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Adapting to Import Competition: Effects of Low-wage Trade on Commodity Mix in Canadian Manufacturing Plants

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Abstract

The paper investigates how Canadian manufacturing plants adjust to an increase in low-wage import competition by changing their commodity portfolios. At the commodity level, we distinguish between 'core' versus 'peripheral' and differentiated versus homogeneous commodities. We also account for cost and technological complementarities using input-output linkages between commodities produced by a plant. We document large commodity turnover within plants over the period from 1988 to 1996. The largest changes happened in multi-commodity plants and involved peripheral commodities. The commodities that were affected the most were those commodities that are potentially used as inputs in production of the 'core' commodity; homogeneous (rather than differentiated) commodities; and, commodities with relatively weak input complementarities with the core product. Plants experiencing large import competition shifted their output toward production of their core commodity and away from production of unrelated peripheral commodities.

Keywords: import competition, product mix

Executive summary

Increasing import competition from low-wage countries over the last decade has provided challenges to the manufacturing sector in Canada. This paper investigates the adaptation that Canadian manufacturing plants have made in their product portfolios. It investigates differences in the rate at which products have been dropped as import competition has increased, and how the boundaries of the firm have changed in response to this competition.

It first asks whether import competition has been found in particular products and particular plants. It then asks whether there is a particular pattern in the exit rates of commodities that suggest that firms have adapted by dropping peripheral or unrelated commodities, and whether this is associated with improvements in performance.

The paper addresses a number of questions.

(1) Do plants facing an increase in low-wage import competition move away from it by divesting products?

The elasticity estimates that are derived indicate that a 10% increase in the initial level of competition a commodity faced in 1988 from low-wages countries increases the exit rate of a commodity by 1.6%, and a 10% change in import competition over the estimating period (1988 to 1996) further increases the exit rate by 0.5%.

The responses differ across types of plants. In particular, larger plants are significantly less likely to divest any type of commodities, while plants with a larger number of commodities produced during the beginning of the period had a higher likelihood of product divestitures. High-productivity plants are less likely to drop commodities.

(2) Does the increase in the low-wage import competition have a stronger effect on the exit of relatively standardized products?

The results show that import competition has a much stronger effect on the exit of homogeneous products than on the exit of differentiated products.

(3) Does the effect of imports differ for core and peripheral products? Does a rise in low-wage import competition force firms to become more specialized in producing core outputs?

Low-wage import competition has no significant effect on the dynamics of core commodities. The lack of effect on core commodities indicates that low-wage import competition is re-shaping commodity composition through inducing changes in peripheral commodities produced by multi-commodity plants.

(4) Does the effect on peripheral commodities depend on technological complementarities between the production of the core and peripheral products? In particular, is it the case that peripheral commodities sharing strong technological complementarities with a core product are less affected by competition from low-wage countries?

Peripheral commodities that faced high import competition from low-wage countries in 1988 were more likely to be divested, and the effect was particularly high for undifferentiated commodities. An increase in the import competition increases exit rates of technologically unrelated commodities, while it somewhat reduces exit rates for technologically related peripheral commodities.

A 10% increase in import competition from low-wage countries increases exit rates among vertically integrated commodities by 3.1% and has no statistically significant effect on non-vertically linked peripheral commodities. The effect of low-wage import competition on the exit of vertically linked commodities is much stronger for homogeneous commodities and those relatively technologically unrelated commodities.

(5) Does an increase in low-wage import competition induce firms to change the focus of their production?

Plants that experienced a high level of low-wage import competition in 1988 were more likely to increase the output share of the core commodity and reduce the output share of unrelated peripheral commodities. Increases in low-wage import competition further contributed to the fall in the output share of unrelated peripheral commodities. These findings support the hypothesis that exposure to low-wage import competition contributes to restructuring within Canadian manufacturing plants, which leads to concentration on core-product lines.

(6) Does the productivity of plants that restructure and focus on core activities increase at a higher rate than does that of those plants that do not make this adjustment?

Plants that have restructured over the period by focusing more on their core commodities generally had higher rates of productivity increases.

Our earlier work (Baldwin, Beckstead and Caves 2002; Baldwin, Caves and Gu 2005; Baldwin and Gu 2008) has demonstrated that Canadian manufacturing plants have responded to trade liberalization with the United States and Mexico by reducing the diversity of their product lines and by increasing their length of production runs. The present study extends this analysis to consider how adaptation is occurring to new developments emerging in the form of competition from low-wage countries. It, too, finds that specialization is being engendered—but this time it is occurring in smaller, lower productivity plants. Smaller plants with sub-optimal productivity performance are more likely to focus on core products. Larger multi-product firms also adapt by dropping peripheral, more standardized products that have less technological complementarity to their core-product offering.

1 Introduction

In recent decades, the Canadian economy has experienced substantial changes in its trade exposure. The signing of the Canada–United States Free Trade Agreement (FTA) in 1988 resulted in a two-fold increase in imports from and exports to the United States over the following decade. In addition, there has been a continuous increase in imports from less developed countries since the early 1990s.

Increases in import competition can re-shape the organizational structure of Canadian firms in a number of ways. Falling transportation costs and tariffs may induce Canadian firms to close plants or divest lines of business in which Canada does not have a comparative advantage. For example, more labour-intensive production activities may move out of Canada to countries with lower labour costs. Also, competitive pressure may force firms to behave more efficiently by specializing their production and increasing their focus on core activities.[1]

As a result, a fall in trade costs may affect production of both final goods and intermediate inputs. Indeed, as the evidence suggests, Canadian companies have outsourced increasing shares of production abroad.[2] The ratio of imported to total intermediate inputs in Canada stayed virtually unchanged over the decade from 1974 to 1984, but it went up by 6% from 14.4% in 1984 to 20.2% in 1993.[3] Over this latter period, the rate of increase in outsourcing of intermediate inputs in Canada exceeded those of the United States, the United Kingdom and Japan.[4]

This paper investigates how import competition from low-wage countries over the 1988-to-1996 period affected manufacturing production in Canada. Specifically, we look at changes in commodity outputs of manufacturing plants by linking plant-level data on outputs of manufacturing commodities to commodity-level imports data.

The empirical literature on the effects of import competition on firm behaviour can be divided into two groups. The first includes studies that examine the effects of changes in import competition in general (Liu 2006, Bowen and Wiersema 2005), including papers that look at the effects of trade liberalization on firm or product dynamics (Baldwin and Gu 2008, Baggs 2005, Lileeva 2008). The second group contains studies that look specifically at the effects of the low-wage import competition on plant and firm strategies (Bernard, Jensen and Schott 2006). The focus of most of these studies is on the exit of plants or firms as a result of changes in imports.

The change in commodity portfolios of firms as a result of import competition has received less attention, but when the impact of import competition in this area has been studied, the focus has been on how commodity portfolios adapt to imports in general. For example, Baldwin, Beckstead and Caves (2002) report a fall in the number of commodities produced by manufacturing plants and increased specialization within 4-digit Standard Industrial Classification (SIC) industries in Canada following the FTA. In the same vein, Baldwin and Gu (2008) look at the effects of trade

1. See Baldwin and Gu (2008).
2. Baldwin and Gu (forthcoming).
3. Particularly large increases were observed in Electrical Machinery (13.8%) and Transportation Equipment (12.7%) industries.
4. Source: Campa and Goldberg (1997).

liberalization on the number of products and the length of manufacturing production runs in Canadian plants, and they report that tariff cuts lead to fewer products and longer production runs. Liu (2006) uses a Compustat database for the period from 1984 to 1996 and finds that a firm that faces an increase in imports of its core product protects the core-industry segment and shifts resources from peripheral industries to the core industry (i.e., contracts the output of peripheral products and expands the output of the core product). On the other hand, the firm that faces a rise in peripheral product imports drops its peripheral products. Bowen and Wiersema (2005) found that import competition in the core line of business reduces a firm's degree of diversification as measured by the Herfindahl index.

These papers do not relate within-firm restructuring directly to low-wage import competition. However, one exception is Bernard, Jensen and Schott (2006), who use the U.S. Longitudinal Research Database and report that U.S. firms close manufacturing plants in response to increased low-wage import competition. They also find that low-wage import competition leads to reallocation of output toward more capital-intensive plants.[5]

In this paper, we extend this research to investigate how commodities, rather than plants, adjust to competition from low-wage countries. This is done in several ways. First, the unit of observation in this study is a manufacturing commodity, defined using a very detailed commodity classification: the six-digit Canadian Standard Classification of Goods (SCG), which consists of over 5,000 commodities. In Liu (2006) and Bernard, Jensen and Schott (2006) commodities are defined at the U.S. SIC 4-digit industry level. Second, while Bernard, Jensen and Schott (2006) examine the exit of plants within firms, we look at divesture of commodities within plants that stay continuously on the market.[6] Third, unlike Liu (2006), whose focus is on overall volumes of imports, we focus specifically on low-wage competition. Fourth, we classify commodities based on a standardization index of product differentiation in order to capture the difference between homogeneous and differentiated products. This allows us to test the commodity life-cycle hypothesis that suggests import competition from low-wage countries should be more intense in the former area. Fifth, we also investigate the relationship between the low-wage import competition and vertical disintegration of production. Finally, both Liu (2006) and Bernard, Jensen and Schott (2006) employ U.S. data in their studies; Canadian data provide a different perspective, since Canada is a small open economy and has an overall higher import penetration.

2 Import competition and its effect on product bundling

In this paper, firms are treated as multi-period profit maximizers, willing to experiment with new packages of products that extend the boundaries of the firm, and letting the market sort the more successful from the less successful. Shocks, coming from exogenous events that increase competitive pressures, will cause a re-evaluation of strategies and the adoption of new policies. It is this adaptation process that we examine here.

5. Our database does not have capital data, so we are not able to replicate Bernard, Jensen and Schott (2006) results for Canada.
6. Liu (2006) uses a Compustat database in which each firm produces in one or several Standard Industrial Classification 4-digit level segments. The exit of a segment may, or may not, signify the exit of a plant.

Firms are heterogeneous entities that experiment with different packages of product lines. Non-core products are introduced to develop complementarities in demand and to reduce costs. In the latter case, firms are assumed to add products to exploit scale economies at the plant level. These products may allow the firm to exploit plant-scale economies, even in the face of scope diseconomies. Or they may allow for the exploitation of scope economies, when the latter exist.

In this world, the impact of import competition will affect unit costs when sales in some product lines decline and affect the firm's overall profits. Product portfolios will be adjusted accordingly. The exact effect of trade restrictions, or liberalization, on firms' diversification choices depends on how competition is modelled. The effect of size on the organization of production depends on how firms compete, the extent to which a product is differentiated, the supply of potential entrants, etc. However, under reasonably general conditions, increased competition should be expected to induce a lower price in parts of the product line and a decline in demand for domestic products. The decline in demand for products will increase unit costs for these products, which will have the most impact on products that have greater product-specific scale economies. In addition, this will affect the unit costs of other products, if there is cost complementarity across products. Products whose cost rises substantially because they have greater production-run diseconomies will be dropped first, because their increased costs are no longer offset by their contribution to plant-scale economies.[7] Products that have little cost complementarity will also be discarded earlier than others.

Estimating the product-level responses to changes in import competition helps to improve our understanding of the ways by which international trade re-shapes the boundaries of a firm. This paper extends the existing literature on boundaries of the firm in several ways. First, we look at differential effects of trade on core and peripheral products, and assume that a firm has a strong competency in producing its key, or 'core,' product.[8] We define the 'core' output using volumes of shipments, i.e., the 'core' commodity of a firm generates the largest proportion of the firm's sales. Second, firms are assumed to produce multiple products that are related to one another through technological complementarities (or scope economies), which make joint production of several products more profitable (Milgrom and Roberts 1992). The ways in which a firm will alter its product mix in response to import competition will depend on the strength of these complementarities and the size of scale economies in each product line. As such, the effects of trade will differ across different goods produced by a firm. Products outside the core are less likely to be large-volume products and to suffer from unit costs that are well above long-run minimum-unit costs. Competition from abroad that reduces sales will lead to rapidly escalating costs in these product lines that may quickly offset scope advantages.

Adaptation to lower trade barriers is also expected because plants that produce both final goods and intermediate inputs used in production of the final goods may disintegrate production and start outsourcing inputs from low-wage countries. The incentive to outsource part of the production process may vary by type of product. Core and peripheral products vary in terms of

7. See Baldwin, Caves and Gu (2005) for a discussion of these trade-offs for a multi-product firm facing competition.
8. The concept of 'core competency' in the theory of the firm was originally used in Prahalad and Hamel (1990) Aghion and Tirole (1995, 1997), Porter (1998).

their contribution to overall profitability. The former are more essential to a firm's existence and therefore offshoring may be expected to be concentrated in the latter areas.

We document large commodity turnover within plants over the period from 1988 to 1996. We also show that this turnover is, in part, related to changes in trade. Increases in a particular commodity's trade with low-wage countries are strongly associated with a higher probability of this commodity being discontinued. The response is particularly strong among multi-commodity plants and it involves changes in peripheral commodities. The commodities that are affected the most are those commodities that are potentially used as inputs in production of the 'core' commodity; homogeneous, rather than differentiated, commodities; and, commodities with relatively weak input complementarities with the core product. Plants experiencing large import competition are also found to shift their output toward production of the core commodity and away from the production of unrelated peripheral commodities.

2.1 Hypotheses

Since the literature on the theory of the firm and the impacts of trade upon manufacturing plants provides us with a rich set of testable hypotheses, we make use of a number of different models of international trade to inform our analysis.

A large body of theoretical literature on the impact of trade reforms considers only single-commodity firms. In monopolistic competition models with firms producing a single differentiated commodity, an increase in import competition induces exit of less productive plants (e.g., Melitz 2003). Baldwin and Gu (2008) have extended this model to firms producing multiple commodities and they show that an increase in exposure to international competition leads to a decline in the number of products produced by plants and to an increase in specialization. Bernard, Redding and Schott (2006) develop a model of multi-product firms in which trade liberalization induces exit of marginally productive products.

With regard to the effects of trade with low-wage countries, Jensen and Thursby (1987) developed a dynamic, product-cycle model of trade in which innovation is done in the North. 'New' goods are introduced and produced in the North. 'Old' goods—those whose production technology has become public knowledge—are produced in the South. Using this model, intensified competition from the South induces the North to reallocate resources toward research and development in order to introduce new products and to reduce resources devoted to production that relocates to the South. These models provide us with our first hypothesis:

> **Hypothesis 1:** Plants facing an increase in low-wage import competition will move away from it by divesting products.

A second set of models suggest that there will be a difference between the impact of trade from low-wage countries on homogenous (standardized) commodities and heterogeneous (unique) products. Vernon (1966) has argued that a good will be produced in less-developed countries only after its production process becomes standardized. Krugman (1979) and Jensen and Thursby (1987) use product life-cycle models in which new products are first introduced and produced in the North, and then production relocates to the South after production technology becomes public

knowledge. Because standardized commodities have simpler production technology, which is more readily codified and transmitted to competitors, we expect that their production will be the first to be relocated to the low-wage countries.

Bernard, Jensen and Schott (2006) use the Factor Proportions framework to explain how a fall in trade costs induces reallocation of U.S. firms' output from labour-intensive industries to capital-intensive industries. This can be modified to change the factors from capital and labour to skilled and unskilled labour. To the extent that differentiated products are more skill-intensive, the Factor Proportions framework can also be applied to explain the re-location of production of standardized products to less skill-abundant countries. This leads to:

> **Hypothesis 2:** The increase in the low-wage import competition will have a stronger effect on exit of relatively standardized or undifferentiated products.

Several models deal with the difference between what is referred to as primary and secondary products. Liu (2006) uses the concept of the firm's core competency to develop an extension of the Aghion and Tirole (1995) model, in which a firm facing an increase in import competition divests peripheral units and strengthens the core-production units. In this framework, the core product generates the firm's cost advantage and, provided that the firm faces resource constraints, import competition overtaxes the scarce monitoring resources and forces the firm to reallocate resources from the periphery to the core. But a more conventional model of a plant that packs products together to exploit plant-scale economies despite scope diseconomies will also yield the same prediction if peripheral products suffer from greater cost penalties as their output is cut back—if they are further up the cost curve because of their smaller size as 'peripheral' goods. If this happens, the cost disadvantages of keeping these products will outweigh the plant-scale economies to which they contribute, and they will be discarded. This leads to:

> **Hypothesis 3:** The effect of imports will differ for core and peripheral products. A rise in low-wage import competition will force firms to become more specialized in producing core outputs.

The theory of the multi-product cost-minimizing firm also suggests that the impact of low-wage competition will be a function of the cost complementarity between products. Because of economies of scale and scope (or technological complementarities), the effect of import competition will differ across commodities produced by a multi-commodity firm, since some products will have weak cost complementarities—not because they are smaller in size (that is, they are peripheral)—but because they involve use of disparate technologies and production processes. This leads to:

> **Hypothesis 4:** The effect on peripheral commodities will depend on technological complementarities between the production of the core and the peripheral products. In particular, peripheral commodities sharing strong technological complementarities with the core product will be less affected by competition from low-wage countries.

Most of the previous models consider only the costs of production of a combined set of products—without considering that some products that are produced are actually consumed in

production themselves as intermediate inputs. The cost of producing a bundle of commodities is the sum of both transformation costs in the plant and the cost of intermediate inputs. The cost complementarities referred to above affect the transformation or operating costs of the firm. The input costs are affected by the make-or-buy decision for intermediate inputs.

A number of models can be used to guide our investigations into the effect of competition from trade on outsourcing the products that are intermediate inputs—on the likelihood that a firm will discard a product line, not just because it no longer reduces the plant operating costs, but also because it directly reduces input costs. Some products are intermediate inputs and, where competition begins to occur from low-wage countries for these products, a plant's substitution of its in-house production for imports (outsourcing) will directly reduce the costs of producing final products.

For example, McLaren (2000) formulates a theoretical model that relates changes in vertical integration of production to increased competition from the international arena. International openness is shown to thicken the market, providing suppliers with more opportunities to match with a buyer of specialized inputs. With more foreign competition, producers have more options to procure inputs. Overall, it is expected that an increase in international openness will facilitate leaner firms with increased rates of outsourcing.

Antràs and Helpman (2004) develop a North–South model of international trade in which differentiated products are produced in the North. Producers of final goods and suppliers make a relationship-specific investment and have a choice of four organizational forms: in-house input production at home, or abroad; and, arms-length input purchases at home, or abroad. In this model, a reduction of costs of foreign sourcing—which could be related to increased competition from low-wage countries—increases both the frequency of outsourcing by Northern firms and the importing of intermediate inputs from the South. In the product-cycle model of Antràs (2005), firms in the North produce goods using high-tech and low-tech inputs, and the production of low-tech inputs is shifted to the South to take advantage of lower wages.

This leads to:

> **Hypothesis 5:** An increase in low-wage import competition in products that are used as intermediate inputs will induce firms to disintegrate production and outsource some of their inputs to low-wage countries.

3 Empirical models

Our empirical investigation proceeds in three stages: by examining the commodity dynamics; by investigating how changes in commodities affect plant specialization; and by studying the relationship of these changes to plant performance.

We use the following empirical models to identify the effects of trade on commodity dynamics. At the plant-commodity level, we estimate the probability of exit and entry of a commodity as a function of trade variables and plant characteristics:

$$\text{Prob}(EXIT_{c,p}) = \Phi(\alpha_0 + \alpha_1 MP_c^{LW} + \alpha_2 \Delta MP_c^{LW} + \alpha_3 Y_p + \Sigma \gamma_i Z_i + \varepsilon_{c,p}), \quad (1)$$

where *c* indexes commodities, *p* indexes plants, *i* indexes industries, MP_c^{LW} is the commodity-level low-wage import competition, ΔMP_c^{LW} is the change in the low-wage import competition, Y_p are plant characteristics and ΣZ_i is a set of industry dummy variables.

We then ask how the trade-induced divesture of commodities shapes the boundaries of a firm. An increased exposure to competition may force firms to behave more efficiently and to increase specialization in their core products. To capture an increase in specialization, we construct the plant-level changes in the output share of the core product and relate it to trade variables:

$$\Delta CORESHARE_p = \beta_0 + \beta_1 MP_p^{LW} + \beta_2 \Delta MP_p^{LW} + \beta_3 Y_p + \Sigma \delta_i Z_i + \zeta_p, \quad (2)$$

where $\Delta CORESHARE_p$ is the change in the share of the core commodity in total output of a plant over the 1988-to-1996 period. The plant-level changes in trade are constructed as the weighted averages of commodity trade variables, where the weights are plant-commodity shipments in 1988.

When estimating Equations (1) and (2), we control for a number of plant characteristics that include employment, productivity, foreign control and exporting status. The complete list of plant controls and sample statistics for them is found in Table 1. The focus of the study is on within-industry changes: all regressions control for 3-digit Canadian Standard Industrial Classification fixed effects (107 manufacturing industries).

Table 1
Sample statistics

Variable	Mean	Standard deviation
Log (Size)	4.27	1.205
Log (Productivity)	11.056	0.672
Exporter	0.713	0.452
Foreign-owned	0.286	0.453
Number of commodities	2.60	2.420
MP_p^{LW}	0.045	0.269
ΔMP_p^{LW}	0.032	0.081

Notes: Number of observations=15,505. MP_p^{LW} is the plant share of imports from lower-wage countries in 1988. ΔMP_p^{LW} is the change in the plant share of imports from lower-wage countries from 1988 to 1996.

Source: Statistics Canada, Annual Survey of Manufactures.

Finally, we ask whether the changes that affect product choice are related to changes in plant performance. The changes that are occasioned by increased competition may engender a series of responses that extend well beyond simply adding or dropping commodities. They may include the substitution of capital for labour, an increase in labour skills and changes in plant scale or firm organization. All these might be expected to influence the productivity of plants. Therefore, in the final section, we investigate whether plants that change their commodity portfolios experience faster productivity growth.

4 Data and variables construction

4.1 Commodity turnover

The main data source is information on commodity-level shipments taken from Statistics Canada's Annual Survey of Manufactures. The data are available only for a limited number of years. To maximize the length of the time span, we look at the first and the last years of available data. Specifically, we look at changes in commodity production over the eight-year period from 1988 to 1996. Data on commodity output were collected by Statistics Canada using the long-form survey questionnaire, which was given out to relatively large plants. Because we are interested in plants that reported commodity data both in 1988 and 1996, we look at plants that stayed in the market continuously over this period, and reported detailed commodity data in both 1988 and 1996. This limits our sample to 6,300 large plants.

For multi-commodity plants, we distinguish between the 'core' product and the 'peripheral' products. We define the core product as that generating the largest proportion of the plant's sales and we use a dichotomous variable to distinguish core products from peripheral products.[9] In order to capture the fact that peripheral products may be technologically related to the core product, we construct the following measures of linkages.

4.2 Technological linkages

We use two measures of technological linkages between the core product and the peripheral products. The first measure captures the possibility that a peripheral product is very close in terms of its input structure to the core product. If this is the case, the existence of economies of scale and scope make it more likely that a plant will find it profitable to co-produce the two products. The second measure captures the possibility that a peripheral product is used as an input in production of the core product, which again may justify joint production of the two goods in the same plant, and also makes the peripheral product a candidate for offshoring because of the savings this will entail in terms of intermediate-input costs.

We define technological complementarity between the core and peripheral products as a similarity between the sets of inputs needed to produce the core product and each of the peripheral products j, j=1…J. For each product j, we know its producing industry, which has a

9. This definition is similar to one used by Liu (2006) except that she defines products at the Standard Industrial Classification 4-digit industry level, so in her work 'core industry' is the same as 'core product.'

certain set of input commodities. We also know the set of input commodities for the core-output industry of the firm. For each product *j,* we compare the set of required inputs with the input requirements of the core segment. The Canadian Input–Output tables give input requirements defined at the level of 476 input commodities used by 243 industries. Let $U^{j,core}$ be a set of inputs that are used both in the production of a product *j* and the core segment, and U^{core} be the set of all inputs needed for production of the core product. Input complementarity is defined as:

$$COMPLEMENT_{j,core} = U^{j,core} \Big/ U^{core} .$$

$COMPLEMENT_{j,core}$ is 0 when none of the inputs used in production of an input *j* is used in the production of the core output, and $COMPLEMENT_{j,core}$ is 1 when all inputs used in the core production can also be used in production of input *j*.

We also use the Input–Output tables to capture the vertical relationship between each peripheral product and the core product. Again, let U^{core} be the set of inputs used by the industry producing the core product. Let $M^{j,core}$ be the set of outputs by an industry producing a peripheral product *j* that is used by the industry producing the core product. The vertical linkage between the commodity *j* and the core commodity is given by:

$$VERT_{j,core} = M^{j,core} \Big/ U^{core} .$$

$VERT_{j,core}$ is equal to 0 when $M^{j,core}$ is 0 and $VERT_{j,core}$ is equal to 1 if all industries producing a peripheral commodity supply all of core's industry inputs. For each peripheral commodity, we can determine whether or not this commodity is a potential input into the production of the core commodity.

Both $COMPLEMENT_{j,core}$ and $VERT_{j,core}$ are proxies for technological linkages created using industry-level data from the Input–Output tables. To reduce measurement error arising from their application, we use dichotomous variables constructed using the sample medians as

$$COMPLEMENT^{D}_{j,core} = \begin{cases} 1, & COMPLEMENT_{j,core} \geq \text{median}(COMPLEMENT_{j,core}) \\ 0, & COMPLEMENT_{j,core} < \text{median}(COMPLEMENT_{j,core}) \end{cases}$$

and

$$VERT^{D}_{j,core} = \begin{cases} 1, & VERT_{j,core} \geq \text{median}(VERT_{j,core}) \\ 0, & VERT_{j,core} < \text{median}(VERT_{j,core}) \end{cases}$$

The sample medians of $COMPLEMENT^{D}_{j,core}$ and $VERT^{D}_{j,core}$ are 1.00 and 0.23, respectively, indicating that many co-produced commodities share similar sets of inputs.

We use a commodity-level Rauch index of product differentiation to capture the difference between homogeneous and differentiated products.[10] We assume that the production of differentiated products requires more research and development or skills than that of homogenous products, so, in the face of increasing low-wage import competition, homogeneous products are more likely to be divested.

4.3 Trade variables

Commodity-level data on imports come from a Canadian trade database. These data were used to construct a measure of low-wage import competition. Our interest is in the differential effects of import competition from rich and poor countries. The measure of the low-wage import competition was constructed following Bernard, Jensen and Schott (2006) as:

$$MP_c^{LW} = \frac{M_c^{LW}}{M_c^{LW} + M_c^{HW}},$$

where c indexes commodities, and M_c^{LW} and M_c^{HW} are imports from low-wage and high-wage countries. We use $5,000 gross domestic product per capita as the cut-off to separate high-wage economies from low-wage economies.[11] The share of low-wage imports in total imports in 1988 was 6% with a standard deviation of 14%, indicating that there was a large variation across commodities. The share went up by 3% over the 1988-to-1996 period, again with considerable variation across industries (the standard deviation is 11%).[12]

The main advantage of our import competition measure is that it is much more detailed than those used in other studies, because it is defined at the commodity, not the industry, level. This level of detail allows us to focus on within-industry changes and within-plant changes, while the previous studies only looked at exits of whole plants, rather than at changes within continuing plants.

10. The Rauch classification divides goods into three groups: differentiated, reference-priced and homogenous. We combine the latter two categories into one. The Rauch index is available at the Standard International Trade Classification (SITC) 4-digit commodity level, which is a somewhat less detailed classification than the Standard Classification of Goods (SCG) 6-digit level. We use the existing concordance to map the Rauch index into the SCG 6-digit classification, but, because of the differences in the two classification systems, the Rauch index is not available for all SCG 6-digit commodities.
11. The data on gross domestic product (GDP) per capita is obtained from World Development Indicators database for 1998. The GDP per capita cut-off was chosen purposefully to identify Canadian major relatively low-wage trading partners China and Mexico (whose respective GDPs per capita were $740 and $4,020) as a part of the low-wage group. As China and Mexico together account for a very large, and increasing, part of Canadian imports originating from outside the United States, the United Kingdom and Japan, our results are not particularly sensitive to modest changes in this cut-off value.
12. The share of low-wage import competition in Bernard, Jensen and Schott (2006) was 3% (standard deviation 6%) in 1987 and became 6% in 1992 (standard deviation 10%). The observation that Canadian low-wage share of imports is growing at a lower rate is explained by the large increase in the denominator as a result of the doubling of U.S. imports after the signing of the Canada–United States Free Trade Agreement.

4.4 Sample statistics

The data are used to construct two databases. The first database is constructed at the plant-commodity level and contains a number of observations equal to the number of plant-commodity pairs (number of observations=15,544). For each commodity produced by a plant, we have commodity-level changes in import competition. It will be used to study how commodities with particular characteristics are added or subtracted from a firm's product mix. The second database is constructed at the plant level, with a number of observations equal to the number of plants (N=6,300). The plant database allows us to examine the characteristics of plants with product turnover. A plant-level import-competition variable is constructed as a weighted average of commodity-level import competition where weights are plant-level commodity shipments.

Table 1 gives sample statistics on plants in the database. On average, plants produce 2.60 six-digit Standard Classification of Goods (SCG) commodities. Plant size is relatively large: the mean log employment of 4.27 corresponds to an average of 157 employees per plant. The vast majority of plants (71.3%) are exporters, and 28.6% of the plants belong to foreign-controlled firms. The share of imports from low-wage countries, MP_p^{LW}, was 4.5% in 1998, with large differences across plants (the standard deviation is 26.9%). On average, it increased by 3.2% over the following eight years, again with a large variation across plants. This relatively low average value is explained by the dominance of imports from the United States in Canadian imports. In absolute terms, the increase in low-wage imports was quite large, considering the about two-fold increase in imports from the United States during the Free Trade Agreement period.

Table 2 shows commodity turnover within these plants using the plant-commodity database (note that 74% of the observations in this database come from multi-commodity plants). Over the eight-year period, 41% of commodities were discontinued. The core commodities were less likely to be discontinued, both by single-commodity plants and by multi-commodity plants. The drop rate for core commodities was 22%. In contrast, in multi-commodity plants, some 52% of peripheral commodities were dropped. If we divide the peripheral commodities into four groups, based on their relationship to the core commodity, the lowest drop rate was for those commodities that are both technologically complementary to the core product (i.e., share similar inputs with the core product) and vertically integrated with core product (i.e., potentially used as inputs into production of the core product). For these commodities, the drop rate was 41%. The highest drop rate of 65% was observed for the commodities that have no relationship with the core product. Commodities that can be used as inputs into the core product, but have little technological complementarity with it, also exhibited a high drop rate of 63%. Homogeneous commodities were slightly more likely to be dropped compared with differentiated commodities.

Table 2
Commodity statistics

	Probability of dropping a commodity	Number of observations
All plants, all commodities	0.41	15,544
Core commodities	0.22	5,994
Core commodities, single-commodity plants	0.23	2,487
Core commodities, multi-commodity plants	0.22	3,507
Peripheral commodities, multi-commodity plants	0.52	9,361
Vertically integrated and technologically complementary (Group A)	0.41	3,259
Non-vertically integrated and technologically complementary (Group B)	0.48	2,345
Vertically integrated and non-technologically complementary (Group C)	0.63	1,786
Neither vertically-integrated nor complementary (Group D)	0.65	1,971
Homogenous (Rauch=0)	0.44	3,775
Differentiated (Rauch=1)	0.40	8,841

Source: Statistics Canada, Annual Survey of Manufactures.

Since the largest change in product composition of output occurred within multi-product plants, Table 3 reports on the reallocation of output, specifically within multi-product plants. These plants are quite specialized at the beginning of the period: the average output share of the core commodity is 69%. Over the 1988-to-1996 period, the share of core commodity went up by 6.7 percentage points, while the share of peripheral commodities that were not linked to the core commodity (Group D) went down by 2.9 percentage points, and the share of output accounted for by vertically-linked commodities (Group C) went down by 1.9 percentage points.

Table 3
Plant-level changes in commodity composition, multi-product plants

	1988		1988 to 1996	
	Mean	Standard deviation	Mean change	Standard deviation
Share of core commodity	0.688	0.205	0.067	0.209
Share of Group A	0.100	0.173	-0.004	0.171
Share of Group B	0.078	0.168	-0.005	0.158
Share of Group C	0.039	0.100	-0.019	0.096
Share of Group D	0.066	0.132	-0.029	0.135

Notes: Number of observations=3,507. Groups A, B, C and D are defined as in Table 2.
Source: Statistics Canada, Annual Survey of Manufactures.

5 Empirical results

5.1 Commodities

5.1.1 Plant controls

Table 4 contains estimates of the impact of plant-level characteristics from Equation (1), using data on different sub-samples of plants and commodities. Estimates in the Column 1 use data on all plants and all commodities; estimates in Columns 2 to 4 use data on core commodities, while

estimates in Columns 5 to 7 use data on peripheral commodities produced by multi-product firms. We separate peripheral commodities into two groups: 'vertically integrated' and 'non-vertically integrated.'

Strong predictors of commodity divestures are a plant's size, productivity and the number of commodities produced at the beginning of the period. Similar effects are estimated using different subsets of data. In particular, larger plants are significantly less likely to divest any type of commodities, while a larger number of commodities produced at the beginning of the period increases the likelihood of product divestures. High-productivity plants are less likely to drop commodities. Plant age and exporter status are not related to product dynamics. Foreign-owned multi-product plants are significantly less likely to change their core product or to divest vertically-integrated peripheral commodities. However, foreign-owned firms are more likely to give up peripheral commodities that were not vertically linked to the core product.

Table 4
Probability of commodity exit

	All	Core	Core, single-commodity plants	Core, multi-commodity plants	Peripheral commodities	Peripheral commodities, vertically integrated	Peripheral commodities, non-vertically integrated
	1	2	3	4	5	6	7
Log (size)	-0.099*	-0.098*	-0.117*	-0.089*	-0.106*	-0.154*	-0.058
P-value	(0.000)	(0.000)	(0.001)	(0.003)	(0.000)	(0.000)	(0.012)
Log (productivity)	-0.046**	-0.088**	-0.158**	-0.058	-0.039	-0.002	-0.079**
P-value	(0.016)	(0.014)	(0.010)	(0.219)	(0.108)	(0.947)	(0.039)
Log (number of commodities)	0.347*	0.194*	…	0.185*	0.182*	0.218*	0.157*
P-value	(0.000)	(0.000)	…	(0.001)	(0.000)	(0.000)	(0.000)
Exporter	-0.009	-0.033	-0.021	-0.035	0.000	-0.021	0.015
P-value	(0.752)	(0.514)	(0.799)	(0.602)	(0.990)	(0.679)	(0.778)
Age	-0.010	-0.005	-0.033	-0.024	-0.034	0.079	-0.109
P-value	(0.845)	(0.953)	(0.797)	(0.848)	(0.643)	(0.443)	(0.321)
Foreign-owned	-0.018	-0.092	0.009	-0.148	0.004	-0.146*	0.127**
P-value	(0.520)	(0.069)	(0.912)	(0.029)	(0.911)	(0.004)	(0.017)
Number of observations	15,505	5,995	2,487	3,508	9,510	4,903	4,286
Log likelihood	-9636.0	-2586.7	-996.0	-1512.0	-6230.1	-3053.7	-2761.1

… not applicable
* estimates significant at 1% level
** estimates significant at 5% level
Notes: Estimating equation is Equation (1) in text. All estimating equations include plant controls (see Table 1) and Standard Industrial Classification 3-digit level industry dummy variables.
Source: Statistics Canada, Annual Survey of Manufactures.

5.1.2 Import competition effects

Table 5 includes estimates of Equation (1) for commodity-level low-wage import competition MP_c^{LW} and changes in low-wage import competition ΔMP_c^{LW}. Commodities that faced high levels of low-wage import competition in 1988 were more likely to be discontinued. An increase in low-wage import competition over the 1988-to-1996 period also contributed to the exit of commodities. The elasticity estimates suggest that a 10% higher MP_c^{LW} increases the exit rate by 1.6%, and a 10% change in import competition over the estimating period further increases the exit rate by 0.5%. The Columns 2 and 3 give estimates of Equation (1), including interactions between each measure of import competition and the product differentiation index. The estimates show that import competition has a much stronger effect on the exit of homogeneous products than on the exit of differentiated products. A 10% increase in low-wage import competition increases exit rates of homogeneous products by 3.7%, and of differentiated products by only 0.4% (=0.37-0.33). A 10% increase in changes of low-wage imports increases exit rates of homogeneous commodities by 3.5%, while decreasing exit rates of differentiated commodities by 0.3%. These estimates are consistent with Hypothesis 2, namely, that standardized products are more likely to be discontinued in Canada in response to low-wage import competition.

Columns 4 to 6 of Table 5 give estimates of the effect of import competition on core commodities. These estimates show that low-wage import competition has no significant effect on the dynamics of core commodities. The lack of effect on core commodities suggests that low-wage import competition is re-shaping commodity composition through inducing changes in peripheral commodities produced by multi-commodity plants. Tables 6 to 9 present estimates using the data only for multi-commodity plants.

Table 5
Probability of commodity exit, all commodities and core commodities

	All commodities			Core commodities		
	1	2	3	4	5	6
MP_c^{LW}	0.389*	0.896*	0.272	0.155	0.640	0.059
P-value	(0.000)	(0.000)	(0.019)	(0.513)	(0.395)	(0.821)
ΔMP_c^{LW}	0.132	0.190	0.842*	-0.080	0.006	0.233
P-value	(0.233)	(0.109)	(0.000)	(0.716)	(0.979)	(0.697)
MP_c^{LW} *Rauch*	…	-0.800*	…	…	-0.639	…
P-value	…	(0.003)	…	…	(0.415)	…
ΔMP_c^{LW} *Rauch*	…	…	-0.916*	…	…	-0.262
P-value	…	…	(0.000)	…	…	(0.685)
Marginal effects						
MP_c^{LW}	0.16	0.37	0.11	0.03	0.14	0.01
ΔMP_c^{LW}	0.05	0.08	0.35	-0.02	0.00	0.05
MP_c^{LW} *Rauch*	…	-0.33	…	…	-0.14	…
ΔMP_c^{LW} *Rauch*	…	…	-0.38	…	…	-0.06
Number of observations	15,505	12,098	12,098	5,995	4,777	4,777
Log likelihood	-9636.0	-7486.8	-7485.0	-2586.7	-1965.9	-1966.2

… not applicable
* estimates significant at 1% level
Notes: Estimating equation is Equation (1) in text. All estimating equations include plant controls (see Table 1) and Standard Industrial Classification 3-digit level industry dummy variables. **Rauch* captures the difference between homogeneous and differentiated products.
Source: Statistics Canada, Annual Survey of Manufactures.

Peripheral commodities that faced high import competition from low-wage countries in 1988 were more likely to be divested, and the effect was particularly high for undifferentiated commodities (Table 6). A 10% increase in low-wage import competition increases exit of peripheral commodities by 2.3% and the exit of standardized peripheral commodities by 4.4 %. Columns 4 and 5 include interaction terms between the low-wage import competition and technological complementarity between the core product and the peripheral products. The estimates indicate that an increase in import competition increases the exit rates of technologically unrelated commodities (the respective elasticity estimates are 4.0 for both MP_c^{LW} and ΔMP_c^{LW}) while it somewhat reduces exit rates for technologically related peripheral commodities.

Table 6
Probability of commodity exit, peripheral commodities

	Peripheral commodities				
	1	2	3	4	5
MP_c^{LW}	0.430*	0.806*	0.243	0.769*	0.282**
P-value	(0.001)	(0.003)	(0.076)	(0.000)	(0.031)
ΔMP_c^{LW}	0.123	0.135	0.628	0.124	0.761*
P-value	(0.364)	(0.344)	(0.014)	(0.368)	(0.000)
MP_c^{LW} *Rauch*	…	-0.744**	…	…	…
P-value	…	(0.013)	…	…	…
ΔMP_c^{LW} *Rauch*	…	…	-0.736**	…	…
P-value	…	…	(0.014)	…	…
MP_c^{LW} *Complement*	…	…	…	-0.797*	…
P-value	…	…	…	(0.000)	…
ΔMP_c^{LW} *Complement*	…	…	…	…	-0.983*
P-value	…	…	…	…	(0.000)
Marginal effects					
MP_c^{LW}	0.23	0.44	0.13	0.40	0.15
ΔMP_c^{LW}	0.07	0.07	0.34	0.07	0.40
MP_c^{LW} *Rauch*	…	-0.41	…	…	…
ΔMP_c^{LW} *Rauch*	…	…	-0.40	…	…
MP_c^{LW} *Complement*	…	…	…	-0.42	…
ΔMP_c^{LW} *Complement*	…	…	…	…	-0.51
Number of observations	9,510	7,321	7,321	9,189	9,189
Log likelihood	-6230.1	-4773.3	-4773.4	-5961.3	-5962.6

… not applicable
* estimates significant at 1% level
** estimates significant at 5% level
Notes: Estimating equation is Equation (1) in text. All estimating equations include plant controls (see Table 1) and Standard Industrial Classification 3-digit level industry dummy variables. **Rauch* captures the difference between homogeneous and differentiated products, and **Complement* measures the technological complementarity between the core product and the peripheral products.
Source: Statistics Canada, Annual Survey of Manufactures.

Finally, we examine whether the effects of import competition differ between peripheral products that are vertically integrated and non-vertically integrated (Hypothesis 4). Tables 7 and 8 give estimates of Equation (1) for the two groups, respectively. A 10% increase in MP_c^{LW} increases exit rates among vertically integrated commodities by 3.1% (Table 7, Column 1) and has no statistically significant effect on non-vertically linked peripheral commodities (Table 8, Column 1). The effect of low-wage import competition on the exit of vertically linked commodities is much stronger for homogeneous commodities—the elasticity estimate is 0.63—and those relatively technologically unrelated—the elasticity estimate is 0.57. The effect of the

low-wage import competition on peripheral commodities that are non-vertically integrated is small in magnitude and never statistically significant.

Table 7
Probability of commodity exit, vertically-integrated commodities

	Peripheral commodities, vertically integrated				
	1	2	3	4	5
MP_c^{LW}	0.633*	1.170*	0.348	1.145*	0.623*
P-value	(0.002)	(0.001)	(0.132)	(0.001)	(0.003)
ΔMP_c^{LW}	0.340	0.371	0.933*	0.326	1.014*
P-value	(0.111)	(0.106)	(0.005)	(0.127)	(0.005)
MP_c^{LW} *Rauch*	…	-1.332*	…	…	…
P-value	…	(0.002)	…	…	…
ΔMP_c^{LW} *Rauch*	…	…	-1.032**	…	…
P-value	…	…	(0.020)	…	…
MP_c^{LW} *Complement*	…	…	…	-0.779	…
P-value	…	…	…	(0.059)	…
ΔMP_c^{LW} * Complement*	…	…	…	…	-1.009**
P-value	…	…	…	…	(0.018)
Marginal effects					
MP_c^{LW}	0.31	0.63	0.19	0.57	0.31
ΔMP_c^{LW}	0.17	0.20	0.50	0.16	0.50
MP_c^{LW} *Rauch*	-0.71	…	…	…	…
ΔMP_c^{LW} *Rauch*	…	…	-0.55	…	...
MP_c^{LW} *Complement*	…	…	-0.39	…	…
ΔMP_c^{LW} *Complement*	…	…	…	…	-0.50
Number of observations	4,903	3,385	3,385	4,903	4,903
Log likelihood	-3053.7	-2102.6	-2104.9	-3051.9	-3050.8

… not applicable
* estimates significant at 1% level
** estimates significant at 5% level
Notes: Estimating equation is Equation (1) in text. All estimating equations include plant controls (see Table 1) and Standard Industrial Classification 3-digit level industry dummy variables. **Rauch* captures the difference between homogeneous and differentiated products, and **Complement* measures the technological complementarity between the core product and the peripheral products.
Source: Statistics Canada, Annual Survey of Manufactures.

To summarize the evidence regarding the commodity dynamics, we find support for hypotheses 1 to 7. Overall, low-wage import competition contributes to re-shaping the output structure of multi-commodity plants in the manner consistent with product-cycle-based theories of trade and the trade-based theories of the firm.

Table 8
Probability of commodity exit, non-vertically integrated commodities

	Peripheral commodities, non-vertically integrated				
	1	2	3	4	5
MP_c^{LW}	0.084	-0.226	0.084	0.339	0.070
P-value	(0.632)	(0.660)	(0.643)	(0.127)	(0.690)
ΔMP_c^{LW}	-0.092	-0.160	-0.136	-0.090	0.279
P-value	(0.628)	(0.417)	(0.799)	(0.633)	(0.355)
MP_c^{LW} **Rauch*	…	0.345	…	…	…
P-value	…	(0.520)	…	…	…
ΔMP_c^{LW} **Rauch*	…	…	-0.005	…	…
P-value	…	…	(0.993)	…	…
MP_c^{LW} **Complement*	…	…	…	-0.458	…
P-value	…	…	…	(0.057)	…
ΔMP_c^{LW} **Complement*	…	…	…	…	-0.555
P-value	…	…	…	…	(0.113)
Marginal effects					
MP_c^{LW}	0.05	-0.12	0.05	0.19	0.04
ΔMP_c^{LW}	-0.05	-0.09	-0.08	-0.05	0.16
MP_c^{LW} **Rauch*	…	0.19	…	…	…
ΔMP_c^{LW} **Rauch*	…	…	0.00	…	…
MP_c^{LW} **Complement*	…	…	…	-0.26	…
ΔMP_c^{LW} **Complement*	…	…	…	…	-0.31
Number of observations	4,286	3,690	3,690	4,286	4,286
Log likelihood	-2761.1	-2374.0	-2374.2	-2759.3	-2759.8

… not applicable
Notes: Estimating equation is Equation (1) in text. All estimating equations include plant controls (see Table 1) and Standard Industrial Classification 3-digit level industry dummy variables. **Rauch* captures the difference between homogeneous and differentiated products, and **Complement* measures the technological complementarity between the core product and the peripheral products.
Source: Statistics Canada, Annual Survey of Manufactures.

5.2 Plant specialization

Until this point, our evidence has focused on restructuring within plants, based on commodity counts. Here, we turn to the question of how these changes affect a plant's specialization in particular types of products. In Table 9, we present estimates of Equation (2), using as dependent variables the output shares of the core commodity and the output shares of each of the four groups of peripheral commodities. The estimates show that plants that experienced a high level of low-wage import competition in 1988 were more likely to increase the output share of the core commodity and to reduce the output share of unrelated peripheral commodities. Increases in low-wage import competition further contributed to the fall in the output share of unrelated peripheral

commodities. Thus, the value-based measures of changes in output structure also support the hypothesis that exposure to the low-wage import competition contributes to restructuring within Canadian manufacturing plants by increasing their focus on their core.

Table 9
Changes in plants' output structure

	Share of core commodity	Share of Group A	Share of Group B	Share of Group C	Share of Group D
	1	2	3	4	5
MP_p^{LW}	0.145*	-0.026	0.080**	-0.017	-0.164*
T-statistic	(2.61)	(-0.56)	(1.87)	(-0.67)	(-4.49)
ΔMP_p^{LW}	0.035	-0.018	-0.013	0.007	-0.097*
T-statistic	(0.58)	(-0.35)	(-0.27)	(0.23)	(-2.42)
Log (Size)	-0.021*	-0.003	-0.001	0.005*	0.001
T-statistic	(-5.54)	(-1.04)	(-0.22)	(2.86)	(0.45)
Log (number of commodities)	0.088*	0.001	0.003	-0.018*	-0.005
T-statistic	(11.26)	(0.22)	(0.42)	(-4.88)	(-1.04)
Log (productivity)	-0.004	0.011**	0.006	0.003	0.009**
T-statistic	(-0.72)	(2.21)	(1.34)	(1.09)	(2.21)
Exporter	-0.018**	0.004	-0.012**	0.002	0.001
T-statistic	(-1.96)	(0.59)	(-1.72)	(0.37)	(0.14)
Foreign-owned	0.002	0.011	0.004	0.003	0.001
T-statistic	(0.24)	(1.49)	(0.53)	(0.71)	(0.17)
Adjusted R-squared	0.07	0.02	0.04	0.04	0.04
Number of observations	3,512	3,512	3,512	3,512	3,512

* estimates significant at 1% level
** estimates significant at 5% level
Notes: Estimating equation is Equation (2) in text. All estimating equations include plant controls (see Table 1) and Standard Industrial Classification 3-digit level industry dummy variables. Groups A, B, C and D are defined as in Table 2.
Source: Statistics Canada, Annual Survey of Manufactures.

5.3 Productivity

Finally, we ask how the move to a more focused core—when this is associated with competition from low-wage imports—is associated with productivity growth. Our focus is on the relationship between increases in productivity and a more focused portfolio of products, but we want to know whether this process of adaptation was more productive when the stimulus was associated with low-wage import competition. To investigate this issue, we examine the difference between the productivity growth of plants that increased their focus on the core and those that did not, and ask whether this difference was larger or smaller in situations that differed in terms of import competition.

We divide plants into two groups based on plant low-wage import competition in 1988, $\tilde{MP}_{p,i}^{LW}$.[13] In each of the two groups, we compare productivity growth of plants with different changes in the

13. Note that all variables here are constructed in deviations from industry means in order to control for industry-specific differences in productivity and low-wage import competition.

share of core commodity, $\Delta \tilde{CORESHARE}_{p,i}$. The first column of Table 10 shows differences in annual average plant productivity growth over the 1988-to-1996 period, $\tilde{\pi}_{p,i}$, between plants that increased the share of the core commodity (large $\Delta \tilde{CORESHARE}_{p,i}$) and that did not increase the share of the core commodity (low $\Delta \tilde{CORESHARE}_{p,i}$) for plants that faced relatively low levels of low-wage import competition in 1988, i.e., low $\tilde{MP}^{LW}_{p,i}$. The second column of Table 10 repeats it for plants with high $\tilde{MP}^{LW}_{p,i}$. This shows that an increase in specialization is not associated with productivity benefits for plants with low $\tilde{MP}^{LW}_{p,i}$. However, among plants facing competition from 'high' low-wage imports, the increase in specialization was associated with significant productivity benefits, especially for the domestic exporting plants. This suggests that some productivity-enhancing changes occurred during the product portfolio adjustments that were associated with 'high' low-wage import competition. Thus, the commodity restructuring described in this paper can be one of the ways in which manufacturers in developed economies managed to improve productivity growth, in spite of increasing competition from the low-wage economies.

Table 10
Annual labour productivity growth differentials

	Productivity growth differential between plants with high versus low increase in the share of core commodity	
	Plants with 'low' low-wage import competition in 1988	Plants with 'high' low-wage import competition in 1988
All plants	-0.002	0.008*
T-statistic	(0.39)	(1.94)
Number of observations	1,739	1,737
Domestic plants	-0.009*	0.009*
T-statistic	(-1.84)	(1.82)
Number of observations	1,241	1,241
Exporting plants	0.000	0.012***
T-statistic	(0.17)	(2.60)
Number of observations	1,281	1,281
Domestic exporters	-0.007	0.014**
T-statistic	(-1.22)	(2.54)
Number of observations	886	886

* estimates significant at 1% level
** estimates significant at 5% level
*** estimates significant at 10% level
Notes: All variables (log productivity growth, low-wage import competition in 1988 and changes in the output share of the core commodity) are demeaned using industry-specific means at the Standard Industrial Classification 3-digit level (107 manufacturing industries).
Source: Statistics Canada, Annual Survey of Manufactures.

6 Conclusion

Earlier work (Baldwin, Beckstead and Caves 2002; Baldwin, Caves and Gu 2005; Baldwin and Gu 2008) has demonstrated that Canadian manufacturing plants have responded to the trade liberalization with the United States and Mexico by reducing the number of products and by increasing their length of production runs. This study extends the analysis to consider how adaptation is occurring to new developments emerging in the form of competition from low-wage countries. It examines how manufacturing plants divest commodities in response to the low-wage import competition: it finds that the largest change happens in multi-commodity plants and is largely confined to changes in peripheral commodities. The commodities that are affected the most are those that are potentially used as inputs in production of the 'core' commodity and those homogeneous (rather than differentiated) products with relatively weak input complementarities with the core input. Plants experiencing large import competition are shifting their output toward production of their core commodity and away from the production of unrelated peripheral commodities. All this has been accompanied by an increase in productivity.

References

Aghion, Philippe, and Jean Tirole. 1995. "Some implications of growth for organizational form and ownership structure." *European Economic Review.* 39, 3–4: 440–455.

Aghion, P., and J. Tirole. 1997. "Formal and real authority in organizations." *Journal of Political Economy.* 105, 1: 1–29.

Antràs, Pol. 2005. "Incomplete contracts and the product cycle."*The American Economic Review*. 95, 4: 1054–1073.

Antràs, Pol, and Elhanan Helpman. 2004. "Global sourcing." *Journal of Political Economy*. 112, 3: 552–580.

Aw, Bee Yan, Geeta Batra and Mark J. Roberts. 2001. "Firm heterogeneity and export-domestic price differentials: A study of Taiwanese electronic products." *Journal of International Economics*. 54, 1: 149–169.

Baggs, Jen. 2005. "Firm survival and exit in response to trade liberalization." *Canadian Journal of Economics*. 38, 4: 1364–1383.

Baldwin, John R., Desmond Beckstead and Richard Caves. 2002. *Changes in the Diversification of Canadian Manufacturing Firms and Plants (1973–1997): A Move to Specialization.* Analytical Studies Branch Research Paper Series. Catalogue no. 11F0019MIE2002179. Ottawa: Statistics Canada.

Baldwin, John R., Richard E. Caves and Wulong Gu. 2005. "Responses to trade liberalization: Changes in product diversification in foreign- and domestic-controlled plants." In *Governance, Multinationals and Growth*. Lorraine Eden and Wendy Dobson (eds.). Northampton, Mass.; Cheltenham, U.K.: Edward Elgar Publishing.

Baldwin, John R., and Wulong Gu. 2008. "The Impact of Trade on Plant Scale, Production-Run Length and Diversification." In *Producer Dynamics: New Evidence from Micro Data.* Timothy Dunne, J. Bradford Jensen and Mark J. Roberts (eds.). Chicago: University of Chicago Press.

Baldwin, John R., and Wulong Gu. Forthcoming. *Outsourcing and Offshoring in Canada: Trends, Causes and Economic Impact.* Analytical Studies Research Paper Series. Ottawa: Statistics Canada.

Baldwin, John R., and Petr Hanel. 2003. *Innovation and Knowledge Creation in an Open Economy: Canadian Industry and International Implications.* Cambridge, U.K.: Cambridge University Press.

Bernard, Andrew B., J. Bradford Jensen and Peter K. Schott. 2006. "Survival of the best fit: Exposure to low-wage countries and the (uneven) growth of U.S. manufacturing plants." *Journal of International Economics*. 68, 1: 219–237.

Bernard, Andrew B., Stephen Redding and Peter K. Schott. 2003. *Product Choice and Product Switching*. NBER Working Paper Series. Working paper 9789. Cambridge, Mass.: National Bureau of Economic Research.

Bernard, Andrew B., Stephen J. Redding and Peter K. Schott. 2006. *Multi-product firms and trade liberalization*. NBER Working Paper Series. Working paper 12782. Cambridge, Mass.: National Bureau of Economic Research.

Bowen, Harry P., and Margarethe F. Wiersema. 2005. "Foreign-based competition and corporate diversification strategy." *Strategic Management Journal.* 26, 12: 1153–1171.

Campa, Jose, and Linda S. Goldberg. 1997. "The evolving external orientation of manufacturing: A profile of four countries." *Economic Policy Review*. 3, 2: 53–81.

Feenstra, Robert C. 1999. "Integration of trade and disintegration of production in the global economy." *The Journal of Economic Perspectives*. 12, 4: 31–50.

Grossman, Gene M., and Elhanan Helpman. 1991. "Endogenous product cycles." *The Economic Journal*. 101, 408: 1214–1229.

Jensen, Richard, and Marie Thursby. 1986. "A strategic approach to the product life cycle." *Journal of International Economics*. 21, 3–4: 269–284.

Jensen, Richard, and Marie Thursby. 1987. "A decision theoretic model of innovation, technology transfer, and trade." *The Review of Economic Studies*. 54, 180: 631–647.

Krugman, Paul. 1979. "A model of innovation, technology transfer, and the world distribution of income." *Journal of Political Economy*. 87, 2: 253–266.

Lee, F.C., and H. Haas. 1996. "A quantitative assessment of high-knowledge industries versus low-knowledge industries." In *The Implications of Knowledge-based Growth for Micro-Economic Policy*. P. Howit (ed.). Calgary: University of Calgary Press.

Lileeva, Alla. 2008. "Trade liberalization and productivity dymanics: Evidence from Canada." *Canadian Journal of Economics*. 41, 2: 360–390.

Liu, Runjuan. 2006. *Import Competition and Firm Refocusing.* Working Paper Series. Social Science Research Network.

McLaren, John. 2000. "'Globalization' and vertical structure." *The American Economic Review.* 90, 5: 1239–1254.

Melitz, Marc J. 2003. "The impact of trade on intra-industry reallocations and aggregate industry productivity." *Econometrica.* 71, 6: 1695–1725.

Milgrom, Paul R., and John Roberts. 1992. *Economics, Organization & Management*. Englewood Cliffs, New Jersey: Prentice Hall.

Porter, Michael E. 1998. *On Competition.* The Harvard Business Review Book Series. McGraw-Hill Ryerson Agency.

Prahalad, C.K., and Gary Hamel. 1990. "The core competence of the corporation." *Harvard Business Review*. 68, 3: 79–91.

Rauch, James E. 1999. "Networks versus markets in international trade." *Journal of International Economics.* 48, 1: 7–35.

Schott, Peter K. 2002. *Moving Up and Moving Out: U.S. Product-level Exports and Competition from Low-wage Countries.* Yale School of Management, mimeo.

Schott, Peter K. 2004. "Across-product versus within-product specialization in international trade." *The Quarterly Journal of Economics*. 119, 2: 647–678.

Tisdale, Sallie. 1994. "Shoe and tell." *The New Republic*. 211, 11: 10–11.

Vernon, Raymond. 1966. "International investment and international trade in the product cycle." *The Quarterly Journal of Economics.* 80, 2: 190–207

Zhu, Susan Chun. 2005. "Can product cycles explain skill upgrading?" *Journal of International Economics*. 66, 1: 131–155.