

Plant Scale and Exchange-Rate-Induced Productivity Growth

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Abstract

In the last two decades, the Canadian economy has experienced large exchange rate swings. This paper examines the exchange rate effects on plant production decisions and productivity growth. Using Canadian plant-level data from 1987 to 1996, we find that a real appreciation of the Canadian dollar reduces plant shipments (i.e., scale of production) and that the negative effect of appreciation is more pronounced for exporters. Moreover, our results show that the exchange rate-induced reductions of plant scale of production negatively affect productivity growth at the plant level.

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1 Introduction

Between 1987 and 1997 the Canadian exchange rate vis-à-vis the US dollar went through a cycle of a 30 percent appreciation between 1987 and 1991 followed by a 30 percent depreciation between 1992 and 1997. Given the importance of international trade in the Canadian economy and the magnitude of the changes, these exchange rate swings are likely to affect firm survival, production decisions and productivity. Harris (2001) argues that the large depreciation of the Canadian dollar in the 1990s may have contributed to the widening productivity gap between Canada and the US by raising the price of investment goods, widening the innovation gap, and slowing down creative destruction. Yan (2002) finds that real exchange rate movements precede movements in the US-Canada productivity differential by one to two years, indicating the possibility that exchange rate movements may affect relative productivity growth. These studies point out the possibility that exchange rate movements may affect productivity, yet the mechanism is not well understood. In this paper, we investigate the connection between firm level productivity growth and the exchange rate.

There are a number of possible channels through which the exchange rate might influence the productivity of firms. For example, depreciations of the home currency might increase firm sales (increasing scale) through higher exports, allowing firms to move down their average cost curves raising productivity. This sales induced productivity effect is known as the scale effect and has often been discussed in the context of tariff reductions. Prior to the implementation of the Canada US Free Trade Agreement (CUSTA), Cox and Harris (1985) suggested that one of the benefits of free trade would be just such productivity increase as Canadian firms expanded into the much larger US market. However, both Head and Ries (1999) and Trefler (2004) find an insignificant effect of the FTA tariff concessions on the scale of production (measured by output per plant). Using micro-level data, Baldwin and Gu (2006) found that Canadian tariff reductions lead to a reduction of plant size for non-exporters while having an insignificant effect for exporters, highlighting the difference in heterogeneous plants' response to tariff changes. This paper contributes to the literature by conducting a micro-level analysis of the heterogeneous nature of firm responses to exchange rate fluctuations and assessing the scale effect of

exchange rate on plant productivity. We empirically examine the possibility that exchange rate does indeed affect plant level productivity, in this case by influencing firm scale.

This paper builds on work in Baggs et al (2007), where we examine the affect of the exchange rate on firm survival, entry rates and total sales and find that real appreciations of the Canadian dollar not only reduce firms' probability of survival and total sales but also discourage firm entry. Comparing the consequences of exchange rate movements to those of tariff reductions, the paper finds that the exchange rate effects on firm survival, entry rate and total sales are *larger* than those of the Canada-US Free Trade Agreement mandated tariff changes. The empirical results also show that the negative effect of appreciation on firm survival is less pronounced for more productive firms, implying that exchange rate movements may affect *industry*-level productivity by driving less productive firms out of business. Due to data limitations, Baggs et al (2007) were unable to examine the effect of the exchange rate on *firm*-level productivity.¹ However, the finding of a significant exchange rate effect on total sales (an effect larger than that observed for tariff reductions), suggests the possibility of a scale effect contributing to firm level productivity. Here we explore this possibility more closely.

In this paper we use Statistics Canada's Annual Survey of Manufacturers (ASM) to investigate the impact of large real exchange rate movements on plant shipments and productivity growth from 1987 to 1996. The ASM is Canadian plant-level data that includes measures of industry affiliation, location, shipments, value-added, payroll information, ownership (foreign or domestic) and exports. This provides us with an excellent opportunity to measure both plant scale and productivity. Matching this plant level data to an industry level trade weighted real exchange rate allows us to look in detail at the link between the exchange rate and plant level productivity. We are also fortunate to have access to data during a time period in which the Canadian economy faced both the tariff concessions mandated by the FTA and a large currency appreciation in the first five years (1987-91) followed by a large depreciation in the later half of this period (1992-96). Our results indicate that there is a negative average effect of real appreciation on plant shipments and that the negative effect is particularly strong for exporters. Further, we find that the

¹ While the T2LEAP data used in this paper consists of the universe of incorporated firms in Canada, it lacks detailed information on firm production, ownership and export market participation.

appreciation-induced reduction of shipments may have an adverse effect on productivity growth.

This work is closely tied to the trade liberalization literature, most of which includes the exchange rate as a control variable. In the industry-level research on the effects of the FTA, Gaston and Trefler (1997) and Beaulieu (2000) find an exchange effect in the labour market, while Head and Ries (1999) found a significant exchange rate effect on the number of plants though the effect on output per plant was insignificant. Although these industry-level studies provide some important insights, they are not able to capture the heterogeneous nature of firms. The different response of heterogeneous firms to exchange rate movements is important because firm behaviour and market share reallocation among firms may lead to productivity growth at the industry level.² At the micro level, studies, such as Baldwin and Gu (2003, 2004), Trefler (2004), Baggs (2005), Baggs and Brander (2006) and Lileeva (2006), have examined the consequences of trade policy for firm (plant) productivity, survival and growth. These studies highlight the heterogeneous nature of firms (plants) and the importance of identifying their differing response to trade policy.

The paper is organized as follows. Section 2 summarizes the theoretical motivation for this study. Section 3 describes the data employed and section 4 presents the empirical findings. Section 5 discusses the economic magnitude of the exchange rate induced productivity changes and the final section offers concluding remarks.

2 Theoretical Motivation

Our theoretical motivation is based on Fung (2007). Fung's (2007) model builds on the Krugman (1979) monopolistic competition model by including an exchange rate variable. In this model, labour is assumed to be the only factor of production, and as a result, an appreciation of the domestic currency gives foreign firms a cost advantage in terms of domestic currency units. This intensifies the competition faced by domestic firms in both domestic and export markets, reducing the price they can charge.³

² Several studies of trade liberalization, such as Pavcnik (2002) and Trefler (2004), discuss the effects that trade liberalization may have on industry-level productivity growth by affecting the entry, exit, production, and market share reallocation among firms that are heterogeneous in productivity.

³ In Fung's (2006) model, the demand function is derived from a symmetric translog expenditure function used by

In Fung (2007), an appreciation of the domestic currency gives foreign firms a cost advantage in both domestic and foreign markets and this drives some domestic firms out of business. For the sales of a surviving firm (to both domestic and foreign markets), the model shows two opposing effects of an exchange rate appreciation. The total sales of incumbent firms has become known as the intensive margin. While the cost disadvantage faced by domestic firms causes each of them to sell less, the exit of some firms leaves surviving firms with a larger market share. Consequently, from a theoretical perspective, the net effect of a currency appreciation on a surviving firm's total sales depends on the direction and relative magnitude of the changes in exports and domestic sales.⁴ If the exit rate is low or the exiting firms are substantially smaller than the incumbent firms, the total shipments of incumbent firms would be expected to decrease when the domestic currency appreciates. Under these conditions, a currency appreciation causes both the exports and domestic sales of a surviving firm to decrease and leads to a reduction in the firm's total sales.⁵ Note that we expect analogous though opposite effects when the domestic currency depreciates. In this case, the cost *advantage* faced by domestic firms encourages each of them to sell more but the entry of new firms may reduce incumbent firms' market shares, lowering the quantity of sales. Theoretically, the implication of currency movements for domestic sales (and total sales) is ambiguous, depending on the intensity of the two effects described above, and becomes an open empirical question.

Extending from scale to productivity, we note that should production technology be characterized by increasing returns to scale, then labour productivity should move in the same direction as the total shipments. Accordingly, if domestic currency depreciations lead to increased shipments, we expect domestic plant productivity to rise as well. This is analogous to the affect predicted by Cox and Harris

Bergin and Feenstra (2000, 2001) and Feenstra (2003). In this model, the (positive) price elasticity of demand is positively related to the relative price of the good to its competing goods. Compared to the profit-maximizing conditions derived from CES utility function, the advantage of using this demand function is that it shows a pro-competitive reduction of mark-ups when facing a reduction in the price of competing goods.

⁴ In the export market, it is more likely that the effects of the cost disadvantage for surviving firms may outweigh the effect of increased market shares, thus exports decrease. However, the effect on domestic sales may be ambiguous, depending on the relative magnitude of the cost disadvantage and market share effects.

⁵ Conversely, a domestic currency appreciation may cause an increase in the domestic sales of continuing firms when the increased market share effect outweighs the cost disadvantage effect. This would occur if the exit rate is high.

(1985) in advance of the FTA. They suggested that the cost advantage Canadian firms would incur as a result of falling US tariffs would allow those firms to expand into the larger US market – increasing their scale and hence improving labour productivity (moving down their average cost curve). We can think of declining foreign tariffs and a depreciating domestic currency as to some degree analogous – both offer domestic firms an improved competitive position. Note, however, that a depreciating domestic currency offers the domestic firm an improved competitive position *both* in their domestic market (competing imports are relatively more expensive) *and* in the foreign market (their exports relatively cheaper) while episodes of trade liberalization, because they tend to reduce both foreign and domestic tariffs simultaneously, work in opposite directions.⁶ Hence, we might expect a larger net effect of exchange rate fluctuations on both sales and productivity when compared with the effect of tariffs.

3 Data

3.1 Exchange Rate Measure and Other Industry Level Data

Since exchange rate changes may affect industries to differing degrees owing to differences in the composition of trade partners, we construct an industry-specific trade-weighted real exchange rate (TWRER) as a measure of exchange rate movements. The formula is similar to Head and Ries (1999) and Bernard and Jensen (2004). Specifically, TWRER is constructed as a weighted average of normalized real exchange rates weighted by the industries trade shares with Canada's top ten trade partners at the 4-digit SIC level. A more detailed description is presented in the appendix.

⁶ Falling foreign tariffs offer firms an improved competitive position in the foreign market, much as a depreciating domestic currency would, but falling domestic tariffs *increase* competition in the domestic market (imports are relatively *cheaper*).

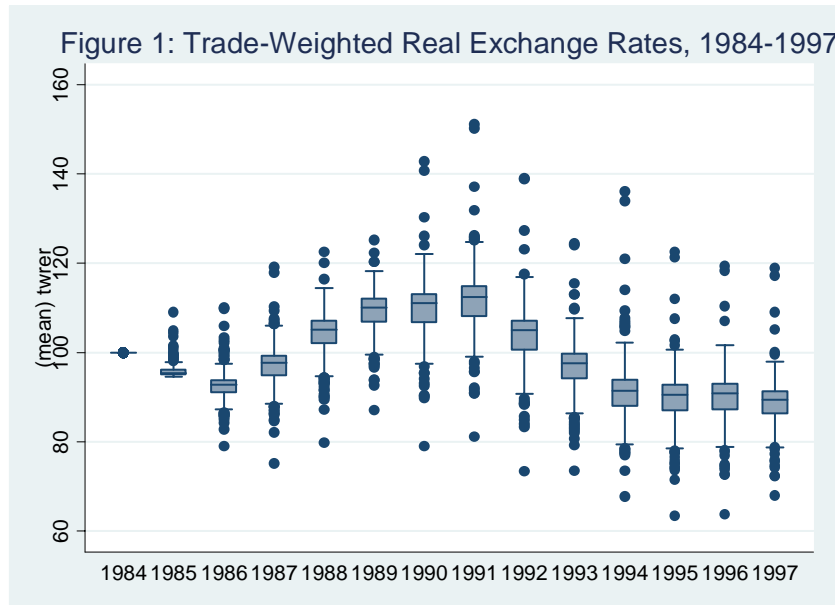


Figure 1 shows the trade weighted exchange rates from 1984 to 1997. Note that the real exchange rates were normalized with 1984 as the based year before the weighted average was constructed. As a result, the 1984 exchange rate was normalized to 100 for all industries. The center line of the box shows the median trade-weighted real exchange rate across industries. From this figure, we can observe that the Canadian dollar experienced a real appreciation from 1986 to 1991 then a real depreciation from 1992 to 1997. Since the US is the most important trade partner for Canada, it is not surprising that the pattern of the movements of TWRRER is in line with Canada/US exchange rate movements.

Data on Canadian tariffs against the US and US tariffs against Canada at the 4-digit SIC level are available from 1987 to 1996 as used in Trefler (2004) and Lileeva (2006).⁷ Both tariffs and trade-weighted real exchange rates are constructed using publicly available data. Out of 236 4-digit SIC industries in the plant-level database (described below), 16 of them have missing data on tariffs or trade-weighted exchange rates and another 16 needed additional concordance. The deflators for output and value-added were provided by the Micro Economic Analysis Division (the base year is 1992).

3.2 Micro Data

We have the good fortune of having access to the Annual Survey of Manufacturers (ASM)

⁷ Special thanks are extended to Dan Trefler and Alla Lileeva for providing us with the tariff data.

database⁸ – a detailed plant level database constructed by Statistics Canada for plants in operation in Canada. We use data for the period of 1987 to 1997. This data set includes annual data on industry affiliation (at 4-digit SIC level), plant location (at province level), age of plant,⁹ plant affiliation to multi-plant firms, shipments and value-added of manufacturing and total activities, materials, number of production and non-production workers and total payments to them, hours paid and hours worked for production workers, and ownership (foreign or domestic). From this, we measure productivity as (the logarithm of) real manufacturing value-added per production worker.¹⁰ Export data are available in 1990, 1993, 1996, and 1997 for plants that filled out the long form (which are usually larger plants). Since a plant's export market participation cannot be observed annually, we define plants that have exported at least once in 1990, 1993, 1996 or 1997 as "exporters". However, we are unable to identify a plant's export status if it did not fill out a long form in those years. For this reason, we exclude plants that did not fill out long form in at least one of the years when exports data are available.

Table 1 presents descriptive statistics for plants in our sample. Column 1 reports the descriptive statistics for all plants in the sample. Columns 2 and 3 report the statistics for exporters and non-exporters separately.¹¹ Column 4 indicates whether the mean value of the variable of interest is significantly different for the population of exporters as compared to non-exporters, at the 5% level. From Table 1, we can see that on average the exporters are older, larger, more productive, more likely to be foreign-owned, and more likely to be affiliated with multi-plant firms. In addition, they tend to be affiliated with industries that are more concentrated, subject to lower trade weighted values of the Canadian dollar, higher industry growth rates, and smaller Canadian and US tariff reductions. Note that the smaller US tariff reduction faced by exporters is a surprising result.

⁸ A debt of gratitude is extended to the Micro Economic Analysis Division at Statistics Canada, especially John Baldwin, for access to the data and for providing us with the output and value-added deflators.

⁹ The first possible year for measuring the age of a plant is 1961.

¹⁰ Although total factor productivity is a better measure of productivity than labour productivity, the lack of capital measures in the ASM data set makes impossible the construction of TFP.

¹¹ Here, exporters are the plants that have exported in 1990, 93, 96 or 97 and non-exporters are defined as plants with zero or missing value in exports in all the years when exports data are available (with at least one zero exports).

Table 1 – Descriptive Statistics

| | All Plants | Exporter | Non-exporter | Exporters and Non-exporters significantly different at the 5% level? |
|--|------------|----------|--------------|--|
| Number of Observations | 225,118 | 129,663 | 95,455 | |
| Mean No of Plants | 20,533 | 11,811 | 8,727 | |
| Mean TWR exchange rate | 99.59 | 99.09 | 100.29 | YES |
| Mean Plant Age | 20.48 | 21.90 | 18.55 | YES |
| Mean Number of Employees | 73.71 | 105.97 | 29.90 | YES |
| Mean Skill Intensity | 10.13 | 16.95 | 0.69 | NO |
| Mean Labour Productivity | 92,808 | 103,093 | 78,469 | YES |
| Mean Canadian Tariff Reduction (in year <i>t</i>) | 0.63% | 0.61% | 0.67% | YES |
| Mean US Tariff Reduction (in year <i>t</i>) | 0.29% | 0.29% | 0.30% | YES |
| Mean Foreign Ownership Dummy | 0.16 | 0.21 | 0.09 | YES |
| Mean Multi-Plant Dummy | 0.29 | 0.36 | 0.20 | YES |
| Mean Annual Industry Shipments Growth | 1.68% | 2.01% | 1.21% | YES |
| Mean Four Firm Concentration Ratio | 0.25 | 0.27 | 0.22 | YES |

Notes: 1. Plant age is measured in the last year when the plant is in the sample.

2. Labour productivity is measured by real manufacturing value-added per production worker.

3. Skill intensity is measured by the payments to non-production workers relative to the payments to production workers.

Further, we divide the plants in our sample into plants that exist throughout the sample period (continuing), plants that exited any time up to 1993 (exiting plants) and plants that entered after 1993 (entering plants). The continuing plants were then subdivided into those that record no exports in our sample, those that record exports in every year exports were surveyed, and those that record exports only in the 1990/93 period or only in the 1996/97 period. Exiting plants are classified as either exporting or non-exporting, as are entering plants. As the fourth row indicates, we have data for 5,837 continuing plants in that were exporters in all years and 7,618 continuing plant that did not record exports in any year. As a share of all continuing and exiting plants, 29 percent of the observations are continuing-exporters and 38 percent are continuing-non-exporters. Slightly more than half (1,603) of exiting plant exported in

the early period and slightly fewer (1,538) recorded no exports. Similarly, about half of the entering plants are exporters (916) and half are non-exporters.

Table 2: Summary Statistics for Continuing, exiting and entering plants

| | | Continuing plants | | | | Exiting plants | | Entering plants | |
|--|------|----------------------|----------------------|---------------|--------------|----------------------|--------------|----------------------|--------------|
| | | Export only in 90/93 | Export only in 96/97 | Always export | Never export | Export only in 90/93 | Never export | Export only in 96/97 | Never export |
| Share of Plants that Existed Prior to 1994 | | 0.16 | 0.08 | 0.29 | 0.38 | 0.04 | 0.04 | | |
| Share of Plants that Entered after 1993 | | | | | | | | 0.50 | 0.50 |
| No. of Observations | | 31,356 | 16,027 | 56,812 | 70,201 | 9,569 | 9,201 | 1,724 | 1,603 |
| Mean No. of Plants | | 3,174 | 1,699 | 5,837 | 7,618 | 1,603 | 1,538 | 916 | 954 |
| Labour Productivity | Mean | 87,960.0 | 93,809.4 | 11,6385.1 | 7,8421.4 | 8,1120.7 | 7,5028.3 | 11,3472.7 | 9,1505.0 |
| | SD | 186299.6 | 148342.0 | 196245.6 | 115109.7 | 104943.1 | 91233.7 | 187829.2 | 153188.5 |
| Total No of Employees | Mean | 55.3 | 56.6 | 155.6 | 29.4 | 67.3 | 36.2 | 59.6 | 22.7 |
| | SD | 131.2 | 90.3 | 395.4 | 85.7 | 120.3 | 64.6 | 104.4 | 41.1 |
| Skill Intensity | Mean | 3.5 | 0.7 | 31.8 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 |
| | SD | 500.6 | 1.0 | 7835.2 | 3.4 | 2.9 | 1.2 | 1.0 | 0.9 |
| Age of the Plant | Mean | 21.3 | 20.1 | 24.4 | 19.5 | 16.6 | 15.3 | 2.8 | 2.7 |
| | SD | 10.2 | 10.6 | 10.4 | 10.2 | 10.2 | 10.2 | 0.9 | 0.9 |
| Exports-Sales Ratio | Mean | 0.22 | 0.20 | 0.35 | -- | 0.23 | -- | 0.38 | -- |
| | SD | 0.27 | 1.05 | 0.33 | -- | 0.27 | -- | 0.54 | -- |
| Foreign Dummy | Mean | 0.15 | 0.12 | 0.27 | 0.08 | 0.22 | 0.14 | 0.14 | 0.11 |
| | SD | 0.36 | 0.32 | 0.44 | 0.28 | 0.41 | 0.34 | 0.35 | 0.31 |
| Multi-Plant Firm Dummy | Mean | 0.22 | 0.25 | 0.47 | 0.20 | 0.29 | 0.24 | 0.36 | 0.30 |
| | SD | 0.41 | 0.43 | 0.50 | 0.40 | 0.46 | 0.43 | 0.48 | 0.46 |
| TWRER | Mean | 99.2 | 99.3 | 98.4 | 99.9 | 105.6 | 106.5 | 89.0 | 90.3 |
| | SD | 9.9 | 9.8 | 9.9 | 9.6 | 7.6 | 7.8 | 4.5 | 4.1 |
| Reduction in Canadian Tariff (in decimal points) | Mean | 0.006 | 0.007 | 0.006 | 0.007 | 0.007 | 0.007 | 0.004 | 0.005 |
| | SD | 0.012 | 0.015 | 0.011 | 0.016 | 0.016 | 0.022 | 0.007 | 0.006 |
| Reduction in US Tariff (in decimal points) | Mean | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.004 | 0.002 | 0.002 |
| | SD | 0.006 | 0.006 | 0.006 | 0.006 | 0.008 | 0.009 | 0.003 | 0.003 |

Table 2 also presents some interesting characteristics of continuing and exporting plants versus others. Based on total employment, continuing-exporters are substantially larger (155 employees) than continuing-non-exporters (29 employees) and continuing plants that exported only in one of the periods. Exporters are larger than non-exporters in all categories of plants (continuing, exiting and entering). Exporting plants are also more skill intensive, older, more likely to be foreign-owned and more likely to

be affiliated with multi-plant firms. In particular, continuing exporters have the highest percentage of foreign ownership (27%) and are more commonly affiliated with multi-plant firms. When comparing the exports-sales ratio among exporters, it is not surprising that continuing exporters have higher exports-sales ratio as compared to continuing plants that exported only in 1990/93 or 1996/97. Entrant exporters also have high exports-sales ratios.¹² We also find that exiting plants faced a higher trade-weighted real exchange rate than both continuing and entering plants.

4 Empirical Analysis

The theoretical model by Fung (2007) yields two empirically testable hypotheses for surviving firms (plants). First, appreciations reduce exports while having an ambiguous effect on domestic sales, depending on the importance of firm exit. The resulting changes in total shipments depend on the direction and magnitude of exports and domestic sales. Second, if the production technology is subject to increasing returns to scale, labour productivity should move in the same direction as shipments.

4.1 Exports

To test our first hypothesis, we begin by confirming that higher values of the Canadian dollar are associated with declining exports. This is both an intuitive and well documented association which we are interested primarily in corroborating for our data. In Table 1, we saw that exporters tend to be in industries that are subject to lower trade-weighted values of the Canadian dollar. In a regression format, since we have export data only for selected years (1990, 1993 and 1996), we are limited to comparing the level of exports in each of those years with the level of the exchange rate. In addition, since the exports data (including zeros) in those years are only available for the plants that filled out the “long form”, we further restrict the sample to all the plants that have data on exports in all three years. Our estimating equation becomes:

$$\ln exports_{jt} = \beta \ln ER_{it} + \lambda_1 \Delta tariff_{it}^{CAN} + \lambda_2 \Delta tariff_{it}^{US} + \gamma x_{jt-3} + \delta y_{it-3} + \varepsilon_{jt}, \quad (1)$$

¹² The exports-sales ratio reported is calculated without zeros and missing values in exports. Therefore, the statistics indicate that the plants that exported in only one period export a smaller share of their output as compared to continuing exporters given that exports are positive.

where f indexes plants, i industries and t indexes year (either 1990, 1993 or 1996). $\ln exports_{ft}$ is the log of real exports, $\ln ER_{it}$ is the log of industry-specific trade-weighted real exchange rate, $\Delta tariff_{it}^{CAN}$ and $\Delta tariff_{it}^{US}$ are changes in the Canadian and U.S. tariff rates at the industry level.¹³ x_{ft-3} is a vector of plant characteristics that includes age, ownership, multi-plant firm indicator, and productivity, and y_{it-3} is a vector of industry or more aggregate level controls such as the growth of industrial shipments,¹⁴ US shipments, and industry concentration (measured by CR4).

The results are reported in Table 3. The first column reports the results of estimating equation (1) using the data for continuing exporters only (those that export in all three years for which we have data). The second column expands our sample to all plants that record export data (even if it is reported as being “zero”) for the three years and have a positive value for exports at least once.¹⁵ The third column expands the sample further to include all the plants that record export data in all three years (including non-exporters with all “zeros”). As expected, in all three specifications, exports are significantly and negatively associated by higher levels of the Canadian dollar. In the first and third columns, reductions in US tariffs have the expected strong positive effect on exports, though this effect is insignificant in the second column. Surprisingly, the effects of Canadian tariff reductions are positive and significant in all three specifications, though this is possibly derived from the reciprocal nature of the tariff reductions. Our other control variables behave as expected with exports positively associated with labour productivity, foreign ownership, age, industry growth, industries with a higher CR4 and plants that are part of a larger, multi-plant firm.

¹³ The exports are deflated using output deflator. All the changes are expressed as average over year $t-3$ and t . Similar to Baggs (2005) and Baggs et al (2007), the difference in tariffs are expressed as the previous tariff minus the current tariff. Therefore, a positive change means a tariff reduction.

¹⁴ To prevent an endogeneity problem, we define industrial shipments as the sum of plant real shipments at the 4-digit SIC level excluding plant f itself.

¹⁵ When the value of exports is 0, it is replaced with 1 before taking logarithm.

Table 3
Dependent Variable: $\ln(\text{Real Exports})_{it}$

| | (1) | (2) | (3) |
|--|-------------------------|-----------|------------|
| Age | 0.021** | 0.038** | 0.054** |
| Years in the sample | (0.003) | (0.006) | (0.007) |
| Exchange Rate | -5.677** | -8.901** | -14.266** |
| = $\ln(\text{twrer})$ | (0.667) | (1.258) | (1.478) |
| Reduction in Canadian Tariffs | 36.520** | 102.054** | 113.726** |
| = $(\text{ctar}_{t-3} - \text{ctar}_t)/3$ | (5.586) | (11.488) | (10.906) |
| Reduction in US Tariffs | 28.837** | 31.527 | 59.746* |
| = $(\text{utar}_{t-3} - \text{utar}_t)/3$ | (11.007) | (23.953) | (25.208) |
| US shipments | 0.210 | -0.291 | 0.828* |
| = $\ln(\text{US shipments by 3-digit industry})$ | (0.182) | (0.334) | (0.331) |
| Labour Productivity | 0.403** | 0.391** | 0.445** |
| = $\ln(\text{vam}/\text{pdworker})_{t-3}$ | (0.045) | (0.097) | (0.099) |
| Foreign Dummy | 0.532** | 0.708** | 1.200** |
| = 1 if Foreign Owned in year t-3 | (0.071) | (0.146) | (0.173) |
| Multi-Plant Firm Dummy | 0.347** | 0.608** | 0.869** |
| = 1 if multi-plant firm in year t-3 | (0.065) | (0.130) | (0.149) |
| Industry Growth | 0.353 | 2.274** | 2.740** |
| = $\Delta \ln(\text{shipments by 4-digit SIC})$ | (0.255) | (0.639) | (0.675) |
| Industrial Concentration | 0.738** | 1.426** | 2.699** |
| 4-digit CR4 (year t-3) | (0.198) | (0.394) | (0.469) |
| Trend | Yes | Yes | Yes |
| = 1 if year = 90 and = 3 if year = 96 | | | |
| Industry Fixed Effects | Yes | Yes | Yes |
| Industry Dummies at 2-digit SIC | | | |
| Estimation Method | OLS | OLS | OLS |
| Observations | 6620 | 11785 | 15240 |
| R-squared | 0.253 | 0.114 | 0.163 |
| Sample | Continuing Exporters | Exporters | All Plants |

Robust standard errors (corrected for clustering at the plant level) are in parentheses

+ significant at 10%; * significant at 5%; ** significant at 1%

Δ denotes changes from year t-1 to t

“Exporters” refer to the plants that have exported at least once in the three years when data on exports are available.

“All Plants” refer to the plants that have export record (including non-exporters) in all three years when export data are available.

4.2 Shipments

Having confirmed that higher values of the Canadian dollar result in lower exports, we now turn to the second component of our first hypothesis and investigate the effect of the exchange rate on total shipments. Our estimating equation becomes:

$$\Delta \ln shipments_{ft} = (\beta_1 + \beta_k interactions_{ft}) \Delta \ln ER_{it} + \lambda_1 \Delta tariff_{it}^{CAN} + \lambda_2 \Delta tariff_{it}^{US} + \gamma x_{ft-1} + \delta y_{it-1} + \varepsilon_{ft}. \quad (2)$$

This specification is similar to the one used in Head and Ries (1999). Since the tariff data is available only until 1996 and lagged values are used for some variables, the regressions are run using each year from 1988 to 1996.¹⁶ Our sample in a given year includes all surviving plants in that year.¹⁷ $Shipments_{ft}$ is real manufacturing shipments, $\Delta \ln ER_{it}$ is the change in industry-specific trade-weighted real exchange rate, $\Delta tariff_{it}^{CAN}$ and $\Delta tariff_{it}^{US}$ are changes in the Canadian and U.S. tariff rates at the industry level.¹⁸ $Interaction_{ft}$ is a vector of variables that will be interacted with the exchange rate and includes ownership (domestic or foreign)¹⁹ and an export dummy.²⁰ x_{ft-1} is a vector of plant characteristics and y_{it-1} is a vector of industry or more aggregate level controls as described in the previous section.²¹

We estimate equation (2) both in logarithms and in changes in logarithms, with the results reported in Tables 4 and 5 respectively.²² Column 1 of Table 4 reports the results without interaction terms and shows that, on average, an increase in the value of the Canadian dollar reduces plant shipments. In addition, a Canadian tariff reduction reduces plant shipments while a reduction in US tariffs increases plant shipments. These results are consistent with the findings of Baggs et al (2007) using the T2LEAP data for firm sales. In addition, higher shipments are associated with plants that are older, more productive, foreign-owned, affiliated with a multi-plant firm and engaged in exporting.

¹⁶ We are not limited here by the availability of export data (which is included as a dummy control variable only) and are able to use annual data for all years 1988 to 1996.

¹⁷ Alternatively, we have estimated equation (2) using only continuing firms and introduce either industry fixed-effects or firm fixed-effects; the results are qualitatively similar to those reported here.

¹⁸ Since the shipments data are available every year, ΔX_t is redefined as $X_t - X_{t-1}$ for most variables except tariffs. For tariffs, $\Delta tariff_t = tariff_{t-1} - tariff_t$.

¹⁹ Around 16% of the plants are foreign owned. Switches in ownership occurred for some plants during this period.

²⁰ In this data set, around 60% of the plants have exported.

²¹ The detail of the data and construction of variables such as labour productivity and industry growth are presented in the appendix.

²² Note that the logarithms and changes are different models so that the coefficient estimates are not expected to be the same.

To explore the role of ownership and export market participation in plants' response to exchange rate movements, we interact the exchange rate with a foreign ownership dummy and with an export dummy. Columns 2 and 3 report the results with these interaction terms included separately and column 4 reports the results with both interactions. We will focus the remainder of our analysis on the column 4. In this specification, the coefficient of the exchange rate term (β_1) can be interpreted as the effect of the exchange rate on domestically owned plants that are non-exporters. This coefficient, while negative, is insignificant suggesting that the shipments of domestically owned non-exporters are not significantly affected by exchange rate fluctuations. While the exchange rate-foreign ownership interaction was negative and significant when incorporated without the exporter interaction (column 2), it too is insignificant in the last specification. Accordingly, the significant negative effect of the exchange rate on plant shipments seen in the first and second specifications appears to be driven by exporters. Our results suggest that the shipments of exporting plants are negatively affected by higher values of the Canadian dollar, while the shipments of non-exporters appear unaffected.

Turning our attentions to the change in shipments result in Table 5, results in column 1 show that larger real appreciation of the Canadian dollar reduce the growth in shipments and that reductions in both Canadian and US tariffs lower the growth of total shipments, possibly due to the reciprocal nature of the tariff concessions. At the same time, we find that younger and exporting plants have higher shipment growth and plants that have higher productivity growth will also have higher shipment growth. Similar to Table 4, in later specifications we add exchange rate change-foreign ownership dummy and exchange rate change-export dummy interaction terms. In column 2 the exchange rate-foreign ownership dummy is negative and significant, indicating that the negative exchange rate effect is more pronounced for foreign-owned plants. However, one of the possible causes of this negative effect is that foreign-owned plants may be more likely to be exporters. In column 3 we see that including an export-exchange rate interaction highlights the importance of exports in driving the negative effect of the exchange rate on shipment growth, by reducing the significance of the direct exchange rate effect (and changing its sign). To identify the combined effect, we include both interaction terms in column 4. In this specification, the

Table 4: Shipments
Dependent Variable: ln(real shipments)

| | (1) | (2) | (3) | (4) |
|---|----------|----------|----------|----------|
| Age | 0.034** | 0.034** | 0.034** | 0.034** |
| Years in the sample | (0.001) | (0.001) | (0.001) | (0.001) |
| Exchange Rate | -0.602** | -0.567** | -0.195 | -0.189 |
| = ln(twrer) | (0.110) | (0.112) | (0.124) | (0.124) |
| Exchange Rate*Foreign Dummy | | -0.270* | | -0.113 |
| | | (0.126) | | (0.128) |
| Exchange Rate*Export Dummy | | | -0.681** | -0.666** |
| | | | (0.098) | (0.100) |
| Reduction in Canadian Tariffs | -0.609** | -0.608** | -0.633** | -0.633** |
| = $ctar_{t-1} - ctar_t$ | (0.152) | (0.152) | (0.152) | (0.152) |
| Reduction in US Tariffs | 1.173* | 1.215* | 1.292* | 1.307* |
| = $utar_{t-1} - utar_t$ | (0.569) | (0.569) | (0.569) | (0.569) |
| Real Interest Rate | -0.014** | -0.014** | -0.014** | -0.014** |
| | (0.003) | (0.003) | (0.003) | (0.003) |
| US shipments | 0.362** | 0.354** | 0.322** | 0.319** |
| = ln(US shipments by 3-digit industry) | (0.063) | (0.063) | (0.063) | (0.063) |
| Labour Productivity | 0.559** | 0.558** | 0.557** | 0.557** |
| = $\ln(vam/pdworker)_{t-1}$ | (0.010) | (0.010) | (0.010) | (0.010) |
| Foreign Dummy | 0.551** | 1.795** | 0.551** | 1.070+ |
| = 1 if foreign owned in year t-1 | (0.025) | (0.580) | (0.025) | (0.590) |
| Multi-Plant Firm Dummy | 0.781** | 0.781** | 0.780** | 0.780** |
| = 1 if multi-plant firm in year t-1 | (0.020) | (0.020) | (0.020) | (0.020) |
| Industry Growth | 0.053** | 0.053** | 0.052** | 0.052** |
| = $\Delta \ln(\text{shipments by 4-digit SIC})$ | (0.015) | (0.015) | (0.015) | (0.015) |
| Industrial Concentration | 0.360** | 0.361** | 0.361** | 0.361** |
| 4-digit CR4 (year t-1) | (0.069) | (0.069) | (0.069) | (0.069) |
| Export Dummy | 0.965** | 0.964** | 4.106** | 4.039** |
| =1 if the plant have exported in 1990, 93 or 96 | (0.017) | (0.017) | (0.455) | (0.463) |
| Trend | Yes | Yes | Yes | Yes |
| =1 if year = 88 and = 9 if year = 96 | | | | |
| Industry Fixed Effects | Yes | Yes | Yes | Yes |
| Industry Dummies at the 3-digit SIC | | | | |
| Estimation Method | OLS | OLS | OLS | OLS |
| Observations | 152404 | 152404 | 152404 | 152404 |
| R-squared | 0.52 | 0.52 | 0.52 | 0.52 |

Robust standard errors (corrected for clustering at the plant level) in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
 Δ denotes changes from year t-1 to t

Table 5: Change in Shipments
Dependent Variable: $\Delta \ln(\text{real shipments})$

| | (1) | (2) | (3) | (4) |
|--|----------|----------|----------|----------|
| Age | -0.002** | -0.002** | -0.002** | -0.002** |
| Years in the sample | (0.000) | (0.000) | (0.000) | (0.000) |
| $\Delta \text{Exchange Rate}$ = $\Delta \ln(\text{twrer})$ | -0.098** | -0.055* | 0.064+ | 0.081* |
| $\Delta \text{Exchange Rate} * \text{Foreign Dummy}$ | | -0.277** | | -0.222** |
| | | (0.044) | | (0.045) |
| $\Delta \text{Exchange Rate} * \text{Export Dummy}$ | | | -0.265** | -0.236** |
| | | | (0.036) | (0.036) |
| Reduction in Canadian Tariffs = $\text{ctar}_{t-1} - \text{ctar}_t$ | -0.269** | -0.256** | -0.249** | -0.241** |
| | (0.070) | (0.070) | (0.070) | (0.070) |
| Reduction in US Tariffs = $\text{utar}_{t-1} - \text{utar}_t$ | -0.772** | -0.759** | -0.758** | -0.749** |
| | (0.175) | (0.175) | (0.175) | (0.175) |
| Real Interest Rate | -0.021** | -0.022** | -0.021** | -0.022** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| US shipments = $\ln(\text{US shipments by 3-digit industry})$ | 0.172** | 0.170** | 0.170** | 0.169** |
| | (0.014) | (0.014) | (0.014) | (0.014) |
| Labour Productivity Growth = $\Delta \ln(\text{vam}/\text{pdworker})$ | 0.160** | 0.160** | 0.160** | 0.159** |
| | (0.003) | (0.003) | (0.003) | (0.003) |
| Foreign Dummy = 1 if Foreign Owned in year t-1 | -0.003 | -0.005* | -0.003 | -0.005* |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Multi-Plant Firm Dummy = 1 if multi-plant firm in year t-1 | -0.004+ | -0.004* | -0.004* | -0.004* |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Industry Growth = $\Delta \ln(\text{shipments by 4-digit SIC})$ | 0.066** | 0.066** | 0.065** | 0.065** |
| | (0.006) | (0.006) | (0.006) | (0.006) |
| Industrial Concentration 4-digit CR4 (year t-1) | 0.039** | 0.039** | 0.039** | 0.039** |
| | (0.007) | (0.007) | (0.007) | (0.007) |
| Export Dummy = 1 if the plant have exported in 1990, 93 or 96 | 0.032** | 0.032** | 0.030** | 0.030** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Trend = 1 if year = 88 and = 9 if year = 96 | Yes | Yes | Yes | Yes |
| Industry Fixed Effects | Yes | Yes | Yes | Yes |
| Industry Dummies at the 3-digit SIC | | | | |
| Estimation Method | OLS | OLS | OLS | OLS |
| Observations | 150564 | 150564 | 150564 | 150564 |
| R-squared | 0.08 | 0.08 | 0.08 | 0.08 |

Robust standard errors (corrected for clustering at the plant level) in parentheses

+ significant at 10%; * significant at 5%; ** significant at 1%

Δ denotes changes from year t-1 to t

coefficient of the direct exchange rate term can again be interpreted as the effect of the exchange rate on domestically owned plants that are non-exporters. Interestingly this coefficient is positive and significant. This suggests that appreciations in the Canadian dollar expand the shipments of domestically owned non-exporters, a result which is broadly counter-intuitive. One possible explanation for this is that the sales of non-exporters benefit from a high Canadian dollar reducing the cost of imported inputs.

Turning our attention to the coefficients of the exchange-foreign dummy and exchange rate-export dummy, in the final column both are negative and significant. In addition, their magnitudes are greater than the magnitude of the direct exchange rate effect, meaning that the overall effect of real currency appreciations on foreign-owned plants and exporters is indeed negative. This effect is sufficiently large so as to show up as a negative direct effect of the exchange rate when the interactions are not included (as in column 1). Accordingly, unlike the case of tariff reductions, as in Head and Ries (1999) and Trefler (2004), we find that exchange rate fluctuations do have significant implications for plant shipments. Note that one possible explanation of the difference between the results in Head and Ries (1999) and ours could be differing degrees of aggregation. While Head and Ries (1999) uses detailed industry-level data compiled from the ASM data base, we use the plant-level data, which enables us to identify between surviving and exiting plants. The difference between Head and Ries' (1999) and our findings show that the shipments of surviving plants do react to exchange rates, but this effect may not be manifested in industry-level research in which plant turnover status cannot be identified.

4.3 Labour Productivity

Our previous results show that, in general, real home currency appreciations reduce plant shipments. If the production technology can be characterized by increasing returns to scale, then it is likely that the appreciation-induced reduction in shipments will cause a decline in productivity. Conversely, a domestic currency depreciation might be expected to improve productivity. We examine the relationship between total shipments and labour productivity using two-stage least squares model. To prevent an endogeneity problem, total shipments are instrumented in the first stage using the exchange rate, export status, industry sales growth, real interest rate, and US shipments. In the second stage,

productivity is estimated using the instrumented shipments from the first stage. The second stage estimating equation is specified as:

$$\Delta \ln productivity_{ft} = \beta_1 \ln shipments_{ft} + \theta \Delta \ln skill_{ft} + \lambda_1 \Delta tariff_{it}^{CAN} + \lambda_2 \Delta tariff_{it}^{US} + \gamma x_{ft-1} + \delta y_{it-1} + \varepsilon_{ft}, (3)$$

where $skill_{ft}$ denotes plant skill intensity approximated by the total payments to non-production workers relative to the total payments to production workers,²³ x_{ft-1} is a vector of plant characteristics that include age, ownership, and multi-plant dummy, and y_{it-1} is a vector of industry or more aggregate level controls that include industry concentration. Both the first and second stage results are reported in Table 6.

The first part of Table 6 reports the first stage results. Similar to our findings when estimating equation (2), the exchange rate effect on total shipments is negative and significant in both logs and change in log specifications. The second part of Table 6 reports the second stage results. We estimate equation (3) both in logarithms of productivity and the change in logarithm, the results are reported respectively in columns 1 and 2. Our results indicate that higher shipments contribute to higher productivity (column 1) and that higher growth of shipments also promotes productivity growth (column 2). It follows that a real currency appreciation reduces shipments and leads to a decline in productivity for surviving plants. Turning our attentions to the other variables, column 1 indicates that reductions in both Canadian and US tariffs lead to higher plant productivity. In addition, plants with higher skill intensities tend to have higher productivity while older plants tend to be less productive. Foreign-owned plants and plants that are affiliated with multi-plant firms tend to be more productive. In column 2, the empirical results indicate that higher growth of skill intensity also leads to higher productivity growth. In addition, reductions in US tariffs lead to higher productivity growth while the Canadian tariff reductions do not have a significant impact. The larger effect of US tariff reductions on plant productivity growth is in line with the findings in Trefler (2004) and Lileeva (2006). Finally, our results show that older plants tend to have lower productivity growth and plants that are affiliated with multi-plant firms tend to have higher productivity growth; however, the influence of foreign ownership on productivity growth is insignificant.

²³ This approximation has been use in Bernard, Jensen, and Schott (2006).

**Table 6: Productivity
First Stage Regressions**

| | ln(shipments) | Δ ln(shipments) |
|---|---------------|------------------------|
| | (1) | (2) |
| Age | 0.034** | -0.003** |
| Years in the sample | (0.000) | (0.000) |
| Skill Intensity | -0.297** | |
| = ln(payments to non-production workers/payments to production workers) | (0.004) | |
| Δ Skill Intensity | | -0.063** |
| = Δ ln(payments to non-production workers/payments to production workers) | | (0.002) |
| Exchange Rate | -0.547** | |
| = ln(twrer) | (0.059) | |
| Δ Exchange Rate | | -0.133** |
| = Δ ln(twrer) | | (0.028) |
| Reduction in Canadian Tariffs | -0.740** | -0.258** |
| = $ctar_{t-1} - ctar_t$ | (0.229) | (0.070) |
| Reduction in US Tariffs | -0.370 | -0.550** |
| = $utar_{t-1} - utar_t$ | (0.597) | (0.186) |
| Real Interest Rate | -0.019** | -0.020** |
| | (0.004) | (0.001) |
| US shipments | 0.485** | 0.200** |
| = ln(US shipments by 3-digit industry) | (0.049) | (0.015) |
| Foreign Dummy | 0.728** | -0.004 |
| = 1 if Foreign Owned in year t-1 | (0.010) | (0.003) |
| Multi-Plant Firm Dummy | 0.900** | -0.003 |
| = 1 if multi-plant firm in year t-1 | (0.008) | (0.003) |
| Industry Growth | 0.007 | 0.073** |
| = Δ ln(shipments by 4-digit SIC) | (0.015) | (0.005) |
| Industrial Concentration | 0.500** | 0.044** |
| 4-digit CR4 (year t-1) | (0.027) | (0.008) |
| Export Dummy | 0.996** | 0.035** |
| = 1 if the plant have exported in 1990, 93 or 96 | (0.007) | (0.002) |
| Trend | Yes | Yes |
| =1 if year = 88 and = 9 if year = 96 | | |
| Industry Fixed Effects | Yes | Yes |
| Industry Dummies at the 3-digit SIC | | |
| Observations | 152320 | 150358 |
| R-squared | 0.493 | 0.027 |

Table 6 (Continued)
Second Stage Regressions

| | ln(Labour Productivity) | Δ ln(Labour Productivity) |
|--|-------------------------|----------------------------------|
| | (1) | (2) |
| ln(shipments) | 0.191** (0.006) | |
| Δ ln(shipments) | | 0.297** (0.040) |
| Age | -0.003** (0.000) | -0.000 (0.000) |
| Years in the sample | | |
| Skill Intensity = ln(payments to non-production workers/payments to production workers) | 0.276** (0.004) | |
| Δ Skill Intensity = Δ ln(payments to non-production workers/payments to production workers) | | 0.222** (0.005) |
| Reduction in Canadian Tariffs = $ctar_{t-1} - ctar_t$ | 0.055 (0.084) | 0.172 (0.109) |
| Reduction in US Tariffs = $utar_{t-1} - utar_t$ | -0.180 (0.293) | 1.249** (0.271) |
| Foreign Dummy = 1 if Foreign Owned in year t-1 | 0.151** (0.012) | 0.000 (0.003) |
| Multi-Plant Firm Dummy = 1 if multi-plant firm in year t-1 | 0.129** (0.010) | 0.007** (0.002) |
| Industrial Concentration 4-digit CR4 (year t-1) | 0.067* (0.027) | 0.010 (0.008) |
| Trend =1 if year = 88 and = 9 if year = 96 | Yes | Yes |
| Industry Fixed Effects Industry Dummies at the 3-digit SIC | Yes | Yes |
| Estimation Method | 2SLS | 2SLS |
| Observations | 152320 | 150358 |
| R-squared | 0.410 | 0.123 |

Standard errors in parentheses.

Robust standard errors (corrected for clustering at the plant level) are reported at the second stage.

+ significant at 10%; * significant at 5%; ** significant at 1%

Δ denotes changes from year t-1 to t

Our results show that an appreciation of the Canadian dollar reduces plant shipments while a depreciation has the opposite effect and that there is a positive relation between shipments and labour productivity. These results are consistent with the existence of a scale effect of exchange rate. However, since the productivity measure here is labour productivity, it is possible that the reduction in labour productivity caused by currency appreciations may result from the decreased investment induced by declined profitability and such investment effect may mitigate the scale effect. More specifically, there are two opposing effects of exchange rate on investment. A depreciation of the home currency, for instance, may increase investment of a plant because of the increase in output and profits; however, it is also possible that a depreciation may reduce investment by making imported machinery and equipment more expensive in domestic currency units. Using industry level data, Harchaoui, Tarkhani, and Yuen (2005) find that the impact of exchange rate on investment is insignificant in the Canadian manufacturing sector. Focusing on the imports of machinery and equipment, Landon and Smith (2007) find that the imports are reduced by a depreciation of the home currency against the import source country but increased by a depreciation against the export destination country. The simulation results in this study show that the net effect for Canada of the depreciation against the US dollar is negative but insignificant. Although we are unable to examine the investment effect at the plant level owing to data limitations, the findings of Harchaoui, Tarkhani, and Yuen (2005) and Landon and Smith (2007) indicate that the direction and the insignificance of the investment effect make it unlikely to dampen the scale effect.

5 Economic Significance

Our empirical findings in section 4 indicate that the exchange rate can influence plant productivity by affecting the scale of production. A real appreciation of the Canadian dollar reduces plant shipments and thus leads to a decrease in labour productivity. Conversely, a depreciation of Canadian dollar promotes plant shipments and results in higher productivity. Similar results appear in term of growth rates. An important aspect of the results that we have not discussed is their economic magnitude. In this section, we calculate the exchange rate induced change in shipments and the resultant change in

productivity using a “fictitious” plant with mean levels of all variables.²⁴ The upper half of Table 7 summarizes the economic implications of level of the exchange rate for plant shipments and the corresponding effect on productivity. The lower half of Table 7 reports the effects of changes in exchange rate on the growth of plant shipments and the associated growth rate of productivity.

The top half of Table 7 shows that when all the independent variables are at their mean, the predicted level of shipments is \$3,031,900 and the predicted labour productivity is \$66,803. When the annual average exchange rate reached the highest level in 1991 (TWRER = 111.36) while other independent variables remain at their mean level, the predicted level of shipments is \$2,868,787. The corresponding predicted level of labour productivity is \$66,072. Relative to the case where all variables are held at the mean levels, this represents a 5.38 percent reduction in shipments and a 1.09 percent reduction in productivity when the exchange rate reached its highest level. On the other hand, when the exchange rate reached its lowest annual average in 1996 (TWRER = 89.89), the predicted level of shipments is \$3,224,215. At this level of shipments, the predicted labour productivity is \$67,548.²⁵ In this case we see reciprocal effects where shipments are 6.34 percent higher and productivity 1.12 percent higher than when the exchange rate was held at its mean level. Comparing the exchange rate at its highest annual average to its lowest value, shipments are 12.39 percent higher and labour productivity increases by 2.23 percent.

We now turn our attention to the lower half of Table 7, reporting the effects of changes in the exchange rate. When all the independent variables are at their mean, the predicted growth rates of shipments and productivity are 1.79 percent and 0.34 percent respectively. The largest average annual appreciation of the exchange rate in our sample period is 6.81 percent. At this magnitude of appreciation, the predicted growth rate of shipments is 0.85 percent, and at this rate of shipment growth, the predicted productivity growth rate is 0.09 percent. The largest average depreciation in the sample period was 7.08 percent and the associated predicted growth rates of shipments and productivity are 2.56 percent and 0.55 percent

²⁴ The calculations reported are based on results from estimating the first-stage and second stage equations separately. The coefficient estimates are similar to the ones reported in Table 6.

²⁵ In all these exercises, all other independent variables are at means.

respectively. Our results show that relative to the mean change in the exchange rate, when the largest

Table 7: Predicted Economic Effects

| Levels | | |
|--|--------------------------------|--|
| | Shipments | Labour Productivity |
| At Mean Values | \$3,031,900 | \$66,803 |
| Level of Exchange Rate | | |
| 1988 Exchange Rate (TWRER = 103.79) | \$2,979,303 | \$66,549 |
| 1991 Exchange Rate (TWRER = 111.36) | \$2,868,787 | \$66,072 |
| 1996 Exchange Rate (TWRER = 89.89) | \$3,224,215 | \$67,548 |
| Changes | | |
| | $\Delta \ln(\text{Shipments})$ | $\Delta \ln(\text{Labour Productivity})$ |
| At Mean Values | 0.0179 | 0.0034 |
| Changes in Exchange Rate | | |
| Large Appreciation ($\Delta \ln \text{TWRER} = 0.0681$) | 0.0085 | 0.0009 |
| Small Appreciation ($\Delta \ln \text{TWRER} = 0.0079$) | 0.0159 | 0.0029 |
| Large Depreciation ($\Delta \ln \text{TWRER} = -0.0708$) | 0.0256 | 0.0055 |
| Small Depreciation ($\Delta \ln \text{TWRER} = -0.0190$) | 0.0193 | 0.0038 |

appreciation occurs, the growth of shipments falls by approximately 1 percentage point and this causes the productivity growth rate to decline by 0.25 percentage points. On the other hand, when the largest depreciation occurs, the growth rate of shipments is 0.77 percentage points higher and the productivity growth rate 0.21 percentage points higher.

Although the absolute magnitude of the changes in productivity growth is small, these are in fact quite substantial effects. Relative to the benchmark case (in which all independent variables are at means) the period of largest appreciation sees productivity growth rates that are *four times* smaller (0.09 percent as compared with 0.34 percent). While the largest depreciation results in a more than fifty percent increase in productivity growth (from 0.34 percent to 0.55 percent). These results suggest that certainly in cases of large shifts in the value of the exchange rate, there are substantial and economically significant implications for plant productivity.

6 Conclusion

This paper sets out to investigate how exchange rate movements affect plant scale of production and

how changes in plant scale of production influence productivity. Using detailed Canadian plant level data covering the period from 1987 to 1996, we find that that, on average, a real appreciation of the Canadian dollar reduces the shipments of surviving plants and a real depreciation increases the shipments. To explore the possibility that exporters and foreign-owned plants may react differently to exchange rate movements as compared to domestic plants that are non-exporters, we introduce exchange rate-exporter and exchange rate-foreign ownership interaction terms. Our results show that the exchange rate effects on the shipments of domestic plants that only serve the Canadian market are insignificant or even positive. However, the effects on exporters are negative and significant. These results indicate that exporters react differently to exchange rate movements as compared to non-exporters.

Further, we investigate the effect of exchange rate induced changes in shipments on labour productivity and find that a real appreciation of home currency leads to a reduction in the growth of shipments and causes a decrease in plant productivity growth while a real depreciation has the opposite effects. We also compute the economic magnitude of exchange rate induced productivity changes based on the empirical model. The results show that the decrease in the growth rate of shipments induced by large real appreciations results in substantial decrease in productivity growth rate while a real depreciation has the opposite effects. Our findings suggest that exchange rate movements may influence plant productivity growth by affecting the scale of production, implying the existence of the scale effects of exchange rates.

Combining the scale effect results with the findings in Baggs et al (2007) that the negative effect of appreciation on firm survival is less pronounced for more productive firms, our findings indicate that a real appreciation of the Canadian dollar, for example, affects productivity growth in two opposite directions. On one hand, the exit of less productive plants shifts up the productivity distribution within an industry, leading to an increase in industry-level productivity. On the other hand, the surviving plants suffer a reduction in the scale of production and productivity. To understand the net exchange rate effect on industry-level productivity, an industry-level investigation is warranted.

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Appendix

A.1 Industry-Level Data

In this paper, we constructed industry-specific trade-weighted real exchange rate, real US shipments, and real interest rate from publicly available data sources. The trade weighted real exchange rate is the weighted average of normalized real exchange rate of Canada's top ten trade partners for each industry at the 4-digit SIC level. A detailed description can be found in the appendix of Baggs, Beaulieu and Fung (2007).²⁶ The exchange rates for countries except the US are converted from the exchange rates against the US dollar and the price index used for the construction of real exchange rate is GDP deflator. These data are from the International Financial Statistics and the World Development Indicators.²⁷ The real exchange rates are normalized with 1984 being the base year before the construction of weighted average. To prevent the endogeneity problem, the share of each trade partner is the sum of this country's exports and imports with Canada from 1990 to 1994 as a fraction of Canada's total volume of trade with the top 10 trade partners for the industry during this period.²⁸ The trade data used for the construction are from Industry Canada's Strategis dataset.

We also use the real US shipments as a control for industry-specific business cycle. The US shipments data are merged to the plant-level data at the 3-digit SIC level. The US shipments data are from the NBER-CES Manufacturing Industry Database by Bartelsman and Gray (1996) (updated to 1996). The nominal interest rate used for the construction of real interest rate is the Government of Canada benchmark bond yields (10-year) and the price index used is the GDP deflator. The Canadian interest rate data is from the CANSIMII database.

²⁶ In Baggs, Beaulieu and Fung (2007), TWRER was calculated at the 3-digit level. For this paper, the same methodology was used, but aggregation was to the 4-digit level.

²⁷ With the exception of Taiwan. The data for Taiwan are from Central Bank of China (Taiwan) and the statistical database of National Statistics.

²⁸ Due to the lack of complete data on exchange rate and price, thirteen countries are excluded from the list of Canada's top ten trade partners. These countries are: Cuba, Czechoslovakia, Czech Republic, Estonia, Former USSR, Iraq, Libya, Netherlands Antilles, Poland, Russia, Vietnam, Yemen and Yugoslavia. In addition, St. Pierre Miq. is combined with France when identifying the top ten trade partners.

A.2 Plant-Level Data

The ASM database consists of data on plants in 236 industries at the SIC 4-digit level. Due to the lack of TWRER or tariffs data on 16 smaller industries, these industries are dropped from our sample. Therefore, we have plants in 220 industries in our analysis. We only include the plants that have filled out the long form at least once in the years when the exports data are available since these are the plants that we can identify their export market participation status. These plants consist of approximately 58 percent of the plants in the survey and 96 percent of total shipments. The shipments of a plant are measured by the real manufacturing shipments. Both shipments and exports are deflated using the industry-specific deflator for output. The labour productivity is measured by real manufacturing value-added per production worker. The value-added is deflated using the industry-specific deflator for value-added. Around 1 percent of the plant-year observations have negative manufacturing value-added. Since we will take logarithm of labour productivity, plant-year observations with negative value-added are excluded. The industry shipments are measured by the sum of the real total shipments after subtracting the plant itself. The industry shipments are used for the construction of annual growth of industry shipments.