

An Investigation and a Simulation Approach on Border
Effects between Canada and the United States

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Abstract

After the Canada-US Free Trade Agreement and North American Free Trade Agreement were signed, Trade flows between Canada and the US increase substantially. The integration between the two countries was thought to be extremely high and border not mattered anymore. However, McCallum (1995) finds that inter-province trade is more than twenty times greater than province-state trade. More recent studies argue that the border effect is smaller than McCallum's surprising finding, but still sizable. There are two approaches to estimate border effects, gravity model and computable general equilibrium (CGE) model. Using CGE model, we simulate the tariff reduction effect on bilateral trade between the two countries and find intra-national trade is somewhat insensitive to international trade agreement.

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1 Introduction

Nearly ten years have passed since the North American Free Trade Agreement (NAFTA) came into effect. There is a deeper integration between Canada and the United States. The formal trade barriers between two countries are low and declining over time. Goods and capital are supposed to flow freely across border. Meanwhile, differences in culture, social and economic structure, also appear small in the two countries.

Many economists compare the volume of trade within a country to the volume of trade cross-border. A surprising result is firstly found by McCallum (1995): inter-province trade is more than twenty times greater than province-state trade. Intra-national trade dramatically exceeds international trade. It means that there still exist sizable border effects between these two countries. Other researchers, such as Wei(1996), Helliwell(1998), Anderson and van Wincoop(2001), obtain significant values about the home bias by using different samples. Thus the border effect is defined as one of the six major puzzles in international macroeconomics by Obstfeld and Rogoff (2000).

In section 2, we assess the impact of the free trade agreement (FTA) by focusing on three microeconomic aspects, namely: (1) Canadian manufacturing, (2) inter-provincial trade, (3) labor market. The FTA/NAFTA have established a strong foundation for future economic growth. Despite that globalization and increasing economic integration in North America have caused great effects on bilateral trade of Canada and the United States, evidences show that national border still plays an

important role in determining trade patterns. So, in section 3, we analyze the economic importance of the Canada-US border, and review some empirical findings on border effects. We also introduce the gravity model and discuss the role of distance and currency on the border effect. In section 4, we simulate the tariff impact on bilateral trade flows between Canada and the U.S. by using a Computable General Equilibrium (CGE) Model. Section 5 gives some conclusions.

2 Impact of Free Trade on Canada

2.1 Overview

Canada's Prime Minister Mulroney and the United States president Reagan signed Canada-US Free Trade Agreement (FTA), which came into force on January 1, 1989. In order to further remove existing trade barriers, Canadian Prime Minister Mulroney, President Bush and Mexican President Salinas signed the famous North American Free Trade Agreement (NAFTA) on December 17, 1992. The purpose of NAFTA is to eliminate all restrictions on North American trade, especially on the goods, services and investment. It came into effect on January 1, 1994. So a huge and integrated market was created among the United States, Canada, and Mexico with about 400 million people, \$6.5 trillion worth of goods and services each year¹. This market is the world's largest free trade area, which is designed to improve trade and investment among the partners.

Nearly ten years have passed since the NAFTA came into effect, it is still generating lots of debates about its impacts on Canada. Supporters argue that the NAFTA has

¹ www.infoplease.com/cgi-bin/id/A0104566.html, North American Free Trade Agreement (NAFTA)

promoted the productivity and efficiency of Canadian businesses. Canada's trade with the United States has increased dramatically during these ten years. For instance, Canadian exports to the United States were 73 percent of total exports in 1988 (\$144 billion) and reached 79 percent in 1996 (\$281 billion). In 2000, Canada obtains about \$292 billions of total foreign direct investment (FDI). There is more than 64 percent of FDI coming from NAFTA countries².

On the other hand, some critics point out that Canada is experiencing firm closures and employment reduction. Aggregate economic indicators appear to show that the primary beneficiary of these agreements is U.S economy. For example, in the first seven years of the 1990s, the average income per capita in the US grew 14 percent, but average income per capita in Canada fell steadily at the same time (Sharpe, 2000). Canada's productivity gap with the United States has continued to widen in every major manufacturing industry since 1985 (Lee and Tang, 1998). The unemployment gap between Canada and United States began the early 1980s and has reached to the present 4 percent in 1998 (Statistic Canada, 1998). There seems to be evidences supporting both sides of the debate. So how to evaluate the net effect of the NAFTA? Aggregate indicators are insufficient for a complete evaluation of the NAFTA. We need to turn on a more microeconomic level analysis. The following sections offer three microeconomic assessments of the effects of the FTA/NAFTA's on the Canadian economy.

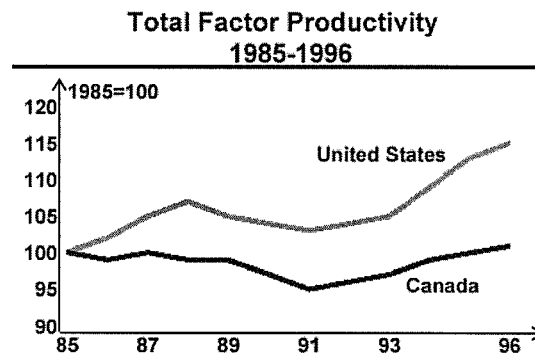
2.2 *Three Micro-Issues on the Impact of the FTA/NAFTA*

2.2.1 Canadian Manufacturing

² Department of Foreign Affairs and International Trade, Overview of the NAFTA

Head and Ries (1999) claim: "Canadian manufacturing employment fell by 326,000 jobs and, in 1995, remained 13 percent below its 1989 level. On the other hand, Canada's exports boomed during the post-FTA period, with trade rising sharply as a percentage of GDP."³

Whether trade liberalization really has brought benefits to the manufacturing sector in Canada or eventually hurt Canadian manufacturing? Compared with its large trading partner-the United States, Canada is a small open economy. Its total factor productivity (TFP) in manufacturing sector was almost flat from 1985 to 1996⁴. In contrast, the total factor productivity has increased about 15 percent in the United States (see Figure 1). Thus a widening of the Canada-U.S. productivity gap is generated by Canada's slower productivity growth.



Source: based on the data of Statistics Canada (1985-1996), Bureau of Labor Statistics

Figure 1. Total Factor Productivity (1985-1996)

Head and Ries (1999) investigate the impact of the Canada-United States FTA on North American manufacturing. They find that the average non-tariff barriers (NTBs)

³ Keith Head and John Ries, 1999, page 14

⁴ TFP assesses the efficiency of productivity when all factors of production are combined.

are between 27 percent and 45 percent on average in 1995. In many industries, they even exceed 80 percent. NTBs have been falling steadily, but in some industries, such as publishing, dairy, non-tariff barriers still have high NTBs. Thus they conclude that in North American markets, manufactured goods lack full integration, which limits the impact of tariff reductions on industrial sector. Lee and Tang (1998) find that Canadian manufacturing sector has accumulated capital in a slow process, which is why that the productivity gap of manufacturing between two countries becomes wider and wider. The productive gap increased from 22% in 1985 to 30% in 1993.

Under the NAFTA, the productivity gap between Canada and the US becomes wider, but there still exists benefits to reap for the firms. For instance, within this tariff free area, Canadian producers are able to obtain higher quality intermediate goods with lower price, and hence produce their final goods for export at a cheaper cost.

2.2.2 Inter-Provincial Trade

Theoretically, the import from the United States increases with the reduction of Canadian tariffs. Inter-provincial trade should decrease than before. However, US tariffs, which also declined under the free trade agreement, should lead to higher exports to the United States and therefore the reduction of US tariffs could stimulate inter-provincial trade.

In order to evaluate the exact size and significance of the FTA on inter-provincial trade, Helliwell, Lee and Messinger (1999) employ the gravity model⁵ to estimate inter-provincial and province-state trade flow. They find that interprovincial trade has been reduced by about 7 percent. Before the FTA was signed, the border effect,

⁵ Explained in section 3.4

defined as the ratio of inter-provincial trade of Canada to Canadian province-US states trade, was estimated to be 18, but it decreased to 12 between 1990 and 1993. It means inter-provincial trade remains twelve times stronger than the trade between Canada and the US. Although the authors show that north-south trade increases faster relative to east-west trade, interprovincial trade is still much stronger than provincial-state trade.

2.2.3 Labor Market

During the NAFTA period, exports to the United State have grown rapidly. The growth rate of imports from the U.S has been slower than the growth rate of exports. What does this mean for labor market? Employment in export industries increased to 28.3 percent of total business sector employment in 1997, which is about 9 percent higher than in 1989. There are about 870,700 jobs created by exports between 1989 and 1997, but 1,147,100 jobs were cut by imports during the same period (Dungan and Murphy, 1999). So the net effect is that 276,000 jobs were dropped.

The level of unemployment in Canada averaged 9.6 percent in the 1990s. This is greater than 5.8 percent average rate observed in the 1990s in the United States (Sharpe, 2000). Those statistics suggest that the economic integration and trade expansion may have had adverse employment effects in Canada under the NAFTA. Sharpe also finds that the labor productivity of the jobs displayed in the export sector is higher than in the import sector. In a long term, the whole economy should reap benefits from this.

The FTA and NAFTA are just like any other major policy changes. Some tradeoffs may occur as a result of the integration. There will be those who obtain more benefits

from the policy and those who benefit less or lose. What criteria should be used to judge the success of the new policy? It is the long-term effects of the policy that determines whether the policy is successful or not. The two agreements seek to promote free trade in services, goods and investments. These goals can be achieved not only by eliminating tariff and reducing non-tariff barriers, but also by introducing trade and investment related harmonization rules into the general agreement on trade. Despite that globalization and increasing economic integration in North America have caused great effects on bilateral trade of Canada and the United States, evidences show that Canadian internal economic and social structure remain much tighter than commonly imaged. National border still does matter and plays an important role in determining trade patterns.

3 Borders Effect

3.1 Economic Importance of the Canada-US Border

Canada and the United States have the world's longest undefended border. The United States is the biggest partner of Canada in international trade⁶. Today, nearly seventy percent of Canada's imports come from the U.S. and eighty five percent of Canada's exports go to the United States (see Figure 2).

⁶ See appendix 1.

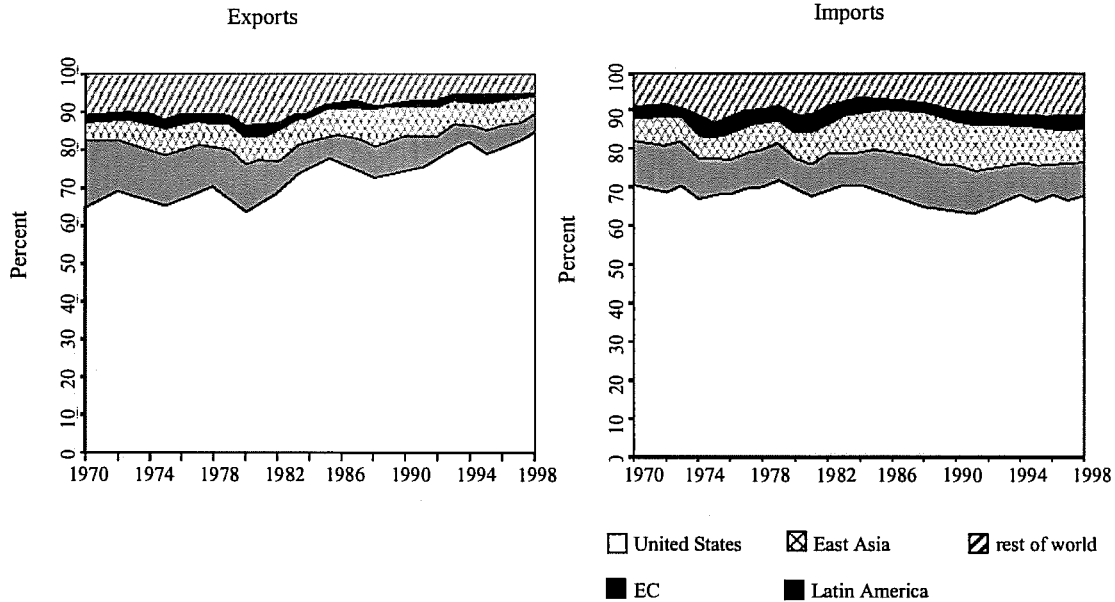


Figure 2. The Direction of Canada's Trade, 1970-98

Source: Safarian and Hejazi (2001)

In recent years, Canada's interests of removing barriers to deepen bilateral integration are much higher than in the past, since Canada believes in the existence of benefits from economic openness. As reported in the following box, the economic importance of the Canada-US border is crucial.

- 70 percent of Canada-US trade is transported by truck.
- Trucks made 11 million crossings in 2000.
- 1000,000 passenger vehicles cross the border every day.
- The Ambassador Bridge between Windsor and Detroit handles 7,000 trucks a day, 24 hours a day.
- 75 percent of bilateral trade in goods moves through one border crossing in British Columbia and four in Ontario.
- 85 border crossings are noncommercial.
- Eight of the top ten border crossings are either bridges or tunnels.
- 200 million individual crossings take place each year, averaging half a million a day.
- 15 million Canadians visit the United States for a day or more each year.

Box 1. Economic Importance of the Canada-US Border

Sources : Hart and Dymond (2001); and Wendy Dobson (2002).

Box 1 shows how important the Canada-US border is for economy. Vehicles, passengers, and goods cross border in a high frequency. For example, nearly thirty thousand trucks cross the border every day during year 2000. As seventy percent of Canada-US trade is transported by truck. However, international trade is vulnerable to security-related issues. After September 11, 2001, some vulnerable industries experienced larger drops in production and sale. For example, the airline industry in Canada and the U.S. has suffered serious drawbacks since September 11. Passenger demand has dramatically decreased. Only few airlines have performed well in recent months.

3.2 Deepen Integration between Canada and the U.S.

Canada faces the difficulty to convince the United States that both countries have the same goal in security for North American economy. Canadians wish to enter the US markets without losing political independence, and to find the best way to pursue deeper integration with the United States. However, some problems are impeding deeper integration between Canada and the US. Dobson (2002) discusses several reasons about the existing issues in deeper integration.

First, deeper integration may require labor mobility across borders. FTA and NAFTA, comparing with the European Common Market, do not much improve labor mobility. Harris (2001) claims that labor mobility would improve efficiency gains. Although for different reasons, Canada and US are not ready to move to a common market.

Second, Canada has a long history with a floating exchange rate. The Canadian dollar has floated more than forty years in the past fifty years. However, with the decline of Canadian currency against the US dollar through the 1990s, many now doubt that a

floating currency is a proper economic policy for Canada. As a separate currency implies certain transaction costs, some economists argue that “dollarization” is the best way to eliminate cross-border transaction costs with the United States. However, the exchange rate regime is not only an economic but also a political issue, and most Canadians are not willing to give up their dollars.

Finally, the differences between the US and Canada tax regime limit cross-border capital flows. For example, Canada levies a 15 percent withholding tax on dividends paid to US residents. These taxes reduce cross-border investment and the amount of capital available for investment to stimulate the Canadian economy. The experience of European Union (EU) also indicates that to abolish withholding taxes is important for integrating capital markets. For example, Mintz (2001) estimates that if Canada and US eliminated withholding taxes, it would cause an increase of capital investment of about \$28 billion annually to Canada.

Dobson (2002) suggests three ideas to solve those problems of deepen integration with Americans. The first one is a customs union. It means that the union establishes a common external tariff toward the other countries outside of the union, but eliminates these barriers among its members. A customs union between Canada and the U.S. would complicate North American unity under NAFTA. For example, there is no common tariff between Mexico and the US. If Mexico wants to enter a North American Customs Union, it has to end its free agreement with the European Union. But Mexico is unwilling to lose its benefits with the European Union. The second idea is a common market. It means the common area only can have a single market. A “common market” between Canada, the United States and Mexico would benefit all

three countries because it allow goods, people and capital flow freely. However, a common market is not so easy to create. European governments spent almost fifty years to build their common market. It began from the postwar years, but the formal common market was not established until 1992. The last one is called a strategic bargain. It means a pragmatic North American route. Canada should deepen the integration with the United States in exchange for a North-America security policy. In this way, deepening the NAFTA can become a pragmatic route.

The United States is paying much attention to homeland and military security. The border could undermine Canada's economy if it is a major barrier between the two countries. Canadian government plays an important role in reducing the impact of border security on trade and at the same time deepening integration with the US and Mexico. Before taking any new policy initiative, it is important to know the degree of integration between Canada and the United States and the value of border effects. A large body of empirical research has been attempted to measure the size of border effects and analyze the reasons about the sizable border effects.

3.3 Empirical Findings on Border Effects

3.3.1 Border Effects inside Canada and U.S.

The formal trade barriers between Canada and the U.S. are low and declining in recent years, especially since the introduction of the two free trade agreements. Goods and capital are supposed to flow freely across the border. Meanwhile, differences in culture, social and economic structure, also appear small in the two countries. In recent years, many economists have been interested in estimating the degree of integration between the two countries. They compare the volume of trade within a

country to the volume of cross-border trade. A surprising result is found that intra-national trade dramatically exceeds by far international trade. It means that there still exist sizable border effects between these two countries.

There are several major puzzles in international macroeconomics. The border effect is defined as one of the six major puzzles by Obstfeld and Rogoff (2000). Researchers obtain different values about the home bias by using different samples and they are surprisingly larger than people would expect. Why do people seem to have such a strong preference to consume their domestic goods? The studies on this puzzle have become very active in recent years.

Although globalization was believed to have dramatically diminished the importance of national borders and distance, both still have surprisingly large and continuing effect on the international trade. McCallum (1995) analyzes trade flow between Canadian provinces and US states. He finds a surprising outcome. Even after controlling the impact of country size and bilateral distance, border effect on US-Canadian trade is still extremely large in 1988. Trade between Canadian provinces is more than twenty times greater than trade between Canadian provinces and American states. The trade volumes are sharply reduced by borders between the two countries.

To better understand this finding, let us take the following example. The distance from Ontario to British Columbia is equal to the distance from Ontario to California. The trade flows between Ontario and British Columbia are larger than trade flows between Ontario and California. The gap is about two times. However, the economic scale of Californian, such as GDP and population, is about ten times larger than those

of British Columbia. Thus the trade flows between Ontario and British Columbia is about twenty times larger than people would be expected. Notice that McCallum got his results by using some data before 1989. At that time the Canada-U.S. Free Trade Agreement was not signed. Because the free trade agreement promotes the Canada-US trade, the results from the subsequent literature show that the border effect is smaller than that of McCallum's. However, McCallum's results still suggest that the extent of globalization is much less than commonly supposed. The intra-national trade is significantly greater than international trade flows.

In recent years, the border effect between Canada and the U.S has been estimated in many occasions. Helliwell and Verdier (2001) estimate that the border effect between Canada and the U.S. dropped from 14.7 in 1991 to 10.2 in 1996. Anderson and Van Wincoop (2001a) evaluate the border effect for Canada with deeper theoretical foundation by using 1993's data. They find that the trade between Canada and the United States only increases 44 percent when the border effect is removed. At the same time, the density of interprovincial trade flows increase by a factor 6 times.

Another valuable finding by Anderson and van Wincoop (2001b) is that there exists an opposite movement between country size and border effect. The border effect of small countries is greater than that of large countries. For example, the population and economy of New York and Texas are not far behind Canada's. California even exceeds Canada in population and output⁷. Thus unlike their Canadian partners, American sellers do not have to search much to expand their markets. Anderson and

⁷ http://www.bts.gov/publications/north_american_trade_and_travel_trends/tables/table_1.html
<http://www.rir.utoronto.ca/report/pdfs/introduction.pdf>

Van Wincoop (2001b) claim that a large home bias in trade for a small country such as Canada may be caused by relatively small trade barriers.

Engel (2001) uses a good example to explain the size effect. It is similar to the example of Anderson and van Wincoop (2001a). Suppose these are only two countries in the world economy. Canada is the smaller one with 10 equal-sized provinces, and the United States is the larger one comprising 50 equal-size states. The province and state are called region in the example. All regions have the same GDP. The numbers of provinces or states do not matter. However, the relative size of the two countries measured by total GDP is very important to test the size effect. Now assume that $1/60$ of output in each region will be consumed by itself and $59/60$ is exported under free trade (borderless trade). It means that total consumption of each region is 1, out of which $1/60$ comes from itself and $59/60$ comes from other regions (provinces or states). So each region in Canada or the United States exports $1/60$ of its output to each one of the other 59 regions.

Now, the total goods in each region are supposed to be 60 units. From the above paragraph, it can be derived each Canadian province exports 9 units to other Canadian provinces, and 50 units to the US states. Assume that a barrier between Canada and the United States reduces Canadian exports to the US by fifty percent. It means that Canada exports 25 units less to the United States. Then consumers of the 10 Canadian provinces would consume the rest 35 ($25+9+1$) units. So each Canadian region will obtain 3.5 ($35/10$) units from each other Canadian regions. On the other hand, there are only 0.5 ($25/50$) units exported to a US region. This shows that even a modest reduction in international trade can lead to a significant trade increase within a small

country, such as Canada. The ratio of trade between Canadian regions to the trade between a Canadian region and a US region is 7(3.5/0.5). On the other side, by using the same approach, the trade between states is about two times greater than the trade between a state and a province.

Anderson and van Wincoop (2001a) solution to the home bias puzzle implies that a relatively small trade barrier can generate a large difference in trade flows between Canada and the United States. On the contrary, this is not the case for the U.S. states. They explain clearly the link between border effect and country economic size. A modest trade barrier for a small country like Canada could increase the transaction cost for both national and international trade, but for a large country like the United States the transaction cost will not increase as much in inter-states trade. However, Coulombe (2003) argues that Anderson and van Wincoop do not take into account distance when they evaluate border effect on economic size. He emphasizes that distance is also an extremely important variable in a gravity model. Coulombe extends the time-series dimension of the border effect. He uses the data of the ten provinces in the 1981-2001 and finds that border effect declines during this period.

Brown (2002) finds that intraprovincial trade flows is six times the trade between provinces and states when controlling for the distance between provinces and states and the economic sizes between them. Hence, by taking into consideration economic size and distance, border effects are reduced substantially. He employs trade data on Canada provinces and US states for 1993.

3.3.2 Border Effect outside Canada and the U.S.

Because intra-country trade data are available only for Canada and the US, most of the available literature about the border effect is about these countries. Attempting to estimate border effects for other countries is not easy since people lack the sub-national trade and distance data. Wei (1996) employs an indirect method to test border effect for Organization for Economic Co-Operation and Development (OECD) country pairs. He uses domestic output to subtract aggregate exports and gets a country's trade with itself without using the trade data on sub-national units. Then he adds a dummy variable and interprets its coefficient as the effects of crossing a border. Wei's estimate could be dramatically reduced due to the effect of common language and distance. The smallest number he got is 2.6. On average, Wei's estimates of the border coefficient are under 10 when he takes the 1982-1994's data in OECD countries. So comparing with McCallum case, Wei's estimate is in a more modest range for the border effect. However, Wei defines one-quarter of the distance from the center of a country to the center of its nearest trading companion as the internal trade distances. Subsequent studies find that his measurement of distance is underestimated because of the definition of internal trade distances. Thus later studies give larger estimates of border effects than Wei's. Helliwell (1998) argues that the border effect is about 10 or more for OECD countries.

Head and Mayer (2000) analyze the border effects on the European Union. They estimate border effects for industries in the European Union by using the monopolistic competition model, and found that the border effect was 20.9 in the end of 1970s. It

fell to 12.68 because the Single European Act (SEA) was completed in 1993-1995.

The following figure illustrates the changes in the border effect from 1976-1995.

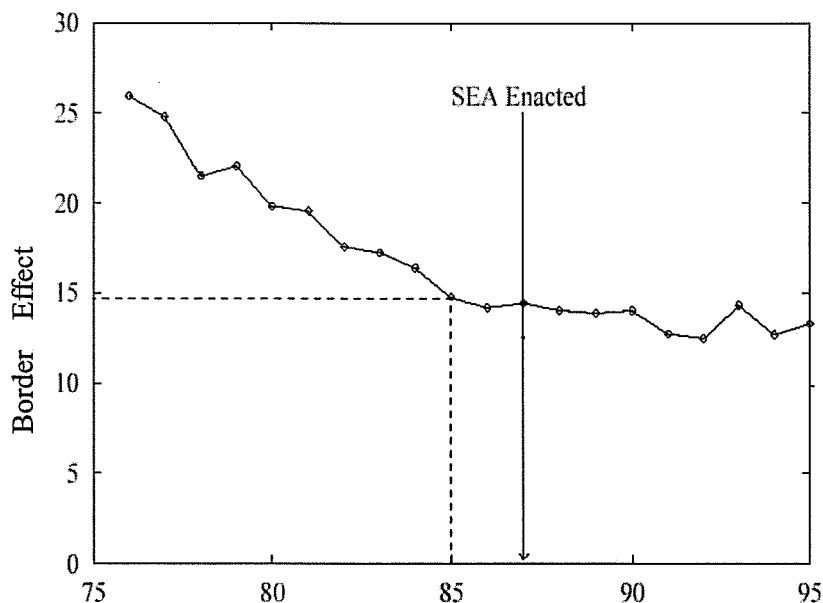


Figure 4. Changes in the border effect 1976-1995

Source: Head and Mayer (2000)

The above figure indicates that the border effect is about 14 for European in 1985. It means that trade flows within European Union is fourteen times larger than trade flows outside Union with controlling the distance effect. If comparing to McCallum's strike finding, the border effect in the European Union is small, but still significant.

Helliwell (1998) shows that the border effect of the services sector is 2 or 3 times higher than that of goods sector. Services is mostly considered a non-traded good sector, intensive in labor. Labor is generally mobile across sectors but not across countries. Thus the sector of services has higher border effects. Even though border effect is higher in services sector, it also gradually decreases. The volume of border

effect on services is changed from 42 to 29 in the period 1988-1996 for OECD countries. In addition, Helliwell also finds that rich countries have smaller border effects than poor countries. This result is consistent with the finding of Frankel and Rose (1998): richer countries are more open to trade.

Overall, the empirical findings show sizable border effects. The lack of integration may impede the Canadian and the U.S. economies to perform better. The border effect is still a major puzzle in international trade and the various estimates, though all significant, vary greatly. We now turn to the methodology used to estimate border effects.

3.4 Gravity Model

The intuition for the gravity model is based on the Newtonian equation. The gravitational attraction between two objects depends inversely with the distance between them and positively on their respective masses. Tinbergen (1962) is the first to apply the gravity model to international trade. He takes advantage of the property of the Newtonian equation on the gravity model. Two important conclusions can be drawn from the gravity model. First, the trade between two distant regions will be less than the trade between two nearby regions. Second, the trade between two small regions will be less than the trade between two large regions.

In order to estimate the border effect, many economists employ the gravity model. It has been widely used to explain bilateral trade flows, and trade flows associated with national border, currency union, and transportation. It also explicitly takes into

account the costs of distance. The empirical success of gravity model has made it popular.

The basic form of the gravity model used by Tinbergen (1962), derived from the multiplicative version of the gravity model shown in Equation (1), is a linear logarithms equation. The bilateral version of the gravity model, as shown in Equation (2), has successfully explained trade flows.

$$S_{ij} = (A Y_i^{\alpha_1} Y_j^{\alpha_2} \exp(\alpha_4 B)) / \text{DIST}_{ij}^{\alpha_3} \quad (1)$$

$$\ln S_{ij} = \alpha_0 + \alpha_1 \ln Y_i + \alpha_2 \ln Y_j - \alpha_3 \ln(\text{DIST}_{ij}) + \alpha_4 B + \varepsilon_{ij} \quad (2)$$

where S_{ij} is some measure of trade flows between country i and country j . Y_i and Y_j are the *GDP* of i and j , DIST_{ij} is the distance between them, B is a dummy variable that possesses some characteristics that economists want to assess. For example, McCallum employs the value 1 for inter-provincial trade and the value 0 for province-state trade. ε_{ij} is a random error term usually taken to be normally distributed.

The elasticity of trade volume related to the dummy variable could be used to estimate the border effect. The inverse log of the dummy coefficient is estimated in a simple log-linear OLS gravity regression. It is equal to the gravity adjusted ratio of domestic to international trade. For example, if the dummy coefficient is equal to 2.32, then the trade between two provinces in Canada is 10 times larger than the trade between a province and a state [$\text{Exp}(2.32) = 10.2$]. So 10.2 could be the approximation value for border effects. McCallum (1995) uses this method to estimate the border effect

between Canada and the United States. In the multiplicative form, trade flows should be weighted by the reverse of GDP and multiplied by the exponent of distance. The border effect becomes the ratio of intra-provincial weighted trade to cross-border weighted trade.

Anderson and Van Wincoop (2001a) argue that the ratio of weighted trade of interstate to U.S. cross-border weighted trade is smaller than the ratio of interprovincial weighted trade to Canadian cross-border weighted trade. It obviously means that the border does not have the same effect on Canada as on the United States. How to measure the border effect does matter. The size of border effects is dramatically affected by the choice of methods and data. In their paper, the border effect is 16.4 when Canadian interprovincial trade data are employed. However, the border effect is only 1.6 using the interstate trade data.

3.4.1 Special Gravity Model for Canada-US Trade

In order to estimate the border effect of Canada-U.S., Wall (2000) uses a standard gravity model. It is very similar to the equation (2):

$$\ln(1+x_{mnp}) = \alpha + \beta_1 \ln Y_{mp} + \beta_2 \ln Y_{np} + \delta \ln D_{mn} + \gamma B_{mn} + \varepsilon_{mnp}, \quad (3)$$

where the export from location m to location n in year p is denoted by x_{mnp} , the income of m in year p is denoted by Y_{mp} , the income of n in year p is denoted by Y_{np} , D_{mn} is the distance between two locations, the dummy variables B_{mn} represents the Canada-U.S. border. Notice that equation allows the inclusion of observations for zero volume exports from one location to another ($x_{mnp} = 0$).

The standard gravity model assumes that the intercept (α) and slope coefficients are homogeneous for all trade partners. However, in reality, the intercept and slope coefficients are associated with locations. Cheng and Wall (1999) show that the trade flows tend to be biased by using the standard gravity model. They recommend a heterogeneous gravity model to deal with some fixed factors that are linked with the border dummies and with trade flows. The following equation represents an heterogeneous gravity model:

$$\ln(1+x_{mnp}) = \alpha_{mn} + \beta_{1mn} \ln Y_{mp} + \beta_{2mn} \ln Y_{np} + \delta_{mn} \ln D_{mn} + \gamma_{mn} B_{mn} + \varepsilon_{mnp} \quad (4)$$

We notice that α_{mn} and slope coefficients are different from those in equation (3). For example, α_{mn} is the trading-pair intercept. In a heterogeneous gravity model, α_{mn} can capture some factors that may affect the volume of trade, such as custom, economy and geography. So if two states have equal GDP and same distance with a province, it is still possible for a province to obtain different trade amounts with the two states.

Wall (2000) finds, however, that using a heterogeneous gravity model does not change the general results for border effect. The Canada-U.S. border still has a reduction effect on the volume of Canada-U.S trade. For example, a home bias ratio is 21.6 when Wall employs the heterogeneous model.

3.4.2 Impact of the Distance on Border Effect

Distance is a natural cost for international trade. It separates the markets and makes consumers, producers, and investors to seriously consider local options before making a decision. Distance may play an important role in the assessment of the border effect. Wei (1996) points out that the method of calculating a country's distance will significantly affects the volume of the border effects.

Most papers about border effect use point-to-point methods to measure external and internal distances. The distances between countries are calculated by using the distance between the country centers. Researchers like to choose the capitals or largest cities as the centers to calculate the border effect. For example, Toronto and New York City are usually chosen as such centers to estimate the trade flow. If the countries are small or the economic activity mostly occurs around the centers, then the choices of as centers are not important.

The distance of trade includes the external distance across borders and internal distance within a country. Both of them are important to estimate the border effect. However, most existing measurements of internal distance are overestimated compared with international distance. Why the internal distance is always overestimated? In many situations, the goods only need transport for a short distance within a country, but the distance between consumer and producers is calculated by using average distance. As a consequence of overestimating the internal distance, the border effect is inflated.

The external and internal distances are not the same within Canada and the United States. Helliwell (1998) estimates separate distance coefficients for intra-national and

inter-national linkages, and then tests for equality. He shows that the average distance between Canadian provinces is 7 percent larger than the average distance between Canadian provinces and the U.S. states. Given this difference, the distance used for econometrics estimation should not be the same.

There exist several different methods to calculate the internal distance. At the beginning, economists employ fractions of distances to the centers of trading partner as the internal distance. For instance, Wei (1996) and Wolf (1997) use this method to calculate within-unit distance. The subsequent researchers, Leamer (1997) and Nitsch (2000), try to employ area-based measures to calculate the mean internal distance. They assume that the shape of a country is a disk. However, the above methods only consider the geometric factor on the distance. Head and Mayer (2000) combine geometric factor with the economic factor. They weight the distance by using GDP shares and average over all interregion distances within a country. Country P 's distance to itself is defined by:

$$d_{ii} = \sum_{j=1}^R w_j \left(\sum_{k=1}^R w_k d_{jk} \right) , \quad (5)$$

where R denotes the number of regions and W_j denotes the GDP shares. They argue that the above measures about the distance all use average distance between internal trading partners, but the average distances are not precise enough.

Since the average distance is not an appropriate method, Head and Mayer try to develop an “effective distance” to measure the internal distance. They divide a state

into some districts. The “effective distance” between two states is defined as the sum of trade, which is a function of district-to-district distances. The following equation satisfies this definition of effective distance:

$$d_{ij} = \left(\sum_{k \in i} (y_k / y_i) \sum_{l \in j} (y_l / y_j) d_{kl}^\theta \right)^{1/\theta}, \quad (6)$$

where y variable defines the total income, k represents exporting district, l represents importing district, and θ is a parameter. By using the data on interstate trade flows in the US and trade flows of members of the EU, Head and Mayer find that the estimated border effects with “effective distance” measurement is smaller than with average distance measurement. If two nations are closer to each other, then overestimating internal distances causes inflated distance effect between the two countries. Canada and the United States are very close and separated just by a political border. The effect of overestimating distance is strong. Despite this, the border effect cannot be eliminated.

Combes, Lafourcade and Mayer (2003) illustrate the effects of distance and borders on trade in one figure. In figure 3, the circle points represent the external gravity. It means that the trade flows occur between countries. The triangles points represent the internal gravity. They use two different sample data sets, which are bilateral trade flows between and within US states in 1997 and between and within European countries in 1993, as shown in Figure 3, 4.

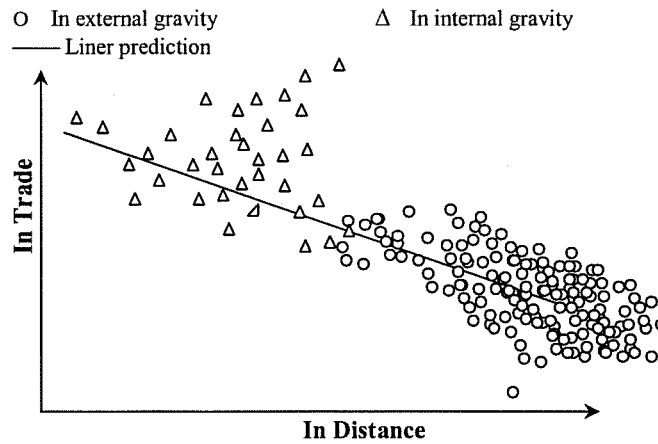


Figure 3. Distance and Borders in Trade in US

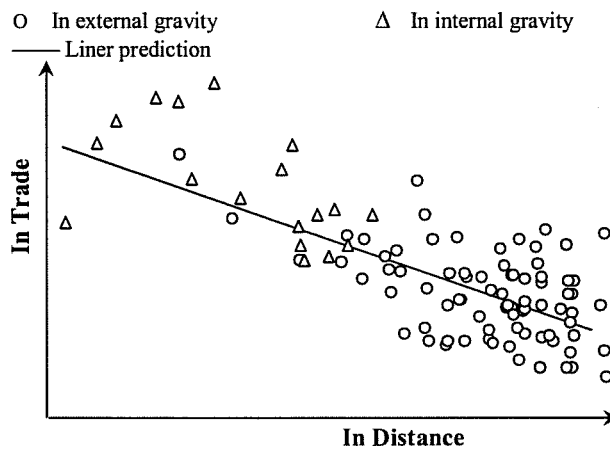


Figure 4. Distance and Borders in Trade in EU

Source: Combes, Lafourcade and Mayer (2003)

From above figures, we notice that the further the distance, the smaller is the volume of trade. Also, the trade flow of external gravity is smaller than that of the internal gravity. For example, Mackay (1958) find that the long distance telephone calls between cities in Ontario, Quebec and the United States have very different frequency. He shows that calls within the province have the highest volume, and the calls within cities with different languages have lower volume. The call frequencies between

Quebec and Toronto are lower than the call between Ottawa and Toronto. Obviously, the call frequencies are the lowest across the international boundary.

What would happen if the Canada-United States border did not exist? Distance would be the only major factor to cause a difference between external trade flows and internal trade flows in this situation.

3.4.3 Impact of Currency on Border Effect

Different countries use different currencies. So if transactions occur within a country, both producers and consumers achieve the benefits from the use of a common currency since the costs associated with buying and selling products are much lower. However, most international trade involves an exchange of currencies, which implies that the transactions costs are higher for international transactions.

Some economists propose to establish the optimum currency area (OCA) in North American. It means to establish a single official currency rather than multiple official currencies. However, there are some advantages and disadvantages in adopting a common currency. For example, in a common currency area, the costs of currency exchange decline. Governments do not need worry about the risks associated with exchange devaluations or fluctuations, but a country could not use its own monetary policy for macroeconomic adjustments.

National currency is a type of political border barrier. Border effects may be caused by some policies that are built for international trade. Some policies such as tariffs or quotas are easy to calculate and can create rents for governments. However, it is

impossible for all border barriers to create rents. For example, different languages, or product standards may affect the volume of the border effect. Obviously, no rents are generated. Part of the existing border effects is likely due to the presence of currency differences. It is hard to separate the effects of national currencies from the effect of other political borders because currency boundaries and political boundaries usually co-exist.

Removing the non-rent barriers is likely to create economic welfare gains. However, it is not easy to reduce or eliminate non-rent barriers by policy choices. Anderson and van Wincoop (2001b) employ currency to measure the size of the non-rent barriers. The table below explains the impact of Currency Unions on trade and welfare.

Table 1. Impact of Currency Unions on Trade and Welfare

	% Trade Increase	% Welfare Increase
EMU for current 12 members	59	11.1
EMU for all 15 EU members	40	14.4
Argentina dollarizes	132	3.3(Argentina)
Mexico dollarizes	53	24.3(Mexico)
Canada dollarizes	38	29.7(Canada)
World monetary union	10	21.3

Source: Rose and van Wincoop (2001, Table 3)

We can see the table that larger a currency union is, larger is the effect on welfare, but smaller is the effect on trade. Also, if dollarization is implemented, the countries that have more trade flows with the US will have less increase in trade, but more increase in welfare. For example, Canada's trade flows with the US are more than that of Argentina. Thus Canada's trade increase with the US is only 38 percent, while Argentina's is 132 percent. On the other hand, the welfare increase (29.7%) in Canada is expected to be 9 times higher than the welfare increase (3.3%) in Argentina.

Common-currency promotes the trade flows among countries. Rose (2001) finds that the trade among the sample common-currency countries is three times higher than that in other countries by using bilateral trade flows among 186 countries, even controlling the effects of income, distance and size among nations.

3.5 The Possible Explanations for Home Bias in Canada-U.S. Trade

Canada and the United States share a common border, the same language and similar cultures. Canada-US Free Trade Agreement and the NAFTA promote the bilateral trade between the two countries. So it is easy to believe that Canada and the United States are greatly integrated and the borders should no longer cause major barriers to bilateral trade. However, the above empirical studies find that intranational trade exceeded international trade. The degree of “home bias” is surprisingly higher than expected. So how can we explain the reasons that cause the large home bias? Hillberry (2000) suggests some potential explanations for the home bias trade puzzle.

The first explanation is that consumers prefer to purchase domestic goods. For the goods produced locally, people may have a greater preference since they are more familiar with domestic goods. This increases demands for these goods. The large border and distance effects may reflect the fact that local products are good substitutes for those coming from foreign countries.

The second explanation is the international trade theory of comparative advantage. As stated by Suranovic (1997), comparative advantage can be defined as “if a foreign

country can supply us with a commodity cheaper than we ourselves can make it, better buy it of them with some part of the product of our own industry, employed in a way in which we have some advantage.” For example, the border’s effect is small for the paper products, lumber and wood products sectors. Canada has a strong comparative advantage on these sectors. On the other hand, the border effect is strong in food products, textiles and apparel sectors (Brown, 2002). However, both Canada and the United States are developed countries and produce similar goods. The price would change significantly because of small border-related trade costs like transportation costs. Consumers are more likely to switch from imports to domestic producers when imports goods are expensive. Comparative advantage explanation has considerable appeal since it is based on the international theory. However, the problem is that economists could not find empirical support for this interpretation.

The third explanation for home bias is that the border induces changes in the composition of trade. It means that some geographic barriers like borders cause the composition of trade to change. For example, software development industry is prosperous in India. Canada can produce its own software products, but importation from India may a good way to reduce the cost.

The fourth explanation is that economists have greatly underestimated the real costs associated with cross-border trade. In recent years, many visible costs of international trade have been removed, but a large number of unobservable costs still remain, such as the costs associated with using foreign currencies as discussed above. The sum of these unobservable costs may become important sources of home bias.

3.6 Policy Implications for Canada

The empirical studies on the Canada-US border effect shows that the border has surprisingly large and persisting effects on the economy. Thus a better understanding of the impact of national borders on trade and welfare is extremely important for policymakers.

More recent work has attempted to answer the key policy-related questions. For example, why a border barrier has a much larger effect on Canadian economy than on the U.S. economy? What would be the consequences of border removal? In order to analyze the welfare effect of border, Anderson and van Wincoop (2001 b) simulate the removal of border effects on a bilateral or multilateral basis by using comparative statics method. They argue that Canadian welfare will increase by more than 50 percent if the border barriers were absent, while welfare will increase only by 6 percent in US. The results are consistent with the theory that a larger country relies less on international trade, thus a larger country such as the United States has smaller welfare effect. Meanwhile, they argue that if the border barriers were removed, the trade between Canada and the United States would increase by 79 percent. The trade among twenty other OECD countries would rise by 41 percent on average⁸.

Although the policy barriers on formal trade are significantly reduced in recent years, the policies affected by borders are still costly. If Canada and the United States deepen integration, both of them can get benefits. Small countries such as Canada may have much more to gain from integration than large countries such as the US.

⁸ Anderson and van Wincoop (2001b), table 2

However, taking a more global perspective, North America is only a small share of the world economy. So if Canada only focuses on deepening integration with the United States, it will affect the independence of Canada and the trade with other countries in the world. In order to investigate such issues as border effects, we use a computable general equilibrium approach in the next section.

4 The Analysis of Tariff Impact on Border Effect by CGE Model

There are two methods to evaluate the effects of border barriers: gravity and computable general equilibrium models. Although the gravity model is useful to measure potential bilateral trade flows, it gives us little about the theoretical causes of trade. Anderson and van Wincoop (2001a, page 1) argue:

“The lack of theoretical foundation of empirical gravity equations has two important implications. First, estimation results are biased due to omitted variables. Second, and perhaps even more important, one cannot conduct comparative statics exercises, even though this is generally the purpose of estimating gravity equations.”

On the contrary, computable general equilibrium (CGE) models are based on strong microeconomic foundations and are useful for policy analysis. As such, this model is used to investigate border effects. To be more precise in following, we use a CGE model to investigate the sensitivity of trade flows to tariff reductions.

In this section, we simulate the tariff reduction effects on Canada, the United States and rest-of-the world. An alteration in tariff rates could cause a series of changes in

many aspects, such as domestic price of imported goods, the demand for domestic goods and foreign goods. By evaluating the economic impacts of tariff reduction on the home country and foreign country. We obtain changes in domestic and international trade flows that may indirectly measure the level of home bias involved in the FTA.

The model we use is a multi-sector, multi-country, computable general equilibrium (CGE) model with perfect competition⁹. It includes preferences, technologies and the full equilibrium conditions for all the countries involved in the analysis. First, we postulate that household of a country i maximizes a Cobb-Douglas utility function, subject to its budget constraint. Notice, it is assumed that tariff revenues are rebated in a lump-sum manner to households. The household in each country determines how much money it wants to spend on consumption and investment. By calculating the first order conditions, the utility function can be maximized and the household can obtain the optimal consumption and investment. Once consumption has been determined, the household has to decide which good and from which origin he wants that good coming. A nest CES (Constant Elasticity of Substitution) utility function permits the derivation of the various solutions of the household problem in separated steps.

Second, we assume that the firm is under perfect competition. The firm's problem is to maximize its profit. The first-order condition to this problem is when the price is equal to the marginal cost. So the profit maximization problem can change to the cost

⁹ The model has been developed by Claude Lavoie, Marcel Mérette, and Mokhtar Souissi (2001).

minimization problem subject to a Cobb-Douglas condition (production level). By some substitutions, we finally get the optimal demand function for the firm.

Finally, the equilibrium conditions close the model. In Equilibrium, supply equals demand in each market. We notice that the balance of payments is always in equilibrium. Since our model is a multi-country model, any changes in other countries will generate changes in import and export of home country. The detailed description about the CGE model can be found in Appendices 2, 3, 4, 5.

In order to provide a better understanding of the model and explain our results on international trade, we do a series of fictive simulation exercises by using the General Algebraic Modeling System (GAMS) software to solve the CGE model. We assume that there are three regions in the model, namely: (1) Canada, (2) the United State, (3) Rest of the world; and three sectors, namely: (1) agriculture, (2) manufacture, (3) services. Services are considered a non-tradable sector. The initial values of all variables are normalized to “one”. This will facilitate the interpretation of the reduction of tariffs.

Table 2. Impact of tariff reduce by 10% on bilateral export flows

Export Country	Import Country: Sector	Export Flows						
		MANUF and AGRIC Sectors					Tariff cuts 10% for MANUF goods by CA and US	Tariff cuts 10% for AGRIC goods by CA and US
		Original tariff	Tariff cuts 10% everywhere	Tariff cuts 10% by CA	Tariff cuts 10% by US	Tariff cuts 10% by CA and US		
CA	CA. A	1.000	0.964	0.989	0.990	0.979	0.998	0.981
	CA. M	1.000	0.964	0.989	0.990	0.979	0.981	0.998
	CA. S	1.000	0.998	0.998	1.001	1.000	1.000	1.000
	US. A	1.000	1.048	1.021	1.043	1.064	0.998	1.067
	US. M	1.000	1.048	1.021	1.043	1.064	1.067	0.998
	US. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	RW. A	1.000	1.048	1.011	0.980	0.991	0.995	0.995
	RW. M	1.000	1.048	1.011	0.980	0.991	0.995	0.995
	RW. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000
US	CA. A	1.000	1.048	1.043	1.021	1.064	0.998	1.067
	CA. M	1.000	1.048	1.043	1.021	1.064	1.067	0.998
	CA. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	US. A	1.000	0.964	0.990	0.989	0.979	0.998	0.981
	US. M	1.000	0.964	0.990	0.989	0.979	0.981	0.998
	US. S	1.000	0.998	1.001	0.998	1.000	1.000	1.000
	RW. A	1.000	1.048	0.980	1.011	0.991	0.995	0.995
	RW. M	1.000	1.048	0.980	1.011	0.991	0.995	0.995
	RW. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000
RW	CA. A	1.000	1.048	0.981	1.013	0.994	1.005	0.988
	CA. M	1.000	1.048	0.981	1.013	0.994	0.988	1.005
	CA. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	US. A	1.000	1.048	1.013	0.981	0.994	1.005	0.988
	US. M	1.000	1.048	1.013	0.981	0.994	0.988	1.005
	US. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	RW. A	1.000	0.964	1.003	1.003	1.006	1.003	1.003
	RW. M	1.000	0.964	1.003	1.003	1.006	1.003	1.003
	RW. S	1.000	0.998	1.000	1.000	0.999	1.000	1.000

Note: CA: Canada, US: the United States, RW: rest of the world.

A: agriculture, M: manufacture, S: service

Table 2 summarizes the impacts of tariff reduction on bilateral export flows. We assume that the original tariff is twenty percent everywhere. When tariff is reduced by

ten percent, the price paid by home countries for imported goods falls. As a result, the demand for the foreign agriculture and manufacture goods increases than before. It follows that the demand for home country goods in the two sectors falls relatively. Therefore, all domestic trade flows decrease in agriculture and manufacture sectors, and all international trade flows increase in these two sectors. However, the tariff reduction does not affect the service sector since the service belongs to the non-tradable sector. This can be seen by comparing column 4 with column 3 of the table. When tariff is decreased by ten percent everywhere, the interprovincial trade flows of agriculture and manufacture sectors in Canada decrease, from 1 to 0.964 (3.6 percent). However, Canadian export flows to the U.S. and rest of the world increase from 1 to 1.048 (4.8 percent). Similarly, the U.S. and rest-of-the world have the same changes as Canada. No matter how the tariff changes, almost all values for the services sector remain equal to one. The decrease degree in demand for home country goods depends on how large the tariff reduction is and on the value of substitution elasticities between goods from different regions.

Table 3. Impact of tariff reduction on income

Country	Income						
	MANUF and AGRIC Sectors					Tariff cuts 10% for MANUF goods by CA and US	Tariff cuts 10% for AGRIC goods by CA and US
	Original tariff	Tariff cuts 10% everywhere	Tariff cuts 10% by CA	Tariff cuts 10% by US	Tariff cuts 10% by CA and US		
CA	1.000	1.009	1.002	1.012	1.014	1.008	1.006
US	1.000	1.009	1.011	1.003	1.014	1.008	1.006
RW	1.000	1.009	1.005	1.006	1.012	1.005	1.005

Table 3 shows that income rise in all regions with the tariff reduction. A change in income causes a change in the demand for a good or service. If the income increases, the demand for a good or service also increases. The results are consistent with the results of table 4. The price of output increases in all regions because of the demand pressure. The tariff creates a linkage between the import price and export price. There are other effects of tariff reduction on intermediate prices, GDP and gross output. Interested readers can consult Appendix 6 for the details.

Table 4. Impact of tariff reduction on price of output

Import Country. Sector	Price of output						
	MANUF and AGRIC Sectors					Tariff cuts 10% for MANUF goods by CA and US	Tariff cuts 10% for AGRIC goods by CA and US
	Original tariff	Tariff cuts 10% everywhere	Tariff cuts 10% by CA	Tariff cuts 10% by US	Tariff cuts 10% by CA and US		
CA. A	1.000	1.011	1.004	1.011	1.015	1.005	1.006
CA. M	1.000	1.011	1.004	1.011	1.015	1.005	1.006
CA. S	1.000	1.011	1.004	1.011	1.015	1.005	1.006
US. A	1.000	1.011	1.010	1.005	1.015	1.008	1.006
US. M	1.000	1.011	1.010	1.005	1.015	1.008	1.006
US. S	1.000	1.011	1.010	1.005	1.015	1.008	1.006
RW. A	1.000	1.011	1.005	1.007	1.012	1.006	1.005
RW. M	1.000	1.011	1.005	1.007	1.012	1.006	1.005
RW. S	1.000	1.011	1.005	1.007	1.012	1.006	1.005

Table 5 indicates that exports grow when tariff reduction increases from 10 percent to 40 percent, and to 80 percent. For example, when tariff cut for MANUF and AGRIC goods by CA and US increases from 10 to 80 percent, Canadian exports to the U.S. increase from 1.064 to 1.633. Meanwhile, its domestic trade flows decrease from 0.979 to 0.800. Thus, under a free trade agreement, international trade increases in both countries. When tariff cuts reach 80 percent, Canadian domestic trade decreases

by 20 percent in manufacture and agriculture sectors, whereas exports rise about 63 percent in the same sectors. Canadian trade with rest of world decreases by 10 percent.

Table 5. Impact of the change of tariff reduction on bilateral export

Export Country	Import Country: Sector	Bilateral Export								
		MANUF and AGRIC Sectors						Tariff cuts for MANUF goods by CA and US		
		Tariff cuts everywhere			Tariff cuts for MANUF and AGRIC goods by CA and US					
		10%	40%	80%	10%	40%	80%	10%	40%	80%
CA	CA. A	0.964	0.851	0.696	0.979	0.908	0.800	0.998	0.990	0.974
	CA. M	0.964	0.851	0.696	0.979	0.908	0.800	0.981	0.918	0.819
	CA. S	0.998	0.990	0.971	1.000	0.996	0.987	1.000	0.998	0.993
	US. A	1.048	1.200	1.420	1.064	1.282	1.633	0.998	0.990	0.974
	US. M	1.048	1.200	1.420	1.064	1.282	1.633	1.067	1.295	1.673
	US. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	RW. A	1.048	1.200	1.420	0.991	0.959	0.906	0.995	0.979	0.953
	RW. M	1.048	1.200	1.420	0.991	0.959	0.906	0.995	0.979	0.953
	RW. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
US	CA. A	1.048	1.200	1.420	1.064	1.282	1.633	0.998	0.990	0.974
	CA. M	1.048	1.200	1.420	1.064	1.282	1.633	1.067	1.295	1.673
	CA. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	US. A	0.964	0.851	0.696	0.979	0.908	0.800	0.998	0.990	0.974
	US. M	0.964	0.851	0.696	0.979	0.908	0.800	0.981	0.918	0.819
	US. S	0.998	0.990	0.971	1.000	0.996	0.987	1.000	0.998	0.993
	RW. A	1.048	1.200	1.420	0.991	0.995	0.906	0.995	0.979	0.953
	RW. M	1.048	1.200	1.420	0.991	0.995	0.906	0.995	0.979	0.953
	RW. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
RW	CA. A	1.048	1.200	1.420	0.994	0.972	0.935	1.005	1.024	1.052
	CA. M	1.048	1.200	1.420	0.994	0.972	0.935	0.988	0.948	0.884
	CA. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	US. A	1.048	1.200	1.420	0.994	0.972	0.935	1.005	1.024	1.052
	US. M	1.048	1.200	1.420	0.994	0.972	0.935	0.988	0.948	0.884
	US. S	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	RW. A	0.964	0.851	0.696	1.006	1.026	1.059	1.003	1.013	1.029
	RW. M	0.964	0.851	0.696	1.006	1.026	1.059	1.003	1.013	1.029
	RW. S	0.998	0.990	1.000	0.999	1.000	0.992	1.000	0.998	0.996

A free-trade agreement between CA and US increases trade flows between the two countries. The increase in trade flow is accompanied by a decline in domestic trade. However, the decline in domestic trade flow is much smaller relative to the increase in international trade flow. So, at least in this model, some border effects may subsist after a free trade agreement. Or, in other words, intra-national trade is somewhat insensitive to international trade agreement.

5 Conclusion

In this paper, firstly, we discuss the impact of free trade agreements on Canada from three micro-aspects: Canadian manufacturing, inter-provincial trade and labor market. Some tradeoffs may occur as a result of free trade agreement. Overall, the Canadian economy has not yet reap fully the benefits from the integration with the United States.

Second, we investigate the border effects between Canada and the United States. McCallum striking finding about the border effect makes people to notice that the borders do matter in interprovincial and international trade flows. Many empirical studies estimate the border effects inside or outside Canada-US by using the gravity model. The exact volume of border effects change with the sample data, but all studies find sizable border effects between Canada and the US.

Finally, we simulate tariff impact on border effect by employing a CGE model, developed by Lavoie, Mérette and Souissi (2001). By using the General Algebraic Modeling System (GAMS) software, we find that interprovincial trade is somewhat insensitive to international trade agreement. Some border effects may easily subsist after a free trade agreement.

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- www.statcan.ca/english/pgdb/intern.htm International trade, imports, exports and trade balance of goods on a balance of payments basis, by country of country grouping.

Appendix

Appendix 1

Source:

www.statcan.ca/english/pgdb/intern.htm International trade, imports, exports and trade balance of goods on a balance of payments basis, by country of country grouping.

Table 6. Imports and exports of goods on a balance-of-payments basis

	1997	1998	1999	2000	2001	2002
	\$ millions					
Exports	303,378.2	327,161.5	369,034.9	430,033.1	421,518.8	414,305.1
United States ¹	242,542.3	269,318.9	309,116.8	359,000.9	352,081.7	346,990.6
Japan	11,925.5	9,745.8	10,125.9	11,386.0	10,227.9	10,291.6
United Kingdom	4,689.5	5,323.3	6,002.9	7,326.3	6,984.7	6,239.4
Other European Economic Community countries	13,260.4	14,000.5	14,383.8	16,982.2	16,887.5	16,496.4
Other OECD ²	8,849.0	9,120.9	9,947.2	12,246.4	12,369.2	12,341.9
Other countries ³	22,111.6	19,652.2	19,458.4	23,091.4	22,967.8	21,945.3
Imports	277,726.5	303,398.6	327,026.0	362,206.5	350,631.9	356,459.3
United States ¹	211,450.8	233,777.6	249,485.3	266,514.5	254,952.6	254,929.0
Japan	8,711.0	9,671.8	10,592.2	11,729.3	10,571.7	11,732.2
United Kingdom	6,126.5	6,083.1	7,685.4	12,289.7	11,947.9	10,312.4
Other European Economic Community countries	18,112.9	19,141.2	20,765.8	21,178.9	23,218.0	25,863.3
Other OECD ²	11,376.7	11,398.8	13,257.2	18,945.0	18,636.7	19,670.3
Other countries ³	21,948.7	23,326.1	25,240.1	31,549.0	31,305.0	33,952.1
Balance	25,651.7	23,762.9	42,008.9	67,826.6	70,886.9	57,845.8
United	31,091.5	35,541.3	59,631.5	92,486.4	97,129.1	92,061.6

States ¹						
Japan	3,214.5	74.0	-466.3	-343.3	-343.8	-1,440.6
United Kingdom	-1,437.0	-759.8	-1,682.5	-4,963.4	-4,963.2	-4,073.0
Other European Economic Community countries	-4,852.5	-5,140.7	-6,382.0	-4,196.7	-6,330.5	-9,366.9
Other OECD ²	-2,527.7	-2,277.9	-3,310.0	-6,698.6	-6,267.5	-7,328.4
Other countries ³	162.9	-3,673.9	-5,781.7	-8,457.6	-8,337.2	-12,006.8
1. Includes also Puerto Rico and Virgin Islands.						
2. Organisation for Economic Co-operation and Development excluding the United States, Japan, United Kingdom and the other European Economic Community.						

Appendix 2

We postulate that household of a country i maximizes a Cobb-Douglas utility function, subject to the special conditions. For example, we maximize Canadian consumer utility, subject to its budget constraint. By using the General Algebraic Modeling System (GAMS) software to solve the CGE model. We assume that there are three sectors, namely: (1) agriculture, (2) manufacture, (3) services. Each sector includes three regions, namely: (1) Canada, (2) the United States, (3) Rest of the World. All the sectors are denoted by SS and separated to the tradable sector ST (agriculture, manufacture) and non-tradable sector SNT (service). All the regions are denoted by II .

$$\text{Max}_{c_{i,s}} U(C_{i,s}) = \prod_s c_{i,s}^{\rho_{i,s}} \quad (1)$$

Subject to:

$$P C_i C_i = \sum_s P c_{i,s} c_{i,s} \quad (2)$$

$$\sum_s \rho_{i,s} = 1 \quad (3)$$

where

$c_{i,s}$: is consumption in country I of good s ,

$P_{i,s}$: is the price in country I of good s ,

$\rho_{i,s}$: is the share in country I of good s .

By calculating the first order conditions, we obtain the optimal consumption of a given good s in the following form (for details see Appendix 3):

$$c_{i,s} = \rho_{i,s} \frac{PC_i C_i}{PC_{i,s}}, \quad (4)$$

then giving the aggregate price PC_i :

$$PC_i = \prod_s \left(\frac{PC_{i,s}}{\rho_{i,s}} \right)^{\rho_{i,s}}. \quad (5)$$

Equation (4) implies that the product of the preference parameter for a good and its relative price can be interpreted by the share of aggregate consumption related to good s .

By maximizing aggregate investment subject to the total investment expenditure level, the value of final investment demand for a commodity s can be generated. Because similar approaches are used to calculate the optimal consumption and investment, the final investment demand will take the same form as (4):

$$I_{i,s} = \omega_{i,s} \frac{PI_i I_i}{PI_{i,s}}, \quad (6)$$

where PI_i is the aggregate investment price and $\omega_{i,s}$ is share parameter in total investment:

$$PI_i = \prod_s \left(\frac{PI_{i,s}}{\omega_{i,s}} \right)^{\omega_{i,s}}. \quad (7)$$

Equations (4) and (6) indicate that the share of each good s in total consumption or in total investment is constant.

The representative household of each country establishes the optimal composition of its purchases in terms of specific purveyors, when the optimal share of each commodity s in aggregate consumption and aggregate investment is determined.

Calculating geographical origins of consumption and investment goods. It does not matter if a client uses its purchases good for consumption or investment purpose, since the price charged by a firm f operating in country i to any clients is the same. This means that firms do not discriminate between investors and consumers,

The household's preferences of country i subject to geographic or firm origin are represented by a constant elasticity of substitution function (CES). The following equations give a solution of optimal consumption in terms of geographic and firm origin:

$$\underset{c_{j,i,s}}{\text{Max}} c_{i,s} = \left[\sum_j \delta_{j,i,s} \frac{\sigma_{c,s,j}^{-1}}{c_{j,i,s}^{\sigma_{c,s,j}}} \right]^{\frac{\sigma_{c,s,j}}{\sigma_{c,s,j}-1}}, \text{ if } s \text{ is produced in a competitive sector} \quad (8)$$

subject to:

$$P c_{i,s} c_{i,s} = \sum_j (1 + \tau_{j,i,s}) P_{j,i,s} c_{j,i,s}, \text{ if } s \text{ is competitive} \quad (9)$$

where:

$c_{j,i,s}$: consumption by country i of goods s produced in country j ,

$P_{j,i,s}$: price in country I of goods s produced in country j ,

$\sigma_{c,s,i}$: Armington elasticity of substitution for consumption in country I between goods s produced by competitive firms,

$\delta_{c,s,i}$: consumption share parameters in country I for goods s produced by competitive firms,

$\tau_{j,i,s}$: tariff rate on goods s purchased by country I from country j .

The first-order conditions for a given goods produced by a competitive sector s and originating from a given country k takes the following form (for details see Appendix 4):

$$c_{k,i,s} = \delta_{k,i,s}^{\sigma_{c,s,i}} \left[(1 + \tau_{k,i,s}) P_{k,i,s} \right]^{-\sigma_{c,s,i}} P c_{i,s}^{\sigma_{c,s,i}} c_{i,s} \quad (10)$$

Combining (10) with the constraint (9) gives the aggregate price $P c_{i,s}$:

$$\begin{aligned} P c_{i,s} &= \frac{\sum_j (1 + \tau_{j,i,s}) P_{j,i,s} c_{j,i,s}}{c_{i,s}} \\ &= \frac{P c_{i,s}^{\sigma_{c,s,i}} c_{i,s} \sum_j \delta_{j,i,s}^{\sigma_{c,s,i}} \left((1 + \tau_{j,i,s}) P_{j,i,s} \right)^{1 - \sigma_{c,s,i}}}{c_{i,s}} \\ &= \left[\sum_j \delta_{j,i,s}^{\sigma_{c,s,i}} \left((1 + \tau_{j,i,s}) P_{j,i,s} \right)^{1 - \sigma_{c,s,i}} \right]^{\frac{1}{1 - \sigma_{c,s,i}}} \end{aligned} \quad (11)$$

This indicates that the demand of an individual of country i for a good produced with a competitive sector s in country k is function of the price. This price is related to the

price of goods for type s in all other countries and the quantity of good for type s the individual wants to buy.

Similar to the methods to solve the optimal consumption problem, the optimal investment composition in terms of its geographic or firm origins is obtained from a maximization of a CES composite of investment goods s from all possible origins, subject to an investment expenditure level. As a result, the final investment demands take an identical form to (10). For goods s originating from competitive firms, we have:

$$i_{j,i,s} = \beta_{j,i,s}^{\sigma_{i,s}} \left[(1 + \tau_{j,i,s}) P_{j,i,s} \right]^{-\sigma_{i,s}} P_{i,s}^{\sigma_{i,s}} I_{i,s} ; \quad (12)$$

where the β are share parameters. The aggregate investment prices also have similar forms to that of aggregate consumption. For goods s produced by competitive firms, it follows:

$$P_{i,s} = \left[\sum_j \beta_{j,i,s}^{\sigma_{i,s}} \left((1 + \tau_{j,i,s}) P_{j,i,s} \right)^{1-\sigma_{i,s}} \right]^{\frac{1}{1-\sigma_{i,s}}} , \quad (13)$$

The demand functions are based on the combined Cobb-Couglas/CES functional forms, which are frequently used in this model. These demand functions are relatively easy for us to compute and calibrate.

Competitive industries. The firm operates with constant returns to scale technologies and behaves as a price taker on products in competitive industries. The goal of a firm is to maximize its profits:

$$\text{Max}_{Q_{i,s}} P_{i,s} Q_{i,s} - v_{i,s} Q_{i,s} , \quad (14)$$

where $Q_{i,s}$ and $v_{i,s}$ represent for country i , sector s , the production level and the marginal cost respectively. The first-order condition to this problem is that the price is equal to the marginal cost:

$$P_{i,s} = v_{i,s} . \quad (15)$$

The firm's unit cost, factors and materials demands are determined by the following total cost minimization problem when the price is given:

$$\text{Min}_{L_{i,s}, K_{i,s}, X_{i,sd,s}} v_{i,s} Q_{i,s} = w_i L_{i,s} + r_i K_{i,s} + \sum_{sd} P x_{i,sd,s} X_{i,sd,s} , \quad (16)$$

subject to a (Cobb-Douglas) technology:

$$Q_{i,s} = L_{i,s}^{\alpha_{L_{i,s}}} K_{i,s}^{\alpha_{K_{i,s}}} \prod_{sd} X_{i,sd,s}^{\alpha_{X_{i,sd,s}}} , \quad (17)$$

where:

w_i : wage rate in country I ,

$L_{i,s}$: quantity of labour in sector s ,

r_i : rental rate of capital in country I ,

$K_{i,s}$: stock of capital in sector s ,

$P_{x_{i,sd,s}}$: average price paid by sector s of country I for goods sd ,

$X_{i,sd,s}$: average price paid by sector s of country I for goods sd ,

α_s : share parameters.

Assuming constant returns to scale, the share parameters sum to one:

$$\alpha_{L_{i,s}} + \alpha_{K_{i,s}} + \sum_{sd} \alpha_{X_{i,sd,s}} = 1 . \quad (18)$$

The first order conditions to this problem yield the demand conditions (for details see Appendix 5).

First, for labour:

$$L_{i,s} = \frac{\alpha_{L_{i,s}} v_{i,s} Q_{i,s}}{w_i} ; \quad (19)$$

Second, for capital:

$$K_{i,s} = \frac{\alpha_{K_{i,s}} v_{i,s} Q_{i,s}}{r_i} ; \quad (20)$$

Third, for inputs originating from sector sd :

$$X_{i,sd,s} = \frac{\alpha_{X_{i,sd,s}} v_{i,s} Q_{i,s}}{P_{X_{i,sd,s}}} . \quad (21)$$

Equations (19) to (21) imply that the proportions of labour cost, capital cost, and intermediate good cost in total cost are constant. Substituting these demand functions into the production function (17) gives:

$$\begin{aligned} Q_{i,s} &= \left(\frac{\alpha_{L_{i,s}} v_{i,s} Q_{i,s}}{w_i} \right)^{\alpha_{L_{i,s}}} \left(\frac{\alpha_{K_{i,s}} v_{i,s} Q_{i,s}}{r_i} \right)^{\alpha_{K_{i,s}}} \prod_{sd} \left(\frac{\alpha_{X_{i,sd,s}} v_{i,s} Q_{i,s}}{P_{X_{i,sd,s}}} \right)^{\alpha_{X_{i,sd,s}}} \\ &= (v_{i,s} Q_{i,s})^{\alpha_{L_{i,s}} + \alpha_{K_{i,s}} + \sum_{sd} \alpha_{X_{i,sd,s}}} \left(\frac{\alpha_{L_{i,s}}}{w_i} \right)^{\alpha_{L_{i,s}}} \left(\frac{\alpha_{K_{i,s}}}{r_i} \right)^{\alpha_{K_{i,s}}} \prod_{sd} \left(\frac{\alpha_{X_{i,sd,s}}}{P_{X_{i,sd,s}}} \right)^{\alpha_{X_{i,sd,s}}} \\ &= v_{i,s} Q_{i,s} \left(\alpha_{L_{i,s}}^{\alpha_{L_{i,s}}} \alpha_{K_{i,s}}^{\alpha_{K_{i,s}}} \prod_{sd} \alpha_{X_{i,sd,s}}^{\alpha_{X_{i,sd,s}}} \right) \left(w_i^{-\alpha_{L_{i,s}}} r_i^{-\alpha_{K_{i,s}}} \prod_{sd} P_{X_{i,sd,s}}^{-\alpha_{X_{i,sd,s}}} \right) . \end{aligned} \quad (22)$$

hence yields the unit cost function:

$$v_{i,s} = \frac{1}{A_{i,s}} \left(w_i^{\alpha_{L_{i,s}}} r_i^{\alpha_{K_{i,s}}} \prod_{sd} P_{X_{i,sd,s}}^{\alpha_{X_{i,sd,s}}} \right) ,$$

where (23, 24)

$$A_{i,s} = \left(\alpha_{L_{i,s}}^{\alpha_{L_{i,s}}} \alpha_{K_{i,s}}^{\alpha_{K_{i,s}}} \prod_{sd} \alpha_{X_{i,sd,s}}^{\alpha_{X_{i,sd,s}}} \right) \text{ is a constant.}$$

Given the materials and factors prices of a firm in the competitive sector s of country i , equations (19) to (21) determine its factors demands. Equations (15), (23) and (24) determine its optimal supply. Under the condition of constant returns to scale

technology, the market demand determines quantities of good and inputs demanded by industry s .

The intermediate inputs come from competitive industries of different countries. Therefore, the firm s in country i needs to select regions and firms to purchase its intermediate inputs. It is assumed that the firm's preference subject to geographical and firm origin of a commodity sd is a CES aggregation function of inputs from all possible sources. The solution to the following problem determines the share from each origin:

$$\text{Max } X_{i,sd,s} = \left[\sum_j \eta_{j,i,sd,s} X_{j,i,sd,s}^{\frac{\sigma_{x,i,j}-1}{\sigma_{x,i,j}}} \right]^{\frac{\sigma_{x,i,j}}{\sigma_{x,i,j}-1}}, \text{ if } sd \text{ is produced by competitive firms,} \quad (25)$$

Subject to:

$$P_{i,sd,s} X_{i,sd,s} = \sum_j (1 + \tau_{j,i,sd}) P_{j,i,sd} X_{j,i,sd,s}, \text{ if } sd \text{ originates from competitive firms,} \quad (26)$$

where:

$X_{j,i,sd,s}$: amount of intermediate inputs purchased by sector s of country i from sector sd in country j ,

$X_{j,f,i,sd,s}$: amount of intermediate inputs purchased by sector s of country i from firm f of sector sd in country j ,

$P_{j,i,sd}$: price of goods sd sold by country j to country i ,

- $P_{j,f,i,sd}$: price of goods sd sold by firm f of country j to country i ,
- α_s : share parameters,
- $\sigma_{x,s,j}$: Armington elasticity of substitution of sector s in country i , for intermediate inputs produced by competitive firms,

The demand function for a given intermediate input sd from country j is given by the following equation:

$$X_{j,i,sd,s} = \left[(1 + \tau_{j,i,sd}) P_{j,i,sd} \right]^{-\sigma_{x,s,j}} P_{i,sd,s}^{\sigma_{x,s,j}-1} \eta_{j,i,sd,s}^{\sigma_{x,s,j}} P_{i,sd} X_{i,sd,s}, \quad (27)$$

if sd originates from competitive firms, and where:

$$P_{i,sd,s} = \left[\sum_j \eta_{j,i,sd,s}^{\sigma_{x,s,j}} \left((1 + \tau_{j,i,sd}) P_{j,i,sd} \right)^{1-\sigma_{x,s,j}} \right]^{\frac{1}{1-\sigma_{x,s,j}}}, \quad (28)$$

The Equilibrium Conditions. There are 2 equilibrium conditions that close the model.

First, tariff revenues are rebated to consumers lump-sum:

$$G_i = \sum_j \sum_s n_{j,s} \tau_{j,i,s} P_{j,i,s}; n_{j,s} = 1 \quad (29)$$

Second, supply equals demand in each market at every period:

$$q_{i,j,s} = c_{i,j,s} + i_{i,j,s} + \sum_{sd} x_{i,j,s,sd} \quad (30)$$

$$Q_{i,s} = \sum_j q_{i,j,s} \quad (31)$$

$$L_i = \sum_s L_{i,s} + \bar{L}_{i,s} \quad (32)$$

$$K_i = \sum_s K_{i,s} + \overline{K_{i,s}} \quad (33)$$

It is important to note that the balance of payments is always in equilibrium.

Appendix 3.

$$\text{Max}_{c_{i,s}} U(C_{i,s}) = \prod_s c_{i,s}^{\rho_{i,s}} \quad (1)$$

Subject to:

$$P C_i C_i = \sum_s P c_{i,s} c_{i,s} \quad (2)$$

$$\sum_s \rho_{i,s} = 1 \quad (3)$$

The first order condition for a given good s takes the following form:

$$\rho_{i,s} c_{i,s}^{\rho_{i,s}-1} \prod_{w \neq s} c_{i,w}^{\rho_{i,w}} = \lambda P c_{i,s}$$

Multiplying both sides by $c_{i,s}$:

$$\rho_{i,s} \prod_s c_{i,s}^{\rho_{i,s}} = \lambda P c_{i,s} c_{i,s} \quad (4)$$

Taking the sum over all goods gives:

$$\prod_s c_{i,s}^{\rho_{i,s}} \sum_s \rho_{i,s} = \lambda \sum_s P c_{i,s} c_{i,s}$$

Substituting constraints (2) and (3) in the above equation, and given that

$$\prod_s c_{i,s}^{\rho_{i,s}} = C_i$$

then yields the following explicit form for the Lagrange multiplier:

$$C_i = \lambda PC_i C_i \Rightarrow \lambda = \frac{1}{PC_i} .$$

Replacing λ by its value in (3) gives the optimal consumption demand of the representative household of country I for good s.

$$c_{i,s} = \rho_{i,s} \frac{PC_i C_i}{PC_{i,s}} , \tag{5}$$

where the aggregate price PC_i is derived by first using the constraint (2):

$$PC_i = \frac{\sum_s PC_{i,s} c_{i,s}}{C_i}$$

Then, using the objective function (1) and (4):

$$PC_i = \frac{PC_i C_i}{\prod_s \left(\frac{\rho_{i,s} PC_i C_i}{PC_{i,s}} \right)^{\rho_{i,s}}}$$

Rewritten PC_i as:

$$PC_i = \frac{PC_i C_i}{(PC_i C_i)^{\sum_s \rho_{i,s}} \prod_s \left(\frac{\rho_{i,s}}{PC_{i,s}} \right)^{\rho_{i,s}}},$$

To finally get the aggregate price PC_i :

$$PC_i = \prod_s \left(\frac{PC_{i,s}}{\rho_{i,s}} \right)^{\rho_{i,s}}.$$

Appendix 4.

$$\text{Max}_{c_{j,i,s}} c_{i,s} = \left[\sum_j \delta_{j,i,s} c_{j,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} \right]^{\frac{\sigma_{c,s,j}}{\sigma_{c,s,j}-1}}, \text{ if } s \text{ is produced in a competitive sector (1)}$$

subject to:

$$P c_{i,s} c_{i,s} = \sum_j (1 + \tau_{j,i,s}) P_{j,i,s} c_{j,i,s}, \text{ if } s \text{ is competitive}$$

yields

$$\left[\sum_j \delta_{j,i,s} c_{j,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} \right]^{\frac{\sigma_{c,s,j}}{\sigma_{c,s,j}-1}} \delta_{k,i,s} c_{k,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} = \lambda (1 + \tau_{k,i,s}) P_{k,i,s}. \quad (2)$$

By multiplying both sides of equation by $c_{k,i,s}$, we have:

$$\left[\sum_j \delta_{j,i,s} c_{j,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} \right]^{\frac{1}{\sigma_{c,s,j}-1}} \delta_{k,i,s} c_{k,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} = \lambda (1 + \tau_{k,i,s}) P_{k,i,s} c_{k,i,s}. \quad (3)$$

A first-order condition exists for each geographical origin. Taking the sum over all geographical origins gives:

$$\left[\sum_j \delta_{j,i,s} c_{j,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} \right]^{\frac{1}{\sigma_{c,s,j}-1}} \left[\sum_k \delta_{k,i,s} c_{k,i,s}^{\frac{\sigma_{c,s,j}-1}{\sigma_{c,s,j}}} \right] = \lambda \sum_k (1 + \tau_{k,i,s}) P_{k,i,s} c_{k,i,s},$$

or:

$$c_{i,s} = \lambda \sum_k (1 + \tau_{k,i,s}) P_{k,i,s} c_{k,i,s} .$$

Using constraint (2) in the above equation yields an explicit expression for the Lagrange multiplier:

$$c_{i,s} = \lambda P c_{i,s} c_{i,s} \Rightarrow \lambda = \frac{1}{P c_{i,s}} .$$

The following demand function for a good s produced by a competitive sector in country k is yielded by: Replacing λ in (3):

$$c_{k,i,s} = \delta_{k,i,s}^{\sigma_{c,i,s}} \left[(1 + \tau_{k,i,s}) P_{k,i,s} \right]^{-\sigma_{c,i,s}} P c_{i,s}^{\sigma_{c,i,s}} c_{i,s} \quad (4)$$

Combining (4) with the constraint (2) gives the explicit form of the aggregate price

$P c_{i,s}$:

$$\begin{aligned}
Pc_{i,s} &= \frac{\sum_j (1 + \tau_{j,i,s}) P_{j,i,s} c_{j,i,s}}{c_{i,s}} \\
&= \frac{Pc_{i,s}^{\sigma_{c,s,j}} c_{i,s} \sum_j \delta_{j,i,s}^{\sigma_{c,s,j}} \left((1 + \tau_{j,i,s}) P_{j,i,s} \right)^{1 - \sigma_{c,s,j}}}{c_{i,s}} \\
&= \left[\sum_j \delta_{j,i,s}^{\sigma_{c,s,j}} \left((1 + \tau_{j,i,s}) P_{j,i,s} \right)^{1 - \sigma_{c,s,j}} \right]^{\frac{1}{1 - \sigma_{c,s,j}}}.
\end{aligned}$$

Appendix 5.

$$\underset{L_{i,s}, K_{i,s}, X_{i,sd,s}}{\text{Min}} v_{i,s} Q_{i,s} = w_i L_{i,s} + r_i K_{i,s} + \sum_{sd} P x_{i,sd,s} X_{i,sd,s} , \quad (1)$$

subject to a (Cobb-Douglas) technology:

$$Q_{i,s} = L_{i,s}^{\alpha_{L_{i,s}}} K_{i,s}^{\alpha_{K_{i,s}}} \prod_{sd} X_{i,sd,s}^{\alpha_{X_{i,sd,s}}} ,$$

Assuming constant returns to scale, the share parameters sum to one:

$$\alpha_{L_{i,s}} + \alpha_{K_{i,s}} + \sum_{sd} \alpha_{X_{i,sd,s}} = 1 . \quad (2)$$

The first order conditions to this problem are:

$$\begin{aligned} w_i L_{i,s} &= \lambda \alpha_{L_{i,s}} Q_{i,s} , \\ r_i K_{i,s} &= \lambda \alpha_{K_{i,s}} Q_{i,s} , \\ P x_{i,sd,s} X_{i,sd,s} &= \lambda \alpha_{X_{i,sd,s}} Q_{i,s} . \end{aligned} \quad (3)$$

Substituting these conditions within the total cost equation (1) gives:

$$\begin{aligned} v_{i,s} Q_{i,s} &= w_i L_{i,s} + r_i K_{i,s} + \sum_{sd} P x_{i,sd,s} X_{i,sd,s} \\ &= \lambda (\alpha_{L_{i,s}} + \alpha_{K_{i,s}} + \sum_{sd} \alpha_{X_{i,sd,s}}) Q_{i,s} . \end{aligned} \quad (4)$$

Given (2), (4) can be rewritten as:

$$v_{i,s} Q_{i,s} = \lambda Q_{i,s} \Rightarrow \lambda = v_{i,s},$$

and substituting the above into the first-order conditions (3) yields the demand conditions. First, for labour:

$$L_{i,s} = \frac{\alpha_{L_{i,s}} v_{i,s} Q_{i,s}}{w_i};$$

second, for capital:

$$K_{i,s} = \frac{\alpha_{K_{i,s}} v_{i,s} Q_{i,s}}{r_i}; \tag{5}$$

and third, for inputs originating from sector sd :

$$X_{i,sd,s} = \frac{\alpha_{X_{i,sd,s}} v_{i,s} Q_{i,s}}{P_{X_{i,sd,s}}}; \tag{6}$$

Appendix 6.

Table 7. Impact of tariff reduction on price of composite intermediate

Export Country	Import Country: Sector	Price of Composite Intermediate						
		MANUF and AGRIC Sectors					Tariff cuts 10% for MANUF goods by CA and US	Tariff cuts 10% for AGRIC goods by CA and US
		Original tariff	Tariff cuts 10% everywhere	Tariff cuts 10% by CA	Tariff cuts 10% by US	Tariff cuts 10% by CA and US		
CA	CA. A	1.000	1.001	1.008	1.001	1.009	1.009	1.001
	CA. M	1.000	1.001	1.008	1.001	1.009	1.009	1.001
	CA. S	1.000	1.001	1.008	1.001	1.009	1.009	1.001
	US. A	1.000	1.001	1.008	1.001	1.009	1.009	1.010
	US. M	1.000	1.001	1.008	1.001	1.009	1.009	1.010
	US. S	1.000	1.001	1.008	1.001	1.009	1.009	1.010
	RW. A	1.000	1.001	1.011	1.004	1.015	1.012	1.010
	RW. M	1.000	1.001	1.011	1.004	1.015	1.012	1.010
	RW. S	1.000	1.001	1.011	1.004	1.015	1.012	1.010
US	CA. A	1.000	1.001	1.002	1.006	1.009	1.009	1.001
	CA. M	1.000	1.001	1.002	1.006	1.009	1.009	1.001
	CA. S	1.000	1.001	1.002	1.006	1.009	1.009	1.001
	US. A	1.000	1.001	1.002	1.006	1.009	1.001	1.010
	US. M	1.000	1.001	1.002	1.006	1.009	1.001	1.010
	US. S	1.000	1.001	1.002	1.006	1.009	1.001	1.010
	RW. A	1.000	1.001	1.005	1.010	1.015	1.007	1.010
	RW. M	1.000	1.001	1.005	1.010	1.015	1.007	1.010
	RW. S	1.000	1.001	1.005	1.010	1.015	1.007	1.010
RW	CA. A	1.000	1.001	1.008	1.006	1.014	1.009	1.009
	CA. M	1.000	1.001	1.008	1.006	1.014	1.009	1.009
	CA. S	1.000	1.001	1.008	1.006	1.014	1.009	1.009
	US. A	1.000	1.001	1.008	1.006	1.014	1.009	1.009
	US. M	1.000	1.001	1.008	1.006	1.014	1.009	1.009
	US. S	1.000	1.001	1.008	1.006	1.014	1.009	1.009
	RW. A	1.000	1.001	1.007	1.005	1.012	1.009	1.008
	RW. M	1.000	1.001	1.007	1.005	1.012	1.009	1.008
	RW. S	1.000	1.001	1.007	1.005	1.012	1.009	1.008

Table 8. Impact of tariff reduction on GDP

Country	GDP						
	MANUF and AGRIC Sectors					Tariff cuts 10% for MANUF goods by CA and US	Tariff cuts 10% for AGRIC goods by CA and US
	Original tariff	Tariff cuts 10% everywhere	Tariff cuts 10% by CA	Tariff cuts 10% by US	Tariff cuts 10% by CA and US		
CA	7930	8025.406	8021.768	7960.091	8053.606	8027.173	7981.462
US	7930	8025.406	7971.501	8010.286	8053.606	7988.607	7981.462
RW	7930	8025.406	7982.534	7971.108	8053.606	7997.110	7967.215

Table 9. Impact of tariff reduction on gross output

Produce Country. Sector	Gross Output						
	MANUF and AGRIC Sectors					Tariff cuts 10% for MANUF goods by CA and US	Tariff cuts 10% for AGRIC goods by CA and US
	Original tariff	Tariff cuts 10% everywhere	Tariff cuts 10% by CA	Tariff cuts 10% by US	Tariff cuts 10% by CA and US		
CA. A	1.000	1.002	1.000	1.001	1.001	0.997	1.004
CA. M	1.000	1.002	1.000	1.001	1.001	1.004	0.997
CA. S	1.000	0.998	1.001	0.998	1.000	1.000	1.000
US. A	1.000	1.002	1.001	1.000	1.001	0.997	1.004
US. M	1.000	1.002	1.001	1.000	1.001	1.004	0.997
US. S	1.000	0.998	0.998	1.001	1.000	1.000	1.000
RW. A	1.000	1.002	1.000	1.001	1.000	1.004	0.996
RW.M	1.000	1.002	1.000	1.000	1.000	0.996	1.004
RW. S	1.000	0.998	1.000	1.000	0.999	1.000	1.000