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Industry Productivity in the Manufacturing Sector: The Role of Offshoring

by Lydia Couture, Aaron Sydor, and Jianmin Tang

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^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

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Lydia Couture, Economic Analysis Division, Statistics Canada
Aaron Sydor, Department of Foreign Affairs, Trade and Development
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Abstract

Two sources of industry productivity growth are firm productivity improvements and the reallocation of productive resources from less productive to more productive firms. This paper studies the role of offshoring in improving industry productivity through these two channels, using a new Canadian manufacturing data base that links the Annual Survey of Manufactures and the Importer Register database at the commodity level. The database provides information on direct imports of intermediate inputs by firms. This allows us to estimate offshoring intensity in Canada at the firm level, and to differentiate those imports by region of origin. The results show that compared with non-offshoring firms, firms engaging in offshoring have higher productivity, and that the productivity gain increases with offshoring intensity. In addition, this paper finds that offshoring facilitates resource reallocation within industries, especially when offshoring is to non-U.S. locations.

Keywords: offshoring, productivity

JEL Classifications: F14, L20

Executive summary

Using a Canadian manufacturing microdata base that links the Annual Survey of Manufactures and the Importer Register database at the commodity level, this paper examines the relationship between offshoring and industry productivity.

Offshoring refers to the sourcing of intermediate inputs for domestic production abroad. Specifically, in this paper, offshoring refers to goods imported directly by manufacturers, including both intra- and inter-firm transactions across international borders. Excluded, because of data limitations, are goods imported through intermediaries as well as services.

Firms engaging in offshoring are found to be more productive than those not engaging in offshoring. This result holds for those offshoring to either U.S. or to non-U.S. markets, but especially those offshoring to both locations simultaneously. On average, the labour productivity of a firm engaging in offshoring was 6.8% higher than a similar firm that did not offshore its intermediate inputs.

In addition, firms with higher offshoring intensity (measured by the share of inputs that are imported) are characterized by higher labour productivity levels. Multivariate analysis confirmed that these results hold even when firm characteristics, such as industry, nationality of ownership, exporter status, and being a multi-establishment firm, are taken into account.

While offshoring is found to have a positive relationship with productivity, this does not establish the direction of causality between offshoring and productivity. Granger causality tests are employed to explore the direction of causality.

The generalized method of moments (GMM) estimation is used to address the potential endogeneity issue. The results indicate that offshoring intensity generates higher productivity, especially for offshoring to non-U.S. locations.

The results show that offshoring has a direct effect on industry productivity by raising average firm-level productivity. Firms engaging in offshoring thus become more competitive and may then expand their market shares at the expense of less productive firms. The last sections examines whether offshoring has an indirect effect on industry productivity, by encouraging the reallocation of resources from less to more productive firms. They find that a larger percentage of productivity growth comes from resource reallocation from the less to the more productive firms in industries that have more offshoring, especially for offshoring to non-U.S. locations.

Further work needs to be undertaken since the present analysis applies only to manufacturing and is based on a short time series. Additional research based on a longer time series as well as in other sectors and on the timing of offshoring would provide useful extensions.

1 Introduction

Offshoring has been the subject of public and academic scrutiny in recent years. The term 'offshoring' often refers to the shift of domestic production of intermediate inputs to foreign locations. For some, offshoring has been associated with the loss of domestic jobs. For this reason, much of the debate in both public and academic circles has focused on the labour market impacts of offshoring (e.g., Blinder 2009; Feenstra and Hanson 1996, 1999, and 2003).

A less studied, but equally important aspect is the productivity impact of offshoring. If offshoring contributes to improvements in productivity, the firms that offshore inputs may become more competitive, expand market share, hire more workers, and pay higher wages. This potentially offsets short-term employment losses that may be related to offshoring.

The productivity impact of offshoring can be studied in a parallel fashion to investigations that explore the productivity impacts of exporting. Exporters have consistently been found to be more productive than non-exporters.[1] The challenge is to identify the direction of causation of this performance: is it that exceptional firms self-select into exporting, or that the act of exporting imparts benefits to those firms taking part in it? The case for firms self-selecting into exporting is strong, and is consistent with heterogeneous firm models of trade, such as those of Melitz (2003) and Bernard et al. (2003), whereby only the most productive firms find it profitable to export. Canadian research (Baldwin and Gu, 2003, 2004; Baldwin and Yan, 2012a, 2012b) confirm that entry to export markets is associated with increases in productivity in Canada.[2]

More recently, research on the impact of trade on productivity has been shifting to imports. Bernard et al. (2007), for example, demonstrate that importers have a similar profile to that of exporters, in that they are larger, more productive, and pay higher wages than non-importers.[3]

As with exporters, importers have been found to self-select when participating in importing. Morrison Paul and Yasar (2009) find that more productive Turkish manufacturing plants are more likely to purchase external inputs from both domestic and foreign sources. McCann (2011) also finds support for self-selection in the Irish case. The subsequent impact on productivity, however, has been identified more consistently in the case of importing than it has been with exporting. Egger and Egger (2006) and Amiti and Wei (2009) both identify the productivity effects of offshoring, using industry-level data for the European Union and the United States, respectively. However, the latter study shows that the effects for material offshoring were not significant in all specifications. In addition, Yasar and Morrison (2007), Kasahara and Rodrique (2008), Morrison Paul and Yasar (2009), and McCann (2011) all find direct evidence that offshoring leads to improved productivity performance.

This paper provides empirical evidence of the link between offshoring and firm and industry productivity in Canadian manufacturing. Specifically, three questions are addressed:

1. After controlling for other factors, is there a direct link between offshoring and firm productivity?
2. Which way does the causality run between offshoring and firm productivity?
3. Is offshoring related to the degree to which resources are reallocated within an industry via shifts from less to more productive firms?

1. Bernard and Jensen (1995, 1999), Mayer and Ottaviano (2007), Kugler and Verhoogen (2009).
2. For studies in other countries that find otherwise, see Clerides, Lach and Tybout (1998) using data for Mexico, Colombia and Morocco and Bernard and Jensen (1999) using data for the United States.
3. They also demonstrate that there is a high degree of overlap between exporters and importers, and firms that engage in both importing and exporting demonstrate the strongest performance.

Offshoring in this paper refers to goods imported directly by manufacturers, including both intra- and inter-firm transactions across international borders. Because of data limitations, goods imported through intermediaries, as well as services, are excluded.[4]

2 Data and measuring offshoring

The data for this study are taken from Statistics Canada's Annual Survey of Manufactures (ASM), which is linked to the Importer Register at the commodity level for the 2002-to-2006 period.[5] The microdata base provides data at the enterprise level, and contains information on production (shipments, value added, employment, total material cost, and fuel and power consumption), export status, foreign ownership, North American Industry Classification System (NAICS) six-digit code, import value by HS10 commodity (Harmonized System code), and source country.[6]

The capital input data that are required for productivity analyses are not available from the ASM and were imputed at the firm level. This was done by using the ratio of capital input to fuel and power consumption, derived from Statistics Canada's industry productivity database (often referred to as the KLEMS[7] database), at the detailed industry level. The capital input for a firm is calculated as the firm's fuel and power consumption multiplied by this ratio.

Offshoring intensity is defined as the share of imported intermediate inputs in a firm's total intermediate inputs. Traditionally, the 'proportionality assumption'—that an imported commodity is used in the same proportion for final consumption as for intermediate inputs—has been used to impute this measure. The accuracy of the proportionality assumption has recently been challenged (Couture, Tang and Yan forthcoming 2015). The linkage of the ASM and the Importer Register provides an estimate of offshoring intensity that does not rely on the proportionality assumption.[8] As previously noted, however, this measure of offshoring captures only intermediate inputs that are imported directly by the manufacturer.[9]

Table 1 reports the average offshoring intensity by industry for 2002 and 2006, as presented in Couture, Tang and Yan (forthcoming 2015). For the Canadian manufacturing sector as a whole, offshoring intensity was 26.5% in 2006—slightly down from 28.7% in 2002.[10] During this period, offshoring intensity increased in non-durable manufacturing industries, but this increase was offset by a sharp decline in the more offshoring-intensive durable manufacturing sector, because of declines in the highly integrated transportation equipment industry and the computer and electronic products industry. Nonetheless, both industries were still the two most offshoring-intensive manufacturing industries in 2006. On the other hand, the least offshoring-intensive industries were the food, printing, wood products, and clothing manufacturing industries.

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4. Service offshoring is much smaller in magnitude than material offshoring for manufacturing. For instance, according to Amiti and Wei (2009) material offshoring intensity for U.S. manufacturing in 2000 was 17.3% while service offshoring intensity was only 0.3%.
5. In 2007, the ASM was redesigned to adjust to changes in Statistics Canada's Business Register. The dataset used in this paper was specifically created for this project by choosing a period of time over which the components were defined consistently and could be reliably linked together.
6. For a description of the data linkage, see Couture, Tang and Yan (forthcoming 2015).
7 . KLEMS: capital (K), labour (L), energy (E), materials (M) and purchased services (S).
8. See Baldwin, Gu, Sydor and Yan (2013) for a discussion of alternate offshoring measures.
9. Baldwin et al. (2013) find that data on direct imports produce a measure of offshoring that is a good proxy for offshoring in the durables sector, but may underestimate offshoring in non-durables. This is because of the acquisition of imported intermediate inputs through third-party importers.
10. Prices are assumed to be the same for a given type of intermediate input, regardless of its origin. This may underestimate offshoring intensity, and may affect its trend development, as imported intermediate inputs, especially from emerging economies, are cheaper than domestic intermediate inputs (Houseman 2007). However, prices of imported intermediate inputs are not available to confirm this hypothesis.

Table 1
Offshoring intensity by industry, 2002 and 2006

	2002	2006
	percent	
Total manufacturing	28.7	26.5
Non-durables	16.4	20.9
Food	5.2	4.7
Beverage and tobacco	8.8	12.1
Textile	26.2	36.9
Textile product	14.0	16.2
Clothing	6.6	8.3
Leather	16.1	20.9
Paper	13.1	13.5
Printing	5.0	6.0
Petroleum and coal	22.8	33.8
Chemical	29.5	26.0
Plastics and rubber	28.1	27.4
Durables	38.4	31.6
Wood product	5.7	7.4
Non-metallic mineral	13.8	17.1
Primary metal	27.3	30.9
Fabricated metal	19.8	15.7
Machinery	22.6	22.3
Computer and electronic	43.7	37.9
Electrical equipment and appliance	29.4	27.2
Transportation equipment	60.0	45.8
Furniture	8.7	11.7
Miscellaneous	11.4	12.4

Source: L. Couture, J. Tang and B. Yan, 2015, *Offshoring and Business Organization: Evidence from Canadian Manufacturing firms,* mimeo, Industry Canada and Statistics Canada research paper. Forthcoming.

3 Offshoring and productivity

Using the newly-linked Canadian manufacturing microdata base, this paper studies the role of offshoring in industry productivity growth through improvements in firm productivity and the efficient allocation of resources among firms. These two possible impacts of offshoring on industry productivity performance are also discussed in Altomonte and Ottaviano (2011).

The framework for the analysis of the impact of offshoring on productivity uses a decomposition of industry productivity developed by Olley and Pakes (1996).

Let Z_t^i be the labour productivity of industry i, defined as the real value added per worker for that industry at time t, $Z_t^i = \sum_j l_t^{ij} Z_t^{ij}$, where l_t^{ij} and Z_t^{ij} are the labour share and labour productivity of firm j in industry i at time t, respectively. Following Olley and Pakes (1996), industry productivity is decomposed as

$$Z_t^i = \sum_j \left(\overline{l}_t^{\,i} + \Delta l_t^{ij}\right)\left(\overline{z}_t^i + \Delta z_t^{ij}\right) = \overline{z}_t^i + \sum_j \Delta l_t^{ij} \Delta z_t^{ij}, \qquad (1)$$

where $\overline{l}_t^{\,i}$ and $\overline{z}_t^i$ are the unweighted mean of firm labour shares and the unweighted mean of firm labour productivities in industry i, and Δl_t^{ij} and Δz_t^{ij} are the deviations of firm j's labour share and labour productivity from the means.

The covariance term is commonly referred to as the Olley and Pakes (OP) covariance term. It is a summary measure of the within-industry, cross-firm covariance between size and productivity. A high positive number suggests a more efficient resource (labour in our case) allocation from less to more productive firms within an industry.

Table 2 provides a snapshot of unweighted means of firm labour productivity and OP covariance terms, by industry, for 2006. The industry with the highest OP covariance was petroleum and coal, followed by beverage and tobacco, transportation equipment, and primary metal. Interestingly, those industries also tend to be highly productive. In fact, average firm labour productivity and OP covariance are strongly correlated, the correlation coefficient being 0.83. This suggests that resources tend to be efficiently allocated within industries with higher average firm productivity.

Table 2
Unweighted mean of firm labour productivity and Olley-Pakes covariance by industry, 2006

	Firm labour productivity	Olley-Pakes covariance
	unweighted mean	covariance
Total manufacturing	91.7	5.1
Non-durables	97.6	4.6
Food	83.8	1.9
Beverage and tobacco	151.4	16.3
Textile	70.5	2.4
Textile product	63.7	1.6
Clothing	47.1	0.4
Leather	39.0	0.7
Paper	130.3	5.3
Printing	94.3	0.9
Petroleum and coal	212.0	35.2
Chemical	187.8	10.0
Plastics and rubber	99.6	0.9
Durables	88.7	5.4
Wood product	114.3	2.9
Non-metallic mineral	105.3	3.5
Primary metal	123.4	11.2
Fabricated metal	80.4	1.2
Machinery	93.3	1.1
Computer and electronic	100.2	1.4
Electrical equipment and appliance	87.4	0.6
Transportation equipment	118.1	12.7
Furniture	54.0	0.9
Miscellaneous	73.4	0.4

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

In their paper, Olley and Pakes (1996) analyze productivity in the U.S. telecommunications equipment industry. The authors find that, following deregulation and rapid technological change, the primary source of productivity growth in that industry was through the reallocation of capital towards the more productive firms. Utilizing the OP covariance term, Bartelsman, Haltiwanger and Scarpetta (2013) find that capital allocation between firms within industries plays an important role in explaining cross-country difference in productivity. Furthermore, the authors find a larger reallocation of resources for transition economies, as they move to a market economy. Similarly to Olley and Pakes (1996) and Bartelsman, Haltiwanger and Scarpetta (2013), this study uses the OP covariance term to see if offshoring induces efficient reallocation of labour among firms within an industry.

According to the OP decomposition, industry productivity can vary (1) if there is a variation in the average firm productivity; and/or (2) if there is a variation in the covariance between firm size and firm productivity, as in Equation (1). Offshoring is thus expected to have a direct effect on industry productivity if it raises average firm-level productivity, and an indirect effect if it encourages a reallocation of resources from less to more productive firms.

3.1 Offshoring and firm productivity

Offshoring may directly improve productivity at the firm level, which will, in turn, raise the unweighted mean of firm labour productivity for each industry. There are a number of potential channels through which offshoring can affect productivity.

One channel is through a specialization effect that occurs when a firm focuses resources on its core activities. To the extent that these activities have a higher average productivity than activities being offshored, and that there are economies of scale in the core activities, the firm's overall productivity will increase. Indeed, Morrison Paul and Yasar (2009) find that firms tend to externally source relatively low-skilled and low-productivity activities, thus raising aggregate productivity levels.

An additional source of productivity gain from offshoring may come from the adoption of more advanced technologies, or what may be associated with a 'learning-by-offshoring' effect. This mirrors the better known learning-by-exporting effect. The firm may adopt best practices and improve its innovation performance when it is exposed to intense international competition, to the world technology frontier, and to the best global management practices. Bitzer and Geishecker (2006) find that imported intermediate inputs have a positive productivity effect through knowledge spillovers. Morrison Paul and Yasar (2009) also report a greater productivity impact for foreign-purchased inputs compared to domestically purchased inputs, which they interpret as supporting a technology transfer hypothesis that reflects similar findings from Yasar and Morrison Paul (2007). In addition, McCann (2011) finds that arms-length purchases produce greater productivity impacts than intra-firm trade, with the former having a stronger case for technology transfer.[11]

Offshoring may also affect a firm's productivity through its impact on input variety. By enabling the firm to choose from a wider variety of intermediate inputs, offshoring allows the firm to identify a better match between its inputs and outputs, resulting in improved economic performance. This matching effect is examined by Amiti and Konings (2007) and Goldberg et al. (2009) for Indonesia and India, respectively. Goldberg et al. (2009) conclude that an important aspect of opening industries to trade was the availability of new varieties of imported intermediate inputs—most notably, higher quality varieties from advanced countries.

Offshoring also enables the firm to access a large pool of expertise and maintain production flexibility.

To estimate the relationship between productivity and offshoring, the following regression model is used:

$$\begin{aligned}\ln(P_{i,t}^{j}) &= \alpha_0 + \alpha_1 \ln(k_{i,t}^{j}) + \alpha_2 OF_{i,t}^{j} + \alpha_3 F_{i,t}^{j} + \alpha_4 E_{i,t}^{j} + \alpha_5 \ln(S_{i,t}^{j}) \\ &+ \alpha_6 M_{i,t}^{j} + \sum_m \beta_m I_i + \sum_k \gamma_k T_k + \varepsilon_{i,t}^{j}, \end{aligned} \qquad (2)$$

where $\ln(P_{i,t}^{j})$ is labour productivity of firm j in industry i at time t, defined as log value added per worker;

$\ln(k_{i,t}^{j})$ is log capital input per worker for firm j;

$OF_{i,t}^{j}$ is offshoring, either log offshoring intensity of firm j or an offshoring incidence variable, which equals 1 if firm j engages in offshoring and 0 otherwise;

11. Gorg, Hanley and Strobl (2008), however, find no positive productivity impact for material offshoring, although they report a positive impact for service offshoring.

$F_{i,t}^{j}$ is a dummy variable for foreign ownership, which equals 1 if firm j in industry i is foreign-controlled and 0 otherwise;

$E_{i,t}^{j}$ is a dummy variable for exporting, which equals 1 if firm j in industry i exports and 0 otherwise;

$\ln(S_{i,t}^{j})$ is the firm size, as measured by the employment of firm j relative to the average employment for industry i;

$M_{i,t}^{j}$ is the dummy variable for multi-establishment, which equals 1 if firm j is a multi-establishment firm;

I_i is a dummy variable for industry, which equals 1 for industry i and 0 otherwise;

T_k is a dummy variable for year, which equals 1 for year k and 0 otherwise; and

$\varepsilon_{i,t}^{j}$ is the error term.

In the regression, controls for relative firm size, and whether it exports, is foreign-controlled, and is a multi-establishment structure are included. Each of those variables is directly or indirectly linked to productivity performance. This reflects firm-level specific characteristics such as economies of scale, innovation, special technology, management, and markets (Couture, Tang and Yan forthcoming 2015).

It has been shown that small producers are, on average, less productive than large ones (Baldwin, Jarmin and Tang 2004; Baldwin, Leung and Rispoli 2013; Tang 2014) and are less likely to benefit from economies of scale. Small producers may also have had less opportunity to learn how to make use of capital intensive techniques or have more difficulty obtaining financing than large producers, which may lead them to being less capital intensive. To reflect the impact of firm size, a size variable is introduced, defined as firm employment relative to the industry average.

Exporters have been found to have higher productivity levels. As discussed in the introduction, this can be either because highly productive firms self-select into exporting or because exporting improves firm productivity (Bernard and Jensen 1995; Baldwin and Gu 2003). Exporters are also more capital-intensive and innovative. Compared with non-exporters, they are more likely to acquire new technology from their international contacts, or are forced by international competition to become more innovative (Baldwin and Gu 2003).

Studies show that foreign-controlled firms in Canada are significantly more productive than Canadian-controlled firms because they are more innovative and benefit from advanced technology and superior managerial practices from their parent companies. They also pay higher wages and are more trade-oriented. As Baldwin and Gellatly (2007) summarize, foreign-controlled firms are found to be positively linked to higher productivity because of their scale, scope, diversified markets, unique technology, and superior business organizations.[12]

A control for multi-establishment structure is also included. Firms with a multi-establishment structure are found to be more productive than those that are stand-alone (Baldwin and Gu

12. Note, however, that studies show that the advantage for foreign-controlled plants is a multinational enterprise advantage, not an ownership one (Baldwin and Gu 2005). Canadian-controlled multinational enterprises perform equally well as foreign-controlled multinationals. Unfortunately, data are not available to identify Canadian multinationals in the data base used here.

2006). This is because the former are more likely to specialize to take advantage of economies of scale at the firm level, and to efficiently allocate resources among related plants.

Finally, dummy variables for year are introduced to capture business cycles, and dummy variables for industry to capture specific effects from differences in financial and technological opportunities across different industries.

3.1.1 Offshoring incidence and firm productivity

The first set of regressions examines labour productivity against the incidence of offshoring, controlling for other firm characteristics, as well as year- and industry-specific effects. The estimation is based on firm-level data, with 174,550 observations from 2002 to 2006. The results presented in Table 3 confirm expectations that capital intensity, foreign ownership, exporting, and large size are all positive and statistically significant. What is most relevant for this paper, firms engaging in offshoring are found to be more productive than those that do not engage in offshoring. This result holds for those offshoring either to U.S. or to non-U.S. markets, but especially for those offshoring to both U.S. and non-U.S. locations simultaneously. On average, the labour productivity of a firm engaging in offshoring was 6.8% higher than that of a similar firm that did not offshore.

Table 3
Offshoring incidence and firm labour productivity

	Ordinary least squares regression results					
	Regression 1		Regression 2		Regression 3	
	coefficient	p-value	coefficient	p-value	coefficient	p-value
Constant	7.46 **	0.00	7.73 **	0.00	7.74 **	0.00
Capital intensity	0.37 **	0.00	0.35 **	0.00	0.35 **	0.00
Offshoring (dummy variable)	0.10 **	0.00	0.07 **	0.00	...	...
To U.S. locations only	...	...	...	...	0.06 **	0.00
To non-U.S. locations only	...	...	...	...	0.05 **	0.00
To both U.S. and non-U.S. locations	...	...	...	...	0.08 **	0.00
Foreign control	...	...	0.17 **	0.00	0.17 **	0.00
Exporting	...	...	0.02 **	0.00	0.02 **	0.00
Relative firm employment	...	...	0.06 **	0.00	0.06 **	0.00
Multi-establishment structure	...	...	0.01	0.14	0.01	0.38

... not applicable

** significantly different from reference category (p<0.01)

Notes: All regressions include dummy variables for industry and year. The number of observations is 174,550. The adjusted R-squared is 0.36 in Regression 1 and 0.38 in Regressions 2 and 3.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

3.1.2 Offshoring intensity and firm productivity

This section asks whether more offshoring associated is with higher productivity. The offshoring incidence from the previous regressions is replaced with a measure of offshoring intensity. Offshoring intensity is positively and significantly associated with productivity (regressions 1 to 3 in Table 4-1). Once again, the results are robust to the inclusion of controls for foreign ownership, exporting, and being multi-establishment. It is noteworthy that the coefficient on offshoring to non-U.S. locations is modestly larger than that on U.S. offshoring, suggesting that the productivity link to non-U.S. offshoring is greater than that to U.S. offshoring.

Table 4-1
Relationship between firm labour productivity and offshoring intensity, all firms and unbalanced panel — Ordinary least squares regressions

	Regression 1		Regression 2		Regression 3	
	coefficient	p-value	coefficient	p-value	coefficient	p-value
Constant	7.46 **	0.00	7.74 **	0.00	7.74 **	0.00
Capital intensity	0.37 **	0.00	0.35 **	0.00	0.35 **	0.00
Offshoring intensity	0.26 **	0.00	0.14 **	0.00	...	...
U.S. offshoring intensity	...	...	...	...	0.12 **	0.00
Non-U.S. offshoring intensity	...	...	...	...	0.17 **	0.00
Foreign control	...	...	0.15 **	0.00	0.15 **	0.00
Exporting	...	...	0.02 **	0.00	0.02 **	0.00
Relative firm employment	...	...	0.06 **	0.00	0.07 **	0.00
Multi-establishment structure	...	...	0.02 *	0.04	0.02 *	0.03

... not applicable

* significantly different from reference category ($p<0.05$)

** significantly different from reference category ($p<0.01$)

Notes: All regressions include dummy variables for year and industry. The number of observations is 174,050. The adjusted R-squared is 0.36 in Regression 1 and 0.38 in Regressions 2 and 3.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

The positive relationship between offshoring intensity and labour productivity continues to hold when the regressions are estimated with firm fixed effects (Regressions 4 to 6 in Table 4-2). Firm fixed effects are introduced to control for firm-specific factors that are time-invariant over the sample period, including a firm-specific productivity advantage due to superior management practices, advanced manufacturing processes, or innovative products. Interestingly, however, the firm size variable becomes negative in the new regressions. As estimations with firm fixed effects are used primarily to study changes over time, this result may suggest that large firms were disproportionally affected by the deterioration of external demand conditions in the post-2000 period. It is consistent with the finding that the labour productivity level of large manufacturing firms, relative to its industry average, declined between 2002 and 2007, while it improved for small manufacturing firms (Tang 2014).

Table 4-2
Relationship between firm labour productivity and offshoring intensity, all firms and unbalanced panel — Fixed effects

	Regression 4		Regression 5		Regression 6	
	coefficient	p-value	coefficient	p-value	coefficient	p-value
Constant	8.03 **	0.00	8.08 **	0.00	8.08 **	0.00
Capital intensity	0.32 †	0.00	0.29 **	0.00	0.30 **	0.00
Offshoring intensity	0.14 †	0.00	0.13 **	0.00	...	...
U.S. offshoring intensity	...	...	...	...	0.12 **	0.00
Non-U.S. offshoring intensity	...	...	...	...	0.15 **	0.00
Foreign control	...	...	0.05 †	0.06	0.05 †	0.06
Exporting	...	...	0.02 **	0.00	0.02 **	0.00
Relative firm employment	...	...	-0.26 **	0.00	-0.17 **	0.00
Multi-establishment structure	...	...	0.07 **	0.00	0.07 **	0.00

... not applicable

** significantly different from reference category (p<0.01)

† significantly different from reference category (p<0.10)

Notes: All regressions include dummy variables for year. The number of observations is 174,050. The adjusted R-squared is 0.24 in Regression 4 and 0.19 in Regressions 5 and 6.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

3.1.3 Causality between offshoring and firm productivity

The regressions reported in Table 3 and the regressions in Tables 4-1 and 4-2 establish that there is a relationship between offshoring and firm productivity. They cannot, however, address the direction of causation between offshoring and productivity. A characteristic of one of the most cited theoretical models of offshoring predicts that firms with high productivity are more likely to engage in offshoring activities than firms with low productivity (Antràs and Helpman 2004) Amiti and Wei (2009), Morrison Paul and Yasar (2009). More recently, Altomonte and Ottaviano (2011) empirically examine the issue of endogeneity between offshoring and productivity.

To shed light on this important issue, a Granger causality test is employed to see if offshoring 'Granger-causes' productivity. This involves using F-tests to test whether or not lagged offshoring variables provide any statistically significant information about productivity in the presence of lagged productivity variables.[13] If not, then offshoring does not 'Granger-cause' productivity. A similar test can also be employed to verify if productivity Granger-causes offshoring. The tests show that both hypotheses are accepted at the 1% significance level. The hypotheses evaluate the predictive links between offshoring and productivity, and the results suggest a potential endogeneity issue associated with offshoring.[14]

To address this issue, the offshoring intensity regression model is estimated, using the generalized method of moments (GMM) estimation. Besides offshoring, capital intensity is also considered to be endogenous, since productivity shocks may affect capital formation. With lagged offshoring and capital intensity being the instruments, the GMM estimation, once again,

13. See Alexopoulos (2011) for such a test.
14. It is important to note that the Granger causality test is used to determine if offshoring is useful in forecasting productivity (or if productivity is useful in forecasting offshoring). It is not sufficient to determine true causality.

shows that offshoring—especially offshoring to non-U.S. locations—is positively related to productivity (Regressions 7 to 9 in Table 4-3).[15]

Table 4-3
Relationship between firm labour productivity and offshoring intensity, all firms and unbalanced panel — Generalized method of moments estimation

	Regression 7		Regression 8		Regression 9	
	coefficient	p-value	coefficient	p-value	coefficient	p-value
Constant	7.48 **	0.00	7.94 **	0.00	7.94 **	0.00
Capital intensity	0.35 **	0.00	0.31 **	0.00	0.31 **	0.00
Offshoring intensity	0.29 **	0.00	0.15 **	0.00	...	...
U.S. offshoring intensity	...	...	...	...	0.14 **	0.00
Non-U.S. offshoring intensity	...	...	...	...	0.17 **	0.00
Foreign control	...	...	0.18 **	0.00	0.18 **	0.00
Exporting	...	...	0.02 **	0.00	0.02 **	0.00
Relative firm employment	...	...	0.06 **	0.00	0.06 **	0.00
Multi-establishment structure	...	...	0.03 **	0.00	0.03 **	0.00

... not applicable

** significantly different from reference category (p<0.01)

Notes: For the generalized method of moments estimation, the endogenous variables are offshoring and capital intensity, with instruments being their lags. All regressions include dummy variables for year and industry. The number of observations is 104,793. The adjusted R-squared is 0.37 in Regression 7 and 0.39 in Regressions 8 and 9.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

3.1.4 Robustness check with additional estimations

So far, the econometric analysis has been based on an unbalanced panel, with all firms in the database. Most missing observations are from new entrants or exits. The specific pattern of missing observations indicates that the observations may not be missing at random. If this is the case, the estimation results may be biased and inconsistent.

To see whether the unbalanced panel affects our results, the regressions in Tables 4-1, 4-2 and 4-3 are re-estimated by using a balanced panel consisting of firms with observations for each year from 2002-to-2006. The estimation results based on the balanced panel are reported in Tables 5-1, 5-2 and 5-3. They confirm the findings based on the unbalanced panel (Table 4) under each of the three different estimation methodologies.

15. GMM estimations were also conducted with current and lagged material use per worker as additional instrument variables, and produced similar results.

Table 5-1
Relationship between firm labour productivity and offshoring intensity, all firms and balanced panel — Ordinary least squares regressions

	Regression 1		Regression 2	
	coefficient	p-value	coefficient	p-value
Constant	8.65 **	0.00	8.65 **	0.00
Capital intensity	0.26 **	0.00	0.26 **	0.00
Offshoring intensity	0.16 **	0.00	...	...
U.S. offshoring intensity	...	...	0.13 **	0.00
Non-U.S. offshoring intensity	...	...	0.20 **	0.00
Foreign control	0.27 **	0.00	0.28 **	0.00
Exporting	0.05 **	0.00	0.05 **	0.00
Relative firm employment	-0.01 **	0.00	-0.01 **	0.00
Multi-establishment structure	0.11 **	0.00	0.11 **	0.03

... not applicable

** significantly different from reference category (p<0.01)

Notes: All regressions include dummy variables for year and industry. The number of observations is 75,711. The adjusted R-squared is 0.36.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 5-2
Relationship between firm labour productivity and offshoring intensity, all firms and balanced panel — Fixed effects

	Regression 3		Regression 4	
	coefficient	p-value	coefficient	p-value
Constant	8.79 **	0.00	8.79 **	0.00
Capital intensity	0.23 **	0.00	0.23 **	0.00
Offshoring intensity	0.11 **	0.00	...	...
U.S. offshoring intensity	...	...	0.10 **	0.00
Non-U.S. offshoring intensity	...	...	0.13 **	0.00
Foreign control	0.04	0.27	0.04 †	0.27
Exporting	0.02 **	0.00	0.02 **	0.00
Relative firm employment	-0.22 **	0.00	-0.22 **	0.00
Multi-establishment structure	0.08 *	0.01	0.08 **	0.00

... not applicable

* significantly different from reference category (p<0.05)

** significantly different from reference category (p<0.01)

† significantly different from reference category (p<0.10)

Notes: All regressions include dummy variables for year. The number of observations is 75,711.
The adjusted R-squared is 0.22.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 5-3
Relationship between firm labour productivity and offshoring intensity, all firms and balanced panel — Generalized method of moments estimation

	Regression 5		Regression 6	
	coefficient	p-value	coefficient	p-value
Constant	8.59 **	0.00	8.59 **	0.00
Capital intensity	0.25 **	0.00	0.25 **	0.00
Offshoring intensity	0.18 **	0.00	...	...
U.S. offshoring intensity	...	...	0.15 **	0.00
Non-U.S. offshoring intensity	...	...	0.23 **	0.00
Foreign control	0.27 **	0.00	0.27 **	0.00
Exporting	0.04 **	0.00	0.04 **	0.00
Relative firm employment	0.00	0.87	0.00	0.86
Multi-establishment structure	0.10 **	0.00	0.10 **	0.00

... not applicable

** significantly different from reference category (p<0.01)

Notes: For the generalized method of moments estimation, the endogenous variables are offshoring and capital intensity, with instruments being their lags. All regressions include dummy variables for year and industry. The number of observations is 59,490. The adjusted R-squared is 0.37.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

The previous regressions are estimated using data with both offshoring and non-offshoring firms. The results may, to a large extent, reflect the productivity difference between these two groups of firms. To see whether this is an issue, the previous regressions were re-estimated with data on offshoring firms only. The estimation results with the unbalanced panel are reported in Tables 6-1, 6-2 and 6-3, while the results for the balanced panel are reported in Tables 7-1, 7-2 and 7-3. Once again, both sets of regressions support the conclusion that offshoring intensity is positively and significantly associated with productivity, especially for offshoring to non-U.S. locations.

Table 6-1
Relationship between firm labour productivity and offshoring intensity, offshoring firms and unbalanced panel — Ordinary least squares regressions

	Regression 1		Regression 2	
	coefficient	p-value	coefficient	p-value
Constant	8.87 **	0.00	8.87 **	0.00
Capital intensity	0.23 **	0.00	0.23 **	0.00
Offshoring intensity	0.09 **	0.00	...	...
U.S. offshoring intensity	...	...	0.07 **	0.00
Non-U.S. offshoring intensity	...	...	0.12 **	0.00
Foreign control	0.23 **	0.00	0.24 **	0.00
Exporting	0.03 **	0.00	0.03 **	0.00
Relative firm employment	0.02 **	0.00	0.02 **	0.00
Multi-establishment structure	0.11 **	0.00	0.11 **	0.03

... not applicable

** significantly different from reference category (p<0.01)

Notes: All regressions include dummy variables for year and industry. The number of observations is 65,195. The adjusted R-squared is 0.33.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 6-2
Relationship between firm labour productivity and offshoring intensity, offshoring firms and unbalanced panel — Fixed effects

	Regression 3		Regression 4	
	coefficient	p-value	coefficient	p-value
Constant	9.39 **	0.00	9.39 **	0.00
Capital intensity	0.17 **	0.00	0.17 **	0.00
Offshoring intensity	0.06 **	0.00	...	...
U.S. offshoring intensity	...	...	0.05 †	0.09
Non-U.S. offshoring intensity	...	...	0.08 *	0.04
Foreign control	-0.01	0.87	-0.01	0.87
Exporting	0.01 **	0.00	0.02 **	0.00
Relative firm employment	-0.25 **	0.00	-0.25 **	0.00
Multi-establishment structure	0.06 †	0.05	0.06 †	0.05

... not applicable

* significantly different from reference category (p<0.05)

** significantly different from reference category (p<0.01)

† significantly different from reference category (p<0.10)

Notes: All regressions include dummy variables for year. The number of observations is 65,195. The adjusted R-squared is 0.19.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 6-3
Relationship between firm labour productivity and offshoring intensity, offshoring firms and unbalanced panel — Generalized method of moments estimation

	Regression 5		Regression 6	
	coefficient	p-value	coefficient	p-value
Constant	9.12 **	0.00	9.12 **	0.00
Capital intensity	0.21 **	0.00	0.21 **	0.00
Offshoring intensity	0.13 **	0.00	...	...
U.S. offshoring intensity	...	...	0.12 **	0.00
Non-U.S. offshoring intensity	...	...	0.13 **	0.00
Foreign control	0.26 **	0.00	0.26 **	0.00
Exporting	0.03 **	0.00	0.03 **	0.00
Relative firm employment	0.01 *	0.04	0.01 *	0.04
Multi-establishment structure	0.12 **	0.00	0.12 **	0.00

... not applicable

* significantly different from reference category (p<0.05)

** significantly different from reference category (p<0.01)

Notes: For the generalized method of moments estimation, the endogenous variables are offshoring and capital intensity, with instruments being their lags. All regressions include dummy variables for year and industry. The number of observations is 37,562. The adjusted R-squared is 0.36.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 7-1
Relationship between firm labour productivity and offshoring intensity, offshoring firms and balanced panel — Ordinary least squares regressions

	Regression 1		Regression 2	
	coefficient	p-value	coefficient	p-value
Constant	9.18 **	0.00	9.18 **	0.00
Capital intensity	0.20 **	0.00	0.20 **	0.00
Offshoring intensity	0.14 **	0.00	...	...
U.S. offshoring intensity	...	...	0.12 **	0.00
Non-U.S. offshoring intensity	...	...	0.17 **	0.00
Foreign control	0.34 **	0.00	0.34 **	0.00
Exporting	0.05 **	0.00	0.05 **	0.00
Relative firm employment	-0.03 **	0.00	-0.03 **	0.00
Multi-establishment structure	0.17 **	0.00	0.17 **	0.03

... not applicable

** significantly different from reference category (p<0.01)

Notes: All regressions include dummy variables for year and industry. The number of observations is 39,588. The adjusted R-squared is 0.37.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 7-2
Relationship between firm labour productivity and offshoring intensity, offshoring firms and balanced panel — Fixed effects

	Regression 3		Regression 4	
	coefficient	p-value	coefficient	p-value
Constant	9.63 **	0.00	9.63 **	0.00
Capital intensity	0.15 **	0.00	0.15 **	0.00
Offshoring intensity	0.07 **	0.00	...	...
U.S. offshoring intensity	...	...	0.06 †	0.09
Non-U.S. offshoring intensity	...	...	0.09 *	0.02
Foreign control	0.02	0.62	0.02	0.63
Exporting	0.02 **	0.00	0.02 **	0.00
Relative firm employment	-0.29 **	0.00	-0.29 **	0.00
Multi-establishment structure	0.07	0.10	0.07 **	0.10

... not applicable

* significantly different from reference category (p<0.05)

** significantly different from reference category (p<0.01)

† significantly different from reference category (p<0.10)

Notes: All regressions include dummy variables for year. The number of observations is 39,588.
The adjusted R-squared is 0.23.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

Table 7-3
Relationship between firm labour productivity and offshoring intensity, offshoring firms and balanced panel — Generalized method of moments estimation

	Regression 5		Regression 6	
	coefficient	p-value	coefficient	p-value
Constant	9.15 **	0.00	9.15 **	0.00
Capital intensity	0.20 **	0.00	0.20 **	0.00
Offshoring intensity	0.16 **	0.00	...	...
U.S. offshoring intensity	...	...	0.14 **	0.00
Non-U.S. offshoring intensity	...	...	0.19 **	0.00
Foreign control	0.32 **	0.00	0.32 **	0.00
Exporting	0.04 **	0.00	0.04 **	0.00
Relative firm employment	-0.02 **	0.00	-0.02	0.00
Multi-establishment structure	0.16 **	0.00	0.16 **	0.00

... not applicable

** significantly different from reference category (p<0.01)

Notes: For the generalized method of moments estimation, the endogenous variables are offshoring and capital intensity, with instruments being their lags. All regressions include dummy variables for year and industry. The number of observations is 27,851. The adjusted R-squared is 0.38.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

3.2 Offshoring and resource allocation

The productivity performance of an industry depends not only on the productivity performance of firms within the industry, but also on how productive resources are allocated among those firms because of heterogeneity in the productivity performance of firms. As discussed before, offshoring allows firms to focus on their core competence, take advantage of inexpensive foreign intermediate inputs and special skills/expertise, and adopt a scalable business model that relies more on variable than fixed-cost structures. As a result, offshoring firms become more productive. This may push those firms to expand their market shares, at the expense of less productive firms, leading to the reallocation of resources from less productive to more productive firms within an industry.

This shift in labour, from less to more productive firms within an industry, will be reflected in the OP covariance term from Equation (1). To test the relationship between offshoring and the impact of reallocation of labour among less and more productive firms within an industry, the following regression model is used:

$$OP_{i,t} = \alpha_0 + \alpha_1 OF_{i,t} + \sum_j \beta_j I_j + \sum_k \gamma_k T_k + \varepsilon_{i,t}, \quad (3)$$

where $OP_{i,t}$ is the OP covariance for industry i;

$OF_{i,t}$ is the offshoring intensity of industry i;

I_j is a dummy variable for industry, equal to 1 for industry j and 0 otherwise;

T_k is a dummy variable for year, equal to 1 for year k and 0 otherwise; and

$\varepsilon_{i,t}$ is the error term.

Year dummies are introduced to capture business cycle effects, and industry dummies are introduced to capture industry-specific effects, such as the extent of industry concentration.

The results of an estimation of OP covariance against offshoring is reported in Table 8, which are based on data at the detailed industry level (six-digit NAICS level). The coefficients show a positive and highly significant link between offshoring and the OP covariance term. Notably, it is offshoring to non-U.S. locations that generates this result. The results continue to hold when the regressions are estimated using the GMM, with the endogenous offshoring variables being instrumented by lagged offshoring and exporting variables.

The finding that offshoring to non-U.S. locations was mainly responsible for the link between offshoring and efficient resource allocation suggests that offshoring to U.S. locations plays a different role in firm business organization and production than offshoring to non-U.S. locations. This is possible, given that the differences in many factors (e.g., labour supply and costs) between Canada and non-U.S. locations, especially Asian countries, are larger than those between Canada and the United States.

Table 8
Estimation of resource allocation against offshoring

	Ordinary least squares						Generalized method of moments estimation			
	Regression 1		Regression 2		Regression 3		Regression 4		Regression 5	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Constant	3.75 **	0.00	2.31 **	0.00	2.51 **	0.00	2.83 **	0.00	2.73 **	0.00
Offshoring intensity	...	...	8.06 **	0.00	...	...	6.74 **	0.00	...	...
Offshoring to U.S. locations	...	...	...	...	3.14	0.10	...	...	2.83	0.28
Offshoring to non-U.S. locations	...	...	...	...	17.10 **	0.00	...	...	16.10 **	0.01

... not applicable

** significantly different from reference category (p<0.01)

Notes: Instruments for the generalized method of moments estimation are lagged offshoring and exporting intensities. All regressions include dummy variables for industry and year. The number of observations is 1,295 for ordinary least squares regressions and 1,036 for generalized method of moments estimations. The adjusted R-squared ranges from 0.23 to 0.30.

Source: Statistics Canada, authors' calculations based on data from the linked Annual Survey of Manufactures and Importer Register.

4 Conclusion

This paper investigated the relationship between offshoring and industry productivity with a new Canadian manufacturing microdata base that links the Annual Survey of Manufactures and the Importer Register at the commodity level. Goods imported through intermediaries and services from foreign countries were excluded because of data limitations. Offshoring was estimated using data on intermediate inputs directly imported by enterprises for the production of other goods. These direct imports represent an important segment of firm participation in global value chains. The results are consistent with previous findings in that the causality between offshoring and productivity may be reciprocal. They are also consistent with the theoretical prediction that more productive firms are more likely to engage in offshoring. Using GMM estimation to address this endogeneity issue, this paper found evidence that the firm productivity premium increases with offshoring intensity, which suggests that offshoring improves firm productivity. In addition, it showed that offshoring is associated with the reallocation of resources (i.e., labour) within industries from less productive to more productive firms.

The finding that offshoring to non-U.S. markets generates a larger effect on firm productivity and resource allocation than offshoring to U.S. markets may suggest that offshoring to non-U.S. locations plays a different role in firm business organization and production than offshoring to U.S. locations.

These results provide additional support to the important role of international trade in industry productivity performance. They show that productivity gains are possible, not only through exporting, which has been the primary focus of most academic and policy analyses, but also through importing and offshoring. The results are also consistent with the literature that indicates that international production sharing is associated with stronger competitiveness, not only at the firm level, but also at the industry level (e.g., Altomonte and Ottaviano 2011).

Further work needs to be undertaken in this area since the present analysis applies only to manufacturing and is based on a short time series, in which endogeneity could be persistent. Additional research based on a longer time series as well as on information about other sectors and the timing of offshoring would provide useful extensions. In addition, further studies are required to examine the impact of offshoring on other economic variables that are important to the Canadian economy, including job creation.

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