Catalogue no. 11F0027M — No. 051
ISSN: 1703-0404
ISBN: 978-0-662-48443-1

Research Paper

Economic Analysis (EA) Research Paper Series

Trade Liberalization and Productivity Dynamics: Evidence from Canada

by Alla Lileeva

Micro-economic Analysis Division
18-F, R.H. Coats Building, 100 Tunney's Pasture Driveway

Telephone: 1-800-263-1136

Statistics Canada Statistique Canada

Canada

Trade Liberalization and Productivity Dynamics: Evidence from Canada

by
Alla Lileeva*

11F0027MIE No. 051
ISSN: 1703-0404
ISBN: 978-0-662-48443-1

Statistics Canada
Micro-economic Analysis Division
18-F, R.H. Coats Building
Ottawa, K1A 0T6

*Department of Economics, York University
416-736-2100 ext. 20581
E-mail: lileeva@dept.econ.yorku.ca

May 2008

Published by authority of the Minister responsible for Statistics Canada.

La version française de cette publication est disponible (n° 11F0027MIF au catalogue, n° 051).

Economic Analysis Research Paper Series

The Economic Analysis Research Paper Series provides for the circulation of research conducted by the staff of National Accounts and Analytical Studies, visiting Fellows and academic associates. The research paper series is meant to stimulate discussion on a range of topics including the impact of the New Economy, productivity issues, firm profitability, technology usage, the effect of financing on firm growth, depreciation functions, the use of satellite accounts, savings rates, leasing, firm dynamics, hedonic estimations, diversification patterns, investment patterns, the differences in the performance of small and large, or domestic and multinational firms, and purchasing power parity estimates. Readers of the series are encouraged to contact the authors with comments, criticisms and suggestions.

The primary distribution medium for the papers is the Internet. These papers can be downloaded from the Internet at www.statcan.ca for free.

All papers in the Economic Analysis Series go through institutional and peer review to ensure that they conform to Statistics Canada's mandate as a government statistical agency and adhere to generally accepted standards of good professional practice.

The papers in the series often include results derived from multivariate analysis or other statistical techniques. It should be recognized that the results of these analyses are subject to uncertainty in the reported estimates.

The level of uncertainty will depend on several factors: the nature of the functional form used in the multivariate analysis; the type of econometric technique employed; the appropriateness of the statistical assumptions embedded in the model or technique; the comprehensiveness of the variables included in the analysis; and the accuracy of the data that are utilized. The peer group review process is meant to ensure that the papers in the series have followed accepted standards to minimize problems in each of these areas.

Publications Review Committee
Analytical Studies Branch, Statistics Canada
18th Floor, R.H. Coats Building
Ottawa, Ontario K1A 0T6

Acknowledgements

The author is grateful to John Baldwin (Director, Micro-economic Analysis Division, Statistics Canada) for his help throughout the project. The paper benefited from the guidance provided by her thesis supervisors: Dan Trefler, Nadia Soboleva and Johannes Van Biesebroeck. The author also wishes to thank Keith Head, Wulong Gu, Gary Sawchuk and seminar participants at the University of Toronto, York University and Statistics Canada for valuable comments and suggestions. The kindness and hospitality of the Micro-economic Analysis Division of Statistics Canada are greatly appreciated. The author would also like to express her appreciation to Industry Canada for providing financial support at the initial stages of her work.

Table of contents

Abstract 6

Executive summary 7

1 Introduction 8

2 Literature review 10

3 Data 12

4 Estimation strategies and results 14

4.1 Change in the productivity distribution in Canada from 1980 to 1996 14
4.2 Between-plant productivity growth 17
4.3 Within-plant productivity growth 26

5 Conclusion 34

Appendix 35

Bibliography 41

Abstract

This paper investigates the productivity effects of the Canada–United States Free Trade Agreement (FTA) on Canadian manufacturing. It finds that Canadian tariff cuts increased exit rates among moderately productive non-exporting plants. This led to the reallocation of market share toward highly productive plants, which helps explain why aggregate productivity gains were observed when Canadian tariffs were reduced. The paper also finds that all of the within-plant productivity gains resulting from the U.S. tariff cuts involved exporters and, especially, new entrants into the export market. It demonstrates that any lack of output responses and labour-shedding as a consequence of the FTA were experienced by Canadian plants who were non-exporters, while exporters captured the gains from the FTA.

Keywords: productivity, trade, exporters, trade liberalization

JEL codes: F14, L6, L1

Executive summary

The paper investigates the productivity effects of the Canada–United States Free Trade Agreement (FTA) on Canadian manufacturing. Using industry data, it was earlier established that Canadian tariff concessions contributed to Canadian productivity growth through inducing changes in market shares of plants. It was also established that U.S. tariff concessions were related to improvement in productivity growth of individual plants. In this paper we use microdata and explicitly evaluate the roles of market-share reallocations (‘between-plant’ growth) and productivity growth at the individual plant level (‘within-plant’ growth) in trade-induced productivity gains. In particular, we look at entry and exit of plants, and in differential responses to trade of exporters and non-exporters.

The paper finds that

- Canadian tariff cuts increased exit rates among moderately productive non-exporting plants. This led to the reallocation of market share toward highly productive plants, which in turn helps explain why aggregate productivity gains were observed when Canadian tariffs were reduced.

- All of the ‘within-plant’ productivity gains resulting from the U.S. tariff cuts involved exporters, and, especially, new entrants into the export market. These results additionally resolve puzzles in Trefler (2004) whose estimated output and employment responses to the FTA reflect the problem of pooling exporters (who expanded) and non-exporters (who contracted).

1 Introduction

During the period from 1989 to 1999, tariffs between Canada and the United States were gradually eliminated. As a result of the Free Trade Agreement (FTA) and North American Free Trade Agreement (NAFTA), Canadian trade with the United States grew dramatically. Up-to-date research on the effects of trade liberalization shows that it had a huge impact on the Canadian manufacturing sector, in particular on productivity gains and short-term job losses (Trefler 2004). Trefler estimates that for the group of industries that received the largest Canadian tariff cuts, employment fell by 12% while productivity rose by 15%. These productivity gains were at the industry level, not the plant level. Further, Trefler found that the U.S. tariff reductions resulted in considerably higher Canadian productivity at the plant level, but only in modestly higher productivity at the industry level. These striking results present a few puzzles. First, how is it that Canadian tariff reductions resulted in an increase in industry-level productivity, but had no effect on the productivity growth of individual plants? Second, why did U.S. tariff reductions increase the productivity growth of individual plants, but have no significant effect on industry-level productivity growth?

These two questions suggest that there exists, behind the effects of trade liberalization, some complex industry dynamics. Papers by Melitz (2003), Melitz and Ottaviano (2005), Bernard et al. (2004) and Ederington and McCalman (2008) consider the environment with heterogeneous firms in which trade liberalization induces exit of less-productive plants and market share reallocation towards more productive plants, which leads to improvement in industry-level productivity (‘between-plant’ productivity growth). All these models predict that, as a result of trade liberalization, the lower tail of the productivity distribution will improve as a result of exit of the least productive non-exporting plants.

Trefler (2004) showed that the FTA also resulted in a strong trade-induced impact on the productivity of individual plants (the ‘within-plant’ productivity growth effect). One may expect that trade liberalization induces within-plant productivity growth both because it allows exporting firms to increase their output and move down their average cost curves (Cox and Harris, 1985), and possibly because exposure to stronger competition forces plants to behave more efficiently. Recent papers by Costantini and Melitz (2007), Bustos (2005), Ederington and McCalman (2008), Yeaple (2005), Ekholm and Midelfart (2005) show that trade liberalization increases firms’ incentives to invest in new technologies. Such investment leads to productivity growth within plants. This trade-induced within-plant productivity growth effect typically does not involve the least productive plants, but rather it affects plants that have already reached some threshold level of productivity π_0, which is essential for their survival in domestic or foreign markets. Therefore, this within-plant productivity growth effect should be observed for the medium-upper part of the productivity distribution.

This paper investigates the comparative importance of the within- and between-plant productivity growth effects of the Canada–United States FTA upon Canadian manufacturing, and contrasts the findings against the predictions of trade theory. The paper examines changes in Canadian manufacturing productivity at both the industry and the plant levels, exploring the effects of the FTA on entry and exits of plants, changes in the distribution of productivity across plants, and plant- and industry-level productivity growth. Detailed industry-level data on

Canadian and U.S. tariff concessions allow for the separate examination of the import-competition effect of trade liberalization from the increased export market access effect.

The paper finds that Canadian tariff cuts increased industry-level productivity by inducing plant exits and by increasing the market shares of highly productive plants—i.e., through the between-plant productivity growth effect. However, this between-plant effect based on market share reallocation differs from Melitz's predictions. The paper finds that the exit rates of low-productivity plants are not strongly affected by trade liberalization. Also, plants in the bottom productivity quartile produce only about 5% of total output. On the other hand, plants in the top productivity decile increased their market share by 18% over the FTA period. So, even if every single low-productivity plant exited the market as a result of tariff cuts, these plant closures would hardly be large enough to generate the observed market share reallocation toward high-productivity plants. The observed market share reallocation takes place only within the top half of the productivity distribution, from relatively productive plants in the 3rd productivity quartile to highly productive plants in the 4th productivity quartile. Thus, there is Melitz-style selection only when plants in the bottom half of productivity distribution are excluded.

As for the within-plant productivity growth effect, the paper finds that the U.S. tariff cuts contributed to the productivity growth of exporters, in particular of new entrants into the U.S. export market, but had no effect on productivity growth of non-exporters. Canadian tariff cuts have only a weak effect on the within-plant productivity growth.

To summarize, the FTA-mandated tariff concessions resulted in the following productivity dynamics. Increase in import competition (captured by Canadian tariff concessions) led to exits of non-exporting plants and expansion of high-productivity plants. Increase in export market access (captured by the U.S. tariff concessions) led to within-plant growth, but only for exporters. It also contributed to exits among non-exporters and market-share reallocation toward exporters.

The paper also resolves two puzzles in Trefler (2004) by using a triple-differencing methodology that builds on Trefler's double-differencing methodology. In addition to Trefler's pre-post FTA contrast, it also adds an exporter-non-exporter contrast. The first puzzle concerns Trefler's finding of a strong effect of U.S. tariff cuts on plant-level productivity growth, but a weak effect on industry-level productivity growth. The productivity distribution of plants is tightly related to their size distribution. Given that the U.S. tariff reductions increased productivity growth only for relatively low-productivity exporters, the small output weights of these plants explain why any induced productivity growth of individual exporters shows only weakly in the aggregate productivity-growth figures. The second puzzling result in Trefler's work was that the U.S. tariff cuts did not raise Canadian employment or output. Allowing for a difference in exporter and non-exporter responses to free trade, the paper finds that exporters experienced an increase in output, while non-exporters suffered a contraction in their output (which is consistent with the predictions of Melitz and Ottaviano 2005).

2 Literature review

Melitz (2003) models industry dynamics in a highly influential theoretical work on trade reforms. He uses a framework where the reallocation of market shares toward more productive plants (the 'between-plant' productivity growth effect) leads to higher aggregate productivity. As the survival threshold productivity increases and the export market entry threshold productivity falls, less productive non-exporting plants exit the market and more plants start exporting. Applied to the Free Trade Agreement (FTA) experience, this means that the fall in the U.S. tariff would increase the exit rates of Canadian non-exporters and lead to output declines in surviving non-exporters, while increasing the number of exporters and expanding their output. The fall in the U.S. tariff would also increase exports by all firms and induce new entry into the export market. Melitz and Ottaviano (2005) develop an alternative heterogeneous-firms model, in which trade also increases the industry average productivity by forcing the least productive firms to exit. In Melitz (2003) trade increases competition for labour, and wages go up, forcing the least productive producers to exit. This effect is driven by an increase in exports, while imports competition does not play a role in reallocation. In Melitz and Ottaviano (2005) the effects of the factor market competition and product market competition are reversed: the only channel that matters is the product market competition. Imports competition increases competition in the domestic market, which forces the least productive firms to exit. Applied to the FTA experience, these papers suggest that reduction in both the U.S. and Canadian tariffs would increase the exit rates of the least productive Canadian plants. Bernard et al. (2004) also have a model with heterogeneous firms in which reduction in costs of exporting leads to aggregate productivity gains through the plants' exits and reallocation. Ederington and McCalman (2008) predict that U.S. tariff cuts would increase the exit rates among Canadian non-exporters, while a fall in Canadian tariffs would increases exit rates among both exporters and non-exporters.

Costantini and Melitz (2007) develop a model that includes self-selection of more productive firms into the export market, the joint export-market participation and innovation decision, and continuing innovation by firms following their export-market entry. In their model, an innovation induces productivity growth and, following the trade liberalization, the majority of exporters—both new and existing—choose to innovate, while plants that remain domestic do not innovate. Hence, one may see a positive effect of the U.S. tariff cuts on productivity growth of Canadian exporters. Other theoretical models predicting that a foreign tariff cut increases exporters' productivity by inducing investment in technology include Bustos (2005), Ederington and McCalman (2008), Ekholm and Midelfart (2005) and Yeaple (2005). In particular, Bustos (2005) predicts that a decline in the costs of exporting increases technology uptake by new exporters and low-productivity continuing exporters, i.e., firms in the middle range of productivity distribution. Ederington and McCalman (2008) predict that trade liberalization increases technology uptake, both in exporters and non-exporters. In their model, the U.S. tariff cuts increase technology uptake (and hence the productivity growth) of exporters first, followed by non-exporters. If late technology adoption is sufficiently delayed, one is likely to observe productivity growth in exporters following the trade liberalization. The reduction in Canadian tariff in their model has mixed effects, with the direct effect decreasing the technology uptake by reducing the market share of domestic firms, however, the indirect effect—through exit of plants—results in proportionately more plants adopting technology.

A number of papers investigated the effects of the Canada–United States FTA on different components of industry dynamics. In particular, the link between trade liberalization and changes in the number of plants in Canada was the subject of a number of studies. Head and Ries (1999) looked at changes in the number of plants and average output per plant that were consequences of the North American Free Trade Agreement (NAFTA). They found that the number of plants declined in response to tariff cuts, in particular among large plants. They also found that Canadian tariff reductions "appear to have reduced the scale and number of Canadian manufacturing plants, while U.S. tariff reductions had the opposite effect on scale and no effect on entry" (p. 297). Trefler (2004) found this effect at the industry level, but not at the plant level. Gu, Sawchuk and Rennison (2003) found that a fall in Canadian tariffs increased exit rates of Canadian firms, with larger increases observed for smaller firms. Beaulieu (2001) also showed that Canadian tariff cuts were associated with exits of plants, but he found the change in exit rates to be independent of firm size. As well, Baggs (2005) established that Canadian tariff reductions increased the exit rates of Canadian firms, while U.S. tariff concessions increased the survival rates of firms in Canada. In her study, larger firms were better shielded from the adverse effects of Canadian tariff changes. Insofar as large firms are generally more productive and exiting firms are less efficient, her findings are consistent with the between-plant productivity growth effect. Baggs, Head and Ries (2002) found, using Canadian firm-level data, that Canadian and U.S. tariff cuts had reverse effects on productivity growth, with Canadian tariff cuts increasing productivity growth of low-productivity firms and reducing it for high-productivity firms, while U.S. tariff cuts increased productivity growth of high-productivity firms and reduced it for low-productivity firms. They conclude that Canadian tariff reductions can contribute to productivity growth by increasing productivity of inefficient firms and share-shifting toward high-productivity firms.[1]

To gain more insight into the importance of the between-plant productivity growth effect, it is imperative to show that tariff-induced exits of low-productivity plants were substantial enough to generate aggregate productivity growth. Baldwin and Gu (2004a) used a novel productivity growth decomposition technique to estimate the contribution of between-plant output reallocation to aggregate productivity growth. Consistent with findings in this paper, they estimated that for 13 of 22 manufacturing industries over half of the productivity growth over the period from 1988 to 1997 could be attributed to the reallocation of output toward more productive plants. In particular, they found that for a number of industries (including 'Clothing' and 'Textile'—industries that experienced vast tariff cuts under the NAFTA) "90 to 100 percent of productivity growth was due to the reallocation of output" (p. 26).

Similar effects were found in a number of empirical studies on the impacts of trade liberalization upon domestic firms for other countries. For instance, several studies employing data on developing countries concluded that the exit of low-productivity firms as a result of trade reforms contributes positively to aggregate productivity gains. These include Pavcnik (2000) for Chile and Muendler (2002) for Brazil. Bernard and Jensen (2002) and Bernard, Jensen and Schott (2002) use U.S. data and find that exposure to low-wage import competition increases the probability of exit among manufacturing plants.

1. Note that Baggs, Head and Ries (2002) use a data set covering a different universe of producers (in particular, they use a firm-level data set while this paper uses a plant-level data set) so the results are not directly comparable.

A number of studies for other countries also found an improvement in the productivity growth of individual plants as a result of trade liberalization. However, the majority of these studies focus on developing countries, for which there is some difficulty distinguishing the effects of trade liberalization from other market reforms (Trefler 2004). Also, the predictions from these studies may not be truly applicable for analysing the consequences of trade liberalization for industrialized economies. Further, these studies are usually about import liberalization, not export liberalization. While there also exists vast literature on the positive link between plant productivity growth and export activity, only a few studies were able to find causality between export market entry and subsequent productivity growth (e.g., Van Biesebroeck 2005). In the case of Canada, Baldwin and Gu (2003) did find that exporting was associated with a consequent improvement in the productivity growth of Canadian plants.

3 Data

The plant-level data come from Statistics Canada's Annual Survey of Manufactures (ASM), a longitudinal database with information about plants operating in Canada. For these plants, the database has information on output, employment, value added and industry of a plant at the 4-digit level of the Canadian Standard Industrial Classification (SIC).[2] The sample statistics on all plants are provided in Table 1. The number of plants in the database for each year is around 35,000. The productivity and size distribution of Canadian manufacturers is substantially biased in favour of small manufacturers, with both median productivity and employment being much lower than their means. The ASM does not collect data on capital or investment. For this reason the productivity is defined as value added per worker. This research covers the time period from 1980 to 1996, which allows to distinguish between the pre-Free Trade Agreement (FTA) period (from 1980 to 1988) and the FTA period (from 1988 to 1996) and to control for industry-specific trends that are common to both periods. The length of this timeframe gives a very important advantage, as earlier studies on trade reforms used shorter time spans. For example, Baggs (2005) examined data on Canadian firms that started in 1988, Pavcnik (2000) used eight years of Chilean data, Harrison (1994) used nine years of data for Côte d'Ivoire and Levinsohn (1993) used four years of Turkish data. Another important feature of the ASM database is the availability of information on small producers. In many countries, only larger plants are surveyed, which makes an accurate understanding of trade-reform impacts difficult, especially since small plants are generally found to be less productive and have exit rates that are dissimilar and affected in different ways from large plants. Most importantly, the availability of data on small and less-productive plants is crucial for testing the Melitz hypothesis.[3]

To estimate the effects of tariff cuts on within-plant productivity growth effect, we look at a group of 10,821 plants that remained in existence during the whole period from 1980 to 1996 ('continuing' plants). For them, we are able to calculate changes in within-plant productivity growth rates over the pre-FTA period (from 1980 to 1986) and the FTA period (from 1988 to 1996). The sample statistics on such continuing plants are provided in Table 1. While continuing

2. See Appendix for more details.
3. Note that the paper avoids the problem of undercounting of small establishments in the Annual Survey of Manufactures that occurred in the early 1990s because we take differences that do not use 1990-to-1993 data.

plants in each year represent only around one third of the total number of plants, they constitute the most economically important part of Canadian manufacturing: in 1996, continuing plants produced over 80% of the total Canadian manufacturing output.

Table 1
Sample statistics, plants and industries

	1980	1988	1996
All plants			
Number of plants	33,613	39,714	35,670
Mean productivity	42,205	50,166	51,251
Mean employment	53	47	48
Continuing plants[1]			
Number of plants	10,821	10,821	10,821
Mean productivity	52,899	60,558	67,124
Mean employment	93	100	94
Continuing never exporters[2]			
Number of plants	3,133	3,133	3,133
Mean productivity	49,978	55,011	59,063
Mean employment	37	42	42
Continuing exporters[3]			
Number of plants	5,806	5,806	5,806
Mean productivity	60,061	70,981	81,597
Mean employment	151	160	148
Continuing exporters, 10%[4]			
Number of plants	3,766	3,766	3,766
Mean productivity	59,481	71,416	84,322
Mean employment	188	196	180
Standard Industrial Classification industries			
Number of industries	213	213	213
Mean U.S. tariff against Canada	0.056	0.040	0.008
Standard deviation	0.055	0.044	0.012
Mean τ^{US}	-0.009	-0.006	-0.026
Standard deviation	0.034	0.022	0.027
Mean Canadian tariff against the United States	0.103	0.082	0.014
Standard deviation	0.069	0.074	0.024
Mean τ^{CA}	0.007	0.000	-0.041
Standard deviation	0.031	0.035	0.043

1. Plants with positive output in 1980, 1986, 1988 and 1996.
2. Plants with zero or missing exports in each year of 1979, 1984, 1990 and 1996.
3. Plants with positive exports in at least one year of 1979, 1984, 1990 or 1996.
4. Plant exports at least 10% of output in at least one year of 1979, 1984, 1990 or 1996.
Notes: Productivity is labour productivity defined as value added per worker, measured in Canadian dollars adjusted using output deflators at the Standard Industrial Classification 4-digit level. τ^{US} : the tariff is constructed as the U.S. tariff against Canada minus the U.S. tariff against the Rest-of-the-World. τ^{CA} : the tariff is constructed as the Canadian tariff against the United States minus the Canadian tariff against the Rest-of-the-World.

Information on export activity in the ASM is available for selected years: 1979, 1984, 1990 and 1996. These export data are available only for those plants that received an extended ('long-form') survey questionnaire, which is most often given to relatively larger plants.[4] Table 1 also gives sample statistics on exporting plants. Note that the average size and productivity of exporters are larger than those of non-exporters.

Industry-level data on tariffs and business-cycle controls come from the database created by Trefler and described in Trefler (2004).[5] The key variables from this database are Canadian and U.S. tariffs, which are used to measure the extent of trade liberalization for each industry. To isolate the effect of the Canada–United States Free Trade Agreement (FTA) from other globalization processes taking place, the paper uses the FTA-mandated tariff concessions as proposed by Trefler (2004): $\tau_{i,s}^{CA}$ and $\tau_{i,s}^{US}$ are defined as a country's tariff against its trading partner minus a country's tariff against the rest of the world. Let i index industries and s=0 and s=1 index pre-FTA and FTA periods. Before the implementation of the FTA, tariff reductions were set according to Most Favoured Nation Treatment. Because these pre-FTA tariff reductions occurred at the same rates across countries, the change in the *relative* tariff is set to 0 for s=0. So the FTA tariff changes are given by:

$$\Delta\tau_{i,s}^{CA} = \begin{cases} \left(\tau_{i,96}^{CA} - \tau_{i,88}^{CA}\right)/\left(1996-1988\right), & s=1 \\ 0, & s=0 \end{cases}; \qquad \Delta\tau_{i,s}^{US} = \begin{cases} \left(\tau_{i,96}^{US} - \tau_{i,88}^{US}\right)/\left(1996-1988\right), & s=1 \\ 0, & s=0 \end{cases}.$$

The average Canadian tariff against the United States and the average U.S. tariff against Canada were 10.3% and 5.6%, respectively in 1980 (Table 1).[6] During the following 16 years both tariffs declined to about 1.0%. The mean values of $\Delta\tau_{i,s}^{CA}$ and $\Delta\tau_{i,s}^{US}$ over the FTA period (s=1) are 4.2% and 2.0%, respectively.

4 Estimation strategies and results

4.1 Change in the productivity distribution in Canada from 1980 to 1996

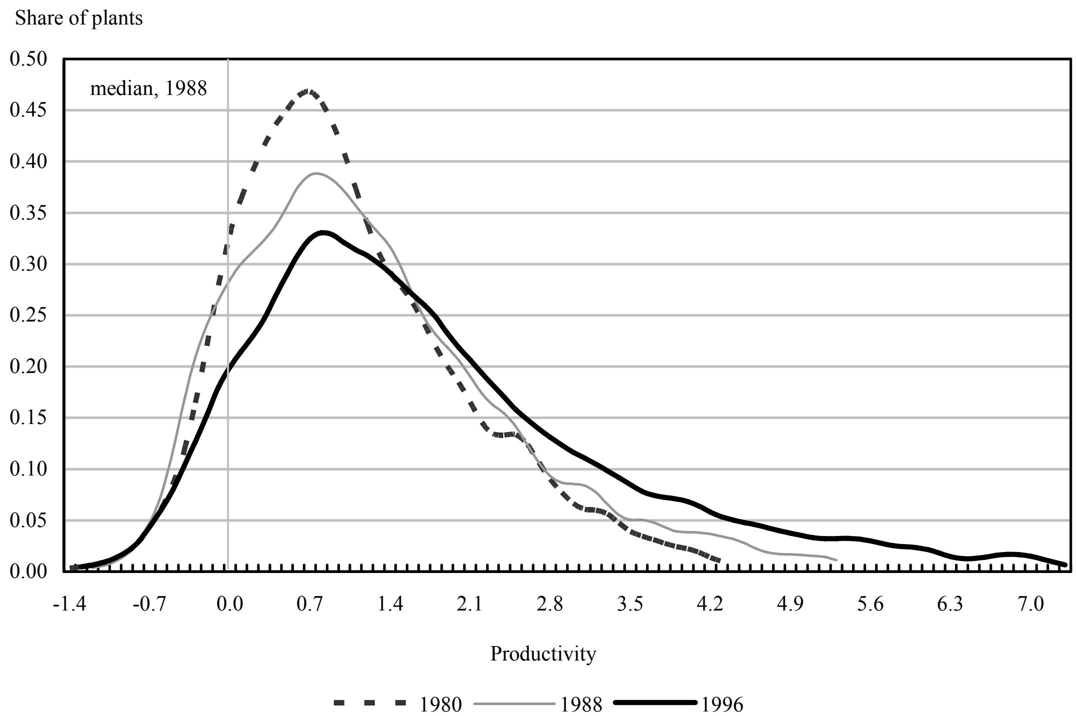
There is a substantial variation in productivity levels across industries. To be able to compare changes in productivity distribution across industries, the following adjustment is used. Let i index industries, p index plants and t index years. The productivity of a plant p is given by:

4. The Annual Survey of Manufactures in 1974 collected exporting data from all plants. According to it, smaller plants indeed do not export—only 0.4% of reporting short-form plants reported some positive exports (Baldwin and Gu 2003b). So it is reasonable to impute the 'non-exporter' status to smaller plants which get the short-form questionnaire.
5. See Appendix for details.
6. Note that even though the tariffs may not seem high enough, Trefler (2004) points out that, (1) in 1988 tariffs in excess of 10% sheltered one in four Canadian industries and (2) 8% Canadian tariff corresponded to 16% effective tariff rate.

$$\hat{\pi}_{p,i,t} = \frac{\pi_{p,i,t} - \pi_{50,i,88}}{\pi_{75,i,88} - \pi_{25,i,88}},$$

where $\pi_{p,i,t}$ is the labour productivity of a plant *p*, and $\pi_{25,i,88}$, $\pi_{50,i,88}$ and $\pi_{75,i,88}$ are the 25th, median and 75th productivity percentiles of industry *i* in 1988.[7] The distribution plots were constructed using log employment weights. Figure 1 plots kernels of productivity $\hat{\pi}_{p,i,t}$ densities in 1980, 1988 and 1996. The choice of years permits a contrast of the evolution of the productivity distribution before and after the signing of the Free Trade Agreement (FTA). Figure 1 shows that the distribution of plants shifts steadily to the right over time. The change in the upper tail of the distribution becomes particularly pronounced in the FTA period.

Figure 1
Productivity density plots, 1980, 1988 and 1996

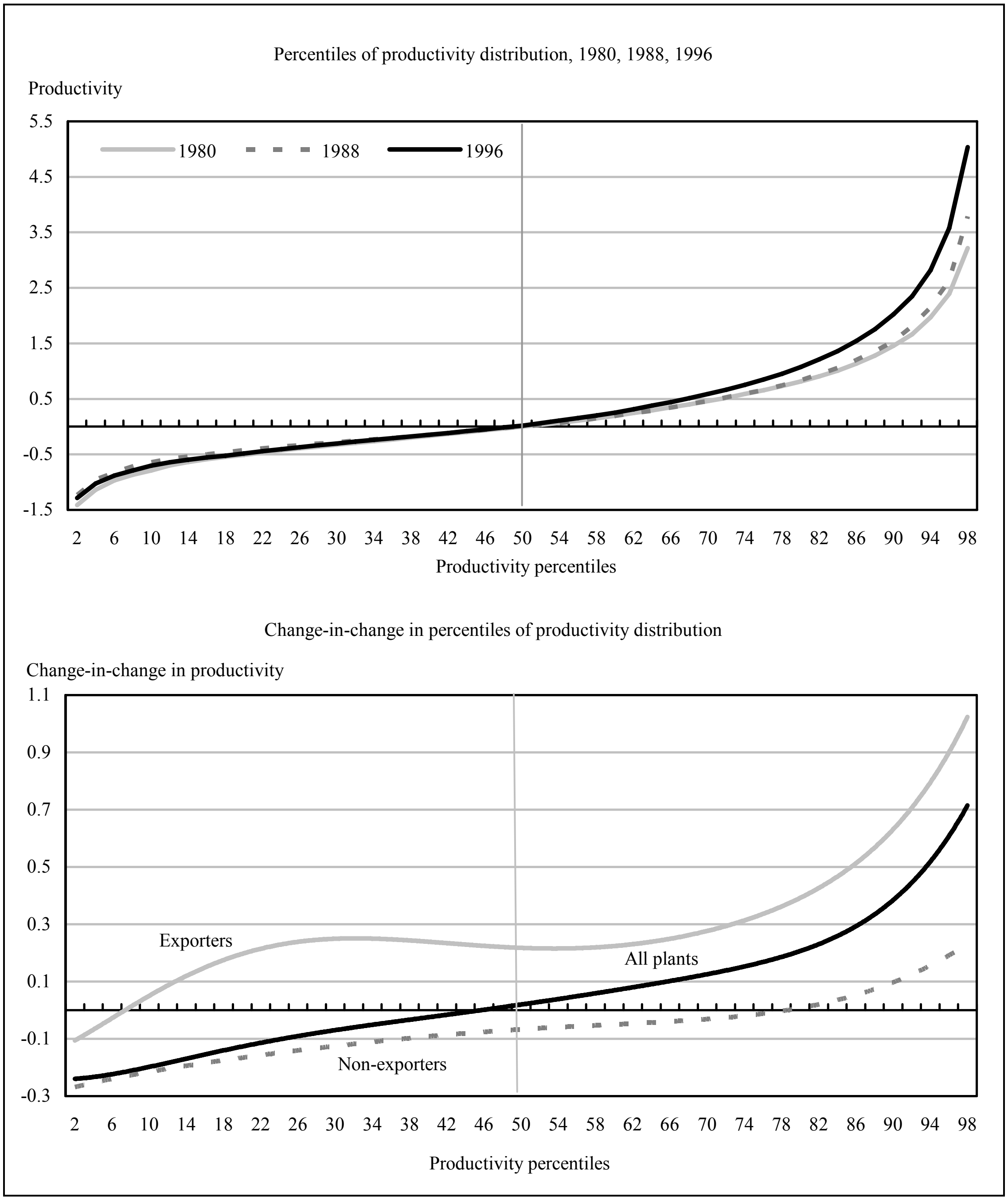


Note: 'Productivity' is the adjusted measure $\hat{\pi}_{p,i,t}$, constructed as $\hat{\pi}_{p,i,t} = \frac{\pi_{p,i,t} - \pi_{50,i,88}}{\pi_{75,i,88} - \pi_{25,i,88}}$,

where $\pi_{p,i,t}$ is the labour productivity of a plant *p*, and $\pi_{25,i,88}$, $\pi_{50,i,88}$ and $\pi_{75,i,88}$ are the 25th, median and 75th productivity percentiles of industry *i* in 1988.
Source: Statistics Canada, Annual Survey of Manufactures.

7. We get similar conclusions when using industry median as a scale, rather than inter-quartile range. However, we prefer to use the inter-quartile range as a scaling factor because, first, it controls for industry-specific means as well as for industry-specific dispersion and, second, it is positive by definition, while median productivity can be zero or negative for some industries.

Figure 2
Productivity percentile plots, 1980, 1988 and 1996



Note: 'Productivity' is the adjusted measure $\hat{\pi}_{p,i,t}$, constructed as $\hat{\pi}_{p,i,t} = \dfrac{\pi_{p,i,t} - \pi_{50,i,88}}{\pi_{75,i,88} - \pi_{25,i,88}}$, where $\pi_{p,i,t}$ is the labour productivity of a plant *p*, and $\pi_{25,i,88}$, $\pi_{50,i,88}$ and $\pi_{75,i,88}$ are the 25th, median and 75th productivity percentiles of industry *i* in 1988.
Source: Statistics Canada, Annual Survey of Manufactures.

Figure 2 shows productivity in each percentile of the productivity distribution. For example, the productivity $\hat{\pi}_{p,i,t}$ of the plant at the 90th percentile in 1996 (black line) is higher than the productivity of the plant at the 90th percentile in 1988 (dashed line), which in turn is higher than the productivity of the plant at the 90th percentile in 1980 (gray line). Note two things. First, it is a different plant at the 90th percentile in each year. Second, the productivity of the median plant is virtually unchanged in each year. From 1980 to 1988, productivity went up in both the low and high percentiles. In contrast, from 1988 to 1996, only productivity in the high percentiles went up and it went up by a much larger amount than it did in the pre-FTA periods. The point is easier to see in the bottom of Figure 2, which plots change-in-change of $\hat{\pi}_{p,i,t}$, $(\hat{\pi}_{p,i,1996} - \hat{\pi}_{p,i,1988}) - (\hat{\pi}_{p,i,1988} - \hat{\pi}_{p,i,1980})$. Among all plants (black line), the change-in-change is negative for plants with productivity below the median, and is positive for plants with productivity above the median. That is, productivity among less productive plants deteriorates in the FTA period compared with the pre-FTA period, while productivity among high-productivity plants improves. It shows, further, that the relatively poor FTA performance is driven by non-exporters (dotted line). For exporters (gray line), productivity goes up in all productivity percentiles starting with the 10th percentile, and the improvement is particularly high among high-productivity plants.

Overall, one may see a substantial difference in the evolution of the productivity distribution in the pre-FTA and the FTA eras, as well as a vast difference in productivity distribution changes between exporters and non-exporters. We would like to investigate whether these changes can be attributed to the implementation of the Canada–United States FTA, and whether the observed improvement was caused by the entry and exit of plants and by the within-plant productivity growth.

4.2 Between-plant productivity growth

We start by replicating the results found in Trefler (2004) for aggregate productivity growth. Let *i* index industries and *s*=0 or 1 index pre-FTA or FTA periods. For the remainder of the paper the annual change in an outcome variable *y* is defined as

$$\Delta y_{i,s} = \begin{cases} (y_{i,96} - y_{i,88})/(1996-1988), & s=1 \\ (y_{i,88} - y_{i,80})/(1988-1980), & s=0 \end{cases}.$$

Table 2 gives industry-level (as opposed to plant-level) estimates of equations of the form:

$$\Delta\pi_{i,1} - \Delta\pi_{i,0} = \beta_0 + \beta^{CA}\Delta\tau_i^{CA} + \beta^{US}\Delta\tau_i^{US} + \beta^{BC}(\Delta b_{i,1}^{\pi} - \Delta b_{i,0}^{\pi}) + \varepsilon_i \qquad (1)$$

where $\Delta\pi_{i,s}$ is annual change in log industry *i*'s productivity,[8] and $\Delta b_{i,s}^{\pi}$ is a business cycle control for pro-cyclical productivity in industry *i,* which captures how movements in gross domestic product and the real exchange rate affect industry *i*'s productivity. The double-differencing—comparing the change in the variables before and after the FTA—serves two

8. Industry productivity is constructed as total industry value added divided by total employment at the 4-digit level of the Canadian Standard Industrial Classification.

purposes.[9] For one, it allows to difference out industry-specific growth effects common to both periods, so that these effects are not attributed to tariff cuts. For another, most plant-level variables used in the paper (productivity, entry and exits, output) are strongly pro-cyclical. As the 1980-to-1988 and 1988-to-1996 periods are roughly similar in terms of business cycle fluctuations, time-differencing implicitly controls for the effects of business cycle on the variables of interest.

Table 2
Aggregate productivity changes and tariff cuts

	β^{CA}		β^{US}		R-squared	Number
All industries						
All plants	-0.901**	(0.460)	0.750	(0.974)	0.10	213
< 50th percentile	-0.193	(0.804)	-1.248	(1.600)	0.02	199
> 50th percentile	-1.129**	(0.491)	1.481	(1.043)	0.06	213
Most impacted industries						
All plants	-1.055**	(0.429)	0.285	(0.950)	0.27	109
< 50th percentile	-0.172	(0.688)	2.068	(1.426)	-0.01	105
> 50th percentile	-1.249*	(0.415)	0.658	(0.940)	0.20	109

* indicates significance at the 1% level
** indicates significance at the 5% level
Notes: The estimating equation is Equation (1). Standard errors are in parentheses. The dependent variable is change-in-change in labour productivity. The productivity percentiles are based on the 1988 distribution. Estimates on business cycle control are not presented. The most impacted industries are industries that received large U.S. or Canadian tariff cuts. β^{CA} is the coefficient on Canadian tariff, and β^{US} is the coefficient on U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

Results are reported separately for all industries and for industries that received the highest Canadian or U.S. tariff cuts—most impacted industries. The estimated β^{CA} is -0.901 (t=-1.96), which largely repeats Trefler's (2004) result.[10] Negative coefficients on the Canadian tariff indicate that tariff reductions had a positive effect on productivity growth. The effect of the Canadian tariff is stronger for the group of the most impacted industries: β^{CA} is -1.055 (t=-2.46). The coefficient on the U.S. tariff is positive, but not statistically significant. While the magnitude of the effects will be explained later, one can note that the average change in the U.S. tariff is half that of the average change in the Canadian tariff, so to compare the two effects, the coefficient on the U.S. tariff should be discounted by a factor close to two. We then repeat the estimation of Equation (1), dividing plants into the low- and high-productivity groups, based on the median industry productivity in 1988. To do so, productivity of each plant in years 1980, 1988 and 1996 is compared with the median industry productivity in $\pi_{50,i,88}$. Plants which have

9. This approach follows Trefler (2001 and 2004).
10. There are two differences from Trefler (2004). First, he uses labour productivity adjusted for hours worked. This adjusted productivity measure is available only for large plants. Second, since a plant's probability of exit in each year is a nonlinear function of a plant's age, in this case it is important to compare exit probabilities between time periods of equal length. Trefler (2004) experiments with a number of alternative definitions of the pre-Free Trade Agreement (FTA) and FTA periods, with his preferred definition being from 1980 to 1986 for the pre-FTA period, and from 1988 to 1996 for the FTA period. He finds that his results are not sensitive to the choice of the time frames. Here we define the pre-FTA period as from 1980 to 1988 and the FTA period as from 1988 to 1996.

productivity below $\pi_{50,i,88}$ in years 1980 or 1988 or 1996 constitute the lower part of productivity distribution each year. If tariff cuts improve the bottom part of productivity distribution, either by inducing plant exit or within-plant growth, one would expect that productivity among low-productivity plants increased.[11] However, it appears that the Canadian tariff has no effect on the aggregate productivity of plants below the median. The Canadian tariff effect for 'All plants' is driven by productivity improvements among the more productive plants. The estimated β^{CA} for high-productivity plants is -1.129 (t=-2.30) for all plants and -1.249 (t=-3.01) for the most impacted industries. Evaluated at the average Canadian tariff cut due to the FTA (at 4.0 percentage points over the eight-year period, or 0.5 percentage points per year), it led to 3.6% productivity growth in all industries. For the most impacted industries, where the annual Canadian tariff cut averaged 0.9 percentage point per year, it led to productivity growth of 9.0%.[12]

Is it possible that these industry-level effects are related to entry and exits of plants? Table 3 provides plants' relative exit and entry rates over the pre-FTA and FTA periods by productivity quartiles. It shows that exit rates declined in the bottom productivity quartile, but went up among plants with high productivity. Entry rates declined in all productivity quartiles, but the largest decrease occurred in the two lower quartiles, where entry rates went down by 15% and 18%, respectively. Entry rates in the top quartile went down only by 2%. Let $N_{i,s}$ be the number of plants, i index industries, s index periods (pre-FTA and FTA). To relate the plant turnover to the tariff cuts, we estimate the equation:

$$\Delta N_{i,1} - \Delta N_{i,0} = \beta_0 + \beta^{CA} \Delta \tau_i^{CA} + \beta^{US} \Delta \tau_i^{US} + \beta^{BC} (\Delta b_{i,1}^N - \Delta b_{i,0}^N) + \varepsilon_i \,. \qquad (2)$$

In Equation (2), the dependent variable is the change-in-change in the number of plants and $b_{i,t}$ is the business cycle control for the number of plants in year t. To be consistent, the distribution of plants in 1988 is taken as the benchmark, and all numbers of plants (overall, exiting and entering) are scaled by the number of plants in a respective industry in 1988. We estimate Equation (2) for the overall turnover rates and for turnover rates in each productivity quartile (Table 4). Canadian tariff reductions led to a fall in the overall number of plants (β^{CA} is 1.184 [t=2.68] for all industries). Separating the plants into productivity quartiles shows that the

11. Productivity for each group '< 50th percentile' and '> 50th percentile' was calculated as a total value added divided by total employment by plants within a group. Separate regressions were run for each group.
12. Note that the estimates of productivity growth are lower in this paper than in Trefler (2001 and 2004) for two reasons. Most importantly, he uses the hours-adjusted productivity measure, which increases the estimates of β^{CA} as is shown in Trefler (2001), Table 7. Our coefficient on Canadian tariff is most close to his estimates in Section 3 of Table 7, where the periods are defined as from 1980 to 1988 and from 1988 to 1996 with β^{CA}=-0.88. For this specification he estimates that Canadian tariff concessions increased productivity growth by 3.0% for all industries and by 10.9% for the most impacted industries. These estimates are smaller than his benchmark estimates that use the hours-adjusted productivity measure. The hours-adjusted measures are available only for the long-form plants, which represent about one half of all manufacturing plants in each year. Therefore, this paper cannot use the hour-adjusted productivity measure. Secondly, in calculating the tariff impacts, Trefler uses industry output weights, so that larger industries get higher weights in calculation of the aggregate tariff effects. However this adjustment has a relatively minor effect on the estimates of the tariff effects and is not used in this paper.

Canadian tariff cuts reduced the number of plants in the 3rd productivity quartile. Further, the Canadian tariff cuts were associated with the exits of plants in the 3rd productivity quartile (β^{CA} is -0.378 [t=-3.64]). Exit rates among plants in the top 4th productivity quartile also increased, but the effects were not statistically significant. (Estimates in Appendix Table A.1 show similar but stronger results for the most impacted of industries.)

Table 3
Entry and exit rates

Productivity quartile	Exit rates		Percentage-point change	Entry rates		Percentage-point change
	1996 to 1988	1988 to 1980		1996 to 1988	1988 to 1980	
	percent			percent		
1st quartile (low)	58	66	-8	41	55	-15
2nd quartile	44	37	8	34	51	-18
3rd quartile	39	31	8	29	43	-14
4th quartile (high)	35	27	8	33	35	-2

Notes: The productivity quartiles are defined using productivity percentiles in 1988, and the 1st quartile is the lowest productivity quartile. The industry exit (entry) rates are constructed by dividing the number of exiting (entering) plants in a given period by the number of plants in the industry in 1988. Averages of industry rates are reported.
Source: Statistics Canada, Annual Survey of Manufactures.

Table 4
Changes in number of plants and tariff cuts

	β^{CA}		β^{US}		R-squared	Number
Number of plants						
All productivity quartiles	1.184*	(0.442)	1.221	(0.939)	0.07	212
< 25th quartile	0.314	(0.296)	0.224	(0.622)	0.02	212
25th to 50th quartile	0.079	(0.239)	0.648	(0.514)	0.00	212
50th to 75th quartile	1.007*	(0.295)	-1.301**	(0.629)	0.08	212
> 75th quartile	0.353***	(0.204)	0.748***	(0.435)	0.12	212
Exits						
All productivity quartiles	-0.822**	(0.350)	0.265	(0.736)	0.02	212
< 25th quartile	-0.353***	(0.201)	0.427	(0.427)	0.03	212
25th to 50th quartile	-0.126	(0.145)	-0.121	(0.310)	-0.01	212
50th to 75th quartile	-0.378*	(0.104)	0.362	(0.222)	0.06	212
> 75th quartile	-0.120	(0.092)	-0.216	(0.196)	0.01	212
Entries						
All productivity quartiles	0.362	(0.237)	1.487**	(0.504)	0.09	212
< 25th quartile	0.132	(0.115)	0.456***	(0.245)	0.04	212
25th to 50th quartile	0.127	(0.103)	0.273	(0.220)	0.01	212
50th to 75th quartile	0.057	(0.097)	0.185	(0.206)	0.00	212
> 75th quartile	0.153***	(0.089)	0.462**	(0.191)	0.12	212
Exporters as a percentage of all plants						
All productivity quartiles	-0.215***	(0.120)	-0.785*	(0.241)	0.09	212

* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level
Notes: The estimating equation is Equation (1). Standard errors are in parentheses. The productivity percentiles are based on the 1988 productivity distribution. Estimates on business cycle control are not presented. The dependent variables are number of plants, exits and entries. β^{CA} is the coefficient on Canadian tariff, and β^{US} is the coefficient on U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

Apart from the increase in the exit and the fall in entry rates, there is also an increased presence of exporters. The number of exporters in the database goes up from 4,750 plants in 1984 to 8,421 plants in 1990 and then levels down to 8,289 plants in 1996. It appears that most of the export market entry occurred in the first two years after the signing of the FTA. Given the limited data on exporting, we are not able to estimate Equation (2) for the number of exporters in double differences. For them we estimate the effect of tariff cuts on the change in the relative number of exporters from 1984 to 1996:[13]

$$N_{i,96} - N_{i,84} = \beta_0 + \beta^{CA} \Delta \tau_i^{CA} + \beta^{US} \Delta \tau_i^{US} + \beta^{BC} \Delta b_{i,84-96}^{N} + \varepsilon_i . \qquad (2')$$

The estimated β^{CA} is -0.215 (t=-1.79) and β^{US} is -0.785 (t=-3.64) (Table 4). So, while tariff cuts are associated with reductions in the overall number of plants, they are also associated with an increased number of exporters.

How can reductions in the Canadian tariff increase aggregate productivity, given that they induce the exit of relatively more productive plants? One can observe an increase in industry-level productivity only if the exits of plants in the 3rd quartile of the productivity distribution generate significant shifts in market shares toward even more productive plants in the top 4th quartile. Table 5 gives estimates of Equation (2) when the dependent variable is a change-in-change in the market share of plants belonging to each of the productivity quartiles. Market shares of plants in the first and second quartiles of productivity distribution are not significantly affected by the tariff concessions. The market share of plants in the 3rd quartile is reduced, as a result of a decline in the Canadian tariffs (β^{CA} is 1.168 [t=3.04]), while the market share of plants in the top 4th quartile is increased (β^{CA} is -1.111 [t=-2.84]). Are Canadian tariff cuts capable of explaining the observed market share reallocation in the FTA period?

Table 5
Changes in the market shares and tariff cuts

	β^{CA}		β^{US}		R-squared	Number
Change in the market share of plants						
0 to 25th percentile	-0.261	(0.172)	0.377	(0.334)	0.01	210
25th to 50th percentile	0.265	(0.255)	-0.217	(0.505)	0.00	209
50th to 75th percentile	1.168*	(0.384)	-0.929	(0.815)	0.03	213
75th to 100th percentile	-1.111*	(0.391)	0.689	(0.830)	0.04	213

* indicates significance at the 1% level

Notes: The estimating equation is Equation (2). Standard errors are in parentheses. The dependent variable is change-in-change in the market shares of plants. The productivity percentiles are based on the 1988 productivity distribution. β^{CA} is the coefficient on Canadian tariff, and β^{US} is the coefficient on U.S. tariff.

Source: Statistics Canada, Annual Survey of Manufactures.

13. Note that using a single difference instead of a double difference is similar to setting the change in the number of exporters in the pre-Free Trade Agreement (FTA) period to 0. As exporters made up 22% of all plants in the Annual Survey of Manufactures in both 1979 and 1984, this assumption is not unreasonable. Since there was only a small increase in Canada's exports to the United States over the period from 1984 to 1988 (based on CANSIM data), the use of 1984 data for pre-FTA export values should not distort the results.

Table 6 shows the distribution of output by productivity quartiles. Plants below the 25th productivity percentile produce only about 5% of total output. The majority of output is produced by plants in the top half of the productivity distribution, and their share of output was increasing over time from 78% in 1980 to 86% in 1996. The largest increase over the FTA period was in the output share of plants above the 90th percentile. Their share went up by 18%, from 28% in 1988 to 46% in 1996. The observed change-in-change in the market share of plants in the 4th productivity quartile is 4%. Estimates of β^{CA} imply that a 1% decrease in the Canadian tariff increases the market share of top productivity plants by 1.1 percentage points. At the average tariff cut of 4.2% one expects the market share to go up by 4.6 percentage points. It appears that Canadian tariff reductions are capable of explaining the observed market share shifts.

Table 6
Share of output produced by plants (in percentage)

Year of output share	Plants above 25th productivity percentile	Plants above 50th productivity percentile	Plants above 75th productivity percentile	Plants above 90th productivity percentile
1980	94	78	47	24
1988	94	82	56	28
1996	95	86	69	46

Notes: The output shares of plants in each productivity range are calculated for each Standard Industrial Classification (SIC) 4-digit industry. Table 6 reports averages of output shares across SIC 4-digit industries.
Source: Statistics Canada, Annual Survey of Manufactures.

What about the effects of the U.S. tariff changes? Reductions in the U.S. tariffs are also associated with a decrease in the number of plants (Table 4), but the effects are not statistically significant. Unlike Canadian tariff reductions, the U.S. tariff concessions appear to act by reducing the number of entrants, particularly in the upper half of the distribution. The U.S. tariff changes are not significant in the estimated equation for the market share (Table 5).

Why would relatively productive plants exit the market? To answer this question we estimate a probit model of plants' exits. Exit probabilities are allowed to depend on tariff reductions, as well as on the number of plant characteristics and industry-specific fixed effects. Note that while the previous analysis used only industry-level data, this estimation uses plant-level data. The estimating equation is:

$$\Pr(EXIT_{p,i,s}=1)=\Phi(\lambda_0+\lambda^{CA}\Delta_s\tau_i^{CA}+\lambda^{US}\Delta_s\tau_i^{US}+\lambda_1 X_{p,i,t_0}+\lambda_2 Z_i+\lambda_t T),\qquad s=\ 0,\ 1. \tag{3}$$

In Equation (3), s=0 denotes pre-FTA period (from 1980 to 1988), and s=1 denotes FTA period (from 1988 to 1996). For s=0, t_0 and t_1 refer to 1980 and 1988, while for s=1, t_0 and t_1 1988 and 1996, respectively. The exit indicator, $EXIT_{p,i,s}$, equals to 1 if plant exits over the period s, and equals 0 otherwise. The explanatory variables are changes in Canadian and U.S. tariff rates, a vector of plant-level controls X_{p,i,t_0}, which include productivity, size, foreign control and multi-plant status of a plant p at time t_0, industry fixed effects Z_i and a time dummy T that is equal to 1 in the FTA period.

The observed exit rates vary dramatically across quartiles and across different types of firms. For example, the exit rate among low-productivity non-exporters is 60%, while the exit rate among top productivity exporters is only 24%. To compare the importance of tariff reductions across different productivity quartiles, Equation (3) is estimated for each productivity quartile for all plants, exporters and non-exporters, and the ratios of the marginal effects of tariffs to the observed exit rate are reported.[14] Both Canadian and U.S. tariff cuts increase exit rates of all plants and for non-exporters by 2% to 3% (Table 7, Columns 1 and 3). The largest joint effect of the U.S. and Canadian tariff cuts is observed for plants in the 3rd productivity quartile: together, the tariff concessions increase exit rates by 5% for all plants, and by 6% for non-exporters.[15]

The two processes observed in the last decade in Canadian manufacturing were closures of plants belonging to multi-plant firms and increased rationalization of output within manufacturing plants (Baldwin and Gu 2004b). To test whether tariff cuts contributed to rationalization by inducing plant closures, we use the interaction between tariff cuts and proximity of a plant's output to the firm's key area of specialization. For each firm, the database has the Standard Industrial Classification (SIC) 4-digit industries of all plants that belong to the firm. Using these data, we calculate the share of the firm's output in each of its SIC 4-digit industries. For a plant this share is equal to one if a firm has only one plant, or if all plants of a firm produce output within the same SIC 4-digit industry. The shares are small for plants of highly diversified firms and for plants whose output is outside of the core SIC 4-digit industry of a firm.

In Table 7, Columns 2, 4 and 6 report the effects of the interaction between the tariff cuts and this diversification indicator for 'All plants,' 'Non-exporters' and 'Exporters.' The coefficients on the interaction terms are negative in all productivity quartiles for non-exporters. This indicates that, among non-exporters, both Canadian and U.S. tariff cuts decrease survival of plants of highly diversified firms, or plants whose output is outside of the core industry of a firm. Controlling for this, the effects of both Canadian and U.S. tariff concessions on exit of plants are huge. For a non-exporting plant whose productivity is above the 25th productivity percentile and whose diversification index is close to zero, the joint effect of the Canadian and U.S. tariff amounts to an increase in a probability of exit by 16% to 17%. This effect is statistically significant at over 1% level for plants in the 3rd and 4th productivity quartiles. This strong evidence shows that domestic tariff reductions contributed to restructuring within Canadian manufacturing by inducing the exit of plants that belong to highly diversified firms serving the domestic market. By noticing that plants of multi-plant firms are generally more productive compared with plants of single-plant firms, one may explain the unexpected finding regarding the stronger effects of the FTA on exits of relatively high-productivity plants.

14. The estimates of probit regressions are in the Appendix, in Tables A.2, A.3 and A.4.
15. Note that the estimates on the U.S. tariff for very low productivity exporters are very high but not very precise. This is likely explained by the very small number of observations (574). Because regressions control for fixed effects at the level of 213 industries, there is a small number of observations in each industry cell. Estimating the same probit using Standard Industrial Classification 3-digit industry fixed effects results in no statistically significant estimates for low-productivity exporters.

Table 7
Effects of tariff reductions on exit rates

	All plants		Non-exporters		Exporters	
	(1)	(2)	(3)	(4)	(5)	(6)
All plants						
$\Delta\tau^{CA}$	0.03*	0.09*	0.03*	0.10*	0.04*	0.04***
$\Delta\tau^{US}$	0.02*	0.05*	0.02*	0.06*	-0.02***	0.00
$\Delta\tau^{CA} * DIV$		-0.06*		-0.07*		0.00
$\Delta\tau^{US} * DIV$		-0.03*		-0.04*		-0.03
First quartile						
$\Delta\tau^{CA}$	0.02*	0.07**	0.02*	0.07***	0.00	-0.10
$\Delta\tau^{US}$	0.01**	0.02	0.01***	0.01	0.16**	0.20
$\Delta\tau^{CA} * DIV$		-0.05		-0.05		0.09
$\Delta\tau^{US} * DIV$		-0.01		0.00		-0.04
Second quartile						
$\Delta\tau^{CA}$	0.03*	0.12*	0.03*	0.12*	0.00	0.15***
$\Delta\tau^{US}$	0.01	0.02	0.02**	0.04	-0.06***	-0.14**
$\Delta\tau^{CA} * DIV$		-0.09*		-0.09*		-0.13**
$\Delta\tau^{US} * DIV$		-0.01		-0.03		0.09
Third quartile						
$\Delta\tau^{CA}$	0.03*	0.08*	0.03*	0.10*	0.04	-0.02
$\Delta\tau^{US}$	0.02*	0.07*	0.03*	0.07*	-0.04	0.04
$\Delta\tau^{CA} * DIV$		-0.05**		-0.07**		0.06
$\Delta\tau^{US} * DIV$		-0.04**		-0.04		-0.08**
Fourth quartile						
$\Delta\tau^{CA}$	0.02**	0.08*	0.02**	0.08*	0.05**	0.08***
$\Delta\tau^{US}$	0.02**	0.07*	0.03*	0.09*	-0.03	-0.01
$\Delta\tau^{CA} * DIV$		-0.05*		-0.06*		-0.02
$\Delta\tau^{US} * DIV$		-0.05*		-0.06*		-0.02

	Exit rate	Number of observations	Exit rate	Number of observations	Exit rate	Number of observations
All plants	0.45	68,030	0.48	59,587	0.26	8,443
1st quartile	0.57	14,581	0.60	14,007	0.37	574
2nd quartile	0.45	16,969	0.47	15,547	0.27	1,422
3rd quartile	0.39	18,388	0.42	15,708	0.25	2,680
4th quartile	0.36	18,092	0.40	14,325	0.24	3,767

* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level
Notes: The ratios of marginal effect of tariff to quartile-specific exit rates are reported. (The probit estimates are reported in Appendix Tables A.2 and A.3.) The estimating equation is Equation (3). The variables are defined as follows: $\Delta\tau^{CA}$ is the change in Canadian tariff, $\Delta\tau^{US}$ is the change in U.S. tariff, and **DIV* are the interactions of changes in tariffs with share of a plant's Standard Industrial Classification (SIC) 4-digit industry in total output of a firm (equals 1 if all plants of the firm produce in the same SIC 4-digit industry).
Source: Statistics Canada, Annual Survey of Manufactures.

The latter finding is consistent with findings by Head and Ries (1999), who also find that Canadian tariff cuts have stronger effects on exits of larger plants. To explain it, they suggest market-niches hypothesis, according to which small establishments “are insulated from the positive and negative effects of trade liberalization” (p. 314). This finding on exits of plants of multi-plant firms is also consistent with findings by Baldwin, Beckstead and Caves (2001), who look at changes in entropy of multi-plant firms over time and document a substantial increase in degree of specialization of multi-plant firms across four-digit manufacturing industries after the signing of the FTA. It is also consistent with studies that look at commodity-level firms’ diversification (Baldwin, Beckstead and Caves 2001; Baldwin, Caves and Gu 2005; and Baldwin and Gu 2006a), which find that commodity diversification was reduced in the FTA period. In particular Baldwin, Caves and Gu (2005) linked the reduced commodity-level diversification to tariff cuts, and Baldwin and Gu (2005) found that tariff cuts induced higher product specialization in non-exporting plants.

4.3 Within-plant productivity growth

The paper finds that Canadian tariff reductions led to exits of plants and to market share reallocation—the between-plant productivity growth. There is still a puzzle regarding the within-plant productivity growth. While Trefler (2004) finds that the U.S. tariffs are associated with productivity growth within plants, this effect does not show up in the industry-level productivity growth equation. To investigate in more depth the effect of tariff cuts on within-plant growth, we take two different approaches. First, we look at the relationship between tariff cuts and changes in plants’ positions in productivity distribution. This allows us to capture changes in the productivity of individual plants that are large enough to move a plant up or down in the productivity distribution. Applying this approach allows us to use information on all plants in the database. Second, we look at the change-in-change in productivity growth of individual plants. This limits the analysis to a sample of 10,821 plants that stayed in the market continuously in 1980, 1988 and 1996. The strength of the second approach is that one is able to control for plant-specific productivity growth trajectories. The drawback of it is the possibility of the sample selection problem, which will be dealt with below.

Plant transitions: Assume that in year t_1 (where t_1 is 1988 or 1996) there are $N_{t,1}$ plants in the market. Over the previous eight years, each of these plants made one of the four possible transitions: it entered the market, moved up or down in the productivity distribution, or stayed in the same productivity quartile. To capture the effects of the tariff cuts on these transitions, we estimate the following equation:

$$\frac{N_{88,96}^{q,Trans} - N_{80,88}^{q,Trans}}{N_{88}^{q}} = \alpha_0 + \alpha^{CA}\Delta\tau_i^{CA} + \alpha^{US}\Delta\tau_i^{US} + \alpha^{BC}(\Delta b_{i,1}^{N} - \Delta b_{i,0}^{N}) + \zeta_{i,q}; \qquad (4)$$

where $N_{t_0,t_1}^{q,Trans}$ is a number of plants making one of the four transitions: *ENTER, UP, DOWN* and *STAY*, and q is a plant’s productivity quartile in the end year. Table 8 gives the estimates of Equation (4) for *UP* and *DOWN* transitions.[16] By and large, it shows that plant transitions are not

16. Estimates for ENTER transitions are provided in Appendix Table A.5. They largely repeat the findings regarding entry in the ‘Between-plant productivity growth’ section.

strongly affected by the tariff cuts. The only significant effects are the effects of the U.S. tariff cuts on transition of exporters. The estimated α^{US} in the upward transition equation for exporters are -0.589 (*t*=-2.48) and -1.202 (*t*=-2.60) for plants that reached the 2nd and 3rd productivity quartiles. Note that here the exporting status of a plant is defined based on the end of the period. So these estimates use data on plants that either stayed in the export market continuously, or entered the export market by the end of the period. The importance of this result is threefold. First, it shows that only exporters' productivity significantly benefits from the U.S. tariff reductions. Second, it shows that less productive exporters are more likely to benefit from the U.S. tariff cuts. Third, it may explain why one does not observe the positive effect of the U.S. tariff cut on aggregate productivity growth. Plants whose productivity was positively affected by the tariff reductions were in the first or the second productivity quartiles at the beginning of each eight-year period, so they most likely produce a small share of the industry output (see Table 6). Since their size is small and they account for only a tiny fraction of the industry output, their productivity growth does not influence aggregate productivity growth. This table is also important because it shows no significant effects of Canadian tariff cuts on within-plant growth. Hence, the earlier identified increase in exit rates is the key channel through which Canadian tariff reductions impacted industry-level productivity.

Table 8
Plant transitions and tariff cuts

	α^{CA}		α^{US}		R-squared	Number
			All plants			
UP transition						
2nd quartile	0.093	(0.221)	-0.220	(0.431)	0.02	208
3rd quartile	0.743 **	(0.333)	-0.952	(0.705)	0.01	212
4th quartile	0.371	(0.382)	1.150	(0.810)	0.06	212
DOWN transition						
1st quartile	-0.080	(0.400)	0.843	(0.869)	0.00	209
2nd quartile	-0.020	(0.250)	0.752	(0.519)	0.00	208
3rd quartile	-0.102	(0.204)	0.714 ***	(0.433)	0.02	212
			Exporters			
UP transition						
2nd quartile	0.013	(0.130)	-0.589 **	(0.238)	0.04	208
3rd quartile	0.107	(0.218)	-1.202 *	(0.462)	0.03	212
4th quartile	-0.033	(0.300)	-0.287	(0.624)	0.02	212
DOWN transition						
1st quartile	0.109	(0.214)	-0.346	(0.455)	0.03	209
2nd quartile	0.021	(0.162)	-0.099	(0.330)	-0.01	208
3rd quartile	-0.144	(0.148)	0.023	(0.329)	0.00	212

* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level
Notes: The estimating equation is Equation (4). Standard errors are in parentheses. The productivity percentiles are based on the 1988 productivity distribution; the 1st quartile is the lowest productivity quartile. Estimates on business-cycle control are not presented. The export status for 1980 is based on the export status in 1979, and the export status for 1988 is defined based on the export status in 1984. α^{CA} is the coefficient on Canadian tariff, and α^{US} is the coefficient on U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

Change-in-change in productivity: To investigate the 'within-plant' productivity improvement in more depth, the analysis is limited to a group of plants that stayed in the market continuously. For them, one can compare plant performance between the pre-FTA and FTA periods. Let p index plants, i index industries, s index time periods, and let $\Delta y_{p,i,s}$ be an average annual log change in an outcome y of a plant p in period s. To match Trefler's (2004) choice of time periods, the pre-FTA period is defined as from 1980 to 1986 and the FTA period as from 1988 to 1996. We estimate the equation:

$$\Delta y_{p,i,1} - \Delta y_{p,i,0} = \theta + \beta^{CA} \Delta \tau_{i,1}^{CA} + \delta(\Delta b_{i,1}^{Y} - \Delta b_{i,0}^{Y}) + \phi x_{p,i,1988} + \varepsilon_{p,i} \,. \quad (5)$$

Double-differencing allows to difference out the plant-specific growth component, something one can do only for continuing plants. In Equation (5), $\Delta b_{i,s}^{Y}$ is industry-level business cycle control and $x_{p,i,1988}$ is a vector of plant characteristics, which includes log employment, relative labour productivity, age and foreign control. Table 9 gives estimates of Equation (5) for change in log labour productivity. The first row gives the estimates of productivity effects of the tariff cuts for all continuing plants. This repeats the key result from Trefler (2004): the U.S. tariff cuts are strongly related to within-plant productivity growth in Canadian plants (β^{US} is -1.965, t=-3.58), while Canadian tariff cuts have no effect on productivity growth (β^{CA} is -0.245, t=-0.92).[17]

As the theoretical models suggest, the effect of trade liberalization will differ for exporters and non-exporters. To estimate the effect of tariff cuts on exporters and non-exporters, plants are defined as exporters based on varying export intensities. The dummy variable for exporting, $D_{p,i}$, is equal to one if a plant exports over X% of its total shipments in at least one year of 1979, 1984, 1990 and 1996, and is equal to zero otherwise. The Equation (5) is estimated allowing for interaction of the U.S. tariff cuts with exporters status:

$$\Delta y_{p,i,1} - \Delta y_{p,i,0} = \theta + \beta^{EXP} D_{p,i} + (\beta_0^{US} + \beta_1^{US} D_{p,i}) \Delta \tau_{i,1}^{US} + \beta^{CA} \Delta \tau_{i,1}^{CA} + \delta(\Delta b_{i,1}^{Y} - \Delta b_{i,0}^{Y}) + \phi x_{p,i,1988} + \varepsilon_{p,i} \,. \quad (6)$$

Tables 9-1 and 9-2 gives estimates of Equation (6) when export-to-output ratios are set to 0%, 5%, 10%, 25% and 50%. They show that the U.S. tariff reductions have no effect on the productivity growth of non-exporters ($D_{p,i}$=0), but have a large effect on the productivity growth of exporters ($D_{p,i}$=1). For them, a 1-percentage-point fall in the U.S. tariff ($\Delta \tau_{i,1}^{US}$=0.01) increases annual productivity growth by 3% to 4%, depending on the definition of an exporter.

17. One may argue that tariffs are endogenous in the productivity equation. Trefler (2004) argues against endogeneity of tariffs in plant-level productivity growth equations, and his estimates reject endogeneity. Baggs (2005) rejects endogeneity of tariffs in estimation of plant exit probabilities.

The U.S. tariff fell by on-average 2 percentage points because of the FTA over the period from 1988 to 1996, so the productivity growth of exporters due to FTA increased by 6% to 8%. The estimated effects get larger when exporters are plants with higher export intensity. So, Trefler's (2004) productivity effect of the U.S. tariff cuts depends critically on the export status of a plant: exporting plants obtain productivity benefits from tariff concessions, while non-exporters receive no benefits.[18]

Table 9-1
Effects of tariff on labour productivity — Interaction between tariff reductions and exporter status

	β^{CA}		β^{US}		β^{EXP}		Interaction between $\Delta\tau_i^{US}$ and exporter status	
Tariff cuts for all continuing plants	-0.245	(0.266)	-1.965*	(0.549)	...	...	...	...
Export cut-offs								
0%	-0.425	(0.291)	0.439	(0.967)	0.001	(0.004)	-3.203*	(1.151)
5%	-0.442	(0.292)	0.292	(0.794)	-0.002	(0.004)	-4.149*	(1.084)
10%	-0.467	(0.292)	-0.036	(0.751)	-0.002	(0.004)	-4.061*	(1.099)
25%	-0.450	(0.293)	-0.446	(0.689)	-0.005	(0.004)	-4.537*	(1.201)
50%	-0.419	(0.293)	-0.714	(0.640)	-0.009***	(0.005)	-6.516*	(1.492)

… not applicable
* indicates significance at the 1% level
*** indicates significance at the 10% level
Notes: The estimating equations are Equations (5) and (6). Standard errors are in parentheses. The dependent variable is labour productivity. The export cut-offs indicate the exports–output ratio used in the construction of the export dummy. Estimates of plant controls and business cycle control are not presented. The plant controls are as follows: *Size* is log (employment) of plant *k* in 1988; *productivity* is log (labour productivity of plant *k* in 1988) minus log (mean industry productivity); *age* is log (age) of plant *k* in 1988; *old* is equal to 1 if age in 1988 is 12, and to 0 otherwise; and *foreign control* is a dummy variable equal to 1 if plant *k* is under foreign control, 0 otherwise. The export cut-offs value means that the export-to-output ratio is larger than N% for exporters in at least one year of 1979, 1984, 1990, or 1996. The adjusted R-squared values are all in the range of 12% to 13%. β^{CA} is the coefficient on Canadian tariff, β^{US} is the coefficient on U.S. tariff, β^{EXP} is the coefficient on exporter status and $\Delta\tau_i^{US}$ is the change in U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

18. Note that the results for productivity growth are for labour productivity, not the total factor productivity, because the plant-level capital stock data are not available. However Trefler (2001) found no effects of tariff on capital stock per worker at industry level. He also noted a very small growth in real fixed investment in Canada (compared with the United States) over the 1988-to-1996 period. At the plant-level we found no relationship between tariff cuts and the use of materials per unit of output or the use of energy per output (the latter can be thought of as a proxy for capital stock). This suggests that most likely there were no strong tariff-related capital increase at the plant level.

Table 9-2
Effects of tariff on labour productivity — Interaction between tariff reductions and 'old' exporter status or 'new' exporter status

	β^{CA}		β^{US}		$\beta^{EXP,OLD}$		Interaction between $\Delta\tau_i^{US}$ and 'old' exporter status		$\beta^{EXP,NEW}$		Interaction between $\Delta\tau_i^{US}$ and 'new' exporter status	
Tariff cuts for all continuing plants	-0.245	(0.266)	-1.965*	(0.549)	...	...	...	...	...	...	...	...
Export cut-offs												
0%	-0.384	(0.292)	0.120	(0.948)	-0.002	(0.005)	-2.991**	(1.385)	0.002	(0.004)	-2.634**	(1.277)
5%	-0.392	(0.292)	0.118	(0.814)	-0.004	(0.005)	-2.988**	(1.296)	-0.001	(0.005)	-4.164*	(1.352)
10%	-0.404	(0.293)	-0.164	(0.782)	-0.004	(0.005)	-2.707**	(1.276)	-0.002	(0.005)	-4.131*	(1.434)
25%	-0.417	(0.293)	-0.401	(0.738)	-0.005	(0.004)	-2.470**	(1.249)	-0.003	(0.006)	-5.343*	(1.704)
50%	-0.403	(0.293)	-0.606	(0.705)	-0.005	(0.004)	-2.285**	(1.231)	-0.007	(0.008)	-8.862*	(2.322)

… not applicable
* indicates significance at the 1% level
** indicates significance at the 5% level
Notes: The estimating equations are Equations (5) and (6). Standard errors are in parentheses. The dependent variable is labour productivity. The export cut-offs indicate the exports–output ratio used in the construction of the export dummy. Estimates of plant controls and business cycle control are not presented. The plant controls are as follows: *Size* is log (employment) of plant *k* in 1988; *productivity* is log (labour productivity of plant *k* in 1988) minus log (mean industry productivity); *age* is log (age) of plant *k* in 1988; *old* is equal to 1 if age in 1988 is 12, 0 otherwise; and *foreign control* is a dummy variable equal to 1 if plant *k* is under foreign control, 0 otherwise. The export cut-offs value means that the export-to-output ratio is larger than N% for exporters in at least one year of 1979, 1984, 1990, or 1996. The adjusted R-squared values are all in the range of 12% to 13%. β^{CA} is the coefficient on Canadian tariff, β^{US} is the coefficient on U.S. tariff, $\beta^{EXP,OLD}$ is the coefficient on 'old' exporter status, $\beta^{EXP,NEW}$ is the coefficient on 'new' exporter status and $\Delta\tau_i^{US}$ is the change in U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

Table 9-2 allows for tariff effects to differ for plants that export continuously and plants that entered the export market in the FTA period. There is a striking difference between the two groups of plants: the estimated effects of U.S. tariff concessions are much larger for new entrants to the export market. For a new exporter (a plant that entered the export market after the signing of the FTA in 1990 or 1996 and exported at least 10% of its shipments), a 1-percentage-point cut in the U.S. tariff leads to 4.13 percentage points advantage in annual productivity growth over a non-exporter, while a similar plant that entered the export market before the FTA gets 2.71 percentage points growth advantage over a non-exporter.

One potential problem with the estimates of productivity growth is that Equation (5) uses data on plants that survived for at least 16 years on the market. It does not take exiting plants into account, nor the fact that tariff changes may lead to closures of some plants. If trade liberalization causes exit of less productive plants, then the estimates of the tariff effect on productivity are biased upwards, that is, one would overestimate the productivity-enhancing effects of trade liberalization. To control for selection, we assume that plants that exited the market would indeed have a relatively low-productivity growth in the FTA period. For example, had these plants not exited, they would have productivity growth similar to the relatively poorly growing continuing plants in the same industries. So we impute low-productivity growth to plants that exited, and re-estimate Equation (5). The FTA-period productivity growth for exiting plants is set to the 25th percentile of distribution of productivity growth for continuing plants for each SIC 4-digit industry.[19] If exiting plants had a relatively low-productivity growth in all industries—hence unrelated to the depth of the tariff cuts—one would expect β^{US} to be unaffected by exits. If exiting plants in high tariff industries would have much lower productivity growth in the FTA period had the tariff cuts not occurred, then the estimate of β^{US} is too high. Imputing the low FTA growth to exiting plants would then reduce β^{US}.

Table 10 shows estimates of Equation (5) using an imputed annual-productivity growth for exiting plants. Note that since the exporting status of exiting plants in the FTA period is not observed, the value of $D_{p,i}$ for them is uncertain. The previous estimates suggest that $D_{p,i}$ for exiting plants is more likely to be zero. Still the Equation (5) is estimated separately for non-exporters (assuming that exiting plants that were non-exporters in the pre-FTA period would also stay non-exporters in the FTA period) and exporters (assuming that exiting plants that exported in the pre-FTA period would remain exporters in the FTA period). We show the estimates for exporters defined as plants that export 0% or 10% of their shipments with and without exiting plants. Whether or not we assume that exiting plants are exporters or non-exporters in the FTA period, there is little difference between the estimates obtained using data on only continuing plants and using data on continuing and exiting plants. Hence one may conclude that selection bias does not affect the estimates of productivity effects of tariff cuts.

19. In the pre-Free Trade Agreement (FTA) period from 1980 to 1986, the median productivity growth was 1.50%, while productivity growth in the 25th percentile was -0.04%. The average productivity growth for non-exiting plants during 1980-to-1986 period was 1.9% (t=7.69), while for plants that exited after 1988, it was 1.1% (t=2.93). So while there is a significant difference in productivity growth between continuing and exiting plants, on average productivity growth of exiting plants is much higher than 25th percentile of productivity growth distribution. Hence the 25th percentile may serve as a very low bound for productivity growth of exiting plants in the FTA period.

Table 10
Selection correction

Model	β^{CA}		β^{US}		Adjusted R-squared	Number of observations	Exit rate
							percent
All plants							
Continuing plants	-0.245	(0.266)	-1.955 *	(0.546)	0.12	10,820	...
Selection correction	0.203	(0.199)	-1.194 *	(0.417)	0.08	16,548	35
Non-exporters							
0 cut-off							
Continuing plants	-0.690	(0.473)	0.696	(1.009)	0.12	3,133	...
Selection correction	-0.077	(0.321)	0.393	(0.666)	0.09	5,340	41
Exporters							
0 cut-off							
Continuing plants	-0.289	(0.371)	-2.821 *	(0.737)	0.13	5,806	...
Selection correction	-0.155	(0.323)	-2.639 *	(0.660)	0.10	7,107	18
10% cut-off							
Continuing plants	-0.676	(0.486)	-3.640 *	(0.929)	0.12	3,766	...
Selection correction	-0.455	(0.442)	-3.879 *	(0.854)	0.09	4,501	16

… not applicable
* indicates significance at the 1% level
Notes: The estimating equation is Equation (5). Standard errors are in parentheses. Productivity growth of exiting plants in the Free Trade Agreement period is set to productivity growth in the 25th percentile of continuing plants in a given Standard Industrial Classification 4-digit industry of a plant. The plant controls are as follows: *Size* is log (employment) of plant *k* in 1988; *productivity* is log (labour productivity of plant *k* in 1988) minus log (mean industry productivity); *age* is log (age) of plant *k* in 1988; *old* is equal to 1 if age in 1988 is 16, and to 0 otherwise; and *foreign control* is a dummy variable equal to 1 if plant *k* is under foreign control 0 otherwise. β^{CA} is the coefficient on Canadian tariff, and β^{US} is the coefficient on U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

We also estimate Equation (5) when dependent variables are output and employment (Table 11). Distinguishing exporters from non-exporters helps to effectively resolve Trefler's employment and output paradoxes. Overall, the U.S. tariff reductions have a negative effect on employment (β^{US} is 1.648, *t*=3.06) in continuing plants (as in Trefler 2004). Employment growth is reduced in both exporters and non-exporters, but the effect on non-exporters is somewhat stronger. For non-exporters, a 1-percentage-point fall in the U.S. tariff results in a 1.5% to 3.0% fall in employment growth. Overall, the U.S. tariff cuts have no effect on output growth (as in Trefler 2004). However, U.S. tariff cuts increase exporters' output growth, especially for plants exporting a large part of their output, while reducing output growth among non-exporters. So, export liberalization has led to exporters cannibalizing domestic market shares of non-exporting plants. As non-exporters are relatively less productive, the within-plant estimates show that U.S. tariff cuts, by improving productivity of continuing exporters, also contribute to reallocation of output toward more productive plants in the domestic market. Finally, U.S. tariff concessions are related to an increase in export volumes and export–output ratios of exporting plants.

Another interesting observation from Table 11 is that tariff cuts have different effects on exporters' output and employment. That is, the U.S. tariff-cut-induced expansion of output is larger than expansion of employment. So, one may conjecture that increases in productivity and output result from the realization of scale effects and/or changes in the output composition of exporters.

Table 11
Effects of tariff cuts on plant outcomes

	β^{CA}		β^{US}		β^{EXP}		Interaction between $\Delta\tau_i^{US}$ and exporter status	
	(1)		(2)		(3)		(4)	
Employment								
Continuing plants	0.260	(0.263)	1.648*	(0.539)	...	...	...	...
Export cut-offs								
0%	0.176	(0.279)	3.163*	(0.927)	0.020*	(0.004)	-1.901***	(1.104)
5%	0.131	(0.280)	1.761*	(0.762)	0.020*	(0.004)	0.002	(1.040)
10%	0.087	(0.281)	1.997*	(0.721)	0.020*	(0.004)	-0.681	(1.054)
25%	0.029	(0.281)	2.024*	(0.660)	0.021*	(0.004)	-1.535	(1.152)
50%	0.104	(0.282	1.589*	(0.614)	0.021*	(0.004)	-0.651	(1.434)
Output								
Continuing plants	0.475***	(0.265)	-0.072	(0.554)	...	...	...	...
Export cut-offs								
0%	0.131	(0.286)	3.170*	(0.954)	0.017*	(0.004)	-3.974*	(1.134)
5%	0.081	(0.287)	1.966**	(0.783)	0.015*	(0.004)	-3.249*	(1.069)
10%	0.019	(0.288)	2.139**	(0.741)	0.014*	(0.004)	-4.297*	(1.083)
25%	-0.026	(0.288)	1.663**	(0.679)	0.014*	(0.004)	-5.036*	(1.184)
50%	0.079	(0.289)	0.908	(0.632)	0.012*	(0.005)	-4.939*	(1.476)
Log exports[1]								
Exporters in 1984 and 1996[2]	-1.395	(0.906)	-4.321*	(1.521)	...	...	...	...
Export–output ratio[1]								
Exporters in 1984 and 1996[2]	0.000	(0.148)	-0.614**	(0.249)	...	...	...	...
Exporters in 1984 or 1996[3]	0.106	(0.085)	-0.443*	(0.161)	...	...	...	...

… not applicable
* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level
1. Because data on exporting are available only for selected years, we cannot implement the double-differencing method, and look at changes from 1984 (pre-Free Trade Agreement) to 1996 (Free Trade Agreement). Regressions control for Standard Industrial Classification 2-digit fixed effects.
2. Number of observations: 2,033.
3. Number of observations: 4,492.
Notes: The estimating equations are Equations (5) and (6). Standard errors are in parentheses. The export cut-offs indicate the exports–output ratio used in the construction of the export dummy. The plant controls are as follows: *Size* is log (employment) of plant *k* in 1988; *productivity* is log (labour productivity of plant *k* in 1988) minus log (mean industry productivity); *age* is log (age) of plant *k* in 1988; *old* is equal to 1 if age in 1988 is 16, 0 otherwise; and *foreign control* is a dummy variable equal to 1 if plant *k* is under foreign control, and to 0 otherwise. The adjusted R-squared values for employment are all in the range of 8% to 9%, and for output are all in the range of 6% to 7%. β^{CA} is the coefficient on Canadian tariff, β^{US} is the coefficient on U.S. tariff, β^{EXP} is the coefficient on exporter status, and $\Delta\tau_i^{US}$ is the change in U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

5 Conclusion

This paper looks at the Free Trade Agreement-induced changes in the productivity distribution and productivity growth, with particular interest in the relative importance of between- and within-plant productivity changes. It is found that both Canadian and the U.S. tariff cuts induce market share reallocation in favour of high-productivity plants, with the Canadian tariff effect being more pronounced. The market share reallocation is at least explained in part by higher exit rates among Canadian non-exporting plants caused by tariff reductions. The reductions in the U.S. tariff increase the exit rates only among non-exporters, while increasing survival probabilities for exporters. Also, a fall in the tariffs charged by a trading partner induces transition of plants into higher quartiles of the productivity distribution. The effect is observed for exporters in the relatively low productivity quartiles.

The paper provides new evidence on how the trade liberalization impacted the productivity growth within Canadian plants. It deepens Trefler's (2004) finding that the U.S. tariff cuts led to productivity improvements in Canadian plants. Specifically, it shows that productivity improvements occurred only in exporting plants, while non-exporting plants suffered a deterioration in output and employment growth and acquired no productivity benefits from the trade liberalization.

The share-shifting effect of the Canadian tariff change appears to be more important than the within-plant growth induced by the U.S. tariff cuts, both for changes in productivity distribution and for industry productivity growth. A relatively small effect of the U.S. tariff change on the aggregate productivity can be explained by two factors. First, the U.S. tariff cuts only benefit the productivity of exporters, who constitute less than a half of manufacturing plants, and, in particular, of the low-productivity exporters. Second, the productivity-enhancing effect of the U.S. tariff may be partially offset by Canadian tariff changes that put low-productivity plants at a disadvantage.

Appendix

Industrial classification

The plant-level manufacturing data come from the Canadian Annual Survey of Manufactures. The database provides information on the universe of manufacturing plants operating in Canada. In the database, each plant is assigned an industry based on 1980 Canadian Standard Industrial Classification (SIC) 4-digit level. The industry was assigned based on the largest segment of output of a plant using commodity shipments data, which are not available to researchers.

The 1980 SIC 4-digit level consists of 236 industries. Some of these industry groups are very small, consisting of one or two plants. For the small industries, industry-level data are confidential and cannot be used outside Statistics Canada. For these industries, the data were converted to a higher level of aggregation, which resulted in the total of 213 industries. Because the paper uses publicly available industry-level data from Trefler (2004), it uses the modified SIC 4-digit level with 213 industries. The list of aggregated industries appears in Trefler (2001).

A small number of plants in the database change industries over time. In particular, out of 10,820 continuing plants, 7.9% have different SIC 4-digit industries in 1988 and 1996. The vast majority of plants change industry to a related industry. The paper uses plant-level 4-digit SIC industry in 1988, i.e., right before the tariff cuts occur. A similar approach was taken by Trefler (2004), Baldwin and Gu (2004b). One argument in favour of using tariffs based on 1988 industry is that a plant may change its output composition (and therefore its industry) in response to the tariff cuts. Therefore, assigning the industry codes based on 1996 can make the tariff change endogenous. (However, the robustness checks show that assigning industry based on 1996 data does not affect the results.)

All nominal values were converted to real values using deflators derived from the Canadian Input–Output tables for output. These Input–Output tables are at the Input–Output Classification consisting of 137 industries (which is close to the Canadian SIC 3-digit level).

Tariffs

The tariff data at the SIC 4-digit level were kindly provided by Trefler and details on its construction can be found in Trefler (2004), who obtained the Canadian tariff data from Statistics Canada and used the U.S. product line tariff data to construct industry-level tariffs as duties divided by imports.

To define the 'most impacted industries,' industries were ranked into three groups based on the depths of Canadian or U.S. tariff cuts. The industries with the largest Canadian or U.S. tariff cuts were considered as the most impacted industries.

Business cycle controls

These business cycle control variables were kindly provided by Trefler and details on their construction can be found in Trefler (2001 and 2004). The business cycle control variables are expectations of the effects that business cycle fluctuations may have on productivity, output, employment and exports of different industries. To construct $\Delta b_{i,s}^{y}$ for a change in output, first, annual log change in output, $\Delta_1 y_{i,t}$ was regressed on distributed lag of changes in log real GDP and real exchange rate for each industry *i* in year *t*. Then $\Delta b_{i,s}^{y}$ is the average of predicted effects of business cycle on the output of a given industry *i*, $\Delta b_{i,s}^{y} = \sum_{t_0}^{t_1} \Delta_1 \hat{y}_{i,t} /(t_1 - t_0)$, where t_0 and t_1 are the first and the last years of the period *s*. In a similar way the business cycle controls were constructed for employment, productivity and exports.

Table A.1
Changes in number of plants and tariff cuts, most impacted industries[1]

	β^{CA}		β^{US}		R-squared	Number of observations
Number of plants						
All plants	1.176 **	(0.488)	0.218	(1.090)	0.03	108
< 25th percentile	0.235	(0.331)	0.005	(0.500)	-0.02	108
25th to 50th percentile	0.117	(0.244)	-0.011	(0.550)	-0.03	108
50th to75th percentile	1.090 *	(0.323)	-1.553 **	(0.726)	0.13	108
> 75th percentile	0.399	(0.190)	0.657	(0.427)	0.06	108
Exit						
All plants	-0.809 **	(0.389)	0.937	(0.868)	0.02	108
< 25th percentile	-0.267	(0.212)	0.546	(0.475)	0.00	108
25th to 50th percentile	-0.126	(0.143)	0.317	(0.320)	-0.01	108
50th to75th percentile	-0.435 *	(0.117)	0.567 **	(0.264)	0.16	108
> 75th percentile	-0.158	(0.096)	-0.250	(0.216)	0.02	108
Entry						
All plants	0.368	(0.271)	1.155 **	(0.605)	0.04	108
< 25th percentile	0.068	(0.106)	0.398 **	(0.240)	0.01	108
25th to 50th percentile	0.227 ***	(0.117)	0.327	(0.262)	0.02	108
50th to 75th percentile	0.046	(0.105)	-0.065	(0.232)	-0.02	108
> 75th percentile	0.142	(0.091)	0.365 **	(0.203)	0.07	108

* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level
1. The most impacted industries are those that received largest U.S. or Canadian tariff concessions.
Notes: The estimating equation is Equation (1). Standard errors are in parentheses. The dependent variables are number of plants, exit and entry. The productivity percentiles are based on 1988 distribution. Estimates on business cycle control are not presented. The number of plants in each year is scaled by the number of plants in 1988 in a given industry. β^{CA} is the coefficient on Canadian tariff, and β^{US} is the coefficient on U.S. tariff.
Source: Statistics Canada, Annual Survey of Manufactures.

Table A.2
Probability of exit, by exporter status

	All		Non-exporters		Exporters	
	Probit estimate	Standard error	Probit estimate	Standard error	Probit estimate	Standard error
All plants						
$\Delta\tau^{CA}$	-1.600 *	(0.258)	-1.671 *	(0.273)	-2.654 *	(0.863)
$\Delta\tau^{US}$	-2.510 *	(0.545)	-3.107 *	(0.580)	2.907 **	(1.712)
Productivity	-0.250 *	(0.009)	-0.250 *	(0.009)	-0.270 *	(0.028)
Size	-0.249 *	(0.004)	-0.249 *	(0.005)	-0.253 *	(0.017)
Age	-0.119 *	(0.006)	-0.124 *	(0.006)	-0.167 *	(0.037)
Year	-0.012 *	(0.002)	-0.017 *	(0.002)	0.034 *	(0.006)
Foreign control	0.187 *	(0.021)	0.197 *	(0.026)	0.168 *	(0.039)
Multi plant	0.193 *	(0.017)	0.187 *	(0.020)	0.252 *	(0.037)
All plants, controlling for diversification						
$\Delta\tau^{CA}$	-5.557 *	(0.703)	-6.156 *	(0.838)	-2.665 **	(1.448)
$\Delta\tau^{US}$	-7.053 *	(1.404)	-8.440 *	(1.672)	-0.193	(2.817)
Productivity	-0.252 *	(0.009)	-0.252 *	(0.009)	-0.272 *	(0.028)
Size	-0.248 *	(0.004)	-0.248 *	(0.005)	-0.253 *	(0.017)
Age	-0.122 *	(0.006)	-0.127 *	(0.006)	-0.167 *	(0.037)
Year	-0.012 *	(0.002)	-0.017 *	(0.002)	0.033 *	(0.006)
Multi plant	0.145 *	(0.018)	0.130 *	(0.021)	0.238 *	(0.039)
Foreign control	0.181 *	(0.021)	0.188 *	(0.026)	0.165 *	(0.039)
$\Delta\tau^{US} * DIV$	4.962 *	(1.425)	5.727 *	(1.691)	4.161	(3.060)
$\Delta\tau^{US} * DIV$	4.157 *	(0.705)	4.668 *	(0.840)	-0.132	(1.515)
All plants						
Log likelihood	-41968.5		-37443.9		-4320.7	
Number of observations	68,030		59,587		8,443	
All plants, controlling for diversification						
Log likelihood	-41920.4		-37399.3		-4319.4	
Number of observations	68,030		59,587		8,443	

* indicates significance at the 1% level
** indicates significance at the 5% level

Notes: The estimated equation is Equation (3). The variables are as follows: $\Delta\tau^{CA}$ is the change in Canadian tariff; $\Delta\tau^{US}$ is the change in U.S. tariff; $*DIV$ is the interaction of changes in tariffs with share of a plant's Standard Industrial Classification (SIC) 4-digit industry in total output of a firm (equals 1 if all plants of the firm produce in the same SIC 4-digit industry); *productivity* is log (labour productivity in initial year); *size* is log (size in initial year); *age* is log (plant age); *foreign control* is a dummy variable equal to 1 if plant is under foreign control, and to 0 otherwise; and *year* is a dummy variable equal to 1 in 1988 to 1996. The productivity quartiles are defined using the 1988 productivity distribution. All regressions control for industry fixed effects at the SIC 4-digit level.
Source: Statistics Canada, Annual Survey of Manufactures.

Table A.3
Probability of exit, by productivity quartiles

	1st quartile		2nd quartile		3rd quartile		4th quartile	
	Probit estimate	Standard error	Probit estimate	Standard error	Probit estimate	Standard error	Probit estimate	Standard error
All plants								
$\Delta\tau^{CA}$	-1.811 *	(0.601)	-1.640 *	(0.540)	-1.665 *	(0.493)	-1.213 **	(0.501)
$\Delta\tau^{US}$	-2.354 ***	(1.207)	-1.742	(1.097)	-2.930 *	(1.062)	-2.823 **	(1.143)
Productivity	-0.304 *	(0.027)	-0.505 *	(0.069)	-0.147 **	(0.066)	-0.028	(0.027)
Size	-0.231 *	(0.011)	-0.239 *	(0.010)	-0.258 *	(0.009)	-0.251 *	(0.008)
Age	-0.092 *	(0.013)	-0.148 *	(0.013)	-0.097 *	(0.013)	-0.124 *	(0.013)
Year	-0.013 *	(0.004)	-0.021 *	(0.004)	-0.011 *	(0.004)	0.001	(0.004)
Foreign control	0.128 ***	(0.068)	0.266 *	(0.051)	0.082 **	(0.041)	0.186 *	(0.033)
Multi-plant	0.063	(0.052)	0.186 *	(0.041)	0.237 *	(0.032)	0.178 *	(0.028)
Exporters	0.057	(5.270)	-0.226	(2.737)	-2.499	(1.672)	-2.936 **	(1.398)
$\Delta\tau^{US}$	-33.312 **	(13.868)	8.158 ***	(4.756)	4.915	(3.264)	3.485	(2.935)
Productivity	-0.332 **	(0.137)	-0.423 ***	(0.241)	-0.384 **	(0.189)	-0.061	(0.069)
Size	-0.197 **	(0.086)	-0.235 *	(0.048)	-0.252 *	(0.033)	-0.270 *	(0.026)
Age	0.077	(0.155)	-0.209 **	(0.093)	-0.253 *	(0.076)	-0.234 *	(0.063)
Year	0.018	(0.026)	0.046 *	(0.016)	0.055 *	(0.012)	0.042 *	(0.010)
Foreign control	0.081	(0.214)	0.292 *	(0.109)	0.013	(0.079)	0.228 *	(0.061)
Multi-plant	0.010	(0.173)	0.119	(0.100)	0.349 *	(0.072)	0.304 *	(0.059)
Non-exporters	-1.833 *	(0.612)	-1.843 *	(0.560)	-1.750 *	(0.531)	-1.150 **	(0.552)
$\Delta\tau^{US}$	-2.356 **	(1.228)	-2.524 *	(1.147)	-4.203 *	(1.155)	-3.636 *	(1.268)
Productivity	-0.302 *	(0.027)	-0.539 *	(0.075)	-0.093	(0.072)	-0.026	(0.030)
Size	-0.230 *	(0.011)	-0.242 *	(0.010)	-0.262 *	(0.010)	-0.246 *	(0.009)
Age	-0.096 *	(0.013)	-0.155 *	(0.013)	-0.103 *	(0.013)	-0.126 *	(0.014)
Year	-0.015 *	(0.004)	-0.027 *	(0.004)	-0.019 *	(0.004)	-0.005	(0.004)
Foreign control	0.131 **	(0.076)	0.282 *	(0.062)	0.105 **	(0.051)	0.161 *	(0.041)
Multi-plant	0.084	(0.058)	0.214 *	(0.046)	0.195 *	(0.038)	0.162 *	(0.033)
Number of observations								
All plants	14,581		16,969		18,388		18,092	
Exporters	574		1,422		2,680		3,767	
Non-exporters	14,007		15,547		15,708		14,325	

* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level

Notes: Estimated equation is Equation (3). The variables are defined as follows: $\Delta\tau^{CA}$ is the change in Canadian tariff; $\Delta\tau^{US}$ is the change in U.S. tariff; *productivity* is log (labour productivity in initial year); *size* is log (size in initial year); *age* is log (plant age); *foreign control* is a dummy variable equal to 1 if plant is under foreign control, and to 0 otherwise; and *year* is a dummy variable equal to 1 in 1988 to 1996. The productivity quartiles are defined using the 1988 productivity distribution. All regressions control for industry fixed effects at Standard Industrial Classification 4-digit level.
Source: Statistics Canada, Annual Survey of Manufactures.

Table A.4
Probability of exit, by productivity quartiles, controlling for diversification

	1st quartile		2nd quartile		3rd quartile		4th quartile	
	Probit estimate	Standard error	Probit estimate	Standard error	Probit estimate	Standard error	Probit estimate	Standard error
All plants								
$\Delta\tau^{CA}$	-5.996 **	(3.012)	-6.933 *	(1.770)	-4.382 *	(1.416)	-4.239 *	(1.036)
$\Delta\tau^{US}$	-3.541	(5.325)	-3.019	(3.372)	-8.611 *	(2.765)	-9.163 *	(2.261)
Productivity	-0.304 *	(0.027)	-0.504 *	(0.069)	-0.153 **	(0.066)	-0.033	(0.027)
Size	-0.230 *	(0.011)	-0.238 *	(0.010)	-0.258 *	(0.009)	-0.250 *	(0.008)
Age	-0.092 *	(0.013)	-0.149 *	(0.013)	-0.100 *	(0.013)	-0.130 *	(0.013)
Year	-0.014 *	(0.004)	-0.022 *	(0.004)	-0.011 *	(0.004)	0.000	(0.004)
Multi-plant	0.034	(0.054)	0.137 *	(0.043)	0.197 *	(0.034)	0.127 *	(0.029)
Foreign control	0.125 ***	(0.068)	0.266 *	(0.052)	0.077 ***	(0.041)	0.176 *	(0.033)
$\Delta\tau^{US} * DIV$	1.238	(5.350)	1.321	(3.394)	6.295 **	(2.822)	7.424 *	(2.323)
$\Delta\tau^{CA} * DIV$	4.238	(3.008)	5.522 *	(1.775)	2.813 **	(1.424)	3.316 *	(1.059)
Exporters								
$\Delta\tau^{CA}$	10.418	(14.972)	-11.262 ***	(6.037)	1.317	(3.334)	-4.206 **	(2.142)
$\Delta\tau^{US}$	-41.338	(26.184)	20.333 **	(8.814)	-5.673	(5.813)	0.758	(4.387)
Productivity	-0.339 **	(0.138)	-0.416 ***	(0.242)	-0.411 **	(0.189)	-0.062	(0.069)
Size	-0.197 **	(0.086)	-0.237 *	(0.048)	-0.252 *	(0.033)	-0.269 *	(0.026)
Age	0.077	(0.156)	-0.211 **	(0.094)	-0.252 *	(0.076)	-0.235 *	(0.063)
Year	0.021	(0.027)	0.043 *	(0.016)	0.055 *	(0.012)	0.041 *	(0.010)
Multi-plant	0.033	(0.182)	0.094	(0.105)	0.344 *	(0.075)	0.281 *	(0.061)
Foreign control	0.091	(0.215)	0.297 *	(0.109)	0.007	(0.079)	0.225 *	(0.061)
$\Delta\tau^{US} * DIV$	9.140	(24.079)	-15.026	(9.228)	14.575 **	(6.628)	3.771	(4.634)
$\Delta\tau^{CA} * DIV$	-11.083	(14.999)	13.036 **	(6.279)	-5.241	(3.539)	1.500	(2.146)
Non-exporters								
$\Delta\tau^{CA}$	-6.091 ***	(3.144)	-7.263 *	(2.149)	-5.712 *	(1.728)	-4.398 *	(1.245)
$\Delta\tau^{US}$	-2.097	(5.551)	-6.019	(3.976)	-9.024 *	(3.352)	-11.918 *	(2.777)
Productivity	-0.301 *	(0.027)	-0.540 *	(0.075)	-0.099	(0.072)	-0.032	(0.030)
Size	-0.231 *	(0.011)	-0.241 *	(0.010)	-0.262 *	(0.010)	-0.245 *	(0.009)
Age	-0.096 *	(0.013)	-0.157 *	(0.013)	-0.106 *	(0.013)	-0.132 *	(0.014)
Year	-0.015 *	(0.004)	-0.027 *	(0.004)	-0.019 *	(0.004)	-0.006	(0.004)
Multi-plant	0.056	(0.061)	0.155 *	(0.049)	0.146 *	(0.040)	0.104 *	(0.035)
Foreign control	0.128 ***	(0.076)	0.281 *	(0.062)	0.099 ***	(0.051)	0.145 *	(0.041)
$\Delta\tau^{US} * DIV$	-0.250	(5.577)	3.651	(3.996)	5.253	(3.399)	9.373 *	(2.834)
$\Delta\tau^{CA} * DIV$	4.323	(3.142)	5.583 *	(2.152)	4.122 **	(1.736)	3.499 *	(1.270)
Number of observations								
All plants	14,581		16,969		18,388		18,092	
Exporters	574		1,422		2,680		3,767	
Non-exporters	14,007		15,547		15,708		14,325	

* indicates significance at the 1% level
** indicates significance at the 5% level
*** indicates significance at the 10% level

Notes: The estimated equation is Equation (3). The variables are defined as follows: $\Delta\tau^{CA}$ is the change in Canadian tariff; $\Delta\tau^{US}$ is the change in U.S. tariff; *productivity* is log (labour productivity in initial year); size is log (size in initial year); *age* is log (plant age); *foreign control* is a dummy variable equal to 1 if plant is under foreign control, and to 0 otherwise; *year* is a dummy variable equal to 1 in 1988 to 1996; and $*DIV$ are interactions of changes in tariffs with share of a plant's Standard Industrial Classification (SIC) 4-digit industry in total output of a firm (equal to 1 if all plants of the firm produce in the same SIC 4-digit industry). The productivity quartiles are defined using the 1988 productivity distribution. All regressions control for industry fixed effects at SIC 4-digit level.
Source: Statistics Canada, Annual Survey of Manufactures.

Table A.5
Plant transitions and tariff cuts

Quartile	α^{CA}		α^{US}		R-squared	Number of observations
			All plants			
ENTER						
1st quartile	1.195 *	(0.524)	1.185	(1.107)	0.04	209
2nd quartile	0.572	(0.454)	0.946	(0.892)	0.01	208
3rd quartile	0.152	(0.380)	1.132	(0.814)	0.00	212
4th quartile	0.511	(0.343)	1.789 **	(0.727)	0.10	212
			Exporters			
ENTER						
1st quartile	0.136	(0.114)	0.076	(0.245)	0.00	209
2nd quartile	0.042	(0.111)	-0.118	(0.211)	-0.01	208
3rd quartile	0.156	(0.125)	0.162	(0.266)	0.00	212
4th quartile	0.173	(0.188)	0.870 **	(0.399)	0.07	212

** indicates significance at the 5% level

Notes: The estimating equation is Equation (4). Standard errors are in parentheses. The productivity percentiles are based on the 1988 productivity distribution; the 1st quartile is the lowest productivity quartile. Estimates on business cycle control are not presented. The export status for 1980 is based on the export status in 1979, and the export status for 1988 is defined based on the export status in 1984. α^{CA} is the coefficient for Canada, and α^{US} is the coefficient for the United States.

Source: Statistics Canada, Annual Survey of Manufactures.

Bibliography

Aw, Bee Yan, Sukkyun Chung and Mark J. Roberst. 2000. “Productivity and turnover in the export market: micro-level evidence from the republic of Korea and Taiwan (China).” *World Bank Economic Review*. 14, 1: 65–90.

Baggs, Jen. 2005. “Firm survival and exit in response to trade liberalization.” *Canadian Journal of Economics*. 38, 4: 1,364–1,383.

Baggs, Jen, Keith Head and John Ries. 2002. Free trade, firm heterogeneity, and Canadian productivity. Working paper. Saunder School of Business, University of British Columbia.

Baldwin, John R., and Wulong Gu. 2003a. *Plant Turnover and Productivity Growth in Canadian Manufacturing.* Analytical Studies Branch Research Paper Series. Catalogue no. 11F0019MIE2003193. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu. 2003b. “Export-market participation and productivity performance in Canadian manufacturing.” *Canadian Journal of Economics*. 36, 3: 634–657.

Baldwin John R., and Wulong Gu. 2004a. *Industrial Competition, Shifts in Market Share and Productivity Growth.* Economic Analysis (EA) Research Paper Series Catalogue no. 11F0027MIE2004021. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu. 2004b. “Trade liberalization: export-market participation, productivity growth, and innovation.” *Oxford Review of Economic Policy*. 20, 3: 372–392.

Baldwin, John R., and Wulong Gu. 2006a. *The Impact of Trade on Plant Scale, Production-Run Length and Diversification.* Economic Analysis (EA) Research Paper Series. Catalogue no. 11F0027MIE2006038. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu. 2006b. “Plant turnover and productivity growth in Canadian manufacturing.” *Industrial and Corporate Change.* 15, 3: 417–465.

Baldwin, John R., Desmond Beckstead and Richard Caves. 2001. *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 Caves and Wulong Gu. 2005. *Responses to Trade Liberalization: Changes in Product Diversification in Foreign- and Domestic-controlled Plants.* Economic Analysis (EA) Research Paper Series. Catalogue no. 11F0027MIE2005031. Ottawa: Statistics Canada.

Baldwin, Richard E. 2005. *Heterogeneous Firms and Trade: Testable and Untestable Properties of the Melitz Model.* NBER Working Paper Series. no. 11471. Cambridge, Mass.: National Bureau of Economic Research.

Beaulieu, Eugene. 2000. “The Canada–U.S. Free Trade Agreement and labour market adjustment in Canada.” *Canadian Journal of Economics*. 33, 2: 540–563.

Beaulieu, Eugene. 2001. “North American integration and plant closures in Ontario.” *Canadian Foreign Policy.* 8, 2: 23–39.

Bernard, Andrew B., and J. Bradford Jensen. 1999. “Exceptional exporter performance: Cause, effect, or both?” *Journal of International Economics*. 47, 1: 1–25.

Bernard, Andrew B., and J. Bradford Jensen. 2001. *Who Dies? International Trade, Market Structure, and Industrial Restructuring.* NBER Working Paper Series. no. 8327. Cambridge, Mass.: National Bureau of Economic Research.

Bernard, Andrew B., and J. Bradford Jensen. 2002. *The Deaths of Manufacturing Plants.* NBER Working Paper Series. no. 9026. Cambridge, Mass.: National Bureau of Economic Research.

Bernard, Andrew B., J. Bradford Jensen and Peter K. Schott. 2002. *Survival of the Best Fit: Competition from Low Wage Countries and the Uneven Growth of U.S. Manufacturing Plants.* NBER Working Paper Series. no. 9170. Cambridge, Mass.: National Bureau of Economic Research.

Bernard, Andrew B., Jonathan Eaton, J. Bradford Jensen and Samuel Kortum. 2003. “Plants and productivity in international trade.” *American Economic Review*. 93, 4: 1,268–1,290.

Bustos, Paula. 2005. *Rising Wage Inequality in the Argentinean Manufacturing Sector: The Impact of Trade and Foreign Investment on Technology and Skill Upgrading.* Mimeo. Barcelona: Centre de Recerca en Economia, Universitat Pompeu Fabra.
http://crei.cat/news/recpapers06/JMP_Paula_Bustos.pdf (accessed August 1, 2007.)

Clerides, Sofronis, Saul Lach and James Tybout. 1996. *Is Learning-by-exporting Important? Micro-dynamic Evidence from Columbia, Mexico and Morocco.* NBER Working Paper Series. no. 5715. Cambridge, Mass.: National Bureau of Economic Research.

Costantini, James, and Marc J. Melitz. 2007. “The dynamics of firm-level adjustment to trade liberalization.” Mimeo, CEPR.

Cox, David, and Richard Harris. 1985. “Trade liberalization and industrial organization: some estimates for Canada.” *Journal of Political Economy*. 93, 1: 115–145.

Ederington Josh, and Phillip McCalman. 2008. “Endogenous firm heterogeneity and the dynamics of trade liberalization.” *Journal of International Economics.* 74, 2: 422–440.

Ekholm, Karolina, and Karen Helene Midelfart. 2005. “Relative wages and trade-induced changes in technology.” *European Economic Review.* 49, 6: 1,637–1,663.

Gaston, Noel, and Daniel Trefler. 1997. “The labour market consequences of the Canada-U.S. Free Trade Agreement.” *Canadian Journal of Economics*. 30, 1: 18–41.

Griliches, Zvi, and Haim Regev. 1995. “Firm productivity in Israeli industry 1979–1988.” *Journal of Econometrics.* 65, 1: 175–203.

Gu, Wulong, Gary Sawchuk and Lori Whewell Rennison. 2003. “The effect of tariff reductions on firm size and firm turnover in Canadian manufacturing.” Review *of World Economics/Weltwirtschaftliches Archiv*. 139, 3: 440–459.

Harrison, Ann E. 1994. “Productivity, imperfect competition and trade reform: theory and evidence.” *Journal of International Economics*. 36, 1–2: 53–73.

Harrison, Ann E., and Gordon Hanson. 1999. “Who gains from trade reform? Some remaining puzzles.” *Journal of Development Economics.* 59, 1: 125–154.

Head, Keith, and John Ries. 1999. “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 of the pattern of U.S.–Canada trade.” *American Economic Review.* 91, 4: 858–876.

Levinsohn, James. 1993. “Testing the imports-as-market-discipline hypothesis.” *Journal of International Economics*. 35, 1–2: 1–22.

Levinsohn, James, and Wendy Petropoulos. 2001. *Creative Destruction or Just Plain Destruction? The U.S. Textile and Apparel Industries Since 1972.* NBER Working Paper Series. no. 8348. Cambridge, Mass.: National Bureau of Economic Research.

MacDonald, James M. 1994. “Does import competition force efficient production?” *The Review of Economics and Statistics*. 76,4: 721–727.

Melitz, Marc J. 2003. “The impact of trade on intra-industry reallocations and aggregate industry productivity”*, Econometrica*. 71, 6: 1,695–1,725.

Melitz, Mark J., and Gianmarco I.P. Ottaviano. 2005. *Market Size, Trade and Productivity*. NBER Working Paper Series. no. 11393. Cambridge, Mass.: National Bureau of Economic Research.

Muendler, Marc-Andreas. 2002. *Trade, Technology, and Productivity: A Study of Brazilian Manufacturers, 1986–1998.* Working paper. Available at http://econ.ucsd.edu/seminars/seven_ssrc/muendler_brazprod.pdf (accessed August 1, 2007.)

Pavcnik, Nina. 2000. *Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants.* NBER Working Paper Series. no. 7852. Cambridge, Mass.: National Bureau of Economic Research.

Trefler. 2001. "The long and short of the Canada-U.S. Free Trade Agreement." NBER Working Paper Series. no. 8293. Cambridge, Mass.: National Bureau of Economic Research.

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

Tybout, James R. 2001. *Plant- and Firm-level Evidence on 'New' Trade Theories.* NBER Working Paper Series. no. 8418. Cambridge, Mass.: National Bureau of Economic Research.

Tybout, James R., and M. Daniel Westbrook. 1995. "Trade liberalization and the dimensions of efficiency change in Mexican manufacturing industries." *Journal of International Economics*. 39, 1–2: 53–78.

Tybout, James R., Jamie de Melo and Vittorio Corbo. 1991. "The effects of trade reforms on scale and technical efficiency." *Journal of International Economics*. 31, 3–4: 231–250.

Van Biesebroeck, Johannes. 2005. "Exporting raises productivity in sub-Saharan African manufacturing firms." *Journal of International Economics*. 67, 2: 373–391.

Yeaple, Stephen Ross. 2005. "A simple model of firm heterogeneity, international trade, and wages." *Journal of International Economics*. 65, 1: 1–20.