AN EMPIRICAL INVESTIGATION INTO THE EFFECTS OF TARIFFS ON CANADIAN EXPORT INDUSTRIES

by

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Abstract

The effects tariffs have on trade are central in the current discussions of free trade agreements between Canada and its trading partners. Until now, there has been little empirical work on the effect tariffs have on disaggregated export industries in Canada. Using a relatively new tariff data set, this essay splits Canadian exports into 11 different industries, and using a two-way fixed effects model, estimates the effects foreign tariffs have on the import of Canadian goods. Surprisingly, only 5 of the 11 industries exhibit statistically significant tariff effects. Using the model's predictions, I find that the import of Canadian goods would have increased by roughly $35 billion USD on average per annum (over the period 1970 to 2009) were tariffs eliminated. This annual increase is equivalent to roughly 4% of average real GDP, or 16% of average annual real exports over this period.

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1. Introduction

Trade protectionism is currently a subject of great interest in Canada, especially as Canada seeks to join the Trans-Pacific Partnership (TPP), a large international free(er) trading bloc. The TPP seeks to lift quotas, tariffs, and other impediments to trade. While many issues play a role in this discussion, the effect tariffs have on the volume of Canadian exports is surely at the forefront.

This essay is the first study (to my knowledge) to empirically address specifically the impact of foreign tariff changes on the volume of Canadian exports. Accurate tariff data has not existed in the past, and when it has, research has focused on total world trade rather than country-specific trade. I split Canadian exports into 11 different export industries. Not only does this allow for heterogeneous tariff effects, it also allows one to isolate which Canadian industries benefit most from tariff liberalization; or likewise, are hurt most from trade protectionism.

Using a gravity-like equation I analyze the effect tariffs have on Canadian exports, across 11 different industries. I use a fixed effects panel model that considers both bilateral fixed effects and time fixed effects. This approach presents the best form of estimation, eliminating many of the endogeneity and omitted-variable issues associated with the gravity model (Baldwin and Taglioni, 2006). The model is estimated on Canada's top 10 export markets: the United States, the United Kingdom, China, Japan, Mexico, Germany, South Korea, the Netherlands, Brazil, and Norway. The panel runs annually from 1970 to 2009.[1] The model is estimated separately for each industry.

[1] Time dimensions vary depending on the country and industry. See appendix table A1.

The empirical results of the two-way fixed effects model reveal some interesting findings. Although all 11 industries have economically significant tariff effects on the import of Canadian goods, only 5 of the industries show a statistically significant effect. The statistically significant tariff effects range from -4% to -11% depending on the industry. That is, a one percentage point increase in tariffs results in a percentage decrease in real imports in this range. Additionally, the model predicts that if tariffs were completely eliminated over the period 1970 – 2009, Canada would have increased the import of its goods by an average of $35 billion real USD per annum. This equates to roughly 4% of average real GDP or 16% of average annual real exports over this period.

This essay is organized as follows. Section 2 discusses related research. Section 3 lays out the two model specifications used in estimating the tariff effects. Section 4 describes the data along with some preliminary analysis. Section 5 presents the estimation results of the models. Section 6 discusses some potential econometric issues. Section 7 analyzes some counterfactual predictions, *sans* tariffs, of the models. Section 8 concludes.

2. Related Research

The majority of research analyzing trade flows, and their determinants, focuses on the use of gravity or gravity-like equations. Initially, due to the lack of good tariff data, studies focused on analyzing tariff barriers via Free Trade Agreement (FTA) dummy variables.

Early studies use cross-sectional estimations of the gravity equation with FTA dummy variables. These studies find varied results on tariff barriers, or more precisely, on the effect of Free Trade Agreements on trade volume. For instance, Brada and Mendez (1985) find the European Economic Community (ECC) to have a statistically significant effect on trade, while Frankel *et al* (1995) find it to have an insignificant effect. Baier and Bergstrand (2007) attribute these mixed results to the endogeneity issues associated with the FTA dummies. They find that the endogeneity issues can be dealt with by using a bilateral fixed effects panel approach during estimation.

Some articles using bilateral fixed effects of particular importance include Baier and Bergstrand (2007), and Martínez-Zarzoso *et al* (2009). Both articles find FTAs to have a significant positive effect on trade. Both Baier and Bergstrand and Martínez-Zarzoso *et al* use panel data with bilateral fixed and time-varying country effects to estimate a gravity-like equation. Baier and Bergstrand also estimate a differenced model for robustness and find similar results to their fixed effects model.

Until recently, the explicit effect of tariffs on trade volume has not been modelled empirically due to the lack of accurate tariff data. One of the earliest papers to accurately estimate the effect of tariffs on trade is that of Lai and Zhu (2004). They estimate a gravity-like equation on aggregate manufacturing using bilateral fixed effects. Lai and Zhu also estimate a model accounting for omitted price terms using time-varying country dummy variables. They find their model with time-varying country dummy variables to yield similar results to their bilateral fixed effects model. Lai and Trefler (2004) use a similar model and find comparable results at disaggregated manufacturing levels.

This essay is most similar to the work of Lai and Zhu (2004) in terms of model choice and estimation techniques. Lai and Zhu use a bilateral fixed effects model to estimate the impact of tariffs at the aggregate manufacturing level. However, there are several major differences. First, this essay focuses on unidirectional trade rather than total trade volume. This allows one to isolate a particular country's export sector (in this case Canada), and analyze the effect importer's tariffs have on Canada's export volume. Furthermore, this essay analyzes the effect of tariffs across disaggregated Canadian export industries. Statistically, this allows tariffs to have heterogeneous effects across industries. Economically this is important because one can isolate which export industries have been hurt most due to tariff protectionism. Finally, this essay utilizes a longer tariff data set than Lai and Zhu. Their data set includes 1980, 1984, 1988, and 1992, whereas this paper uses annual data running from 1970 to 2009.[2] Not only is the length of the series important, but the specific time period is important. That is, this essay's data set includes the most recent recession, and the trade protectionism that comes along with this period.

3. Model Specifications

Section 3.1 looks at the base model with only bilateral fixed effects. In section 3.2 I add time dummy variables, creating a bilateral and time fixed effects model (two-way fixed effects).

3.1 Bilateral Fixed Effects Model

The base model is a fixed effects panel representation of the popular gravity equation. The typical gravity equation seeks to explain bilateral trade flows via a country's income, bilateral distance, common language, and most recently trade protectionism measures such as FTAs and tariffs.[3]

The base model gravity equation can be found below labelled as equation (1). The variable lnM_{ijt} is the natural log value of imports of an importing country i (from Canada)

[2] The range of time series depends on which industry and country is being analyzed. See appendix table A1.
[3] See Bergstrand (1985) for a an in-depth look at gravity equations.

for industry *j* at time t.[4] The variable lnY_{it} is the natural log of real Gross Domestic Product (RGDP) of importing country i, while $lnYc_t$ is the natural log of RGDP of Canada. lnX_{ijt} is equivalent to the log of one plus the *ad valorem* tariff rate. Lastly, the error term is $\epsilon_{ijt} = \lambda_{ij} + \nu_{ijt}$; where λ_{ij} accounts for the country-pair fixed effects. The panel runs across importing countries *i* = 1....10 and across time *t* = 1...30.[5] A separate model will be run for each industry *j* = 1...11. The panel equation can thus be written:

$$lnM_{ijt} = \beta_{0j} + \beta_{1j} lnY_{it} + \beta_{2j} lnYc_t + \alpha_j lnX_{ijt} + \epsilon_{ijt} \qquad (1)$$

Bilateral fixed effects between Canada and importing country i account for the variation of the excluded gravity-equation terms such as distance and language. Other time-invariant factors are also captured by the use of bilateral fixed effects. The inclusion of bilateral fixed effects completely eliminates the bias associated with the cross-section correlation between omitted and included terms (Baldwin and Taglioni, 2006). But, one may also want to include time dummy variables to account for possible biases induced by the deflation of import values by an aggregate U.S. price index (Baldwin and Taglioni, 2006). In the next section I consider the model with time dummy variables included.

3.2 Bilateral Fixed Effects model with Time Dummy variables

Next I add year dummy variables to the bilateral fixed effects model. The inclusion of time dummy variables eliminates the "biases via spurious correlations" associated with deflation of all nominal import values by an aggregate U.S. Price index (Baldwin and Taglioni, 2006). The variables in this model still hold the same definitions as in section 3.1.

[4] Import values of the importing country of Canadian goods are used rather than Canadian export values due to data availability. Export values and import values may differ in value as imports are valued Cost Insurance Freight (CIF) and Exports are Free on Board (FOB). This is not a problem as the overall trends are similar.

[5] The range of time series varies by country. See appendix table A1

Additionally, in equation (2) below, Z_t indicates a vector of T time dummy variables. The variable $lnYc_t$, which appeared in equation (1), cannot be included separately as it does not vary across panels (countries). In fixed effects models with time fixed effects, regressors must vary over panels within each time period; Canadian GDP is the same across all countries so it is dropped. Thus the statistical model is:

$$lnM_{ijt} = \beta_{0j} + \beta_{1j}lnY_{it} + \alpha_j lnX_{ijt} + \theta_j Z_t + \epsilon_{ijt} \tag{2}$$

The inclusion of bilateral and time fixed effects completely eliminates the bias associated with the cross-section correlation between omitted and included terms. Furthermore the potential bias associated with the deflation of nominal import values by a U.S. price index is accounted for. However some bias may still remain in the sense that the potential time-varying correlations between the omitted price terms and included regressors has not been taken care of (Baldwin and Taglioni, 2006). Nevertheless this bias is not thought to be a major issue. In fact, Lai and Zhu (2004) find this bias to be small. Their bilateral fixed effects model yielded similar results to their model that accounted for the time-varying portion of the omitted price terms.

4. Data

Next, section 4.1 describes the data used to estimate equations (1) and (2). Following this, section 4.2 introduces some key summary statistics of the main variables: imports and tariffs. Section 4.3 then looks at some preliminary analysis.

4.1 Data Descriptions

A major part of this project included obtaining tariff, import, and GDP data for both Canada, and the top 10 importers in 2010 of Canadian goods. These countries account for nearly 90% of total Canadian exports, or $358 CAD billion, as shown in table 1 (Industry Canada, 2011). The importers, in descending dollar order, are as follows: the United States, the United Kingdom, China, Japan, Mexico, Germany, South Korea, the Netherlands, Brazil, and Norway.

Table 1: Top 10 Canadian Export Countries

Country	Total Exports ($CAD Millions)	Share of Total
United States	298,524	74.90%
United Kingdom	16,396	4.10%
China	13,232	3.30%
Japan	9,194	2.30%
Mexico	5,008	1.30%
Germany	3,938	1.00%
South Korea	3,709	0.90%
Netherlands	3,245	0.80%
Brazil	2,567	0.60%
Norway	2,529	0.60%
Total of Top 10	**358,342**	**89.80%**
Others	40,484	10.20%
Total (All Countries)	398,826	100.00%

Source: Industry Canada, 2011

The tariff and import data are stratified into 11 industries: Agriculture, AgriRaw, Chemical, Food, Manufacturing, Miscellaneous, Ores and Metals, Other Manufacturing, Petroleum Products, Transportation, and Textiles. The 11 industries are constructed by combining SITC levels, and their descriptions can be found in table 2 below. Some industries are listed at the most aggregated level, and then broken into sub-industries. In particular,

Table 2: Industry Descriptions

Industry	Brief Description	SITC Levels
Agriculture	Food and Live Animals; Animal/vegetable oils and fats; Beverages and Tobacco; Wood, lumber, cork ; pulp, paper; crude rubber; skins, furs, crude animal materials.	0+1+2+4-27-28
AgriRaw	Wood, lumber, cork ; pulp, paper; crude rubber; skins, furs, crude animal materials.	2-22-27-28
Food	Food and Live Animals; Beverages and Tobacco; Oils and Nuts	0+1+22+4
Manufactures	All Manufactured Goods (Chemicals, Machinery, Transportation, Manufactured Metal, Wood and Paper Manufactures, Rubber Leather, Furniture, Clothing, etc)	5+6+7+8-68
Other Manufacturing	Same as "Manufactures" industry, excluding: Chemicals, Machinery, Transportation.	6+8-68
Transportation	Machinery and Transport Equipment(Rail, Road, Air, Water)	7
Chemicals	All chemicals	5
Miscellaneous	Firearms, ammunition and Weapons/Vehicles of war, Pets and Zoo animals, Postal Pkgs.	9
Ores & Metals	Metaliferous ores, Non-ferrous metals, Crude fertilizers and Crude minerals	27+28+68
Petroleum Products	Products of Petroleum	332
Textiles	Textile fibres, waste, yarn, fabrics, made-up articles, clothing.	26+65+84

"Agriculture" is agriculture goods at the most aggregate level, while "AgriRaw" and "Food" are subsectors of this industry. Manufacturing is also included under the most aggregate level, "Manufactures", and is split into sub-industries: "Transportation", "Chemicals", and "Other Manufacturing".

Tariff data are obtained from the United Nations Conference on Trade and Development's (UNCTAD) *Trade Analysis and Information System* (TRAINS). Most Favored Nation (MFN) *ad valorem* tariff rates are available at the most detailed level (up to 5 digit) of SITC revision 1 classifications. Data are available for the period running from 1970 to 2009.[6] The tariff data used are the tariff rates imposed by the countries of the top 10 importers of Canadian goods. Furthermore, tariff data are stratified into the 11 industries described above. A weighted average of tariffs in each industry is used using SITC product-level tariff rates of the included products, weighted by their corresponding bilateral import share.[7] This weighted average is calculated separately for each country, for each year, for each industry. Note that *ad valorem* equivalents are also included in the average for many products that have non-*ad valorem* rates.

Bilateral import data is also obtained from the TRAINS database. Bilateral imports are the import values of products into the reporting country (the importer) from the partner country (Canada). The data is also aggregated at the same SITC levels as the tariff rates in order to match industry-level imports with their respective tariffs. The import data is listed in nominal USD and is deflated using a U.S. GDP deflator from the OECD.

[6] The range of time series available depends on the country and SITC level chosen. In most cases, the time series is not continuous and has gaps of missing years. See appendix table A1 for a list of times used per industry, per country.

[7] Bilateral import share is the share of imports imported by country *j* (from Canada) of country *j*'s total imports for that industry.

Real Gross Domestic Products for each country are obtained from the Penn World Tables 7.0 (Aten *et al*, 2011). PPP-adjusted real GDP is used to allow for comparisons between countries.

Some data limitations include: missing years of tariff data due to non-reporting by countries; the use of only 10 importing countries due to feasibility constraints; and the deflation of industry-specific imports by the total U.S. GDP deflator (rather than a product specific measure) due to data availability. However, these limitations still leave the data set with a detailed and representative sample of Canadian export industries.

In the tariff data there are some extreme outliers that heavily skew the analysis. These outlier years are eliminated by the following rule: tariff rates greater than 100% that are *not* consecutively high in subsequent years are dropped. Only 18 data points were lost due to this criterion, leaving nearly 300 points for each industry. [8]

4.2 Summary Statistics

Table 3 lists summary statistics of tariffs and imports. I calculate an arithmetic average across time periods for the *ad valorem* tariffs used in the regression analysis. Table 3 calculates the average separately for each country and for each industry. Additionally, the table includes an arithmetic mean of real $USD imports for each country and for each industry.

In terms of a total cross-country average per industry, Food, Textiles, and Agriculture have the highest trade protectionism, with average tariff rates all above 10 percent. In contrast, the Ores & Metals industry has the lowest tariff rate, with an average of 2.7 percent.

[8] Specifically, the number of observations dropped per industry is as follows: Agriculture-2; AgriRaw-1; Chemicals-0; Food-5; Manufacturing-1; Miscellaneous-2; Ores&Metals-2; OtherManufacturing-2; Petroleum-0; Textiles-2; Transportation-1.

Table 3: Summary Statistics

		Agriculture	AgriRaw	Food	Manufactures	Other Manuf.	Transportation	Chemicals	Miscellaneous	Ores & Metals	Petroleum	Textiles
Brazil	Average Tariff	15.25	10.88	14.22	17.29	17	22.55	8.12	13.19	3.45	11.07	24.89
	Average Imports	169.98	28.51	153.76	741.15	206.2	280.14	262.12	0.1	121.66	0.71	5.28
China	Average Tariff	16.51	3.73	24.22	13.85	17.04	14.71	11.03	10.32	5.64	15.17	22.32
	Average Imports	1709.94	926.09	801.19	2246.1	304.33	1064.84	876.94	0.53	800.05	2.98	56.28
Germany	Average Tariff	6.36	0.91	11.5	4.69	5.5	5.34	3.8	3.99	0.98	4.42	9.93
	Average Imports	652.47	434.53	217.94	1355.04	351.39	791.23	212.42	7.43	590.45	0.32	37.3
Japan	Average Tariff	10.62	1.05	16.6	3.34	4.17	1.79	3.52	1.93	0.45	1.72	11.89
	Average Imports	4652.06	1961.37	2625.92	1499.15	618.64	514.75	365.76	0.54	1079.88	13.87	32.95
S.Korea	Average Tariff	13.46	4.81	27.06	10.11	11.46	10.31	9.22	6.24	4.37	8.25	13.63
	Average Imports	637.09	419.46	217.63	792.3	184.97	302.25	305.08	2.29	389.34	2.08	33.34
Mexico	Average Tariff	21.83	6.59	20.27	14.63	14.03	15.75	11.89	12.94	5.76	12.35	19.18
	Average Imports	741.32	75.93	696.88	2623.52	704.57	1654.1	264.84	1.08	145.01	2.71	74.12
Netherlands	Average Tariff	6.03	1.87	8.95	5.21	5.68	4.57	6.45	2.29	1.65	4.17	10.03
	Average Imports	171.99	75.73	96.26	512.49	140.9	269.29	102.3	2.18	118.25	0.18	10.04
Norway	Average Tariff	11.32	4	12.31	4.44	3.37	1.76	5.19	0.87	0.63	0.25	7.53
	Average Imports	43.94	5.03	38.91	164.75	39.18	112.11	13.19	2.33	694.54	0.74	5.01
United Kingdom	Average Tariff	11.42	1.67	17.44	4.97	5.25	4.96	5.67	2.49	0.97	2.84	9.96
	Average Imports	751.99	349.26	402.72	2165.51	1039.55	978.83	147.13	2.34	736.54	2.55	49.35
United States	Average Tariff	2.53	0.31	5.03	3.52	3.1	3.74	3.43	1.99	2.54	1.02	10.23
	Average Imports	20837.2	10374.49	10462.71	122147.63	33646.01	76202.37	12299.24	246.93	9817.27	306.68	2399.13
Total*	Average Tariff	11.533	3.582	15.76	8.205	8.66	8.548	6.832	5.625	2.644	6.126	13.959
	Average Imports	3036.798	1465.04	1571.392	13424.764	3723.574	8216.991	1484.902	26.575	1449.299	33.282	270.28

Imports are in real USD millions. Ad valorem Tariffs are listed in percent (%). Averages are calculated using an arthimetic average across time periods for a particular industry. Tariff rates for each country are in the non-shaded row, while imports are in the shaded row.

*Total indicates an arthmetic average of the averages listed in the above rows.

In terms of imported Canadian goods, the Manufacturing industries (Manufactures, Transportation, Other Manufacturing) and Agriculture industries (Agriculture, Food) are among the highest in real terms. This is true both in terms of a total average of all 10 countries, and across each individual country. It may come as a surprise that Agriculture is one of the highest-value imported Canadian goods, yet it has one of the largest average tariff rates imposed against it. This may suggest that food, a normal good, may be quite inelastic to price changes.

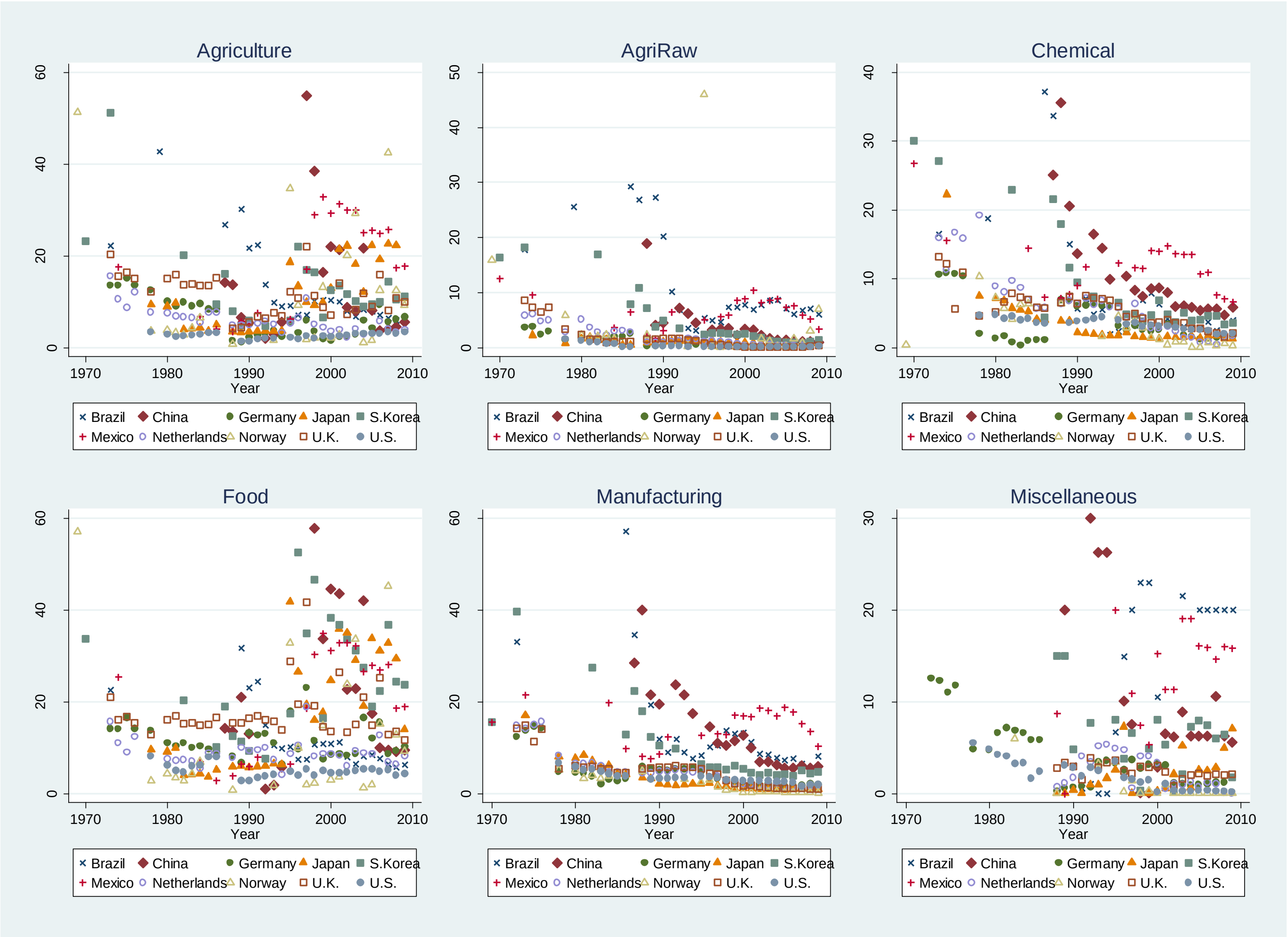
4.3 Preliminary Data Analysis

Below, in figure 1, is a collection of scatter plots of the *ad valorem* tariff rates for each industry across time. The tariff rates imposed by each of the ten importing countries are shown separately. I restrict the graphs to tariff rates below 60 percent to allow for visual interpretation of variation causes.[9] I include these scatter plots for two reasons. First, they allow the reader to visually inspect the roughly 300 data points used per industry. Second, they allow one to decompose the variation in tariffs due to time variation and cross-country variation.

Tariffs vary over time for each industry. The Agriculture, Food, Miscellaneous, Chemical, and Textile industries exhibit the most time variation, with the majority of countries having substantial variation in tariffs across time. The Transportation, Other manufacturing, Ores &Metals, and Petroleum industries all exhibit considerable tariff time-variation, although less so than the previous industries. The AgriRaw industry has the least

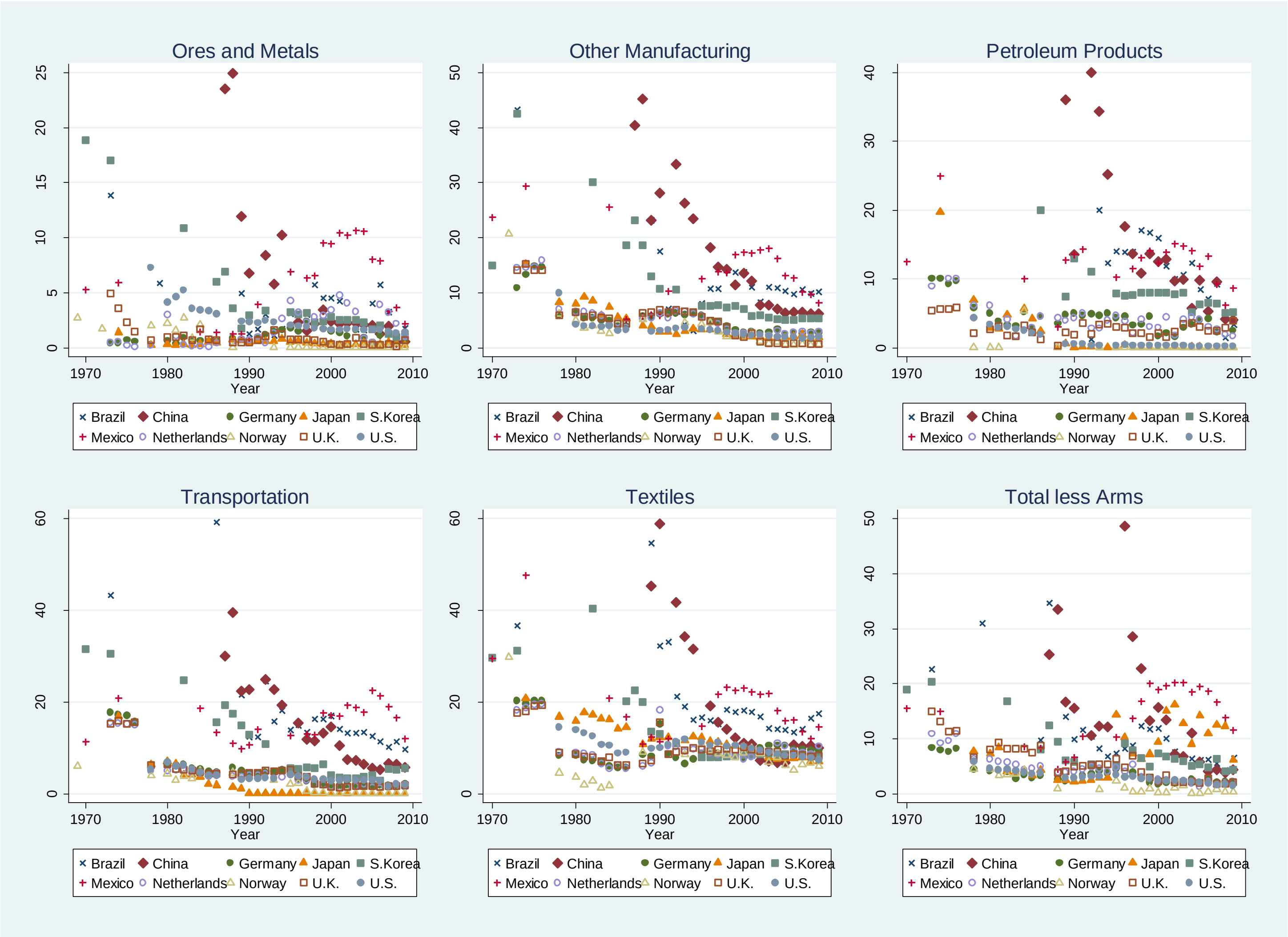
[9] At most there is 1 data point lost per country, or 3 data points for the entire industry.

Figure 1: Variation of *Ad Valorem* Tariffs (percent) by Industry



Data Source: United Nations Conference on Trade and Development, (2011).

Figure 1 (Cont'd): Variation of *Ad Valorem* Tariffs (Percent) by Industry



Data Source: United Nations Conference on Trade and Development, (2011) time variation with only 4 countries displaying noteworthy variation across time.[10] Brazil, Mexico, China, and South Korea exhibit the highest variation in tariff rates across time, while Norway and the United States exhibit the least (yet still important). The time variation of tariffs within each country suggests that tariffs are a good candidate for a fixed effects model which relies on the time variation of the explanatory variable to estimate its effects on the dependent variable.

Finally, there also is a substantial difference in tariff rates between countries. In all industries, China, Mexico, Brazil, and South Korea impose the highest tariff rates; while the United States, Japan, Norway, and the United Kingdom have some of the lowest tariff rates. These differences in the level of tariff rates may hint at the need for differing intercepts in regression analysis.

Next, section 5 exploits this variation to formally estimate the effect tariffs have on the import of Canadian goods.

5. Estimation Results

First, in section 5.1, I estimate and discuss the base model (equation 1). Following this, section 5.2 estimates the base model with time fixed effects included in the model (equation 2). In both models it is suspected that the idiosyncratic error terms suffer from either heteroskedasticity or within-panel serial correlation. To correct for these problems and ensure proper inference I report robust standard errors. The standard errors are clustered at the country level, using the Huber/White estimator. Although there has been some question of how effective the robust estimator is in finite samples, Kenzi (2005) finds encouraging

[10] It should be noted that this does not mean some countries have time invariant tariffs. There still is time variation, although in some cases minimal, still allowing for fixed effects estimation.

evidence in its favor. Kenzi, using Monte Carlo simulations in finite samples (small *N*, small *T*), finds that the robust estimator behaves well, and at the very least is less biased then the conventional estimator.

5.1 Bilateral Fixed Effects Model

Below, in table 4, are the results of the estimation of equation (1). I estimate the bilateral fixed effects model using the fixed effects estimator (within estimator) using the statistical package STATA.[11]

The effect of log real GDP of importing countries, $\hat{\beta}_1$, is statistically significant for half of the industries. For the remaining industries $\hat{\beta}_1$ is insignificant, but only weakly with *p*-values hovering around 0.20. With the exception of the Miscellaneous industry, all industries have the expected positive sign on $\hat{\beta}_1$. That is, an increase in an importing country's real GDP is associated with an increase in the value of Canadian goods it imports.

The effect of Canadian GDP on imports, $\hat{\beta}_2$, is positive and statistically significant for six of the eleven industries. This does not come as a surprise as this is one of the propositions of the gravity model; the bigger the country, the more trade.

The effect of tariffs on the import of Canadian goods, measured by $\hat{\alpha}$, is surprising.[12] In particular, the Agriculture, AgriRaw, Food, Manufactures, Ores&Metals, Petroleum Products, and Textile Industries all have statistically insignificant tariff effects. This is a surprising result given that economic theory stresses the negative impacts of tariffs on trade. However, these industries' tariff effects are only weakly insignificant in the sense that their

[11] This is equivalent to estimating the following equation using OLS: $(y_{it} - \overline{y_i}) = (x_{it} - \overline{x_{it}})\beta + (\varepsilon_{it} - \overline{\varepsilon_i})$; where $\overline{y_i} = \sum_t y_{it}/T_i$; $\overline{x_i} = \sum_t x_{it}/T_i$; $\overline{\varepsilon_i} = \sum_t \varepsilon_{it}/T_i$; *i* is the panel unit, *t* is time.

[12] The coefficient $\hat{\alpha}$ can be interpreted as the percent change in imports due to a one percentage point increase in tariffs.

p-values are near 0.20.[13] Moreover, these industries do show an economically significant impact with $\widehat{\alpha}$'s ranging from -1.7% to -8.9%. All industries, regardless of significance, have the expected negative sign on $\widehat{\alpha}$.[14]

Table 4: Coefficient Results (Bilateral Fixed Effects Model)

$$lnM_{ijt} = \beta_{0j} + \beta_{1j} lnY_{it} + \beta_{2j} lnYc_t + \alpha_j lnX_{it} + \epsilon_{ijt}$$

Industry	$\widehat{\alpha}$	$\widehat{\beta}_1$	$\widehat{\beta}_2$	Constant	R^2 Within	N
Agriculture	-1.708 (0.28)	2.383*** (0.00)	0.063 (0.92)	-38.098*** (0.00)	0.519	276
AgriRaw	-8.073 (0.17)	1.435*** (0.01)	2.073** (0.02)	-60.783*** (0.00)	0.504	276
Food	0.537 (0.50)	2.682*** (0.00)	-0.785 (0.18)	-27.688*** (0.01)	0.575	272
Manufactures	-2.813 (0.17)	1.426*** (0.00)	1.740*** (0.00)	-51.720*** (0.00)	0.733	277
Other Manuf.	-7.881** (0.04)	0.736 (0.20)	1.185** (0.05)	-26.546** (0.05)	0.654	276
Chemicals	-8.445*** (0.00)	2.005* (0.06)	0.734 (0.45)	-44.736*** (0.00)	0.732	278
Transportation	-7.675** (0.02)	0.933 (0.20)	2.682** (0.01)	-61.277*** (0.00)	0.724	277
Miscellaneous	-12.971*** (0.01)	-1.901 (0.18)	5.088*** (0.00)	-57.212*** (0.00)	0.316	216
Ores & Metals	-8.943 (0.21)	1.262 (0.32)	1.563 (0.29)	-45.769** (0.01)	0.445	277
Petroleum Prod.	-3.048 (0.59)	1.43 (0.17)	2.886* (0.10)	-82.780*** (0.01)	0.435	256
Textiles	-3.716 (0.21)	0.368 (0.68)	1.592 (0.11)	-29.805** (0.04)	0.454	275

* for p<.10, ** for p<.05, and *** for p<.01
Clustered standard errors, clustered at the country level, are used. *P*-values are reported in brackets.

Conversely, Other Manufacturing, Chemicals, Transportation, and Miscellaneous all display statistically significant tariff effects on real imports. Of the significant tariff effects, the Miscellaneous industry has the strongest impact on imports with an $\widehat{\alpha}$ of -13% and Transportation the weakest with an $\widehat{\alpha}$ of -7.7%. The Miscellaneous industry contains goods,

[13] Petroleum Products however, are highly insignificant with a p-value of 0.59. This does not come as a surprise as petroleum products are highly inelastic to price (and thus tariff) changes.
[14] Actually, Food has a slightly positive tariff effect, although is highly statistically insignificant.

such as pets, that can be considered luxury goods and are thus highly sensitive to purchasing power changes.

Interestingly, the aggregate manufacturing industry's tariff effect estimate of -2.813% is similar to that of Lai and Zhu's (2004) model that proxies omitted price terms. They find an estimated tariff effect of -2.28% on world manufacturing trade; although in my case the effect is insignificant when using clustered standard errors (*p*-value = 0.17).

The goodness of fit in the industries with a significant tariff effect is quite respectable. In the Chemical and Transportation industry nearly 74% of the variation is explained, while in the Other Manufacturing and Miscellaneous industries 65% and 32% is explained respectively.

5.2 Bilateral and Time Fixed Effects Model (Two-way Fixed Effects)

Next I add year dummy variables to the bilateral fixed effects model. As discussed earlier, the inclusion of time dummy variables eliminates the bias associated with the deflation of nominal import values by an aggregate U.S. GDP deflator. For all industries (excluding Petroleum) the time dummy variables are jointly significant at the 5 percent level using a joint *F*-test. Table 5 presents the coefficient results, corresponding to equation (2). Again I estimate this panel model using OLS with the statistical package STATA. In this specification, Canadian RGDP's effect cannot be estimated separately as it does not vary across panels. That is, time fixed effects requires regressors to vary over panels within each time period otherwise they cannot be estimated. This is not a problem, as the estimation's purpose is to analyze separately the effects of tariffs, not Canadian GDP.

Like the bilateral fixed effects model, the effect of log real GDP of importing countries, $\hat{\beta}_{1,}$ is statistically significant for six of the eleven industries. For the remaining industries $\hat{\beta}_1$ is insignificantly different from zero. Again, with the exception of the Miscellaneous industry, all industries have the expected positive sign on $\hat{\beta}_1$.[15] That is, an increase in an importing countries' real GDP is associated with an increase in the value of Canadian goods it imports.

Table 5: Coefficient Results (Bilateral and Time Fixed Effects Model)

$$lnM_{ijt} = \beta_{0j} + \beta_{1j}lnY_{it} + \alpha_j lnX_{ijt} + \theta_j Z_t + \epsilon_{ijt}$$

Industry	$\hat{\alpha}$	$\hat{\beta}_1$	Constant	R^2 Within	*N*
Agriculture	0.108 (0.92)	2.012*** (0.00)	-29.360*** (0.00)	0.816	276
AgriRaw	-5.365* (0.10)	2.070*** (0.00)	-30.797** (0.02)	0.798	276
Food	0.891 (0.26)	2.312*** (0.00)	-36.349*** (0.00)	0.748	272
Manufactures	-2.500 (0.55)	1.160** (0.02)	-13.036 (0.16)	0.874	277
Other Manuf.	-5.995** (0.03)	0.435 (0.28)	0.890 (0.91)	0.825	276
Chemicals	-8.750*** (0.00)	1.533*** (0.00)	-19.411*** (0.00)	0.825	278
Transportation	-4.894 (0.13)	0.836 (0.13)	-6.197 (0.56)	0.87	277
Miscellaneous	-11.348** (0.03)	-1.760 (0.27)	41.007 (0.23)	0.427	216
Ores & Metals	-7.721 (0.25)	1.643* (0.09)	-21.709 (0.27)	0.644	277
Petroleum Prod.	-4.479 (0.66)	0.586 (0.71)	-9.502 (0.77)	0.498	256
Textiles	-4.151* (0.07)	0.033 (0.96)	7.096 (0.57)	0.681	275

* for p<.10, ** for p<.05, and *** for p<.01
Clustered standard errors, clustered at the country level, are used. *P*-values are reported in brackets. Time dummy variables are omitted for brevity.

The effect tariffs have on the import of Canadian goods, $\hat{\alpha}$, is similar to that of the bilateral fixed effects model. Like the bilateral fixed effects model, the Other Manufacturing, Chemicals, and Miscellaneous industries' tariffs have a significant negative effect on real

[15] Though, the Miscellaneous industry's β_1 is insignificant (*p*-value= 0.27).

imports. However, in the two-way fixed effects model, the transportation industry's tariff effect is insignificant, although just barely (*p*-value = 0.13). Furthermore, there are two additional industries that now display a significant negative tariff effect: AgriRaw and Textiles. In terms of magnitude, the tariff effects in the two-way fixed effects model are less negative, with the exception of the chemical industry which has a slightly stronger tariff effect (more negative). The biggest reduction in $\hat{\alpha}$ is in the Transportation industry's $\hat{\alpha}$, dropping from -7.675% in the bilateral fixed effects model to -4.894% in the two-way fixed effects model.

In comparison to the bilateral fixed effects model, the amount explained in each industry increases with the addition of fixed time effects. This comes as no surprise given that time dummy variables account for any cross-panel invariant regressors that have been omitted.

In summary, the model with only bilateral fixed effects and the model with both bilateral and time fixed effects yield similar results. However, the two-way fixed effects model's estimates of $\hat{\alpha}$ are more modest than those of the bilateral fixed effects model. Furthermore, there are more industries with statistically significant tariff effects and the goodness of fit increases, after including time dummy variables.

6. Potential Econometric Issues

The fixed effects estimator is unbiased only if the explanatory variables are strictly exogenous. Additionally, if the errors are serially correlated or heteroskedasticity exists, than the traditional OLS standard errors are incorrect, preventing inference. Furthermore, if unit roots are present in the data, spurious correlations may result. Sections 6.1 through 6.3 discuss each of these potential issues respectively.

6.1 Endogeneity

With the inclusion of bilateral fixed effects the endogeneity bias associated with the cross-section (time-invariant) correlation between omitted and included terms is completely eliminated (Baldwin and Taglioni, 2006). However, some endogeneity bias may still exist in the sense that the potential time-varying correlations between the omitted terms and included regressors will not be accounted for (Baldwin and Taglioni, 2006). This can be eliminated by the inclusion of time-varying country dummy variables; however this makes the estimation of the tariff effect impossible (Baldwin and Taglioni, 2006). In reference to the gravity equations used in this essay, the time-varying correlations between the omitted terms and included terms are thought to be small as time-varying tariffs are included rather than the free trade dummy variable used by Baldwin and Taglioni.

To formally test the assumption of strict exogeneity, and thus test whether the coefficient results of equations (1) and (2) are unbiased, I use a simple test suggested by Wooldridge (2002, p. 285). To test for strict exogeneity I include the leaded tariff variable, $lnX_{ij,t+1}$, into equation (1) and test whether its coefficient is statistically different from zero.[16] At the 5% significance level, the hypothesis that this parameter is zero is retained for 9 of the 11 industries. Both the AgriRaw and Chemical industries reject this hypothesis indicating the failure of the strict exogeneity assumption (*p*-values of 0.04, and 0.03 respectively). The coefficients in these two industries may be biased, however as Wooldridge (2001, p. 447) notes, the fixed effects estimator is not heavily sensitive to a

[16] This procedure is repeated separately for both lnY_{it+1} *and* $lnYc_{t+1}$ as well. With respect to these variables, strict exogeneity is satisfied for every industry at the 5% significance level.

violation of the strict exogeneity assumption. Thus the estimates of the AgriRaw and Chemical industries may still be reasonable.

6.2 Spurious Correlations

According to Wooldridge (2001, p. 447) when *N* is small and *T* is large, the spurious regression problem can arise if unit root processes are present in the fixed effects model. Baier and Bergstrand (2007) estimate a gravity equation using both a fixed effects panel model and a differenced panel model. They find their results to be similar in both cases, even though trade volume and GDP are likely to follow unit root processes. Like Baier and Bergstrand, even though GDP and imports may be non-stationary, it is likely they are cointegrated. Furthermore, tariff data is likely stationary given the above preliminary data analysis (see figure 1).[17] Thus, the inference associated with $\hat{\beta}$ may be inaccurate; however the inference associated with the tariff effect $\hat{\alpha}$ remains correct. Consequently, in terms of the main variable of interest, spurious correlations are not a problem.

6.3 Residual Heteroskedasticity and Serial Correlation

When serial correlation or heteroskedasticity exist in the error terms, the coefficients of the fixed effects estimator are still unbiased, assuming strict exogeneity holds (Wooldridge p.459). However, with the presence of either serial correlation or heteroskedasticity the traditional OLS standard errors of the coefficients are now incorrect. To ensure proper inference with the potential presence of heteroskedasticity or within-panel serial correlation I use robust standard errors. The standard errors are clustered at the country level, using the Huber/White robust estimator.

[17] Formal stationarity tests are not helpful in this data set due to their low power.

7. Fitted Model

Next I use the fitted values of the two-way fixed effects model to estimate the increase in the import of Canadian goods due to the counterfactual elimination of tariffs over the period 1970 to 2009. However, to interpret the increases in terms of real USD, rather than in log terms, I must first transform the fitted values.

First, the fitted values (which are in natural logarithms) must be converted back to their original units. That is, the real USD fitted values are calculated as $\widehat{M}_{ijt} = e^{\ln \widehat{M}_{ijt} + 0.5\sigma_j^2}$; where $ln\,\widehat{M}_{ijt}$ are the fitted values from equation (2) for industry j, and $\hat{\sigma}_j^2$ is the estimated error variance for industry j.[18] Next, the fitted values are summed across countries for each year. This creates an industry total for each year. That is the real import predictions for industry j thus are: $\widehat{M}_{jt} = \sum_i \widehat{M}_{ijt}$. The predictions, $\widehat{M}_{jt}$, are shown in blue in figure 2 below.

Next I calculate the counterfactual real import predictions where tariffs are completely eliminated. The counterfactual predictions are calculated in the same manner as the predictions; however the actual *ad valorem* tariff rates are set to zero instead. The model is still estimated with lnX_{ijt}, though this term is zeroed out when calculating the counterfactual predictions.[19] The counterfactual predictions are labelled as $\widehat{M}_{jt,No\ Tariff}$, and are shown in red in figure 2 below.

Figure 2 graphically shows the predictions (blue line) and counterfactual predictions (red line) for the industries that have a statistically significant tariff effect in the two-way

[18] The estimated error variance is included when converting to $\widehat{M}_{ijt}$. This assumes $ln\,M_{ijt}$ is distributed normal. This follows from the formula for the mean of the log-normal density.

[19] That is ln (1+0) = 0.

Figure 2: Two-way Fixed Effects Model Predictions

Prediction = $\widehat{M}_{jt}$; these are the summed (across country) fitted values of equation (2).

Counterfactual Prediction = $\widehat{M}_{jt,No\ Tariff}$; these are the summed (across country) fitted values of equation (2) with tariffs = 0.

fixed effects model.[20] These industries include the AgriRaw, Chemical, Miscellaneous, Other Manufacturing, Textile, and Transportation industries.[21] [22] Across all years it appears, the AgriRaw and Miscellaneous industries gain the least from tariff elimination; while the Chemical and Textile industries benefit most. The size of an industry's benefit from tariff removal depends on two things: the size of the tariff effect $\hat{\alpha}$; and the size of the actual tariff rates during this period. To analyze the gains from tariff elimination more formally, I calculate some helpful statistics in table 6 below.

Table 6 calculates both an absolute and relative measure of the real dollar increase in the import of Canadian goods due to the elimination of tariffs. The "Absolute Gain" is calculated as:

$$\text{Absolute Gain} = \sum_t \widehat{M}_{jt,No\ Tariff} - \sum_t \widehat{M}_{jt} = \widehat{M}_{j,No\ Tariff} - \widehat{M}_j \qquad (3)$$

That is, the Absolute Gain is the sum across time of the difference between the counterfactual predictions and predictions (the fitted values). Graphically, this is the area between the red and blue lines. It is an aggregate measure of the total real dollar gain in imports due to the elimination of tariffs in the period 1970 to 2009. The "Proportional Gain" is calculated as:

$$\text{Proportional Gain} = \frac{\text{Absolute Gain}}{\widehat{M}_j}; \text{ where } \widehat{M}_j = \sum_t \widehat{M}_{jt,No\ Tariff} \qquad (4)$$

The proportional gain is calculated because the Absolute Gain may be misleading due to differing industry sizes. That is, an industry may have a large dollar increase in imports when

[20] Confidence intervals are omitted due to the complications of accurate construction when summing fitted values across countries to create an industry total. However, separate p-values for each of the coefficients are included in table 5.

[21] Actually, the transportation industry's $\hat{\alpha}$ has a p-value of 0.13 but is still included.

[22] It should be kept in mind that the data used is from an unbalanced panel; therefore some countries are missing for certain years. For instance, the United States is missing data for 1994, this is why there is a noticeable dip in all six industries in 1994.

tariffs are eliminated, but this may be a small increase relative to its initial (tariff-included) flow of imports.

With proportional gains of 49% and 33% respectively (see table 6), the Textile and Chemical Industries are predicted to realize the greatest gain relative to their tariff-included prediction (over the period 1970 to 2009). In the Textile industry this seems curious as its $\hat{\alpha}$ is the lowest among significant tariff effects. However, the Textile industry has high tariff rates (see table 3), and their elimination would thus cause a large spike in imports. On the other hand the large tariff effect ($\hat{\alpha}$ = -8.75) in the Chemical industry primarily explains the large proportional gain in its imports. The AgriRaw industry benefits the least with a proportional gain of only 1.7% over the period 1970 to 2009. This is mainly due to the extremely low tariff rates in this industry (see figure 1).

Table 6: Import Gain from Tariff Elimination

Industry	T	Absolute Gain (Real USD Millions)	Proportional Gain (%)	$\hat{\alpha}$
AgriRaw	38	10400.92	1.72%	-5.37
Chemicals	38	155395.96	32.61%	-8.75
Miscellaneous	34	1115.24	11.98%	-11.35
Other Manufactures	37	221167.40	18.86%	-6.00
Textiles	37	33612.57	48.70%	-4.15
Transportation	38	596541.78	16.83%	-4.89

*Absolute Gain $= \sum_t \hat{M}_{jt,No\ Tariff} - \sum_t \hat{M}_{jt} = \hat{M}_{j,No\ Tariff} - \hat{M}_j$

** Proportional Gain = Absolute Gain/$\hat{M}_j$

$\hat{\alpha}$'s taken from table 5. The gains are for the period running from 1970 to 2009. See appendix table A1 for industry specific time periods.

In terms of absolute gains, the Other Manufactures and Transportation industries benefit the most with gains in real imports of $221 billion USD and $596 billion USD respectively. These industries do not have the highest relative gain, however due to their initial size, an elimination of tariffs is predicted to cause a large dollar increase in real imports. Summing the predicted absolute gains of all 6 industries, Canada would have increased the export of its goods by just over $1 trillion USD over the period 1970 – 2009. That is roughly an increase of $35 billion USD on average per annum. This annual increase is equivalent to roughly 4% of average real GDP, or 16% of average annual real exports over this period.

8. Conclusion

This essay models the effect tariffs have on the import of Canadian goods. I estimate gravity-like equations using a relatively new data set in a two-way fixed effects model. In a surprising result, only 5 of the 11 Canadian export industries display statistically significant tariff effects. This is important because not only do the models suggest differing tariff effects across industries, but they suggest that some industries are not statistically affected by tariffs. These findings constitute new evidence on Canadian international trade, as there have been no empirical papers (to my knowledge) that specifically analyze the effect tariffs have on disaggregated Canadian export industries.

The estimated two-way fixed effects model is then used to predict the real increase in the import of Canadian goods due to the complete elimination of tariffs. The model reveals the heterogeneity of export increases across industries. This is important because it highlights which export industries would benefit most from tariff removal. Summing the gains of the statistically significant tariff industries, the models predict that the import of Canadian goods would have increased by an average of $35 billion real USD per annum. This equates to roughly 16% of average annual real exports over this time period, or 4% of average real GDP.

Further research may include the application of this essay's model to other countries' export sectors. Although the importing countries used in this essay account for 90% of the dollar volume of Canadian exports, a wider range of countries could also be included. Finally, different model specifications could be analyzed and compared to the estimated tariff effects found in this essay.

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Appendix

Table A1: Available Time Periods Per Industry Per Country											
	AgriRaw	**Agriculture**	**Chemical**	**Food**	**Manuf**	**Misc**	**OresMtls**	**Other Manuf**	**PetrlProd**	**Textiles**	**Transp**
United States	1978 to 2009, Excluding 1979,1987, 1988,1994	1978 to 2009, Excluding 1979,1987, 1988,1994	**	**	**	1978 to 2009, Excluding 1979,1987, 1988,1994	**	**	1978 to 2009, Excluding 1979,1987, 1988,1994	*	**
United Kingdom	1973 to 2009, Excluding 1977,1979, 1987	1973 to 2009, Excluding 1977,1979, 1987	**	**	**	1988 to 2009	**	**	1973 to 2009, Excluding 1977,1979, 1987	*	**
China	1988 to 2009, Excluding: 1991,1995	1987 to 2009, Excluding: 1991,1995	**	**	**	1989 to 2009, Excluding: 1990, 1991,1995	**	**	1989 to 2009, Excluding: 1991,1995	*	**
Japan	1974 to 2009, Excluding: 1975-1977, 1979, 1987	1974 to 2009, Excluding: 1975-1977, 1979, 1987	**	**	**	1987 to 2009	**	**	1974 to 2009, Excluding: 1975-1977, 1979, 1983,1987	*	**
Mexico	1970 to 2009 Excluding: 1971-1973,1975-1983,1985, 1987, 1992-1994, 1996	1970 to 1974 Excluding: 1971-1973,1975-1983, 1987, 1992-1994, 1996	**	**	**	1988 to 2009 Excluding: 1990-1994, 1996	**	**	1970 to 2009Excluding: 2009-1973,1975-1983, 1986,1987, 1992-1994, 1996	*	**

* Same Years available as AgriRaw
** Same Years Available as Agriculture

Table A1 Cont'd: Available Time Periods Per Industry Per Country											
	AgriRaw	**Agriculture**	**Chemical**	**Food**	**Manuf**	**Misc**	**OresMtls**	**Other Manuf**	**PetrlProd**	**Textiles**	**Transp**
Germany	1973 to 2009, Excluding: 1977,1979, 1987	1973 to 2009, Excluding: 1977,1979, 1987	**	**	**	1973 to 2009, Excluding: 1977,1979, 1987	**	**	1973 to 2009, Excluding:1 977,1979,1 987	*	**
South Korea	1970 to 2009, Excluding: 1971,1972, 1974-1981,1983-1985,1991, 1993,1994	1970 to 2009, Excluding: 1971,1972, 1974-1981,1983-1985,1991, 1993,1994	**	**	**	1988 to 2009, Excluding: 1991,1993, 1994	**	**	1986 to 2009 Excluding: 1970-1985, 1987,1988, 1991,1993, 1994	*	**
Netherlands	1973-2009 Excluding: 1977, 1979,1987	1973-2009 Excluding: 1977, 1979,1987	**	**	**	1988-2009	**	**	1973-2009 Excluding: 1974,1977, 1979,1981, 1987	*	**
Brazil	1973 to 2009, Excluding: 1974-1978,1980-1985, 1988	1973 to 2009, Excluding: 1974-1978,1980-1985, 1988	**	1973 to 2009, Excluding: 1974-1978,1980-1985, 1987,1988	**	1973 to 2009, Excluding: 1974-1978,1980-1989,2001, 2002,2004	1973 to 2009, Excluding: 1974-1978,1980-1985, 1987,1988	**	1992 to 2009, Excluding: 1973-1991	*	**
Norway	1969 to2009 Excluding 1970-1971, 1973-1977,1979, 1985-1987,1989-1992,1994	1969 to2009 Excluding 1970-1971, 1973-1977,1979, 1985-1987,1989-1992,1994	**	**	**	1983 to2009 Excluding 1984-1987,1989-1992,1994	**	**	1978 to 2009 Excluding 1971-1977,1979, 1982, 1983,1985-1987,1989-1992,1994	*	**

* Same Years available as AgriRaw
** Same Years Available as Agriculture