing plants engaged in R&D offshoring, which excludes R&D done by foreign affiliates in 2004, representing 1 percent of R&D expenditures. Again, the U.S. was the dominant location for R&D offshoring. In addition, the paper shows that material offshoring is strongly associated with outward-oriented business activities (having foreign affiliates, investing in foreign machinery and equipment (M&E), and exporting), and that R&D offshoring is only associated with investing in foreign M&E. Furthermore, this paper shows that material offshoring to Asia Pacific countries was associated more with productivity performance than material offshoring to the U.S. and other locations 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 econometric analysis, Section 3 relates outward-oriented business activities to offshoring and Section 4 links offshoring to productivity. Section 5 concludes.

2. Data and Sample Profile

The data used in this 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.[8] The one-time cross sectional data contain innovation-related information (for the period 2002–04) 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 2004. The overall response rate for the survey was 71.9 percent, for a total of 6143 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

[7]For apparel and leather, about 18 percent of material offshoring went to Asia Pacific compared to 12 percent for the U.S.

[8]Data were mainly collected from respondents who completed questionnaires in paper format (mail or fax). Each establishment was "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. Mail, telephone, and fax are followed up to elicit responses from non-respondents. In some cases, respondents completed the questionnaire over the phone with responses entered on a paper questionnaire by the interviewer.

information on firms' production activities, such as value added and employment in these two years. The linked SI database contains data on 6109 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 to non-negative values) for the productivity analysis in this study contains data on 5653 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 to non-negative values) is on 5073 in-sample plants, representing a sub-population of 14,101 manufacturing plants.

In the remainder of this section, we provide descriptive statistics on 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.[9]

General Plant Characteristics

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

For the manufacturing sector as a whole, each plant had an average of 8.7 percent of workers with university education in 2004. The average ranged from 3.3 percent in wood to 28.0 percent 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 percent of plants in the Canadian manufacturing sector were affiliated with multinationals (Table 2). The majority of those multinationals had operations in the United States. In contrast, about half of them had operations in Europe and less than one-third in each of: Asia Pacific, Mexico, and other countries. Almost half of plants in the chemical and paper industries were affiliated with multinationals. In contrast, only about 7 percent of plants in apparel and leather were affiliated with multinationals.

[9]The standards include variation of responses, the imputation rate, and confidentiality.

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	Misc. manufacturing	82.8	10.3
Total Manufacturing		65.3	8.7

Note: The quality of all estimates has been assessed and is 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.

Importing Foreign Machinery and Equipment (M&E)

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

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

On average, about 24 percent 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 was small, accounting for less than 5.3 percentage points each. At the industry level, the printing industry had the highest averaged percentage (34 percent), followed by computer and electronics (33 percent) and plastics and rubber (32 percent). This compared to only 11 percent in wood and 13 percent in apparel and leather. It is interesting to note that about half of the imported new M&E in the textile mills and textile product industry was from Europe.

Exporting

The SI asked each plant for the percentage of its total revenue that came from the sale of products (goods or services) to clients in different geographical markets in 2004.

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	Misc. 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 has been assessed and is 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 has been assessed and is 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.

For the manufacturing sector as a whole, 73 percent of plants engaged in exporting (Table 4). The incidence of exporting varied from 55 percent in non-metallic mineral to 90 percent in computer and electronics.

On average, about 30 percent of revenues in manufacturing were 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 percent in printing and 17 percent 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, the majority of plants (76 percent) 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 percent) and electrical equipment (93 percent). As expected, the industries with the lowest proportion of plants that engaged in offshoring were wood (41 percent) and petroleum and coal (64 percent).

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

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

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	Misc. 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 has been assessed and is 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 has been assessed and is 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 has been assessed and is 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.

coal (13 percent), primary metal (9 percent), and computer and electronics (9 percent). On the other hand, only 0.3 percent 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 minerals (0.8 percent).

On average, about 1 percent of R&D services were offshored for the manufacturing sector as a whole. But, at the industry level, the offshoring intensity varied significantly. It was 6 percent 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 percent, the second highest among the industries with data available.

Like material offshoring, most R&D offshoring was to the United States, representing 0.8 percent of total R&D. This was followed by Europe (0.2 percent). The pattern was 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 including Mexico. What factors are influencing or associated with the choice of location for offshoring? This section addresses this question.

Potential Factors

As discussed in the introduction, offshoring is generally influenced by transaction costs (e.g. searching for reliable and quality suppliers, transportation and communication costs) and the market conditions of suppliers (e.g. trade liberalization, FDI restrictions, cheap and skilled labor, and the quality of products). Some of those factors are country- 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' operations after control for other 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 in becoming multinationals (by establishing operations through FDI) in a foreign country is to take advantage of low-cost production in that country for producing certain parts or components of 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 a significant part of offshoring. Thus, being part of a multinational and having a foreign affiliate are important factors underlying where offshoring takes place.

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 manufacturer's expertise (R&D services), in order to ensure that the M&E meet the plant's special needs and operate successfully.

Although exporting, which is associated with final products or inputs to foreign affiliates and non-affiliates for further processing, 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 it 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 revenues coming from a particular location in 2004.[10]

Besides the association with the outward-oriented factors, offshoring may also be influenced by other plant-specific factors: 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). In a theoretical study of global sourcing strategies, Antràs and Helpman (2004) show that high-productivity firms are more likely to engage in offshoring activities than low-productivity firms. In this paper, we use labor productivity performance in 2002 to indicate a plant's productivity level before offshoring in 2004.[11]

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 a firm's ability to coordinate the complexity involved in offshoring, which requires knowledge and skills (Gereffi *et al.*, 2005). Deloitte (2005) finds that manufacturers that master the complexity of managing global value chains are the ones enjoying greater competitive advantage, and experiencing 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.

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.[12] This paper classifies a plant as large if it had more than 250 employees in 2002.

[10]There are no data available for previous years.

[11]Kurz (2006) shows that U.S. plants that offshore tend to be more capital intensive and to have higher multifactor productivity.

[12]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).

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 that the correlations are statistically significant. However, the degree of correlation is different across different geographical locations. In particular, material offshoring to the U.S. is significantly correlated with being a multinational with U.S. operations, imported new M&E from the U.S., and exporting to the U.S. On the other hand, material offshoring to Asia Pacific is not significantly correlated with importing new M&E from this region nor is it correlated with exporting to this region.

The correlations above are uncontrolled relationships. They may be influenced by many factors that are associated with each other. In the remainder of this section, this paper will examine the relationship more formally in a 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:

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

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 operations 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 comes from abroad;

$P_{i,02}$ 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 at province 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 the U.S. be the main offshoring location given the closeness between the two countries.[13] 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.[14] 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 regression shows that all outward-oriented business activities variables are positive and significant for material offshoring (Column (1), Table 7).[15] 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.[16]

In the second regression (Column (2), Table 7), this paper controls for offshoring and operating location specific effects. After controlling for these location effects, the three outward-oriented business activities variables are still positive and highly significant, although the magnitude (both estimated

[13]Besides being neighbors, the U.S. and Canada are alike in many aspects. These include similar levels of social and economic development; a shared language 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.

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

[15]The hypothesis of homoscedasticity is rejected and t-statistics are based on White heteroscedasticity-consistent standard errors.

[16]The fact that both productivity and plant size are insignificant is not due to a multicollinearity problem for two reasons. First, the correlation coefficient between productivity and plant size is only 0.12. Second, estimation shows that when one of them is dropped from the regression, the other is still insignificant.

TABLE 7
Material Offshoring and the Associated Factors

Variable	(1)	(2)
Multinationals	5.873***	4.126***
	(3.5)	(2.8)
Percentage of investment in foreign M&E in 2004	0.168***	0.103***
	(9.7)	(7.2)
Share of revenue from exports in 2004	0.138***	0.071***
	(7.49)	(4.5)
Productivity in 2002	−1.449	−2.289
	(−0.7)	(−1.0)
Share of university educated workers	0.112**	0.036
	(2.1)	(1.0)
Dummy: large-sized plant	0.891	−0.593
	(0.5)	(−0.4)
Dummy: material offshoring to U.S.		22.044***
		(21.7)
Dummy: material offshoring to Europe		11.886***
		(12.5)
Dummy: material offshoring to Asia Pacific		15.974***
		(16.8)
Dummy: plant located in Quebec		1.023
		(0.9)
Dummy: plant located in Ontario		2.485**
		(2.0)
Dummy: plant located in Manitoba		1.025
		(0.3)
Dummy: plant located in Saskatchewan		−0.462
		(−0.1)
Dummy: plant located in Alberta		−2.568
		(−1.0)
Dummy: plant located in British Columbia		1.711
		(0.9)
Industry fixed effects	Yes	Yes
Adjusted R-squares	0.22	0.41
Number of observations	5,073	5,073

Notes: The hypothesis of homoscedasticity is rejected. t-statistics are in parentheses, which are based on White heteroscedasticity-consistent standard errors.

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

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, the U.S., Europe, and Asia Pacific are more significant offshoring locations for Canadian manufacturing plants than all other countries as a group. The most significant offshoring location is the 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 8). 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 controlling 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 becomes negative and significant. Like material offshoring, Europe and Asia Pacific are

TABLE 8
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 university 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	5,073	5,073

Notes: the hypothesis of homoscedasticity is not rejected. t-statistics are in parentheses.
*, **, and ***denote significance at 10%, 5%, and 1%, respectively.

more significant R&D offshoring locations for Canadian manufacturing plants than all other countries as a group. The most significant offshoring location is the U.S.

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

4. Offshoring and Productivity

As discussed in the introduction, 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 emphasize here 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.[17]

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

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;

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

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

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

[17]This paper excludes exporting as an explanatory variable since exporting is an important factor for material offshoring which itself is an explanatory variable. In addition, the empirical literature (e.g. Bernard and Jensen, 1999) shows that causality goes from productivity to exporting, rather than the other way round. Note also that this paper has 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 for the percentage of workers with a university education, which is 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.

$O^{OT}_{i,04}$ 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;[18]
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;
$Q_{i,04}$ 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 at province 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.

Labor productivity is a function of capital intensity (capital stock per worker), but there are no capital stock or investment data available in the linked dataset. To deal with this data problem, 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 used in the literature for Canada (e.g., Globerman *et al*., 1994; 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 affect productivity performance.

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 labor quality or composition is important for productivity performance (Jorgenson *et al*., 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 financial and technological opportunities across different size groups, operating locations and industries. As before, large-sized plants are those with more than 250 employees (small-sized plants, which have 250 employees or less, are the reference group). There are six operating

[18] This regression model does not distinguish between 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.

location dummies, representing Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia (the other provinces and territories are used as the reference). For industry fixed effects, this paper divides the manufacturing sector into 21 industries based on 3-digit NAICS codes.

Empirical Results for the Linkage Between Offshoring and Productivity

We first run regressions to establish the general link between offshoring and productivity, without controlling for variables other than the proxy for capital intensity. To reflect the total subpopulation represented by the sample, the regressions are weighted according to the population weight.[19] The most interesting results are related to material offshoring. The regression shows that material offshoring is positively and significantly associated with productivity (Column (1), Table 9).[20] This result is consistent with the empirical literature based on micro data, for example Kurz (2006) for U.S. manufacturing plants, and Morrison Paul and Yasar (2009) for Turkish textile and apparel manufacturing plants. Unlike material offshoring, R&D offshoring is not statistically significant, although it has a positive sign.

As expected, fuel and power consumption per employee, which is a proxy for capital intensity, is found to be the most significant factor associated with labor productivity performance. This is in line 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: the 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 9) shows that estimated coefficients on material offshoring to all locations are positive and significant (only marginally for other countries). According to t-statistics, the most significant location is Asia Pacific. This suggests that offshoring materials to Asia Pacific tends to be associated more with productivity than offshoring materials to the U.S. and other locations.

After controlling for being multinationals, the share of university educated workers, and plant size, the estimated coefficients on offshoring variables become less significant (Column (3), Table 9). In particular, material offshoring to the U.S. becomes insignificant. This is because these control variables are to a different

[19]The hypothesis of homoscedasticity is rejected and t-statistics are based on White heteroscedasticity-consistent standard errors.

[20]This paper does not deal with causality. Thus, the result does not necessarily suggest that offshoring improves productivity. The same results are obtained when the dependent variable, labor productivity in 2004, is replaced by the labor productivity in 2002. The empirical literature on the impact of offshoring on productivity is also ambiguous at best. Morrison Paul and Yasar (2009) find that plants in Turkish textile and apparel manufacturing increase their relative productivity after offshoring, while Kurz (2006) finds no evidence that productivity growth is higher for U.S. manufacturing plants that offshore. In addition, using plant-level data for Irish manufacturing, Görg *et al.* (2008) show that there are positive effects from outsourcing of services inputs for exporters but not for non-exporters.

TABLE 9
OFFSHORING AND PRODUCTIVITY PERFORMANCE

Variable	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)
Fuel and power consumption per worker	0.285*** (21.0)	0.286*** (21.0)	0.275*** (20.6)	0.270*** (20.6)	0.269*** (20.6)
Material offshoring	0.155*** (5.5)				0.080*** (2.8)
to U.S.		0.151*** (3.3)	0.051 (1.5)	0.039 (1.1)	
to Europe		0.243*** (2.7)	0.153* (1.7)	0.169* (1.9)	
to Asia Pacific		0.219*** (4.2)	0.153*** (3.0)	0.132** (2.5)	
to other countries		0.204* (1.7)	0.195* (1.7)	0.157 (1.4)	
R&D offshoring	0.159 (1.5)	0.157 (1.5)	0.031 (0.3)	0.053 (0.6)	0.054 (0.6)
Multinationals			0.158*** (6.2)	0.150*** (6.0)	0.149*** (6.0)
Share of university educated workers			0.484*** (6.7)	0.467*** (6.4)	0.470*** (6.4)
Dummy: large-sized firms			0.058* (1.8)	0.066** (2.1)	0.066** (2.0)
Dummy: plant located in Quebec				0.224*** (7.1)	0.225*** (7.2)
Dummy: plant located in Ontario				0.277*** (8.4)	0.275*** (8.4)
Dummy: plant located in Manitoba				0.174*** (2.9)	0.171*** (2.8)
Dummy: plant located in Saskatchewan				0.226** (2.3)	0.221** (2.2)
Dummy: plant located in Alberta				0.302*** (5.0)	0.302*** (5.0)
Dummy: plant located in British Columbia				0.314*** (7.6)	0.315*** (7.6)
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squares	0.36	0.37	0.39	0.40	0.40
Number of observations	5,653	5,653	5,653	5,653	5,653

Notes: The hypothesis of homoscedasticity is rejected. t-statistics are in parentheses, which are based on White heteroscedasticity-consistent standard errors.

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

extent associated with offshoring. Thus, with 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; 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 (e.g., Baldwin *et al*., 2004).

After control for operating location specific effects, the previous estimation results generally hold (Columns (4) and (5)). The new regressions show that plants located outside of maritime provinces and territories tend to be more productive.

5. Concluding Remarks

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

Using data from Statistics Canada's Survey of Innovation 2005, linked to the 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 Asia Pacific countries tends to be more associated with productivity performance than material offshoring to the U.S. and other locations.[21]

However, the results should be interpreted with caution, since our analysis 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 a firm's outward-oriented business strategies 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 indicator for pursuing an outward-oriented business strategy and that it is the latter, not the former, that is causing offshoring.

Finally, it should be noted that the result that material offshoring to Asia Pacific countries tends to be associated more with productivity than material offshoring to the U.S. and other locations may be justified by higher transaction cost associated with material offshoring to the Asia Pacific region. This conjecture merits further research.

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[21]These findings generally hold when plants whose operations are part of larger firms are excluded from the sample. This is expected given that about two-thirds of plants in the sample are single unit plants. The estimation results based on single unit plants are not reported.

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