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Geographic Market Access and the Effects of Trade on Length of Production Run, Product Diversity and Plant Scale of Canadian Manufacturing Plants, 1974 to 1999

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Abstract

Over the past three decades, tariff barriers have fallen significantly, leading to an increasing integration of Canadian manufactures into world markets and especially the U.S. market. Much attention has been paid to the effects of this shift at the national scale, while little attention has been given to whether these effects vary across regions. In a country that spans a continent, there is ample reason to believe that the effects of trade will vary across regions. In particular, location has a significant effect on the size of markets available to firms, and this may impact the extent to which firms reorganize their production in response to falling trade barriers. Utilizing a longitudinal microdata file of manufacturing plants (1974 to 1999), this study tests the effect of higher levels of trade across regions on the organization of production within plants. The study finds that higher levels of export intensity (exports as a share of output) across regions are positively associated with longer production runs, larger plants and product specialization within plants. These effects are strongest in Ontario and Quebec, provinces that are best situated with respect to the U.S. market.

Keywords: international trade, industrial organization, geographic market access, manufacturing

Executive summary

Over the past three decades, tariff barriers have fallen significantly, leading to an increasing integration of Canadian manufactures into world markets and especially the U.S. market. Much attention has been paid to the effects of this shift at the national scale, while little attention has been given to whether these effects vary across regions. In a country that spans a continent, there is ample reason to believe that the effects of trade will vary across regions. In particular, location has a significant effect on the size of markets available to firms, and this may affect the extent to which firms reorganize their production in response to falling trade barriers.

Utilizing a longitudinal microdata file of manufacturing plants (1974 to 1999), this study tests the effect of higher levels of trade across regions on the organization of production within plants. In particular, it examines how three characteristics of industrial structure—plant size, plant specialization and the length of production runs—were related to the degree to which regions are integrated into North American markets.

These three structural characteristics help to determine a plant's productivity. Larger plants can take advantage of economies of scale. Plant specialization is a function of the number of products produced. Small plants hiding behind tariff barriers may produce a large number of products, despite scope diseconomies, to try to expand the plant's size in order to exploit plant scale economies. This can lead to suboptimal production runs.

Many Canadian economists have argued that trade barriers lead to suboptimal plant size, or to excessive product differentiation, or to production runs that are too short to fully exploit the economies of production-run length. Trade liberalization was seen to be a solution to these perceived problems. Increased access to U.S. markets was seen to be a way of more fully exploiting scale economies—either through increased plant size, or fewer product lines and the concomitant increase in production-run length.

Most studies on the impact of trade liberalization on the Canadian economy have focused only on the national impact, which belies the fact that Canada is composed of a distinct set of regional economies, whose ties to the North American and global economy are often quantitatively and qualitatively different. An examination of the response at the national level misses differences that may exist at the regional level. The ability of regions to take advantage of trade liberalization and the nature of their trade with the rest of the world depends, at least in part, on their location relative to North American and world markets.

In this paper, we seek to determine how Canada's integration with the world through trade has differentially affected regional economies. To do so, we ask how plant specialization, plant size and production-run length—three characteristics of industrial structure that affect productivity—have changed as manufacturing plants in different Canadian regions have integrated themselves into world markets. The data that are used for the analysis cover the period from 1973 to 1999. Over this period, tariff rates declined steadily, first with the Kennedy Round, then the Tokyo Round, and then with the Canada–United States Free Trade Agreement and the North American Free Trade Agreement.

Even before trade liberalization took place, cross-regional differences in the industrial structure stood out. The Canadian region that is the largest and closest to the centre of the North American market, Ontario, had large plants and longer production runs. This was also the region that started with the highest level of product diversity at the beginning of the period under study—where product packing to achieve economies of scale was most evident.

The effect of integration, though it increased exports, has not been felt equally across all geographic regions or in the same way. It was in Central Canada—primarily Ontario—where plant scale increased the most, where product diversity declined the most and where production-run length increased the most on average. It was here that the relationship between higher levels of export intensity and plant scale, or production-run length, was the strongest. And the reason for this comes from the fact that some aspects of industrial structure reacted more to export change (increased integration into North American markets) than elsewhere. Changes in plant size reacted more to changes in export intensity over time in Ontario than elsewhere.

The paper also examines differences in reactions of exporters and non-exporters by region to changes in trade intensity brought about by trade liberalization. In Canada, non-exporters experienced a reduction in plant size, while exporters increased their plant size and the length of their production runs. But the reactions of the two groups differed between Canada's industrial heartland and other regions. Outside the heartland, non-exporters saw their plant size reduced more in response to increases in trade liberalization, and exporters experienced less of an increase in plant size in response to increases in trade liberalization. Non-exporters outside Ontario saw their length of production runs fall by larger amounts in response to increases in trade liberalization, while exporters saw their length of production runs increase by smaller amounts in response to increases in trade liberalization.

The regional perspective adopted in this paper provides new insights into the underlying effects of trade. The effects of trade are not the same in all locations. And the variations that we observe over space are not random. Instead, we observe patterns that point to the importance of location relative to markets as a key variable determining how trade affects regional economies. Given the geographic diversity of the Canadian economy, taking into account differences related to geography improves our insights on the effects of trade on the economy.

1 Introduction

Over the past three decades, the Canadian economy has become increasingly integrated into world markets as a result of successive rounds of tariff cuts under the General Agreement on Tariffs and Trade and the implementation of the Canada–United States Free Trade Agreement (FTA) and its successor, the North American Free Trade Agreement (NAFTA).

Focusing on the impacts of the FTA and NAFTA, many studies have analyzed how trade has affected employment, plant size and productivity, among other factors (see Schwanen 1997; Head and Reis 1999a, 1999b and 2001; McCallum 1999; Trefler 2004; Baldwin and Gu 2008; Brown 2007). Most studies, however, have focused on only the national impact, which belies the fact that Canada is composed of a distinct set of regional economies whose ties to the North American and global economies are often quantitatively and qualitatively different.

An examination of the response at the national level misses differences that may exist at the regional level. The ability of regions to take advantage of trade liberalization and the nature of their trade with the rest of the world depend, at least in part, on their location relative to North American and world markets. Location is important because distance remains an important determinant of market access (Brown and Anderson 2002). Since distances from main North American markets differ by region, so too might responses to increasing trade liberalization. Gu and Sawchuk (2006) show that the two-way trade at the commodity level with the United States has increased more rapidly for Ontario and Quebec than for Atlantic Canada and the West.

In this paper, we seek to determine how Canada's integration with the world through trade has differentially affected regional economies. To do so, we ask how plant specialization, plant size and production-run length—three characteristics of industrial structure that affect productivity—have changed as manufacturing plants in different Canadian regions have integrated themselves into world markets. The data that are used for the analysis cover the period from 1973 to 1999. Over this period, tariff rates declined steadily, first with the Kennedy Round, then the Tokyo Round, and then with the FTA and NAFTA.

Trade liberalization is expected to affect the industrial organization of production (Horstman and Markusen 1992). Trade barriers have long been held to have a detrimental effect on Canada's industrial structure (Economic Council of Canada 1967, 1975). Some have argued that trade barriers have led to suboptimal plant size, or to excessive product differentiation, or to production runs that are too short to fully exploit the economies of production-run length (Daly, Keys and Spence 1968; Spence 1977; Caves et al. 1980). Trade liberalization was seen to be a solution to these perceived problems (Harris 1984). Increased access to U.S. markets was seen to be a way of more fully exploiting scale economies—either through increased plant size, or fewer product lines and the concomitant increase in production-run length. These changes were expected to have productivity-enhancing effects.

Models of imperfect competition suggest that the impact of increased trade liberalization will be felt differently across regions. In particular, those that face inherently larger markets—those that are larger and closer to U.S. markets—will respond differently to declines in trade barriers.

Therefore, we examine whether each of these industrial characteristics has responded differently across Canadian regions to being integrated into world markets.

In order to address these questions, we focus on that part of Canada's industrial sector where there has been particular concern about efficiency—the Canadian manufacturing sector. It is here that Canada is said to suffer a particularly large productivity disadvantage (Bernstein, Harris and Sharpe 2002). And it is here that advocates of trade liberalization saw the possibility that trade liberalization would effect structural changes that would enhance productivity.

The remainder of the paper is organized as follows. In Section 2, we outline the framework that is used to inform our investigation. In Section 3, we describe the estimating framework and the data that are used in the analysis. Section 4 examines average changes that have occurred across Canadian regions in each of these areas—in plant scale, in product specialization and in the length of the production run. Section 5 provides a multivariate analysis that examines the relationship between plant scale, product specialization, and production-run length and the export intensity of a region—holding other characteristics of the region constant.

2 Trade liberalization and the industrial structure of production

Canadian economists have long argued that tariff protection resulted in plant sizes and production runs within Canadian manufacturing plants that were too short to fully exploit economies of larger scale production. Safarian's (1966, 7) pioneering survey on the relative costs of foreign multinationals operating in Canada reported that most foreign affiliates operating in Canada had higher unit costs than parent companies' plants located in the United States. These higher costs were attributed to a variety of sources; but shorter production runs was the most common response for those reporting higher unit costs.

It is the effect of tariffs on these structural characteristics that provided the foundation for early analyses of the potential consequences of free trade between Canada and the United States (Wonnacott and Wonnacott 1967) and proved to be one of the most important drivers of increases in welfare predicted to result from free trade (Harris 1984; Cox 1994).

Falling trade barriers were seen to lead to longer production runs, either through increases in the size of plants or through the production of fewer varieties of products within plants. Empirical analyses of Canadian manufacturing plants suggested Canadian plants suffered from both suboptimal plant size and excessive production line diversity (Daly, Keys and Spence 1968; Caves 1975), and that falling barriers to trade would result in larger plant sizes (Economic Council of Canada 1967, 1975; Royal Commission on Corporate Concentration 1978). Earlier work by Baldwin and Gorecki (1986) examined the extent to which suboptimal plant scale in Canada was a factor behind Canada–United States productivity differences.

Output diversity in Canadian plants arises not from scope economies, but despite scope diseconomies when the Canadian manufacturing sector is modelled as an import-competing sector serving a small national market (Eastman and Stykolt 1967). Explanations for an industrial structure that produces plants and production runs of suboptimal size have relied on models treating manufacturing industries as containing a small (oligopolistic) number of producers charging a price pegged to the tariff-ridden price of imports. This number of sellers is represented as a free-entry equilibrium, where each (identical) incumbent earns normal profits, or perhaps a bit more, but the entry of one more firm would make all of them unprofitable. Each firm (plant) is treated as facing a downward-sloping demand curve and produces an output that does not exhaust available scale economies. When scale economies are not fully exploited, firms have the incentive to add product lines, even when there are scope diseconomies, if the reduced costs, due to the exploitation of plant-scale economies, offset the disadvantage of scope diseconomies.

In this world, the predicted effect of trade liberalization on firms' diversification choices depends on how competition is modelled. The effect of size on the organization of production depends on firms competition, product differentiation, the supply of potential entrants and other factors. However, under reasonably general conditions, the enlargement of the market should be expected to induce some combination of increased output per firm and increased numbers of competitors, accompanied by a lowered equilibrium price. Given the assumed structure of costs, this change reduces the firm's incentive to pack diversifying products into a plant in order to spread plant fixed costs. As a result, diversification falls. Together, increased plant size and reduced diversification lead to longer production runs.

Baldwin, Caves and Gu (2005) consider the effect of trade policy in this world—one with plant diversification in a market with pervasive product differentiation, resulting in each producer facing a downward-sloping demand curve. The production of each supplier is assumed to be subject to scale economies, and costs curves differ with regards to the level of average costs and the extent of plant scale economies (scale economies for plants with the industry's output as their principal product). Imports and potential imports are similarly differentiated and supplied by price-setting producers. A Nash equilibrium is assumed with each producer (and importer) taking its rivals' prices as given.

In this world, the high protection experienced by Canadian manufacturing industries removes importable varieties from the market, lessening the substitution possibilities that face the typical domestic producer, lowering the elasticity of its individual demand curve and raising the average domestic price. As a result, more entry of domestic producers occurs and, under certain conditions, the typical domestic producer's equilibrium output shrinks and the incentive to pack the domestic plant with diversifying outputs intensifies.

In this case, unilateral tariff reductions by Canada should reduce plant diversity. Simultaneous reductions in U.S. tariffs reinforce this tendency. In this model, when a small country's (e.g., Canada) producers gain access to external markets in which prices now exceed their marginal costs, they are likely to face highly elastic demand curves, thanks to large markets for their exports. They are also likely to select large plant scales that remove the incentive for plant diversification. Other domestic producers with high costs that deny them access to exporting either shut down or expand their production for the domestic market (if the elasticity of the demand that they face has increased). Either way, their actions contribute to a reduction of diversity for the industry's average plant.

Recent analytical work by Baldwin and Gu (2008) develops an extension of this approach using a world of monopolistic competition and heterogeneous producers. This model combines themes regarding product differentiation found in Ottaviano and Thisse (1999) to build on Melitz's (2003) model of heterogeneous single-product plants. It departs from the latter by assuming that firms have multiple products.

Consumers' preferences are represented by a quasi-linear utility function that is defined over a continuum of differentiated varieties. The model assumes that production exhibits economies of scale within varieties and economies of scope across varieties. To enter the differentiated product sector, a firm must bear fixed costs of entry *E,* regardless of the size of its product range, thus implying that economies of scope are present.

An entrant learns about the marginal cost of the production of a variety after commencement of operations. In this world, there are a finite number of multiproduct firms and each firm controls a non-negligible set of varieties. As such, firms are assumed to behave like oligopolists. When choosing its product range and the length of production runs, a firm no longer neglects its impact on the market as in monopolistic competition models of trade.[1] The firm must account for the impact of its choice on the demand for its varieties through its effect on total market demand. Using a two-stage game, a firm chooses its product range Ω_i in the first stage and then the quantity and price of its varieties q_i and p_i in the second stage.

A free-market zero-profits equilibrium determines the number of firms, the variety produced and the average length of a production run. Compared with an average firm in a smaller market, the one in a larger market supplies a larger number of varieties (with a higher degree of product diversification). It has a longer production run and sets a lower price for its product varieties. It is larger, more productive and has higher profits. There are more product varieties and more firms in a larger market.

The analytical model also provides intuitive results on the impact of scale and scope economies on product diversification, length of production run, firm size and firm profits. The existence of strong scale economies within individual products is related to higher product specialization, longer production runs and higher profits. However, it has no effect on firm size and productivity. The existence of strong scope economies at the firm level is related to higher product diversification, larger firm size, lower productivity and higher profits. But it has no effect on the lengths of production runs for individual products.

The model can also be used to generate predictions about the nature of the free-entry equilibrium when trade with other regions is permitted. Firms in this world not only have to decide on offerings for the domestic market but they also have to decide whether they will serve the export market. In this case, firms will divide into non-exporters and exporters—with the more cost-efficient serving both the domestic and the export market. These firms differ in that non-exporters have higher unit costs and their response to declines in profits can be different from

1. In monopolistic competition models of trade in differentiated products, each firm produces one variety because there are no economies of scope across varieties. In these models, each firm correctly neglects its impact on the market.

that of exporters, who have lower unit costs and have more product diversity than do non-exporters. Exporters also respond differently to tariff cuts. Tariffs are incurred to penetrate foreign markets and consist of taxes plus transportation costs. The latter are larger for outlying regions. The overall impact of tariff reductions is gauged by the average change coming from the two different segments—exporters and non-exporters.

The model generates a number of testable implications concerning how the number of products, product diversification, plant size and the length of production runs should change when trade liberalization occurs.

Hypothesis 1: Trade liberalization should lead to a decline in the number of products supplied by individual plants. This decline will be larger for plants with larger home markets and lower transportation costs to access export markets.

For non-exporters, trade liberalization will have a similar effect on measures of the number of products that take into account the distribution of shares across products—such as the entropy measure used here. It has an ambiguous effect on the measure of existing and new exporters.

Hypothesis 2: Trade liberalization has an ambiguous effect on overall plant size since it reduces the size of non-exporters and has an ambiguous effect on the size of current and new exporters. But if the effect is positive, it should be higher for plants with larger home markets and with lower transportation costs to access foreign markets. It should be noted that Baldwin and Gu (2008) find the impact at the national level for exporters to be positive.

Hypothesis 3: Trade liberalization increases the production-run lengths of individual products at existing exporters and new exporters and has no effect on the length of production runs for non-exporters. On average, the length of production runs should increase and it should be higher for plants with larger home markets and lower transportation costs associated with exporting for foreign markets.

Consistent with their analytical predictions, Baldwin and Gu's empirical analysis (2008) shows that declining tariff barriers resulted in increased production-run lengths for Canada as a whole as a result of fewer products being produced within plants.

To summarize, the analytical and empirical literature suggests that smaller regions and those facing higher tariffs will have fewer producers, that they will have less diversification and lower production-run lengths than those facing lower tariffs and with larger populations. They also predict that trade integration will result in increasing specialization and longer production runs. The effect of trade on plant size is more ambiguous. Regardless of the type of adjustment—product diversity, plant size or production-run length—the effects of trade integration will be stronger in those places with larger home markets and those located closer to export markets and, therefore, will incur lower transportation costs.

2.1 Implications

Various analytical models described previously help to inform our examination of differences in plant size and specialization across Canadian regions and the impact of trade liberalization on them. These regions are Atlantic Canada, Quebec, Ontario and Western Canada. These four regions differ substantially from one another in terms of population (Table 1); Ontario had over 11 million inhabitants in 1999, while the smallest region had around 2 million. Over the study period, Ontario and Western Canada grew by over 3 million, Quebec by only about 1 million and Atlantic Canada by less than 200,000.

The regions also differ in terms of their proximity to the focal point of market potential in North America—the U.S. manufacturing belt. Ontario abuts this geographic area that stretches from the mid-Atlantic States to the Midwest, while Atlantic and Western Canada are on the margins of the North American market. Quebec, while not as centrally located as Ontario, is better positioned than Atlantic and Western Canada within the North American market. Transportation costs from these regions act as a type of tariff on products that are exported to this market.

Table 1
Regional population estimates

	Year	
	1974	1999
Atlantic Canada	2,149,046	2,354,163
Quebec	6,268,572	7,323,308
Ontario	8,204,240	11,506,359
Western Canada	6,123,860	9,121,795
Canada	22,807,918	30,403,878

Source: Statistics Canada, CANSIM table 051-0001.

Declining barriers to trade affect regions differently because tariffs are higher for outlying regions, due to higher transportation costs. The model predicts small changes in industrial structure for those regions facing higher tariffs, which consist of taxes plus transportation costs. The reaction of producers in a market to reductions in tariffs depends upon the density of those markets and the distance a region is from its export markets.

Distance to market acts as a tariff on the exports of a region. Empirical studies that model the volume of trade between countries or regions (Frankel, Wei and Stein 1997) have consistently found distances to be one of the most important determinants of the volume of trade. For instance, Brown and Anderson (2002) find the elasticity on distance is around one for the majority of two-digit manufacturing export sectors for interstate and province-state trade in North America. For a continental economy like Canada's, distance has a non-trivial effect on market access and, therefore, location relative to the broader North American market may help to determine how producers react to falling barriers to trade.

To understand this phenomenon, it is helpful to contrast the relative locations of Ontario and Western Canada with respect to the U.S. market. Ontario is within one day's trucking of 100 million people in the United States. There is no location in Western Canada that is comparable in terms of its market access. Therefore, even though both regions may experience the same absolute decline in tariff barriers, this decline serves to increase the total market faced by Ontario firms by far more than it does for firms located in Western Canada. This implies that, *ceteris paribus*, falling tariff barriers from the North American Free Trade Agreement will have a stronger effect on producers in Ontario, specifically Southern Ontario, than in Western Canada.

Placing these results within a geographic context implies the effects of growing integration will vary, depending on the location of a region relative to larger continental markets. These effects should be felt most in those regions that are at the nexus of the North American market. In practical terms, this means producers in Ontario and possibly Quebec will change how they organize their production the most, while Atlantic Canada and Western Canada will experience more muted gains. In the section below, we test these expectations.

3 Research strategy and data

3.1 Research strategy

Our research question focuses on whether those regions that are more integrated into North American markets tend to have those characteristics that would be suggested by the trade literature. To do so, we examine the following relationship:

$$C_{jt} = f\left(EX_{jt}, \mathbf{X}_{jt}\right), \tag{1}$$

where C_{jt} is the characteristic of the census division[2] j in year t (average plant size, average product diversity, or average production-run length), EX is the export intensity of the census division and $\mathbf{X}$ is a set of other characteristics (e.g., region, year, industry and urban/rural class). For this analysis, we created a constant census division geography for the time period studied.

The export intensity of a census division is defined as the proportion of the value of total shipments that are exported abroad. Census divisions that have higher export intensities are those with greater integration into world markets. In other research, we have used the height of tariff barriers and their decline over time to measure the extent to which an industry was exposed to decreases in trade barriers over time (Baldwin, Caves and Gu 2005). Here we choose to focus on export intensity as a more comprehensive measure of trade exposure because we want to understand how integration into world markets is related to the industrial characteristics of regions. Tariffs are only one factor that has led to increased integration. Improved financial markets that allow for exchange-rate derivatives, trade treaties that deal with non-tariff barriers to trade and global arbitration frameworks have also reduced uncertainties surrounding trade and contributed to increasing global integration. We believe that export intensity is a good measure of the actual integration of a plant into foreign markets.

2. Census divisions in most provinces correspond to counties or regional municipalities and are similar in size to U.S. counties.

If estimated as a pooled set of cross-sections, our coefficients on export intensity in (1) would capture two effects. On a cross-sectional basis, they capture the impact of varying degrees of integration at a point in time in the world or North American economy. But they also have a time-series dimension. Here, they capture the extent to which the increasing integration of Canadian plants into world markets—due primarily to trade liberalization—has affected the average plant characteristics in which we are interested.

To disentangle the influence of cross-sectional and time-series variation, we use two different estimators. We use the between estimator, which is based on the means of the left- and right-hand-side variables over time, to capture the effect of cross-sectional variation alone. Alternatively, we use a fixed-effects estimator to capture time-series variation. For this we estimate

$$C_{jt} = f(EX_{jt}, \mathbf{X}_{jt}, \gamma_j), \tag{2}$$

where γ_j is an unobserved characteristic of the region j that may be correlated with export intensity. If there are such characteristics, then the coefficient estimate associated with export intensity resulting from the between estimator will be biased. As in Head and Ries (1999b), we correct for this using the fixed-effects estimator. We also estimated first-difference equations to investigate the effects of changes over time in a different way, and obtained much the same results reported later.

3.2 Data

The data used for this study are derived from a longitudinal microdata file that covers the universe of manufacturing plants in Canada from 1973 to 1999. The longitudinal microdata file is built from both administrative and survey sources, with the primary sources being the Annual Census of Manufacturers in earlier years and the Annual Survey of Manufactures (ASM) in later years. The survey data are derived from the more detailed long-form questionnaires that are primarily sent to larger plants and the less detailed short-form questionnaires that are mainly sent to smaller plants. For the smallest plants, administrative data from tax records are used to measure sales and employment.

It is only the long-form questionnaires that provide information on plant exports and the number and quantities of commodities produced within each plant. Both are key variables to be used in the analysis. As a result, we restrict the data set to plants that respond to the long-form questionnaire (long-form plants). In 1999, long-form plants accounted for 82% of plant-based employment and 93% of manufacturing shipments. Therefore, there is little loss of generality by focusing the analysis on only long-form plants.

Long-form plants were asked to report their exports for only a select number of years: 1974, 1979, 1984, 1990, 1993, and 1996 to 1999. Depending on the circumstances, we will use all or a subset of these years in the analysis.

Throughout the analysis, we investigate several characteristics related to industrial structure that might be expected to have been affected by integration into world markets. These include plant size, plant commodity diversity and the length of production run.

Plant size: The average size of plants within a census division is measured as the value of total manufacturing shipments of plants located in the census division divided by the number of plants, measured in 1992 constant dollars.[3]

Product diversity: Product diversity captures the extent to which plants in a region produce a diversified set of products. It is measured using the entropy index:

$$E = \sum_{p=1}^{\Omega} s_v \log\left(1/s_p\right), \tag{3}$$

where s_v is the share of total sales of a plant accounted for by product p and Ω is the total number of products produced by the plant. The entropy index has a value of zero when sales are concentrated in one product line. At the other extreme, if the plant's output is evenly distributed across all product lines, the entropy index takes on a maximum value of $E = \log(\Omega)$. We will measure product diversity using the numbers equivalent of *E*, which is $NE = 10^E$. The *NE* measure is interpreted as the number of products that would be present in a plant if sales were evenly distributed across all products.[4] The *NE* is averaged across all plants for each census division.

Production-run length: The length of the production run in a plant is measured by dividing each census division's total manufactured shipments (measured in constant 1992 dollars) by the total number of commodities (*NE*) produced in the region.

For the descriptive analysis and econometric analysis to follow, the set of census divisions is limited to those that had manufacturing plants throughout the study period and, hence, were able to supply information on plant size, commodities per plant and the length of production runs. A total of 239 census divisions met this criterion.

3. Industry price indices derived from Statistics Canada's productivity accounts were used for this purpose.
4. More detail on the calculation of these measures can be found in Baldwin, Beckstead and Caves (2000).

4 Differences in industrial organization across Canadian regions

As noted above, integration into world markets can result in changes in the organization of production within plants. This section provides a descriptive analysis of the degree to which regional economies have become more integrated into world markets and whether this is associated with changes in the organization of production within plants.

Over the past quarter century, Canadian manufacturing plants have become increasingly integrated into world markets. The export intensity (exports divided by sales) of the manufacturing sector as a whole more than doubled over a 25-year period—increasing from 0.18 in 1974 to 0.43 in 1999.[5] The average export intensities of census divisions follow a similar, albeit more muted, trend. The average census division included in our study increased its export intensity from 0.23 in 1974 to 0.37 in 1999 (see Table 2).

Across regions, census divisions in Atlantic Canada and Western Canada started the period with export intensities that averaged above those in Ontario and Quebec. Over time, however, the export intensities of Ontario and Quebec's census divisions increased at a faster pace than did those in either Atlantic Canada or Western Canada. As a result, by 1999 the export intensity of Ontario had passed that of Western Canada and was nearly that of the Atlantic region. Meanwhile, Quebec had passed Western Canada, while its census divisions still lagged the average export intensity of those in Atlantic Canada.

It is noteworthy that Western Canada's export intensity declined significantly from 1996 to 1999. At least in part, this reflected declining demand resulting from the Asian financial crisis in 1997. The picture that emerges is of a manufacturing sector that has become increasingly integrated into world markets, especially in Canada's industrial heartland.

Table 2
Average export intensity of regions and Canada, selected years

Year	Atlantic Canada	Quebec	Ontario	Western Canada	**Canada**
1974	0.33	0.16	0.19	0.25	0.23
1979	0.32	0.19	0.22	0.29	0.25
1984	0.37	0.23	0.24	0.30	0.28
1990	0.38	0.28	0.28	0.32	0.31
1993	0.48	0.31	0.36	0.39	0.38
1996	0.48	0.36	0.40	0.42	0.41
1999	0.44	0.35	0.41	0.32	0.37

Note: Special tabulation by the authors.
Source: Statistics Canada, Annual Survey of Manufactures.

5. Special tabulation of the Annual Survey of Manufactures.

The question at hand is how this growing integration is correlated with shifts in the plant size, the number of products (*NE*) per plant and the length of production runs within these broad regions. We measure these characteristics, at the regional level, by taking the average of plants' characteristics for each census division and then taking the average of these across the same regions presented in Table 2.

In accordance with our models, the largest plant size is found in Ontario (Table 3). Over the past quarter of a century, all regions increased their plant sizes, but it was in Ontario, which is closest to the American heartland, where the average plant size increased the most. At the start of the period, average plant size was highest for census divisions in Ontario, followed by Atlantic Canada, Western Canada and Quebec. Although by the end of the period, census divisions in all regions had higher average plant sizes, plants in Ontario more than tripled in size, while those in Quebec and Western Canada doubled and those in Atlantic Canada increased by about 70%. This has resulted in an increasing gap between the average sizes of plants in census divisions found in Ontario compared with the other regions.

The difference in the rate of increase in plant size across regions mirrors differences in changes in export intensity over time. For instance, Ontario experienced the largest increase in export intensity and the largest increases in plant size.

Table 3
Average census division plant size by region, selected years

Year	Region							
	Atlantic Canada		Quebec		Ontario		Western Canada	
	thousands of 1992 constant dollars (index 1974=100)							
1974	11,416	(100)	8,307	(100)	15,998	(100)	11,403	(100)
1979	15,557	(136)	12,546	(151)	24,923	(156)	16,390	(144)
1984	11,501	(101)	14,409	(173)	24,754	(155)	15,817	(139)
1990	8,804	(77)	13,905	(167)	26,859	(168)	14,199	(125)
1993	12,665	(111)	12,021	(145)	35,561	(222)	21,878	(192)
1996	13,820	(121)	14,199	(171)	39,171	(245)	23,295	(204)
1999	19,086	(167)	17,893	(215)	50,543	(316)	24,671	(216)

Note: Special tabulation by the authors.
Source: Statistics Canada, Annual Survey of Manufactures.

The largest industrial region also had the largest number of products per plant, as predicted by our models; changes in the number of products per plant increased, as predicted, with the increasing integration into North American markets (Table 4).

Trade integration can lead to scale economies being more fully exploited, by increasing plant size and/or by decreasing the number of products produced in each plant. As Table 4 indicates, the numbers of products were being reduced throughout the period at the same time that plant size was increasing. There was a decline across all regions in the number of commodities (measured using *NE*) produced in the average census division's plant. At the beginning of the period, the average plant within the average census division produced two and one quarter commodities in all regions, except for Ontario. In Ontario, this figure was just under two and one half commodities. By 1999, this average fell to fewer than two commodities. The rate of decline in the number of products produced was about the same across regions, with a slight advantage for Ontario.

Table 4
Average census division commodities per plant, by region, selected years

Year	Region							
	Atlantic Canada		Quebec		Ontario		Western Canada	
	NE[1] (index 1974 =100)							
1974	2.26	(100)	2.29	(100)	2.41	(100)	2.28	(100)
1979	2.25	(100)	2.26	(99)	2.31	(96)	2.26	(99)
1984	2.10	(93)	2.29	(100)	2.27	(94)	2.35	(103)
1990	1.89	(84)	2.10	(92)	2.17	(90)	2.18	(96)
1993	1.89	(84)	1.98	(86)	2.03	(84)	2.20	(96)
1996	1.81	(80)	1.93	(84)	1.90	(79)	2.00	(88)
1999	1.75	(77)	1.79	(78)	1.84	(76)	1.90	(83)

1. The number of products that would be present in a plant if sales were evenly distributed across all products.
Note: Special tabulation by the authors.
Source: Statistics Canada, Annual Survey of Manufactures.

The analytical framework that informs the analysis also predicts that the average length of a production run should be higher in the larger provinces that are closer to the focal point of the North American market, and it is. Ontario has the longest production-run lengths throughout the period (Table 5).

The effect of larger plant sizes and falling commodity diversity per plant was to increase the length of production runs across all regions (Table 5). In Atlantic Canada, Western Canada and Quebec, production-run lengths, in the average census division, increased by roughly the same amount from 1974 to 1999. In Ontario, the length of production runs increased by a little over fourfold, reflecting both the stronger increases in plant sizes in Ontario and declines in number of commodities per plant.

Table 5
Average census division production run length per plant by region, selected years

Year	Region							
	Atlantic Canada		Quebec		Ontario		Western Canada	
	thousands of 1992 constant dollars (index 1974=100)							
1974	5,294	(100)	3,599	(100)	6,813	(100)	4,782	(100)
1979	7,124	(135)	5,709	(159)	10,953	(161)	7,418	(155)
1984	5,949	(112)	6,410	(178)	11,130	(163)	6,843	(143)
1990	4,640	(88)	6,733	(187)	12,300	(181)	7,145	(149)
1993	6,581	(124)	5,945	(165)	18,435	(271)	10,654	(223)
1996	7,680	(145)	7,211	(200)	21,710	(319)	12,835	(268)
1999	12,421	(235)	9,767	(271)	28,940	(425)	13,741	(287)

Note: Special tabulation by the authors.
Source: Statistics Canada, Annual Survey of Manufactures.

Overall, the picture that emerges is of a Canadian manufacturing sector that is increasingly integrated into export markets across all regions. At the same time, there have been increases in plant size and increases in the length of production runs, both of which should have allowed scale economies to be more fully exploited. These scale-enhancing changes were most marked in Ontario. This was also the economy that experienced the most rapid integration of its manufacturing sector into export markets.

In order to further investigate these associations, we pursue a multivariate analysis in the succeeding sections that allows us to control for variables other than trade intensity that might be associated with the average characteristics of plants across geographic units.

5 Determinants of the industrial structure of production across regions

This section asks whether the differences in the export intensity of different areas are related to differences in several structural characteristics related to productivity—plant size, product diversity and production-run length. It investigates this issue using multivariate analysis. In doing so, it also takes into account other variables that are believed to influence industrial organization or structure. Included in these are export intensity and regional binary variables for Atlantic Canada, Quebec and Western Canada. Ontario is the excluded region.

Structural differences may also reflect differences in the sizes of local markets, either in terms of intermediate demand from other manufacturing firms or final demand. This possibility is investigated by including a measure of the size of the manufacturing sector within each census division as measured by employment and whether the census division is urban. We also include in the model an interaction term between employment and whether the census division is rural or urban.

In order to investigate whether differences in the response to trade liberalization have had different effects across the manufacturing sector, we divide the manufacturing sector into five groups—natural resource-based, labour-intensive, scale-based, product-differentiated and science-based industries. Labour-intensive industries are those with low capital–labour ratios, low wages and considerable import competition. Natural resource-based industries are those that have relatively low value added relative to their inputs—industries like food processing that depend upon agricultural materials. Scale-based industries have large plants, high capital–labour ratios and economies of scale. Product-differentiated industries have high advertising-to-sales ratios and produce a large number of products per plant. Science-based industries have a large white-collar workforce and focus on research and development.[6] In the regressions, each sector enters as its share of overall manufacturing employment in the census division, with natural resource-based industries as the omitted category.

Finally, the export intensity variable is also included as an interaction term with certain of the geographic binary variables—regional or urban—to test whether its effect is greater or less across regions. This serves as a more formal test of whether location relative to markets influences the industrial organization of production within geographic units.

6 . For a description of the sectors, see Baldwin and Rafiquzzaman (1995).

5.1 Plant size

We first examine the relationship between higher levels of export intensity and average plant size using a series of econometric models estimated using a panel of census divisions (see Table 6). Models 1 through 3 are based on the between estimator and, as such, only take into account the effect of cross-sectional variation. Model 4 is estimated using a fixed-effects estimator, which only takes into account the effect of changes over time.[7]

Model 1 includes regional binary variables and controls for industrial structure. Examining differences across regions, we see that over the period the average plant size in census divisions found within Atlantic Canada, Quebec and Western Canada are significantly smaller than those in Ontario, which accords with the basic tabulations (see Table 3).

We then include a measure of the size of the manufacturing sector within each census division and whether the census division is rural or urban. We also include in the model an interaction term between employment and whether the census division is rural or urban. When this is done (Model 2), it is apparent that higher levels of manufacturing employment are associated with larger plant sizes in rural census divisions, reflecting the joint effect of larger downstream intermediate demand and possibly larger local final demand markets, which are likely correlated with the size of the manufacturing sector. In urban census divisions, plant size is also larger since Urban has a positive, albeit weakly significant, coefficient; however, here the relationship between employment and plant size is absent. Merely being part of an urban economy has a stronger effect on plant size than the size of the manufacturing sector within the urban census division.

Also included in Model 2 is the export intensity of census divisions, thereby permitting us to examine the impact of a region's being integrated into the world and North American economies. The coefficient on the export intensity variable is positive and highly significant. Export intensity and the average size of plants in census divisions are positively related. An increase in export intensity from 0.25 to 0.50 is associated with close to a $9 million increase in output, which is a non-trivial amount when compared with the average size of plants.

In Model 3, interaction terms between export intensity and regions are added. They indicate that the relationship between higher levels of export intensity and plant size is much weaker outside of Ontario, which is consistent with our theoretical expectations. It should be noted that inclusion of variables that allow the effect of export intensity to vary across regions eliminated any significant effect of the regional binary variables on plant size. That is, the consistent differences in the average plant size of census divisions across regions we observed in Table 3, and that are reflected in our parameter estimates in Models 1 and 2, are accounted for by the much weaker effect of trade on plant size outside of Ontario.

Also included in Model 3 is an interaction term between the urban binary variable and export intensity. Its coefficient is insignificant, indicating firms in urban areas, whose plant sizes tend to be larger, adjusted their plant sizes no more or no less than those in rural areas.

7. We also estimated a first difference model to capture changes over time and obtained results that were qualitatively similar to those reported here.

There remains the possibility that these results are due to unobserved fixed effects that are correlated with both average plant size and export intensity. Model 4, which corresponds to Model 3, is estimated using a fixed-effects model that controls for both cross-sectional and time-series effects. Time binary variables are also included to allow for long-term time trends in average plant sizes. Their inclusion allows for the possibility that long-term common time trends underlie both changes in export intensity and changes in plant size.

Table 6
Plant size models

	Model 1		Model 2		Model 3		Model 4	
Constant	20,619,000	(0.000)	9,532,000	(0.069)	-3,247,000	(0.634)	8,599,000	(0.003)
Atlantic Canada	-16,950,000	(0.000)	-18,350,000	(0.000)	2,835,000	(0.725)	…	…
Quebec	-16,730,000	(0.000)	-15,170,000	(0.000)	109,000	(0.987)	…	…
Western Canada	-11,970,000	(0.001)	-9,484,000	(0.007)	2,265,000	(0.726)	…	…
Employment	…	…	1,388,000	(0.033)	1,127,000	(0.081)	346,000	(0.068)
× Urban	…	…	-1,393,000	(0.032)	-1,131,000	(0.079)	-342,000	(0.079)
Urban	…	…	5,383,000	(0.102)	8,143,000	(0.147)	…	…
Export intensity	…	…	35,063,000	(0.000)	80,180,000	(0.000)	50,998,000	(0.000)
× Atlantic Canada	…	…	…	…	-63,380,000	(0.001)	-55,850,000	(0.000)
× Quebec	…	…	…	…	-50,130,000	(0.000)	-32,690,000	(0.001)
× Western Canada	…	…	…	…	-39,280,000	(0.001)	-45,000,000	(0.000)
× Urban	…	…	…	…	-14,980,000	(0.610)	-2,998,000	(0.708)
Labour-intensive	-8,903,000	(0.334)	-3,781,000	(0.675)	-3,888,000	(0.665)	-4,860,000	(0.170)
Scale-based	31,196,000	(0.000)	15,328,000	(0.010)	13,599,000	(0.023)	2,927,000	(0.519)
Product-differentiated	-15,250,000	(0.235)	-7,513,000	(0.544)	-4,907,000	(0.689)	-29,440,000	(0.000)
Science-based	46,143,000	(0.002)	33,665,000	(0.027)	36,119,000	(0.017)	30,670,000	(0.011)
1979	…	…	…	…	…	…	5,082,000	(0.000)
1984	…	…	…	…	…	…	3,996,000	(0.001)
1990	…	…	…	…	…	…	2,606,000	(0.028)
1993	…	…	…	…	…	…	5,894,000	(0.000)
1996	…	…	…	…	…	…	7,586,000	(0.000)
1997	…	…	…	…	…	…	8,573,000	(0.000)
1998	…	…	…	…	…	…	11,487,000	(0.000)
1999	…	…	…	…	…	…	12,183,000	(0.000)
Observations	2,151	…	2,151	…	2,151	…	2,151	…
Census divisions	239	…	239	…	239	…	239	…
R-squared	0.32	…	0.39	…	0.43	…	0.23	…
F (Probability>F)	16.8	(0.000)	14.5	(0.000)	11.8	(0.000)	17.5	(0.000)
Estimator	between	…	between	…	between	…	fixed effects	…

… not applicable
Note: P-values are in parentheses and are corrected for heteroskedasticity in Model 4.
Source: Statistics Canada, Annual Survey of Manufactures.

The results presented in Model 4 are similar to those of Model 3. The fixed-effects model purges the results of cross-sectional variation and leaves the estimates mainly to capture the effect of changing export intensity over time. It is therefore noteworthy that export intensity is still significant in this formulation, thereby demonstrating that the changes in export intensity tended to increase plant size.

Perhaps the most significant conclusion to be drawn from Model 4 is that the effect of exports on plant sizes is insignificant outside of Ontario and Quebec. The coefficients on export intensity for Atlantic Canada and Western Canada are not significantly different from zero. For Quebec, the effect of export intensity on plant size is more muted than for Ontario, but remains statistically significant. The impact of growing exports on the average plant sizes of census divisions was limited to census divisions in Central Canada, with by far the largest effect being in Ontario. These results therefore show that adaptation to trade liberalization occurred primarily in Central Canada

5.2 Commodities per plant

It has been argued that trade barriers may not only lead to plants that do not fully exploit economies of scale, but that they may also lead to plants producing too many varieties of products.[8] By doing so, plants can increase overall production to exploit economies of scale more fully at the plant level, all the while losing some of the scale economies that result from long production runs. Essentially, a trade-off occurs between suboptimal plant size and suboptimal production-run length that results from product packing at the plant level—with the outcome depending upon on the relative size of cost penalties in each area.

Baldwin and Gu (2008) demonstrate that declining tariff barriers will result in fewer products being produced within plants. We investigate here how this tendency varies across Canadian regions.

We regress the same set of explanatory variables used in the plant size model against the number of commodities per plant—the numbers equivalent averaged across plants within each census division (see Table 7). Model 1 is the simplest and includes only controls for industry and a set of regional binary variables to account for level differences across regions. Across regions, the average number of commodities per plant in Atlantic Canada, Quebec and Western Canada is statistically not different from that in Ontario.

Model 2 adds the level of export intensity across census divisions, as well as controls for the size of regions. Theoretically, market size is positively associated with the number of commodities (products) produced per plant (see Baldwin and Gu 2008). Therefore, our expectation is that census divisions with larger markets, as proxied by these variables, would have higher average counts of commodities per plant. However, controls for the size of the manufacturing sector in each census division and whether census divisions were rural or urban were insignificant.

8. Earlier work by Safarian (1966) for the 1960s noted that multinationals operating in Canada had short production runs. Scherer et al. (1975) compared several Western countries in the 1970s and found that Canadian production runs were generally lower than those in the United States.

Consistent with expectations, the coefficient on export intensity is negative and significant. Census divisions that are more export-intensive have fewer commodities per plant on average. The differences across regions in terms of product diversity on a cross-sectional basis are strongly related to the degree to which they are integrated into the North American market.

Table 7
Numbers-equivalent[1] commodities per plant model

	Model 1		Model 2		Model 3		Model 4	
Constant	1.91	(0.000)	2.00	(0.000)	1.99	(0.000)	2.30	(0.000)
Atlantic Canada	-0.05	(0.494)	0.02	(0.778)	0.29	(0.047)	…	…
Quebec	-0.0020	(0.972)	0.0020	(0.970)	-0.16	(0.173)	…	…
Western Canada	0.07	(0.245)	0.09	(0.177)	0.09	(0.437)	…	…
Employment	…	…	0.02	(0.183)	0.01	(0.299)	0.01	(0.224)
× Urban	…	…	-0.014	(0.214)	-0.011	(0.354)	-0.003	(0.568)
Urban	…	…	-0.08	(0.157)	-0.07	(0.488)	…	…
Export intensity	…	…	-0.49	(0.000)	-0.45	(0.114)	-0.19	(0.250)
× Atlantic Canada	…	…	…	…	-0.67	(0.058)	0.19	(0.397)
× Quebec	…	…	…	…	0.53	(0.106)	0.13	(0.427)
× Western Canada	…	…	…	…	-0.06	(0.526)	0.15	(0.470)
× Urban	…	…	…	…	-0.14	(0.620)	0.15	(0.468)
Labour-intensive	-0.01	(0.938)	-0.14	(0.393)	-0.09	(0.577)	-0.04	(0.831)
Scale-based	0.17	(0.076)	0.35	(0.001)	0.37	(0.001)	-0.03	(0.816)
Product-differentiated	0.73	(0.001)	0.64	(0.004)	0.67	(0.002)	-0.09	(0.635)
Science-based	0.14	(0.583)	0.33	(0.228)	0.22	(0.402)	0.37	(0.112)
1979	…	…	…	…	…	…	-0.04	(0.316)
1984	…	…	…	…	…	…	-0.03	(0.369)
1990	…	…	…	…	…	…	-0.20	(0.000)
1993	…	…	…	…	…	…	-0.26	(0.000)
1996	…	…	…	…	…	…	-0.37	(0.000)
1997	…	…	…	…	…	…	-0.42	(0.000)
1998	…	…	…	…	…	…	-0.42	(0.000)
1999	…	…	…	…	…	…	-0.47	(0.000)
Observations	2,151	…	2,151	…	2,151	…	2,151	…
Census divisions	239	…	239	…	239	…	239	…
R-squared	0.09	…	0.16	…	0.21	…	0.25	…
F (Probability>F)	3.2	(0.003)	3.8	(0.000)	4.0	(0.000)	41.9	(0.000)
Estimator	between	…	between	…	between	…	fixed effects	…

… not applicable
1. The numbers equivalent measure is interpreted as the number of products that would be present in a plant if sales were evenly distributed across all products.
Note: P-values are in parentheses and are corrected for heteroskedasticity in Model 4.
Source: Statistics Canada, Annual Survey of Manufactures.

To allow for a differential effect of export intensity on the average number of commodities per plant across regions and rural and urban areas, a set of regional interaction terms is included in

Model 3. With the possible exception of Atlantic Canada, none of the regional, or the urban, interaction terms were significant, suggesting the effect of export intensity on the average number of commodities per plant did not vary systematically across geographic regions or urban-rural classes.

Model 4 is a fixed-effects model that corresponds in functional form to Model 3 that captures only changes over time (i.e., that has the cross-sectional effects removed). The effect of export intensity in Ontario was not significantly different from zero. The same was true of the other regions. As this indicated no significant difference in the effect of export intensity across regions, we estimated a variant of Model 4 with the interaction terms removed. The coefficient on export intensity in this model was also not significantly different from zero. Although there was a general decline in the commodity diversity of plants as indicated by the year binary variables, there was no discernable independent effect of changes in the export intensity of census divisions over time. This may, of course, simply mean that it is difficult to separate the impact of export intensity over time and the time trend reduction in commodity diversification—that they were both being caused by the same underlying causes or that export intensity was increasing with a trend and directly driving specialization.[9]

5.3 Length of production run

Previous analytical and empirical work suggests falling barriers to trade will result in increases in the length of production runs. In the models presented below, we test this further by looking at how variations in the export intensity across regions affect the average length of production runs within each region.

Production-run length is derived as the ratio of plant size divided by number of products produced (derived from our numbers-equivalent measure). Thus, we expect that the same variables that were related in a systematic way to plant size and number of commodities will also be related to production-run length. We therefore include binary variables for four broad regions (Atlantic Canada, Quebec, Ontario and Western Canada) and interact these with export intensity to test the differential effect of export intensity across regions. In light of our previous findings, our expectation is that higher levels of export intensity will have the strongest effect on Ontario and Quebec and the weakest effect on Western Canada and Atlantic Canada, which are much more isolated from North American markets.

The results are presented in Table 8. In Model 1, we include only controls for industrial composition and region. After controlling for the industrial composition of regions, the average length of production runs for census divisions in Atlantic Canada, Quebec and Western Canada was less than in Ontario.

In Model 2, we include variables that control for local market size, both in terms of the manufacturing sector and (indirectly) final demand. They show that production-run length

9. This interpretation receives some support when the time binary effects are removed from Model 4. When this is done, export intensity becomes highly significant and the value for Ontario is significantly higher than for other provinces.

increases with the size of manufacturing employment in rural areas and is typically higher in urban areas.

To test the effect of export intensity on the average length of production runs, Model 2 also includes the export intensity of census divisions. As with the analogous plant size model, census divisions with higher levels of export intensity also tend to be characterised by plants with longer production runs.

Table 8
Length of production run

	Model 1		Model 2		Model 3		Model 4	
Constant	10,366,000	(0.000)	4,242,000	(0.142)	-5,173,000	(0.163)	2,611,000	(0.124)
Atlantic Canada	-8,497,000	(0.000)	-9,357,000	(0.000)	3,587,000	(0.414)	…	…
Quebec	-9,202,000	(0.000)	-8,348,000	(0.000)	3,742,000	(0.290)	…	…
Western Canada	-6,761,000	(0.000)	-5,442,000	(0.005)	3,880,000	(0.270)	…	…
Employment	…	…	713,000	(0.046)	581,000	(0.098)	169,000	(0.109)
× Urban	…	…	-712,000	(0.046)	-581,000	(0.097)	-172,000	(0.114)
Urban	…	…	2,924,000	(0.107)	3,825,000	(0.210)	…	…
Export intensity	…	…	19,779,000	(0.000)	51,650,000	(0.000)	27,270,000	(0.000)
× Atlantic Canada	…	…	…	…	-39,330,000	(0.001)	-28,390,000	(0.000)
× Quebec	…	…	…	…	-39,270,000	(0.000)	-23,830,000	(0.000)
× Western Canada	…	…	…	…	-30,090,000	(0.001)	-25,680,000	(0.000)
× Urban	…	…	…	…	-6,054,000	(0.610)	789,000	(0.852)
Labour intensive	-3,021,000	(0.552)	-56,000	(0.991)	-353,000	(0.942)	-2,269,000	(0.204)
Scale-based	17,424,000	(0.000)	8,547,000	(0.009)	7,590,000	(0.019)	4,591,000	(0.130)
Product differentiated	-7,044,000	(0.320)	-2,674,000	(0.695)	-1,372,000	(0.837)	-13,780,000	(0.000)
Science-based	18,546,000	(0.025)	11,420,000	(0.171)	14,355,000	(0.080)	12,803,000	(0.007)
1979	…	…	…	…	…	…	2,486,000	(0.000)
1984	…	…	…	…	…	…	2,026,000	(0.004)
1990	…	…	…	…	…	…	1,933,000	(0.004)
1993	…	…	…	…	…	…	3,860,000	(0.000)
1996	…	…	…	…	…	…	5,660,000	(0.000)
1997	…	…	…	…	…	…	6,322,000	(0.000)
1998	…	…	…	…	…	…	7,662,000	(0.000)
1999	…	…	…	…	…	…	8,891,000	(0.000)
Observations	2,151	…	2,151	…	2,151	…	2,151	…
Census divisions	239	…	239	…	239	…	239	…
R-squared	0.32	…	0.40	…	0.44	…	0.23	…
F (Probability>F)	15.5	(0.000)	13.6	(0.000)	11.9	(0.000)	22.7	(0.000)
Estimator	between	…	between	…	between	…	fixed effects	…

… not applicable
Notes: P-values are in parentheses and are corrected for heteroskedasticity in Model 4.
Source: Statistics Canada, Annual Survey of Manufactures.

Model 3 adds interaction terms between export intensity and regional binary variables. Regions that are more export intensive have average production runs that are longer than regions that are less export intensive. When regional interaction terms are included, substantial differences are seen to exist across regions. In Ontario, which is the excluded region in the regression, the effect of export intensity on average production-run length is significantly higher than in Atlantic Canada, Quebec or Western Canada. As with the analogous plant-size model, the interaction term between export intensity and urban was insignificant.

Shifting from the between to a fixed-effects estimator (Model 4) to purge the relationship of its cross-section dimension and examine just time-series dimension provides similar results. The main differences are that the effect of export intensity on the length of production runs is about halved. Nevertheless, it is still statistically significant. The effect of export intensity outside of Ontario, which was positive in Model 3, is not significantly different from zero in Model 4. It is also noteworthy that export intensity for Quebec has a positive effect on plant sizes, but the effect for the length of production runs is not significantly different from zero.

5.4 Exporters compared with non-exporters

The differences in regional performance described previously are derived from averages in each region that are derived from heterogeneous groups of firms. Baldwin and Gu (2008) predict that exporters and non-exporters may differ in terms of their reaction to increasing trade liberalization. In particular, a decline in tariffs is expected to lead to a decline in average plant size in non-exporters but has an ambiguous effect on existing and new exporters. The plant numbers equivalent should fall for non-exporters but the effect on exporters is ambiguous. A decline in trade costs increases the length of production runs of individual products at existing and new exporters. It reduces the length of the production run of individual products at non-exporters.

In order to test whether these predictions are confirmed across regions and whether there are differential responses of each group across regions, the model was estimated for plant size, number of products and the length of production run for exporters as opposed to non-exporters. The results are reported in Table 9. Only the fixed-effects Model 4 is reported, since we are primarily interested in how changes over time had a differential impact on the structural characteristics. The same set of independent variables that were used in Tables 6, 7 and 8 are employed but only the results on export intensity are reported in Table 9. Export intensity refers to the average export intensity of the census division; the structural attributes refer to the characteristics of exporters and non-exporters within the census division.

For non-exporters, changes in the trade intensity of the region are associated with either no change in plant size for Ontario or a reduction in plant size for the other regions, as was predicted by Baldwin and Gu (2008). The number of commodities falls for Ontario and most of the other regions—though these other regions do not experience a significantly lower reduction than does Ontario. The length of production run decreases as predicted, except in Ontario. In summary, the expected reactions for plant size and commodities are found across most of the outlying regions, but the changes are smaller in Ontario.

For exporters, the model had ambiguous predictions on the effect of trade liberalization on plant size; though at a national level, the empirical results indicated that exporters increased their plant size (Baldwin and Gu 2008). The regional estimates show that reactions to increased trade integration were generally positive but much larger in Ontario compared with both Atlantic Canada and Western Canada, though about the same as in Quebec. For length of production run where the model predicted increases for exporters, the impact of export intensity is once again positive across all regions, but greatest in Ontario. Contrary to the model's predictions of increasing specialization for non-exporters, the predictions for exporters is ambiguous, and the coefficients that relate changes in the number of commodities and trade integration are not significantly different from zero, nor are there significant differences across regions.[10]

Table 9
Exporting and non-exporting plant fixed-effects models

	Plant size		NE[1] commodities per plant		Production-run length	
			Exporters			
Export intensity	47,732,000	(0.000)	-0.19	(0.406)	23,079,000	(0.001)
× Atlantic Canada	-29,420,000	(0.037)	0.16	(0.570)	-13,490,000	(0.106)
× Quebec	1,428,323	(0.920)	0.09	(0.709)	-11,120,000	(0.108)
× Western Canada	-39,890,000	(0.005)	0.28	(0.334)	-26,240,000	(0.001)
Observations	2,084	…	2,084	…	2,084	…
Census divisions	239	…	239	…	239	…
R-squared	0.12	…	0.15	…	0.17	…
F (Probability>F)	7.3	(0.000)	24.7	(0.000)	14.1	(0.000)
			Non-exporters			
Export intensity	4,189,000	(0.309)	-0.50	(0.000)	4,258,000	(0.054)
× Atlantic Canada	-27,620,000	(0.007)	0.27	(0.333)	-14,510,000	(0.000)
× Quebec	-20,790,000	(0.000)	0.29	(0.182)	-12,860,000	(0.000)
× Western Canada	-14,880,000	(0.001)	0.06	(0.823)	-8,666,000	(0.000)
Observations	2,107	…	2,107	…	2,107	…
Census divisions	239	…	239	…	239	…
R-squared	0.08	…	0.16	…	0.10	…
F (Probability>F)	7.5	(0.000)	24.9	(0.000)	9.1	(0.000)

… not applicable
1. Number of products that would be present in a plant if sales were evenly distributed across all products.
Notes: P-values are in parentheses and are corrected for heteroskedasticity. All models are estimated using Model 4 from Tables 6 through 8 using subsets of exporters and non-exporters. Only the coefficients for export intensity and its regional interaction terms are presented. The same set of 239 census divisions are used for the estimation as in previous estimations. However, because there were years when some census divisions either had no exporters or non-exporters, the number of observations is reduced by a small amount. As such, the models are estimated using a (slightly) unbalanced panel.
Source: Statistics Canada, Annual Survey of Manufactures.

Not only do these results provide broad confirmation for the predictions of the model, they show that the reactions generally differed between Canada's industrial heartland and the other regions. Whether they involve the reactions of exporters or non-exporters, cross-regional differences reinforced the averages that were previously reported. Outside the heartland, non-exporters were

10. These results accord more closely with the predictions if the time series variables are removed.

likely to see their plant size reduce more and exporters were more likely to see their plant size increase less in response to an increase in trade intensity. Non-exporters saw the length of their production runs fall by larger amounts and exporters saw their length of production runs increase by smaller amounts.

6 Conclusions

Over the past three decades, Canada's manufacturing sector has become increasingly integrated into world markets. The effect of integration through increased exports has not been felt equally across all geographic regions or in the same way.

This paper has provided a cross-regional comparison of the impact of trade intensity on the structural characteristics of the manufacturing sector—characteristics like plant size, product line diversity and production-run length—that are associated with higher productivity. It has been argued in the past that Canadian plants were too small and produced too many products, resulting in short production runs and high unit costs, and that greater integration into North American markets would partially overcome these deficiencies. We find that across regions, higher levels of export intensity are positively associated with longer production runs, larger plant sizes and a smaller number of product varieties per plant.

Throughout the paper, cross-regional differences in the industrial structure stand out. Regions that are smaller and further from the centre of the North American market have smaller plants and have shorter production runs. In addition, these regions are less integrated into North American markets as indicated by their export intensities, and this has an additional impact on their plant size, specialization and length of production runs. Export intensity is directly related to plant size, product specialization and production-run length. Plants are more likely to be larger where there is more exporting taking place—in Ontario and Quebec, the industrial heartland of Canada. These are the regions that are best situated with respect to the U.S. market and, therefore, are best able to take advantage of its large market. These were also the markets that started with the highest level of product diversity at the beginning of the period—where product packing to achieve economies of scale was most evident.

It was in these regions where the response to increases in export intensity was largest. It was in Central Canada (primarily Ontario) where plant scale increased the most, where product diversity declined the most and where production-run length increased the most on average. It was here that the relationship between higher levels of export intensity and plant scale, or production-run length was also the strongest. The reason for this comes from the fact that some aspects of industrial structure reacted more to export change (increased integration into North American markets) than elsewhere. Changes in plant size over time reacted more to changes in export intensity over time in Ontario than elsewhere. Not all aspects of industrial structure that are studied here reacted similarly. The impact of export intensity is not different for the number of products when the time dimension is considered, but it is different for the average plant size and the length of the production run. There is a greater impact of change in export intensity on these two variables in Ontario than in Quebec and an often lesser one in the two outlying regions—Atlantic and Western Canada.

The changes in plant size, number of products and length of production runs come from two quite different groups of firms whose reaction were not expected to be the same—non-exporters and exporters. In each case, the group reacted much as the model predicted; generally the differences reinforced regional disparities. While non-exporters were expected to see a characteristic like plant size decrease in response to integration, the response was larger in the outlying regions. While exporters were expected to see a characteristic like plant size increase in response to integration, the response was largest in the central heartland.

In summary, the regional perspective adopted in this paper provides new insights into the underlying effects of trade. The effects of trade are not the same in all locations. And the variations that we observe over space are not random. Instead, we observe patterns that point to the importance of location relative to markets as key variables determining how trade affects regional economies. Given the geographic diversity of the Canadian economy, taking into account differences related to geography substantially improves our insights on the effects of trade on the economy.

References[11]

Baldwin, John R., Desmond Beckstead and Richard E. 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.*" 209–248. N. Lorraine Eden and Wendy Dobson (eds.). Cheltenham, U.K.: Edward Elgar. (Also available in Economic Analysis [EA] Research Paper Series. Catalogue no. 11F0027MIE2005031. Ottawa: Statistics Canada.)

Baldwin, John R., and Paul K. Gorecki. 1986. *The Role of Scale in Canada-U.S. Productivity Differences in the Manufacturing Sector, 1970–1979*. Toronto: University of Toronto Press.

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 Mohammed Rafiquzzaman. 1995. *Restructuring in the Canadian Manufacturing Sector from 1970 to 1990: Industry and Regional Dimensions of Job Turnover.* Analytical Studies Branch Research Paper Series. Catalogue no. 11F0019MIE1995078. Ottawa: Statistics Canada.

Bernstein, Jeffrey I., Richard G. Harris and Andrew Sharpe. 2002. "Explaining the widening Canada–U.S. productivity gap in manufacturing." *International Productivity Monitor.* 5, Fall: 3–22.

Brown, W. Mark. 2007. *The Ebb and Flow of Comparative Advantage: Trade and the Industrial Specialization of Canadian Manufacturing Regions, 1974 to 1999.* Economic Analysis (EA) Research Paper Series. Catalogue no. 11F0027MIE2007044. Analytical Studies Branch. Ottawa: Statistics Canada.

Brown, W. Mark., and William P. Anderson. 2002. "Spatial markets and the potential for economic integration between Canadian and U.S. regions." *Papers in Regional Science.* 81, 1: 99–120.

Caves, Richard E. 1975. *Diversification, Foreign Investment, and Scale in North American Manufacturing Industries*. Ottawa: Economic Council of Canada.

11. English version of Statistics Canada research papers can be downloaded from http://www.statcan.ca/english/freepub/11-623-XIE/11-623-XIE2003001.htm. French versions are available from http://www.statcan.ca/francais/freepub/11-623-XIF/11-623-XIF2003001.htm.

Caves, Richard E., Michael E. Porter and A. Michael Spence, with John T. Scott. 1980. *Competition in the Open Economy: A Model Applied to Canada*. Cambridge, Mass.: Harvard University Press.

Cox, David J. 1994. "Some applied general equilibrium estimates of the impact of a North American free trade area on Canada." 2, 4. In *Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade.* Joseph F. Francois and Clinton R. Shiells (eds.). Cambridge, U.K.; New York: Cambridge University Press.

Daly, Donald James, B. Allan Keys and E.J. Spence. 1968. *Scale and Specialization in Canadian Manufacturing*. Economic Council of Canada Staff Study no. 21. Ottawa: Queen's Printer.

Eastman, Harry C., and Stefan Stykolt. 1967. *The Tariff and Competition in Canada.* Toronto: Macmillan.

Economic Council of Canada. 1967. *Fourth Annual Review: The Canadian Economy from the 1960s to the 1970s*. Ottawa: Queen's Printer.

Economic Council of Canada. 1975. *Looking Outward: A New Trade Strategy for Canada*. Ottawa: Information Canada.

Frankel, Jeffrey A., Shang-Jin Wei and Ernesto Stein. 1997. *Regional Trading Blocs in the World Economic System*. Washington, D.C.: Institute for International Economics.

Gu, Wulong, and Gary D. Sawchuk. 2006. *How are Canadian Regions Adjusting to a Larger and More Integrated North American Market?* Economic Analysis (EA) Research Paper Series. Catalogue no. 11F0027MIE2006039. Analytical Studies Branch. Ottawa: Statistics Canada.

Harris, Richard G. 1984. "Applied general equilibrium analysis of small open economies with scale economies and imperfect competition." *The American Economic Review* 74, 5: 1016–1032.

Head, Keith, and John Ries. 1999a. "Can Small-Country Manufacturing Survive Trade Liberalization? Evidence from the Canada-U.S. Free Trade Agreement." *Industry Canada Research Publications Program: Perspectives on North American Free Trade*. Paper No 1. Catalogue no. C21-28/2-1999. Ottawa: Industry Canada.

Head, Keith, and John Ries. 1999b. "Rationalization effects of tariff reductions." *Journal of International Economics*. 47, 2: 295–320.

Head, Keith, and John Ries. 2001. "Increasing returns versus national product differentiation as an explanation for the pattern of U.S.–Canada trade." *The American Economic Review*. 91, 4: 858–876.

Horstmann, Ignatius J., and James R. Markusen. 1992. "Endogenous market structures in international trade (natura facit saltum)." *Journal of International Economics.* 32, 1-2: 109–129.

McCallum, J. 1999. "Two cheers for the FTA: Tenth-year review of the Canada–U.S. Free Trade Agreement." *Econoscope.* Toronto: Royal Bank of Canada.

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

Ottaviano, Gianmarco I. P., and Jacques-François Thisse. 1999. *Monopolistic Competition, Multiproduct Firms and Optimum Product Diversity.* Center for Operations Research and Econometrics. Discussion Paper no. 9919. Louvain-la-Neuve, Belgium: Université Catholique de Louvain.

Royal Commission on Corporate Concentration (Bryce Commission). 1978. *Report.* Ottawa: Minister of Supply and Services Canada.

Safarian, A. E. 1966. *Foreign Ownership in Canadian Industry.* Toronto: McGraw-Hill of Canada.

Scherer, Frederic M., Alan Beckenstein, Eric Kaufer, Dennis R. Murphy and Francine Bougeon-Massen. 1975. *The Economics of Multi-plant Operation: An International Comparisons Study.* Cambridge, Mass.: Harvard University Press.

Spence, A.M. 1977. "Efficiency, scale and trade in Canadian manufacturing industries." In *Studies in Canadian Industrial Organization.* R.E. Caves, M.E. Porter, A.M. Spence, J.T. Scott with A. Lemelin (eds.). Study No. 28 for the Royal Commission on Corporate Concentration. Ottawa: Minister of Supply and Services Canada.

Schwanen, Daniel. 1997. *Trading Up: The Impact of Increased Continental Integration on Trade, Investment, and Jobs in Canada*. C.D. Howe Institute Commentary 89. Toronto: C.D. Howe Institute.

Trefler, Daniel. 2004. "The long and short of the Canada–U.S. Free Trade Agreement." *The American Economic Review*. 94, 4: 870–895.

Wonnacott, Ronald J., and Paul Wonnacott. 1967. *Free Trade Between the United States and Canada: The Potential Economic Effects*. Harvard Economic Studies, Volume 129. Cambridge, Mass.: Harvard University Press.