Assessing the Cost of Post-9/11 Security Measures and the Impact of a North American Security Perimeter – A Computable General Equilibrium Analysis

Patrick Georges, Marcel Mérette, and Qi Zhang

University of Ottawa

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1. Introduction and Motivation

As Canada is a very open economy characterized by an economic prosperity highly dependent on trade with the U.S., it has good reasons to have concerns with the security measures that have been implemented post-9/11 to secure the movement of goods and people. Beyond the possible impact on trade, however, an additional risk of border delays could be a shifting in the sourcing of U.S. firms away from Canadian suppliers. This risk increases with high-valued activities which depend on "just in time" processes. Consequently, border delays may distort investment decisions against Canada and its sectors that are most affected, generating sectoral and hence regional reallocation of resources. Even firms operating on a worldwide scale might be more reluctant to invest in Canada if they perceive a high likelihood of considerable delays in their supply chains. In such a case, border delays would divert foreign direct investment (FDI) away from Canada and hurt its GDP.

There has been no empirical study to date that has attempted to illustrate the impact of post 9/11 security measures on trade *and* on foreign direct investment in Canada. This paper proposes to address this gap using a three-region nine-sector Computable General Equilibrium (CGE) model. The CGE model that we have developed estimates post 9/11 security-related border costs and assesses the impact of eliminating

these costs on both trade (exports and imports) and foreign direct investment. Our study does not focus on the specifics of those security measures that should be taken at the Canada-US border and elsewhere, to decongest the Canada-US border; but our study can be interpreted as giving an estimate of the economic gain of eliminating the post 9/11 security measures if it was possible to design an alternative security scheme, for example the long-discussed continental perimeter (Clarkson, 2008), that might decongest the Canada-US border.

In the following section, we first report the evidence on border delay costs. In Section 3 we provide a brief description of the model we have built for this study while Section 4 describes the data sets. In Section 5 we report our simulation results. Section 6 provides concluding remarks.

2. Evidence on Border Delay Costs

A series of studies have been produced since 2001 to estimate and analyse border delay costs. These reports try to estimate and identify border delay costs, how these costs are split between Canada and the U.S., which sector, region or mode of transportation are mostly affected. In this section we report the most salient results of these studies.

Estimation and Identification of border delay costs in general

Anderson and Marcouiller (2002) report abundant evidence suggesting that transactions costs and uncertainty associated with insecure deal significantly impede international trade. Canada-United States Ontario-Michigan Border Transportation Partnership Planning Committee (2004) discusses in detail how congestion and delays at border crossings increase the overall transit time (which is the value of time spent in transportation) for transportation services and the probability of occasional or unscheduled delays (i.e. delays that exceed substantially the average delay). Transit time cost increases to lead to an overall increase in transport costs, which may require a larger number of truckers for a company since regulatory restrictions restrict the number of hours a trucker can spend behind the wheel. Border delay costs are expected to be higher for perishable products, just-in-time deliveries, and other time-sensitive deliveries.

OCC Borders and Trade Development Committee (OBTDC, 2004) estimates that some carriers that conduct cross border shipping often charge a cross-border freight rate that is 10-15% higher than domestic rates. Depending on the commodity, transportation costs can account for 5% to 40% of the delivered price of a good. Leonard (2001) estimates that total costs of extra security measures implemented after the September 11 events could amount to 1 to 3 percent of the value of the traded goods. Limão and Venables (2001) who investigate bilateral trade between 103 countries, report elasticities of trade flows with respect to transport cost in the range of -2 to -3.5, implying that a transport cost increase of 1 percent would lead to a reduction in trade volume by 2 to 3.5 percent.

Border delay costs between Canada and the U.S.

OCC Borders and Trade Development Committee (OBTDC, 2005) estimates average border delay for traffic entering Canada to be between 30 and 60 minutes, while for traffic entering the US, wait time ranges from 10 minutes up to four hours. Belzer and Arbor (2003) estimate that the average time to cross the border from Canada to the U.S. is 2.5 longer than from U.S. to Canada. OBTDC (2004) claims that Canada absorbs 70% of the total costs associated with border delays, while OBTDC (2005) claims that the U.S. economy absorbs 40% of the cost of border delays. The estimation reported by OBTDC (2004) suggests border-delay costs representing $1,100 per year for every Ontario taxpayer.

Canada-United States Ontario-Michigan Border Transportation Partnership Planning Committee (2004) claims that the economic impact of these costs in Canada amounts to a cut in (final) domestic expenditure by 1,293 million of CAN$ (of year 2000). Simulation results in Nguyen and Wigle (2009) show that the impacts of delay costs on merchandise and services on welfare change for Canada as a whole is between -1% and -1.8%.

Regional, Sectoral and Transportation Mode Impact

Belzer and Arbor (2003) observe that for trade between Canada and the U.S. just-in-time delivery dominates largely inventory strategies. The most prefer mode to accommodate the just-in-time delivery is trucks. OBTDC (2005) confirms that trucks move 72.6% of the value of exports from the U.S. to Canada, while OBTDC (2004) claims that approximately 70% of Canada-US trade travels by truck. These estimates are consistent with the study of Belzer and Arbor (2003) inference that suggests that inventory costs are very small. OBTDC (2004) states that a "just in time" logistics system implies that border delays result in substantial economic loss for most sectors. Burt (2007), Globerman and Storer (2009) and Grady (2009) provide sectoral and national quantitative impact for Canada, and they show that the automotive industry is specifically affected.

Investment

OBTDC (2004) discusses how delays and uncertainty surrounding the border affect investment, and foreign direct investment. They claim that in the case of Ontario, delays at the borders hinder the province's ability to attract new, as well as maintain existing investments. The report suggests that the uncertainty surrounding the border effectively acts as a tariff-like barrier to the import and export of goods, and hence reduces the incentive for companies to locate on the Canadian side. In addition, Canada is also affected by American companies de-sourcing Canadian components manufacturers in favour of domestic sources that are not affected by such border delays.

3. Description of the FDI-Model

This section provides a brief description of the model. Appendix 1 gives further details on the equations. We present a multi-region multi-sector static general equilibrium model that features production activities and consumption in each region as well as the flow of investment among regions. The representative household in each region decides, on the one hand, about the allocation of its total spending among different commodities and, on the other hand, about the allocation of its wealth (capital) among different activities. A peculiar characteristic of the model is the distinction between the activities of domestic and foreign-owned firms at the microeconomic level, both in terms of

demand and production characteristics, inspired by similar approaches by Petri (1997) and Verikios and Zhang (2001).

3.1 Capital Allocation

A key feature of the model is the determination of FDI investment, or more broadly the regional allocation of wealth. The investment decision is modeled in an optimizing framework that allocates wealth to the highest return activities, but also takes into account investor preferences (or bias) for a particular mix of instruments (portfolio approach to investment decision). The parameters that account for these preferences are calibrated from initial capital stock data, much the same way as the parameters of consumer preferences are calibrated from observed demand.

As illustrated in Figure 1, total or aggregate physical wealth (assets) of country *i* is assumed fixed (at $TTWealth0_i$). Aggregate wealth, however, is allocated across all sectors *s* and all countries *j*. The allocation is done such as to maximize returns on wealth; changes in relative returns bring about changes in the composition of the portfolio.

We use a three-level nested constant elasticity of transformation (CET) function to represent the allocation of aggregate wealth. With finite elasticities of transformation, capital is less than perfectly mobile across sectors and regions. At the first level, aggregate wealth of country *i* is allocated to physical capital across different sectors *s* as a function of the relative rate of returns on capital invested in various sectors (equation 1). At the second level, physical capital in sector *s* is allocated between capital supplied in the domestic economy (*i*) (equation 4) and an aggregate of capital invested in all foreign countries *j* ($j \neq i$) in the same sector *s* -- outward foreign direct investment from *i*'s perspective -- (equation 3). Finally, at the third level, the stock of FDI outflows from country *i* to the sector *s* is allocated among subsidiaries located across specific countries *v* (= *j*), ($WEALTH_{i,v,s}$ in equation 6).

At each step, a revenue-maximizing rule is used to determine the allocation of the index of physical capital into each of its components. Basically, the relative supply of capital in two competing destinations within a nest depends on their relative returns

($R_{i,v,s}$). The higher the relative return in one destination the higher the share of physical capital in that destination. The return to physical capital in a given sector/destination takes into consideration existing restrictions to FDI. Any change in these restrictions would translate into a change in the relative returns and consequently into a change in FDI in the given sector or country. Technically, this is implemented through a change in the parameter $CTAX_{i,v,s}$ at the third level of the nested CET (equations 6 and 7). This parameter is the tax rate that the government of a country *v* would impose on foreign capital originating from country *i*. As such, this rate is a tax equivalent of FDI restrictions imposed by country *v* and a policy change which partially liberalizes FDI is modeled as a change in $CTAX_{i,v,s}$, which will affect both the net returns on assets, $R_{i,v,s}$ ($1\text{-}CTAX_{i,v,s}$) in equation 7, and the allocation of assets, $WEALTH_{i,v,s}$ in equation 6.

3.2 Household consumption demand

In each region *j*, the representative consumer derives income from labour, net of tax returns to capital invested in the domestic economy and abroad, and (because household and governments accounts are consolidated), tariff revenue collected by the government and tax revenue perceived on capital incomes accruing to domestic and foreign subsidiaries located in *j* (equation 35). The representative consumer does not value leisure so that the supply of labour in each region is fixed.

We assume that the representative household cares about the nationality *and* the place of production of the good produced in a given sector. To account for this differentiation, we represent its preferences by a series of nested utility functions as illustrated in Figure 2. At the first level, total utility or aggregate consumption (CON_j in equation 8) is a Cobb-Douglas index of consumption of different sector-goods *s* ($CONS_{j,s}$) At the second level, consumption of good *s* is a CES aggregate of the index of goods produced domestically (including those produced by foreign-nationality subsidiaries located in the domestic economy), $ECDOM_{j,s}$ in equation 10, and of the index of those produced in foreign countries and imported, $ECFOR_{j,s}$ in equation 11. At the third level, consumption of good *s* (by households of country *j*) produced domestically (in *j*), is another CES aggregate of consumption of good *s* produced by subsidiaries (located in *j*)

of different nationality *v*, including firms of domestic-nationality *v=j*, ($ECV_{v,j,j,s}$ in equation 13). In another nest (the Armington assumption), the index of imported good *s* is a CES aggregate of imported goods from geographical origin *i*, ($ECIJFOR_{i,j,s}$ in equation 15). Finally, in the fifth nest, the import into *j* of good *s* from a specific country *i* is a CES aggregate of goods produced by subsidiaries of different nationalities *v* located in *i*, $ECV_{v,i,j,s}$ in equation (17).

Utility maximization subject to budget constraint allows the determination of the demand for each commodity. In particular, a multi-step budgeting process in which the representative household minimizes expenditures allows the derivation within each nest of the expression of its components. In particular, the ratio of the demand for two competing goods within a nest is inversely related to their relative prices (see equations 8, 10, 11, 13, 15 and 17).

3.3 Investment demand

Final demand is made of household demand and investment demand. Aggregate investment demand in country *j* (INV_j) is a Cobb-Douglas index of different investment goods *s* produced by different subsidiaries *v*, independently on their geographical location, $INVVS_{v,j,s}$ in equation 19. The second (CES) level describes from which country *i* the investment good *s* produced by subsidiary *v* is bought, $EVV_{v,i,j,s}$ in equation 21 (the Armington assumption).

3.4 Supply side

In each country *j*, the representative firm of nationality *v*, operating in sector *sd*, combines local labour, capital (of ownership *v*) and intermediate inputs to produce an output using a constant-returns-to-scale technology. It operates in a competitive setting where it considers factor and output prices as given. It determines the optimal level of output by maximizing profits and using a marginal-cost pricing rule (equation 23). We assume that the production function is a Cobb-Douglas function of capital, labour and the index of intermediate inputs. Because of the constant-returns-to-scale property of the technology, the cost function is linear in output and thus the marginal cost is equal to

average cost and is independent of the level of production (equation 27). It follows that the optimal level of inputs can be determined from a cost-minimization rule (equations 24, 25, 26). At each node of the technology representation, the demand for each input increases with the price of the good produced ($PV_{v,j,sd}$) and decreases with its own price.

Finally, the aggregate intermediate input *s* used in sector *sd*, $EI_{v,j,s,sd}$, is a multi-level Leontief function of goods produced by subsidiaries of different nationality *vo* and located in different countries *i*, $EIVV_{vo,v,i,j,s,sd}$, all complements in the aggregation index $EI_{v,j,s,sd}$ (equation 28).

3.5 Equilibrium conditions

A general equilibrium of this model economy is represented by a set of endogenous real and nominal variables such that all economic agents maximize their objective functions while respecting their budget constraints, and all factor and good markets clear. In particular, in each region *j*: 1. The wage rate would adjust so as to equate total demand for (local) labour with the total fixed supply of labour (equation 30); 2. The return to capital should adjust such as to equate the supply of capital for subsidiary *v* located in country *j* in sector *sd* with the demand for capital in the same sector, by the same subsidiary *v* in country *j*, (equation 31) and: 3. Good prices should adjust such as to equalize the supply of each good produced in sector *s* by subsidiary *v* to total demand for consumption, investment and intermediate uses, by domestic and foreign agents (equations 33-34).

4. Data

The aggregate variables and trade flows of the model were calibrated to GTAP7. In Table 1 of Appendix 2, we provide the regional and sectoral aggregation mapping from GTAP to the Model. The GTAP Armington elasticities and tariffs rates are also reported (Tables 2a/b and 3).

In Table 4.1 below we report the FDI ownership ratio that we use to dissagregate the GTAP data. In other words, we use the ratios of the table below to add a nationality

dimension to sectoral and regional production activities that were obtained from GTAP. In the second column, the number 0.998 for CAN.CAN.AGRI indicates that 99.80% of the capital stock in the primary sector in Canada is owned by Canadian firms. The number 0.001 for US.CAN.AGRI indicates that 0.1% of the capital stock in the primary sector in Canada belongs to American firms located in Canada. Finally the number 0.001 for ROW.CAN.AGRI indicates that 0.001% of the capital stock in the primary sector in Canada belongs to rest-of-the-world firms located in Canada. Note that these three ratios sum to 100%. To build this matrix, we have used the recent GTAP-FDI database (Boumellasa, Gouel and Laborde, 2007). For the rest-of-the-world, we impose a structure of ownership of the capital stock which is similar to the U.S. The level of production for subsidiary of different nationality was calibrated accordingly to the ratios of this matrix.

Table 4.1: FDI ownership ratio[1]

Countries *v.i.*	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN.CAN	0.998	0.877	0.568	0.921	0.752	0.751	0.798	0.913	0.988
US.CAN	0.001	0.114	0.235	0.025	0.163	0.222	0.152	0.052	0.007
ROW.CAN	0.001	0.009	0.197	0.054	0.085	0.027	0.05	0.035	0.005
CAN.US	0.001	0.013	0.002	0.008	0.028	0.046	0.054	0.004	0.001
US.US	0.998	0.972	0.92	0.953	0.903	0.872	0.821	0.923	0.993
ROW.US	0.001	0.015	0.078	0.039	0.069	0.082	0.125	0.073	0.006
CAN.ROW	0.001	0.013	0.002	0.008	0.028	0.046	0.054	0.004	0.001
US.ROW	0.001	0.015	0.078	0.039	0.069	0.082	0.125	0.073	0.006
ROW.ROW	0.998	0.972	0.92	0.953	0.903	0.872	0.821	0.923	0.993

[1] *v* is the nationality of the owners of a firm operating in sector *s* of country *i*

Source: GTAP-FDI data (Boumellassa, Gouel and Laborde, 2007). Additional data: For Canada: Corporation Return Act, Statistics Canada and Direct Investment of Canada Abroad and Foreign Direct Investment in Canada, Statistics Canada; For the U.S.: Bureau of Economic Analysis

The other indicator that will matter a lot for the simulations results is the initial tax rate on foreign assets. The numbers in Table 4.2 report the initial tax rate on foreign asset in each of the three regions and for each of the nine sectors of the economy. The rates were retrieve from the OECD's FDI restrictiveness index study (Kalinova, Palerm, and Thomsen, 2010), based on the methodology of Golub (2003), whose methodology was itself largely inspired by Hardin and Holmes (1997). The rates for Canada, the U.S. and the ROW are explicit in the study. It is worth noticing that the degree of restrictions for inward FDI (equivalent to the tax rates of Table 4.2) is still slightly higher in Canada than in other regions of the world with the exception of the transport sector where it is the highest in the US.

Table 4.2: Tax on foreign assets ($CTAX_{i,j,s}$)[1]

Countries *i.j*.	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN.CAN	-	-	-	-	-	-	-	-	-
US.CAN	0.0	0.153	0.1	0.1	0.1	0.1	0.1	0.153	0.267
ROW.CAN	0.0	0.153	0.1	0.1	0.1	0.1	0.1	0.153	0.267
CAN.US	0.0	0.116	0.0	0.0	0.0	0.0	0.0	0.116	0.553
US.US	-	-	-	-	-	-	-	-	-
ROW.US	0.0	0.116	0.0	0.0	0.0	0.0	0.0	0.116	0.553
CAN.ROW	0.163	0.117	0.04	0.04	0.04	0.04	0.04	0.117	0.249
US.ROW	0.163	0.117	0.04	0.04	0.04	0.04	0.04	0.117	0.249
ROW.ROW	0.163	0.117	0.04	0.04	0.04	0.04	0.04	0.117	0.249

[1] Country *j* imposes a tax on foreign assets originating from country *i*

Source: Kalinova, Palerm, and Thomsen (2010)

5. Simulation Results

The starting point of our empirical analysis is the existing literature on the effects that border security measures post-2001 have had on Canadian exports to the US. Several studies have used gravity-type econometric tools to provide quantitative estimates of the impact of the 9/11 thickening of the Canada-U.S. border both at sectoral and global levels (Grady, 2009; Globerman and Storer, 2009, Burt, 2007). Table 5.1 shows the estimates obtained by Grady on selected sectors. For example, real (volume) export of the Canadian Automotive (AUTO) sector to the U.S. has been cut by 8.9% as a consequence of the thickening of the border. The High Tech (TECH) and Transport (TRAN) sectors have been affected even more deeply (respectively -26.8% and -14.9%), while the Agriculture (AGRI) and Energy (RESO) sectors have been only modestly affected (-1.9% and 0%).

Table 5.1: Sectoral real export (volume) impact of border security measures[1]

AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
-1.9	-0.0	-1.9	-5.9	-5.9	-26.8	- 8.9	-7.9	-14.9

1.The sectoral decomposition in our model matches roughly the product category used by Grady (2007).
Source: Grady (2009)

The objective of our empirical study is to provide a general equilibrium analysis (*i.e.*, to describe the general ramifications throughout the economy) of the potential economic benefits for the Canadian economy of a security scheme such as a continental perimeter (Clarkson, 2008) that would improve the flows of goods by decongesting the Canada-U.S. border.

In order to assess the economic benefits of decongesting the Canada-US border in a general equilibrium setting, we first need to gauge the tariff-equivalent of the post 9/11 border security measures (including the trusted trader programs) that led to the export impacts given in Table 5.1. In other words, we answer the following question: If the U.S. government had imposed in early 2000s a protectionist measure (an increase in tariffs on goods and services) leading to a reduction in Canada's export of the magnitude given by Table 5.1, what would have been the increase in the U.S. tariff? This is a very complex question and we answer it by simulating the model described in the appendix, where the imposed exogenous shock is the real export impact of the security measures (including the trusted trader programs) as estimated in Table 5.1.

Table 5.2 provides these sectoral tariff equivalents. For example, the tariff equivalent of the post 9/11 border security measures (including the trusted trader programs) in the manufacture sector is 9%, and 18% in the transport sector. These tariff equivalents are quite significant and their magnitude can be put in perspective by

comparing them to the U.S. tariff typically imposed on Canada's goods and given in Table 3 of the Appendix (for example, 3.7% on the Food sector, which includes dairy products—see the explicit definition of Food sector in Table 1 of the Appendix). Clearly, the post-9/11 border security measures (even when we include the trusted trader programs) have eroded any positive impact of the FTA/NAFTA. In fact, these post-9/11 border security measures have pushed Canada in a situation much worse than the pre-FTA period because FTA/NAFTA only reduced tariffs by around one per cent according to Grady (2009). Furthermore, if the security measures are specific to the Canada-U.S. border, then the competitiveness of Canadian firms in the U.S. market must have dramatically worsened with respect to firms from third countries.

Table 5.2: Tariff equivalents of the border security measures

AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
0.07	0.05	0.07	0.06	0.09	0.11	0.07	0.13	0.18

Source: Simulation results

In the following, we use the results in Table 5.2 to extent our analysis in different directions. First, we address the important question of assessing the economic impact of a continental perimeter (Clarkson, 2008) that would permit to decongest the Canada-U.S. border. In other words, if the continental perimeter permits to eliminate the *U.S.-imposed* post-9/11 border security measures, what would be the benefit for the Canadian economy? This is analysed in Section 5.1 and presented as scenario 1. Second, we extend the analysis by also taking into account the effects that *Canadian-imposed* post-9/11 border measures might have had on the US economy with possible feedback effects on the Canadian economy (Section 5.2, Scenario 2). Finally, we provide some sensitivity

analysis on the magnitude of the impacts of border measures on real exports. In other words, the results in Table 5.1 (and therefore 5.2) are probably upper-bound estimates. Studies by Burt (2007) and Goldfarb (2007) suggest that the export impacts of the post-9/11 border security measures might have been much lower than those estimated by Grady (2009) and Globerman and Storer (2009). We therefore propose to redo our analysis by halving the export impact as given in Table 5.1 (Section 5.3, Scenario 3).

5.1 Scenario 1: Removing US security measures

The most direct impact of eliminating border delays imposed by U.S. security measures is on Canadian exportations to the U.S. Table 5.3 below confirms that Canadian exportations to the U.S. increase substantially. The second row of the table indicates that firms of Canadian nationality located in Canada increase their export to the U.S. by 26.8% in the Technology (TECH) sector and 14.9% in the Transportation (TRAN) sector. Exportations from Canada to the U.S. also increase significantly in the Textile (TEXT, 5.9%), Manufacturing (MANU, 5.9%), Automotive (AUTO, 8.9%) and Service (SERV, 7.9%). Notice that exportations to the U.S. of firms of U.S. and ROW nationality located in Canada also rise substantially (11^{th} and 20^{th} row of Table 5.3). In fact the numbers reported in rows 2, 9, and 20 correspond exactly to the Grady numbers reported in Table 5.1. This should give some comfort with respect to our simulation strategy and model.

From Table 5.3 we also observe that Canada reduces its export to the ROW. The elimination of the US security measures at the Canada-US border thus tends to create trade diversion: more trade with the US at the expense of Canada's trade with the ROW

in almost all sectors as it can be seen in rows 3, 12 and 21 of Table 5.3. Finally it is worth observing that the elimination of border delays for goods exported from Canada to the U.S. also stimulates Canadian importations. Indeed, while Canadian exports to the U.S. increase at the expense of exportations to the ROW, the rise in Canadian importations occurs for good produced in both the U.S. (see rows 4, 13, and 22) and the ROW regions (see rows 7, 16, and 25 of Table 5.3). Moreover, the increase in Canadian importations is more balanced across sectors than for exportations.

Table 5.3 Sectoral trade flows by nationality of firms [Domestic production for domestic use on the diagonal (CAN.CAN, US.US, ROW.ROW)]

Nationality	From:	To:	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	CAN	1.4	4.1	1.6	-0.6	4.4	2.8	4.1	1.3	2.5
CAN	CAN	US	1.9	0.0	1.9	5.9	5.9	26.8	8.9	7.9	14.9
CAN	CAN	ROW	-8.5	-1.2	-14.0	-17.5	-5.4	-15.1	-12.3	-9.7	-7.7
CAN	US	CAN	7.0	5.0	9.7	12.1	8.8	22.4	14.2	6.4	7.1
CAN	US	US	-1.6	-0.5	-1.9	-0.8	-0.7	-4.1	-3.5	-2.2	-0.5
CAN	US	ROW	-1.0	0.0	-0.4	-0.1	-0.1	1.3	0.8	-0.5	-0.5
CAN	ROW	CAN	6.8	5.0	9.1	10.6	8.4	20.2	12.6	5.6	6.4
CAN	ROW	US	-2.5	0.0	-2.3	-2.4	-2.0	-5.6	-5.9	-1.8	-1.5
CAN	ROW	ROW	-1.9	-1.1	-2.1	-1.4	-0.7	-0.2	-0.6	-2.3	-1.2
US	CAN	CAN	2.7	4.9	4.4	0.8	4.5	-2.3	2.3	3.6	3.4
US	CAN	US	1.9	0.0	1.9	5.9	5.9	26.8	8.9	7.9	14.9
US	CAN	ROW	-7.1	-1.0	-12.2	-16.3	-5.0	-15.0	-11.4	-8.6	-6.8
US	US	CAN	10.6	5.2	11.4	13.0	8.4	10.1	10.4	7.3	8.5
US	US	US	-0.1	0.0	-0.1	0.1	0.1	0.0	-0.1	-0.1	0.0
US	US	ROW	0.8	0.3	1.2	0.7	0.3	0.5	0.6	0.6	0.5
US	ROW	CAN	10.3	5.2	11.0	12.2	8.2	9.4	9.7	7.1	8.2
US	ROW	US	-0.4	0.0	-0.6	-0.5	-0.8	-1.0	-1.7	-0.5	-0.4
US	ROW	ROW	0.0	-0.1	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0
ROW	CAN	CAN	2.7	4.9	4.3	0.8	4.5	-2.5	2.4	3.6	3.3
ROW	CAN	US	1.9	0.0	1.9	5.9	5.9	26.8	8.9	7.9	14.9
ROW	CAN	ROW	-7.1	-1.0	-12.2	-16.3	-5.0	-14.9	-11.3	-8.6	-6.8
ROW	US	CAN	10.6	5.2	11.4	13.0	8.4	9.6	10.4	7.3	8.5
ROW	US	US	-0.1	-0.1	-0.2	0.1	0.1	0.4	0.2	-0.1	0.0
ROW	US	ROW	0.8	0.3	1.2	0.6	0.3	0.6	0.7	0.6	0.5
ROW	ROW	CAN	10.3	5.2	11.0	12.2	8.2	9.0	9.7	7.1	8.2
ROW	ROW	US	-0.4	0.0	-0.6	-0.5	-0.8	-0.6	-1.4	-0.5	-0.4
ROW	ROW	ROW	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Table 5.4 reports the changes in the stock of capital. With the rise in Canadian exportations to the U.S. one may expect that doing business in Canada is now more appealing from the investors' point of view. In Table 5.4, we observe that the stock of capital in Canada (rows 1, 4, and 7) enlarges in almost all sectors. This implies that Canadian investors (row 1) but also foreign investors (FDI in rows 4 and 7) reallocate their wealth in favour of the Canada region. Table 5.4 also reports that Canada outward FDI (or Canadian investment abroad) in the U.S. and in the ROW declines significantly (row 2 and 3). The results in Table 5.3 and 5.4 suggest that U.S. direct investment into Canada and US export to Canada (and Canadian export to the U.S.) are complementary. We also observe that Canada's reduction in export to the ROW (Table 5.3) does not lead to an increase in Canada's direct investment to the ROW. Quite the opposite – Canadians divest from the ROW (as they divest from the U.S.) and for a good reason: the return to investing in Canada has increased (Table 5.6 below).

Table 5.4 Physical capital stock - Impact of Scenario 1 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.3	1.8	0.6	0.0	2.3	5.1	2.5	1.5	1.7
CAN	US	-3.8	-2.6	-4.2	-3.6	-3.5	-4.4	-4.3	-4.4	-3.6
CAN	ROW	-4.0	-2.8	-4.3	-3.9	-3.5	-3.4	-3.7	-4.3	-3.8
US	CAN	3.6	4.5	5.4	3.8	5.9	7.5	5.7	6.3	5.8
US	US	0.1	0.0	0.0	0.1	0.1	0.2	0.3	-0.1	0.0
US	ROW	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0
ROW	CAN	3.6	4.5	5.3	3.8	5.8	7.4	5.6	6.2	5.7
ROW	US	0.1	0.0	-0.1	0.1	0.1	0.3	0.4	-0.2	-0.1
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Table 5.5 shows the sectoral impact. Sectoral production in Canada increases for all sectors. This holds for Canadian firms located in Canada (CAN, CAN) as well as multinationals located in Canada ((US, CAN) and (ROW, CAN)). This result is

consistent with the increase in Canadian exports (Table 5.3) and in the capital stock in Canada (Table 5.4). Note that Canadian multinationals located in the U.S. (CAN.US) tend to reduce their activity over there (Table 5.4). Security measures might have provided a rationale for Canadian firms to increase their activity directly in the US instead of exporting. With the elimination of the US security measures, some of these activities can now be repatriated in Canada. This channel illustrates that Canadian direct investment in the U.S. is a substitute for Canadian export to the U.S. If Canadian export to the U.S. is stimulated through the elimination U.S. border security measures (Table 5.3), then this will have a negative impact on Canadian investment in the U.S. (Table 5.4).

Table 5.5 Sectoral output - Impact of Scenario 1 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.7	2.3	1.0	0.4	4.0	9.7	6.3	1.2	2.2
CAN	US	-1.4	-0.4	-1.8	-0.6	-0.4	-2.0	-1.6	-2.1	-0.5
CAN	ROW	-1.9	-1.0	-2.1	-1.4	-0.7	-0.6	-0.9	-2.3	-1.2
US	CAN	0.5	2.8	3.3	1.3	4.2	7.6	5.9	3.4	3.0
US	US	0.2	0.1	0.0	0.3	0.3	0.5	0.8	-0.1	0.1
US	ROW	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0
ROW	CAN	0.5	2.8	3.3	1.3	4.2	7.5	5.9	3.4	3.0
ROW	US	0.2	0.0	0.0	0.3	0.3	0.8	1.0	-0.1	0.1
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0

Source: Simulation results

Finally, Table 5.6 reports the impact of eliminating the U.S. security measures at the Canada-US border on aggregate indicators for the three regions of the world. Real wage in Canada would increase by an impressive 2.8%, thanks to the increase in economic activity (Table 5.5) and in the capital stock (Table 5.4). This generates an increase in purchasing power which sustains an increase in real consumption (welfare) by 3.1% on a permanent basis. Total revenue in Canada increases by 1.35%, which is equivalent to $1.79 billion of 2010 dollars. The increase in total revenue essentially

reflects an increase in production in Canada that is driven by an increase in export to the U.S. as well as an increase in U.S. direct investment in Canada due to the increase of the return of investing in Canada (+4.1%).[1,2] The annual amount of money Canada would gain if (post-9/11) border delays were eliminated is estimated to be $1.79 billion. This suggests that any alternative approach that would permit the elimination of post 9/11 border measures and with an annual cost under $1.79 billion would generate a net gain for Canada.

Table 5.6 Some Aggregates - Impact of Scenario 1 (in %)

	Real GNP (Revenue)	Real Wage	Real Consumption	Return on Capital owned by Nationals of:
CAN	+1.35	+2.78	+3.14	+4.15
US	-0.15	+0.01	-0.17	-2.15
ROW	-0.03	-0.03	-0.03	-0.18

Source: Simulation results

5.2 Scenario 2: Removing US and Canadian security measures

The second scenario assumes that both U.S. and Canadian security measures are eliminated. This scenario is closer to the idea of a continental security perimeter (Clarkson, 2008) that decongests the Canada-U.S. border in both directions. As in this scenario we are eliminating security measures on both sides of the border, export of U.S. to Canada should also increase further (as comparing Table 5.7 and 5.3 makes clear). Table 5.7 reports that this is indeed the case, and this is at the expense of trade between Canada and ROW and between the U.S. and ROW. Table 5.8 confirms that trade and

[1] We are using a static model, so the increase in real GNP must be considered a lower bound of the long run impact. Indeed, in a dynamic set up, total wealth would increase and so physical capital stock. Consequently, GNP would increase by more.

[2] Note that 4.1% is the increase in the return on capital owned by Canadians. As this return is mainly the return on assets held by Canadians in Canada, this is also a proxy for the return of investing in Canada.

FDI are complementary as foreign investment in ROW declines at the benefit of the capital stock in Canada and the U.S. Not surprisingly sectoral output percentage changes (Table 5.9) are consistent with the changes in the capital stock reported in Table 5.8. It is worthy to note that percentage changes in capital stock and output in Canada are larger in Scenario 2 than for Scenario 1 for specific sectors such as MANU, TECH and AUTO. Also percentage changes for capital stock and output located in Canada are much larger than for the ones located in the U.S. Two mains reasons explain this asymmetrical outcome. First trade matters much more for Canada than for the U.S. Second security measures are much stricter for the trade flow going from Canada to the U.S. than flow the U.S. to Canada. The asymmetry in the results between Canada and the U.S. is also reflected in the aggregates indicators reported in Table 5.10. Notice that the 0.79 increase in real GNP for Canada is equivalent to an amount $1.05 billion of dollars of 2010. As mentioned in a footnote above, this is likely a lower bound as in the long run this amount would increase with the rise of total wealth. As a result, unless the cost of implementing a continental security perimeter (including the political costs of sovereignty loss) is very large, the net benefit for Canada as reported in Scenario 1 and Scenario 2 would likely be substantial. Note that in comparison to Scenario 1, the indicators for the U.S. tend to improve in Scenario 2.

Table 5.7 Sectoral trade flows by nationality of firms [Domestic production for domestic use on the diagonal (CAN.CAN, US.US, ROW.ROW)]

Nationality	From:	To:	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	CAN	1.4	4.1	1.6	-0.6	4.4	2.8	4.1	1.3	2.5
CAN	CAN	US	1.9	0.0	1.9	5.9	5.9	26.8	8.9	7.9	14.9
CAN	CAN	ROW	-8.5	-1.2	-14.0	-17.5	-5.4	-15.1	-12.3	-9.7	-7.7
CAN	US	CAN	7.8	5.0	10.5	14.7	11.4	35.6	18.2	9.7	13.5
CAN	US	US	-1.6	-0.5	-1.9	-0.8	-0.7	-4.1	-3.5	-2.2	-0.5
CAN	US	ROW	-1.0	0.0	-0.4	-0.1	-0.1	1.3	0.8	-0.5	-0.5
CAN	ROW	CAN	6.8	5.0	9.1	10.6	8.4	20.2	12.6	5.6	6.4
CAN	ROW	US	-2.5	0.0	-2.3	-2.4	-2.0	-5.6	-5.9	-1.8	-1.5
CAN	ROW	ROW	-1.9	-1.1	-2.1	-1.4	-0.7	-0.2	-0.6	-2.3	-1.2
US	CAN	CAN	2.7	4.9	4.4	0.8	4.5	-2.3	2.3	3.6	3.4
US	CAN	US	1.9	0.0	1.9	5.9	5.9	26.8	8.9	7.9	14.9
US	CAN	ROW	-7.1	-1.0	-12.2	-16.3	-5.0	-15.0	-11.4	-8.6	-6.8
US	US	CAN	11.5	5.2	12.2	15.6	10.9	21.9	14.3	10.7	15.0
US	US	US	-0.1	0.0	-0.1	0.1	0.1	0.0	-0.1	-0.1	0.0
US	US	ROW	0.8	0.3	1.2	0.7	0.3	0.5	0.6	0.6	0.5
US	ROW	CAN	10.3	5.2	11.0	12.2	8.2	9.4	9.7	7.1	8.2
US	ROW	US	-0.4	0.0	-0.6	-0.5	-0.8	-1.0	-1.7	-0.5	-0.4
US	ROW	ROW	0.0	-0.1	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0
ROW	CAN	CAN	2.7	4.9	4.3	0.8	4.5	-2.5	2.4	3.6	3.3
ROW	CAN	US	1.9	0.0	1.9	5.9	5.9	26.8	8.9	7.9	14.9
ROW	CAN	ROW	-7.1	-1.0	-12.2	-16.3	-5.0	-14.9	-11.3	-8.6	-6.8
ROW	US	CAN	11.4	5.2	12.2	15.6	10.9	21.4	14.3	10.7	15.0
ROW	US	US	-0.1	-0.1	-0.2	0.1	0.1	0.4	0.2	-0.1	0.0
ROW	US	ROW	0.8	0.3	1.2	0.6	0.3	0.6	0.7	0.6	0.5
ROW	ROW	CAN	10.3	5.2	11.0	12.2	8.2	9.0	9.7	7.1	8.2
ROW	ROW	US	-0.4	0.0	-0.6	-0.5	-0.8	-0.6	-1.4	-0.5	-0.4
ROW	ROW	ROW	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Table 5.8 Physical capital stock - Impact of Scenario 2 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.2	1.8	0.5	1.0	2.8	7.7	4.2	1.0	1.6
CAN	US	-3.2	-2.0	-3.6	-3.1	-2.9	-4.4	-4.4	-3.7	-2.9
CAN	ROW	-3.6	-2.5	-3.8	-3.4	-3.1	-3.1	-3.3	-3.8	-3.3
US	CAN	3.0	4.1	4.4	4.3	5.7	9.1	7.4	4.8	4.9
US	US	0.1	0.1	0.0	0.1	0.2	0.4	0.4	-0.1	0.0
US	ROW	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1
ROW	CAN	3.1	4.2	4.5	4.4	5.9	10.7	7.6	5.0	5.1
ROW	US	0.2	0.2	0.1	0.2	0.3	0.5	0.5	0.0	0.1
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0

Source: Simulation results

Table 5.9 Sectoral output - Impact of Scenario 2 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.2	2.7	1.1	2.5	5.4	15.9	10.3	0.8	2.5
CAN	US	-1.2	-0.1	-1.5	-0.6	-0.3	-2.8	-2.6	-1.8	-0.3
CAN	ROW	-1.7	-0.9	-1.8	-1.2	-0.6	-0.7	-1.0	-2.0	-1.1
US	CAN	0.8	3.2	3.0	3.2	5.3	12.7	10.6	2.6	3.1
US	US	0.2	0.3	0.0	0.2	0.4	0.8	0.9	-0.1	0.2
US	ROW	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.1
ROW	CAN	0.8	3.2	3.1	3.3	5.4	15.4	10.8	2.7	3.2
ROW	US	0.3	0.3	0.1	0.2	0.4	0.8	1.0	0.0	0.2
ROW	ROW	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0

Source: Simulation results

Table 5.10 Some Aggregates - Impact of Scenario 2 (in %)

	Real GNP (Revenue)	Real Wage	Real Consumption	Return on Capital owned by Nationals of:
CAN	+0.79	+2.94	+2.35	+3.35
US	-0.11	+0.08	-0.11	-1.91
ROW	-0.03	-0.04	-0.04	-0.17

Source: Simulation results

5.3 Scenario 3: Removing US security measures: halving the impacts

As Scenario 3 refers to 50% removal of US security measures, the results are similar to Scenario 1 but at half magnitude. This is why we report in this section the results for the aggregate indicators only.

Not surprisingly Table 5.11 reports that total revenue in Canada increases by 0.62%, real wage increases by 1.3%, and real consumption (welfare) increases by 1.51%. The impact is about 50% of the ones observed in Scenario 1. The 50% reduction in U.S. security measures triggers a smaller production increase in Canada and export flows toward the U.S. The increase in U.S. direct investment in Canada is also at a lower magnitude since the rise of the return to capital in Canada is only 0.86%.

Table 5.11 Some Aggregates - Impact of Scenario 3 (in %)

	Real GNP (Revenue)	Real Wage	Real Consumption	Return on Capital owned by Nationals of:
CAN	+0.62	+1.30	+1.51	+0.86
US	-0.07	+0.01	-0.08	-2.13
ROW	-0.01	-0.02	-0.02	-0.19

Source: Simulation results

5.4 Scenario 4: Removing US and Canadian security measures: halving the impacts

Scenario 4 removes half of the U.S. and Canadian security measures. This scenario is similar to Scenario 2 but at 50% in terms of magnitude. Compared to the results reported for Scenario 2, both Canada and U.S. benefits are cut in half. Total revenue in Canada increases by 0.36% (i.e. around $478 millions of dollars of 2010). Real wage and welfare increases by 1.37% and 1.12% respectively. The rate of return on capital owned by Canadians drops from 3.35% to 0.46%.

Table 5.12 Some Aggregates - Impact of Scenario 4 (in %)

	Real GNP (Revenue)	Real Wage	Real Consumption	Return on Capital owned by Nationals of:
CAN	+0.36	+1.37	+1.12	+0.46
US	-0.05	+0.04	-0.05	-2.01
ROW	-0.01	-0.02	-0.02	-0.18

Source: Simulation results

6. Conclusion

The objective of study was to provide a sophisticated (*i.e.*, to describe the general ramifications throughout the economy) quantitative analysis of the potential economic benefits for the Canadian economy of an alternative security scheme such as the long-discussed continental perimeter (Clarkson, 2008) that would improve the flows of goods

by decongesting the Canada-U.S. border. The results of the study suggest that the economic gains for Canada would be substantial. Trade flows (exports and imports) of goods would improve significantly, especially for sectors like textile, manufacturing, high technology and automotive. But our study also suggests that economic gains would also be important in terms of revenue and welfare. The annual amount of money Canada would gain if (post-9/11) border delays were eliminated is estimated to be $1.79 billion. This suggests that any alternative approach that would permit the elimination of post 9/11 border measures and with an annual cost under $1.79 billion would generate a net economic gain for Canada.

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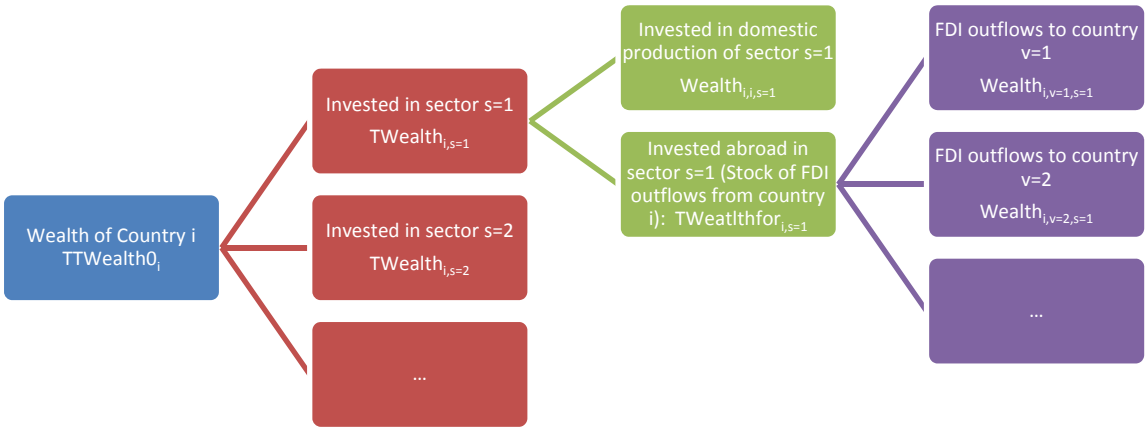
Appendix: Equations and notation of the FDI model

1. Wealth allocation structure and notation

Figure 1. Allocation of wealth (assets)



First level CET

(1) $$TWEALTH_{i,s} = ETAW_{i,s}\left(\frac{RTW_{i,s}}{RTTW_i}\right)^{\sigma TTW_i} TTWEALTH0_i$$

(2) $$\left(RTTW_i\right)^{1+\sigma TTW_i} = \sum_s ETAW_{i,s}\left(RTW_{i,s}\right)^{1+\sigma TTW_i}$$

Second level CET

(3) $$TWEALTHFOR_{i,s} = ETAWFOR_{i,s}\left(\frac{RWFOR_{i,s}}{RTW_{i,s}}\right)^{\sigma TW_{i,s}} TWEALTH_{i,s}$$

(4) $$WEALTH_{i,i,s} = ETAWDOM_{i,s}\left(\frac{R_{i,i,s}}{RTW_{i,s}}\right)^{\sigma TW_{i,s}} TWEALTH_{i,s}$$

(5) $$\left(RTW_{i,s}\right)^{1+\sigma TW_{i,s}} = ETAWFOR_{i,s}\left(RWFOR_{i,s}\right)^{1+\sigma TW_{i,s}} + ETAWDOM_{i,s}\left(R_{i,i,s}\right)^{1+\sigma TW_{i,s}}$$

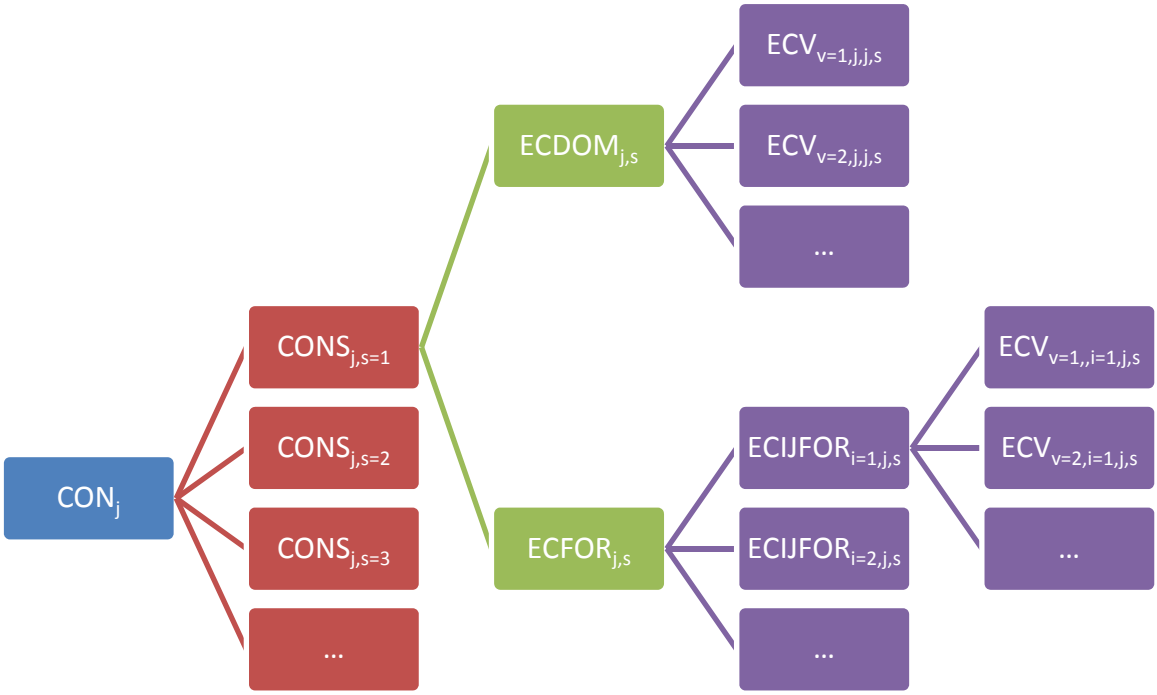
Third level CET

(6) $$WEALTH_{i,v,s} = ETAWW_{i,v,s}\left(\frac{R_{i,v,s}\left(1-CTAX_{i,v,s}\right)}{RWFOR_{i,s}}\right)^{\sigma W_{i,s}} TWEALTHFOR_{i,s}$$

(7) $$\left(RWFOR_{i,s}\right)^{1+\sigma W_{i,s}} = \sum_v ETAWW_{i,v,s}\left[R_{i,v,s}\left(1-CTAX_{i,v,s}\right)\right]^{1+\sigma W_{i,s}}$$

2. Consumption structure and notation

Figure 2. Structure of final consumption demand



First level Cobb-Douglas

(8) $$CONS_{j,s} = \frac{\rho_{j,s} CON_j PCON_j}{PCFC_{j,s}}$$

(9) $$Log\left(PCON_j\right) = \sum_s \rho_{j,s} \log\left(PCFC_{j,s}\right)$$

Second level CES

(10) $$ECDOM_{j,s} = ETADOMC_{j,s}\left[\frac{PCFC_{j,s}}{PDOM_{j,s}}\right]^{\sigma FORC_{j,s}} \underbrace{\frac{\rho_{j,s} PCON_j CON_j}{PCFC_{j,s}}}_{CONS_{j,s}}$$

(11) $$ECFOR_{j,s} = ETAFORC_{j,s}\left[\frac{PCFC_{j,s}}{PFOR_{j,s}}\right]^{\sigma FORC_{j,s}} \underbrace{\frac{\rho_{j,s} PCON_j CON_j}{PCFC_{j,s}}}_{CONS_{j,s}}$$

(12) $$\left(PCFC_{j,s}\right)^{1-\sigma FORC_{j,s}} = \left[ETADOMC_{j,s}\left(PDOM_{j,s}\right)^{1-\sigma FORC_{j,s}} + ETAFORC_{j,s}\left(PFOR_{j,s}\right)^{1-\sigma FORC_{j,s}}\right]$$

Third level CES

(13) $$ECV_{v,j,j,s} = ETADOMV_{v,j,j,s}\left[\frac{PDOM_{j,s}}{PV_{v,j,s}}\right]^{\sigma DOMV_{j,s}} ECDOM_{j,s}$$

(14) $$\left(PDOM_{j,s}\right)^{1-\sigma DOMV_{j,s}} = \sum_{v} ETADOMV_{v,j,j,s}\left(PV_{v,j,s}\right)^{1-\sigma DOMV_{j,s}}$$

Fourth level CES

(15) $$ECIJFOR_{i,j,s} = ETAFC_{i,j,s}\left[\frac{PFOR_{j,s}}{PIJ_{i,j,s}}\right]^{\sigma_{j,s}} ECFOR_{j,s}$$

(16) $$\left(PFOR_{j,s}\right)^{1-\sigma_{j,s}} = \sum_{i} ETAFC_{i,j,s}\left(PIJ_{i,j,s}\right)^{1-\sigma_{j,s}}$$

Fifth level CES

(17) $$ECV_{v,i,j,s} = ETAFORV_{v,i,j,s}\left[\frac{PIJ_{i,j,s}}{PV_{v,i,s}\left(1+TAR_{v,i,j,s}\right)}\right]^{\sigma FORV_{j,s}} ECIJFOR_{i,j,s}$$

(18) $$\left(PIJ_{i,j,s}\right)^{1-\sigma FORV_{j,s}} = \sum_{v} ETAFORV_{v,i,j,s}\left(PV_{v,i,s}\left(1+TAR_{v,i,j,s}\right)\right)^{1-\sigma FORV_{j,s}}$$

3. Investment demand

In the first level, there is a demand in country *j* for different (investment) goods *s* produced by different subsidiaries *v*. The second level describes from which country the agent of country *j* buys the (investment) good.

First level Cobb-Douglas

(19) $$INVVS_{v,j,s} = \frac{\gamma_{v,j,s} INV_j PINV_j}{PCFV_{v,j,s}}$$

(20) $$\log PINV_j = \sum_{v}\sum_{s} GAM_{v,j,s} \log PCFV_{v,j,s}$$

Second level CES

$$(21) \qquad EVV_{v,i,j,s} = ETAFV_{v,i,j,s}\left[\frac{PCFV_{v,j,s}}{PV_{v,i,s}(1+TAR_{v,i,j,s})}\right]^{\sigma_{j,s}} \underbrace{\frac{\gamma_{v,j,s} INV_j PINV_j}{PCFV_{v,j,s}}}_{INVVS_{v,j,s}}$$

$$(22) \qquad \left(PCFV_{v,j,s}\right)^{1-\sigma_{j,s}} = \sum_i ETAFV_{v,i,j,s}\left[PV_{v,i,s}\left(1+TAR_{v,i,j,s}\right)^{1-\sigma_{j,s}}\right]$$

4. Supply side

The firm operates in sector *sd* of country *j* and is of nationality *v* (*i.e.*, a subsidiary originating from country-*v*). From profit maximisation, we obtain the marginal cost pricing:

$$(23) \qquad PV_{v,j,sd} = \nu_{v,j,sd}$$

where $\nu_{v,j,sd}$ is the unit (average and marginal) cost.

Conditional factor demands from cost minimization:

$$(24) \qquad L_{v,j,sd} = \frac{\alpha_{L\,v,j,sd} PV_{v,j,sd} Z_{v,j,sd}}{W_j}$$

$$(25) \qquad K_{v,j,sd} = \frac{\alpha_{K\,v,j,sd} PV_{v,j,sd} Z_{v,j,sd}}{R_{v,j,sd}}$$

$$(26) \qquad EI_{v,j,s,sd} = \frac{\alpha_{X\,v,j,s,sd} PV_{v,j,sd} Z_{v,j,sd}}{PCI_{v,j,s,sd}}$$

Unit cost function is:

$$(27) \qquad \log PV_{v,j,sd} = \alpha_{L\,v,j,sd} \log\left(W_j\right) + \alpha_{K\,v,j,sd} \log\left(R_{v,j,sd}\right) + \sum_s \alpha_{X\,v,j,s,sd} \log\left(PCI_{v,j,s,sd}\right)$$

Nationality/ownership and geographic origin of the intermediary good:

(28) $$EIVV_{vo,v,i,j,s,sd} = ETAII_{vo,v,i,j,s,sd} \underbrace{\frac{\alpha_{X\,v,j,s,sd} PV_{v,j,sd} Z_{v,j,sd}}{PCI_{v,j,s,sd}}}_{EI_{v,j,s,sd}}$$

(29) $$PCI_{v,j,s,sd} = \sum_{i} \sum_{vo} ETAII_{vo,v,i,j,s,sd} PV_{vo,i,s} \left(1 + TAR_{vo,i,j,s}\right)$$

5. Equilibrium conditions

Labour market equilibrium

(30) $$\sum_{v} \sum_{sd} \frac{\alpha_{L\,v,j,sd} PV_{v,j,sd} Z_{v,j,sd}}{W_j} = LSUP0_j$$

Capital market equilibrium

(31) $$\frac{\alpha_{K\,v,j,sd} PV_{v,j,sd} Z_{v,j,sd}}{R_{v,j,sd}} = KSUP_{v,j,sd}$$

where we assume no cross-ownership:

(32) $$KSUP_{v,j,sd} = WEALTH_{v,j,sd}$$

Good market equilibrium

(33) $$E_{vo,i,j,s} = ECV_{vo,i,j,s} + EVV_{vo,i,j,s} + \sum_{sd} \sum_{v} EIVV_{vo,v,i,j,s,sd}$$

(34) $$\underbrace{Z_{vo,i,s}}_{\substack{\text{supply of good s by subsidiary vo} \\ \text{located in country i}}} = \underbrace{\sum_{j} E_{vo,i,j,s}}_{\substack{\text{demand for good produced by subsidiary vo located in country i} \\ \text{and expressed by all countries j (including country i)}}}$$

6. Revenue equation

$$REV_i = \sum_v \sum_{sd} \alpha_{Lv,i,sd} PV_{v,i,sd} Z_{v,i,sd} + \sum_v \sum_{sd} R_{i,v,sd} WEALTH_{i,v,sd} (1 - CTAX_{i,v,sd}) + \sum_{vo} \sum_{sd} \sum_j E_{vo,j,i,sd} PV_{vo,j,sd} TAR_{vo,j,i,sd} + \sum_v \sum_{sd} R_{v,i,sd} WEALTH_{v,i,sd} CTAX_{v,i,sd} \quad (35)$$

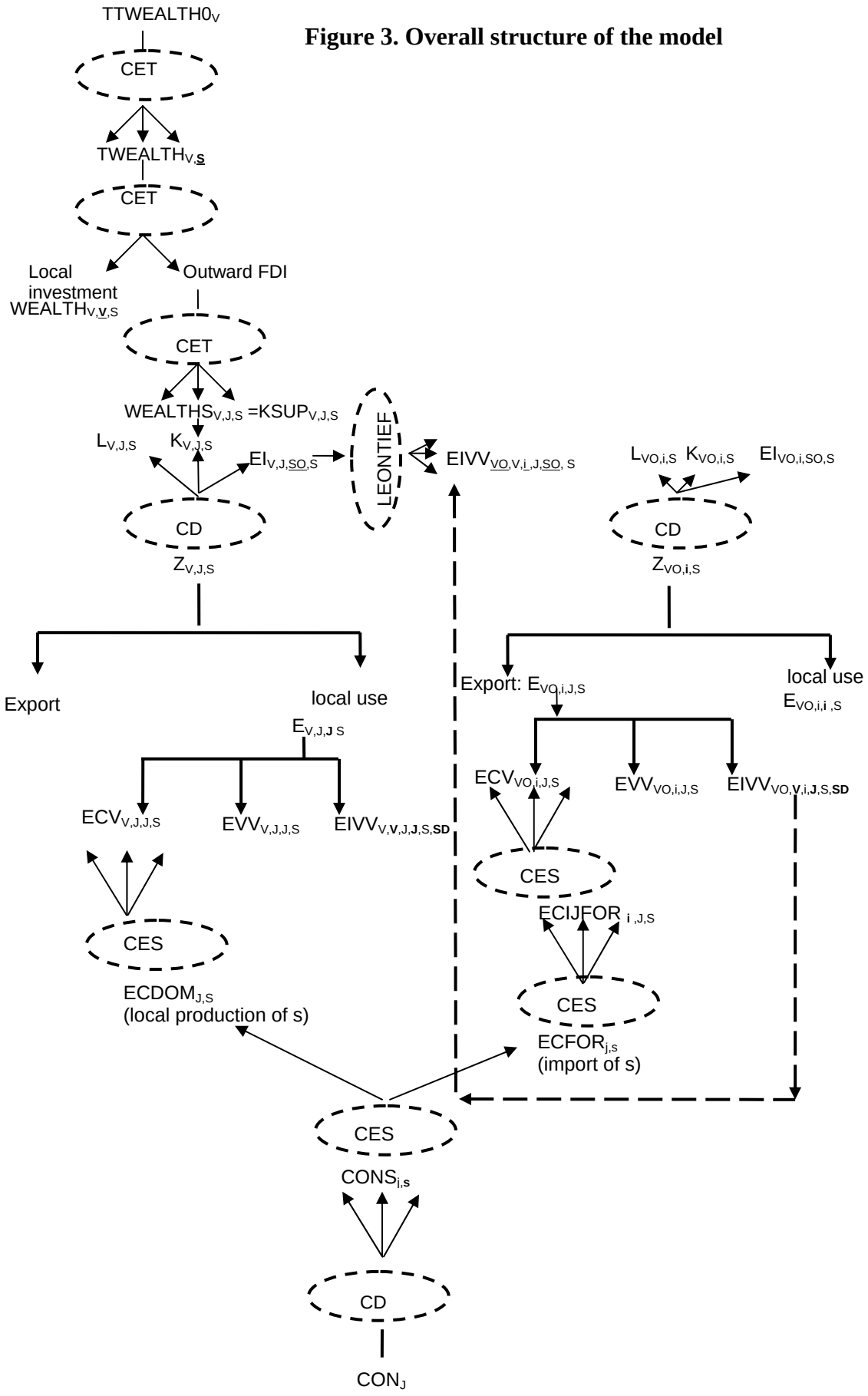
7. Steady state

In the steady state, investment equals depreciation of the stock of capital and the current account of each country is in equilibrium so that trade balance deficit equals interest receipt on foreign (financial) assets.

$$INV_i = \frac{\sum_v \sum_s DEPR_{i,v,s} KSUP_{i,v,s}}{SCR_i} \quad (36)$$

$$ESC.DET_j = CON_j PCON_j + INV_j PINV_j - REV_j \quad (37)$$

Figure 3. Overall structure of the model



Appendix 2

Table 1: Aggregation mapping from GTAP to Model

A. Regions of the Model	Regions/countries in GTAP database
Canada (CAN)	Canada
USA (US)	USA
Rest of the World (ROW)	Australia; New Zealand; Rest of Oceania; China; Hong Kong; Japan; Korea; Taiwan; Rest of East Asia; Cambodia; Indonesia; Lao People's Democratic Republic; Myanmar; Malaysia; Philippines; Singapore; Thailand; Viet Nam; Rest of Southeast Asia; Bangladesh; India; Pakistan; Sri Lanka; Rest of South Asia; Mexico; Rest of North America; Argentina; Bolivia; Brazil; Chile; Colombia; Ecuador; Paraguay; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Nicaragua; Panama; Rest of Central America; Caribbean; Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Switzerland; Norway; Rest of EFTA; Albania; Bulgaria; Belarus; Croatia; Romania; Russian Federation; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyztan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Iran, Islamic Republic of; Turkey; Rest of Western Asia; Egypt; Morocco; Tunisia; Rest of North Africa; Nigeria; Senegal; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Madagascar; Malawi; Mauritius; Mozambique; Tanzania; Uganda ; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; South Africa; Rest of South African Customs Union.

B. Sectors of the Model	Sectors in GTAP database
Agriculture (AGRI)	Paddy rice; wheat; cereal grains nec; vegetables, fruit, nuts; oil seeds; sugar cane, sugar beet; plant-based fibers; crops nec; bovine cattle, sheep and goats, horses; animal products nec; raw milk; wool, silk-worm cocoons.
Resource (RESO)	Forestry; fishing; coal; oil; gas; minerals nec.
Food (FOOD)	Bovine cattle, sheep and goat meat products; meat products; vegetable oils and fats; dairy products; processed rice; sugar; food products nec; beverages and tobacco products.
Textile (TEXT)	Textiles; wearing apparel; leather products.
Manufacture (MANU)	Wood products; paper products, publishing; petroleum, coal products; petroleum, coal products; chemical, rubber, plastic products; mineral products nec; ferrous metals; metals nec; ferrous metals; metals nec; metal products; manufactures nec.
Automobile (AUTO)	Motor vehicles and parts; transport equipment nec.
High Tech (TECH)	Electronic equipment; machinery and equipment nec.
Services (SERV)	Electricity; gas manufacture, distribution; water; construction; trade; communication; financial services nec; insurance; business services nec; recreational and other services; public admin. and defence, education, health; ownership of dwellings.
Transport (TRAN)	Transport nec; water transport; air transport.

Source: Authors own classification

Table 2: Elasticities

Table 2a: Armington CES elasticities of substitution for domestic goods and composite imports ($\sigma FORC_{j,s}$)

	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	2.4	5.1	2.4	3.8	3.1	4.2	3.1	1.9	1.9
US	2.4	5.1	2.4	3.8	3.1	4.2	3.1	1.9	1.9
ROW	2.4	5.1	2.4	3.8	3.1	4.2	3.1	1.9	1.9

Source: Based on top parameters ESBD in GTAP7

Table 2b: Armington CES elasticities of substitution for regional (geographical) allocation of imports ($\sigma_{j,s}$)

	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	4.9	11.8	4.9	7.6	6.5	8.4	6.3	3.9	3.8
US	4.9	11.8	4.9	7.6	6.5	8.4	6.3	3.9	3.8
ROW	4.9	11.8	4.9	7.6	6.5	8.4	6.3	3.9	3.8

Source: Based on bottom parameters ESBM in GTAP7

Table 3: Bilateral Tariff[1]

Countries I.J	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN.CAN	-	-	-	-	-	-	-	-	-
US.CAN	0.012	0	0.155	0	0	0	0	0	0
ROW.CAN	0.008	0	0.136	0.119	0.017	0.008	0.041	0	0
CAN.US	0.006	0	0.037	0	0	0.044	0	0	0
US.US	-	-	-	-	-	-	-	-	-
ROW.US	0.031	0.002	0.054	0.094	0.014	0.007	0.016	0	0
CAN.ROW	0.106	0.009	0.219	0.083	0.027	0.031	0	0	0
US.ROW	0.115	0.015	0.195	0.066	0.034	0.021	0.028	0	0
ROW.ROW	-	-	-	-	-	-	-	-	-

[1] Tariff imposed by country *j* on goods originating from country *i*

Source: GTAP7

Appendix 3

Sectoral output - Impact of Scenario 3 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.4	1.1	0.5	0.2	2.0	4.7	3.1	0.6	1.1
CAN	US	-0.7	-0.2	-0.9	-0.3	-0.2	-1.1	-0.9	-1.0	-0.2
CAN	ROW	-0.9	-0.5	-1.0	-0.7	-0.3	-0.3	-0.4	-1.1	-0.6
US	CAN	0.2	1.4	1.6	0.6	2.0	3.6	2.9	1.6	1.5
US	US	0.1	0.0	0.0	0.2	0.1	0.2	0.4	0.0	0.1
US	ROW	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0
ROW	CAN	0.2	1.3	1.6	0.6	2.0	3.5	2.9	1.6	1.4
ROW	US	0.1	0.0	0.0	0.2	0.1	0.4	0.5	0.0	0.1
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Physical capital stock - Impact of Scenario 3 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.2	0.9	0.3	0.0	1.2	2.5	1.3	0.7	0.8
CAN	US	-1.8	-1.3	-2.1	-1.7	-1.7	-2.2	-2.1	-2.2	-1.7
CAN	ROW	-2.0	-1.4	-2.1	-1.9	-1.7	-1.6	-1.8	-2.1	-1.8
US	CAN	1.7	2.2	2.5	1.8	2.8	3.5	2.8	3.0	2.7
US	US	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.0	0.0
US	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROW	CAN	1.7	2.1	2.5	1.8	2.8	3.5	2.7	3.0	2.7
ROW	US	0.0	0.0	-0.1	0.0	0.0	0.2	0.2	-0.1	0.0
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Sectoral trade flows by nationality of firms [Domestic production for domestic use on the diagonal (CAN.CAN, US.US, ROW.ROW)] - Impact of Scenario 3 (in %)

Nationality	From:	To:	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	CAN	0.7	2.0	0.8	-0.3	2.1	1.3	2.0	0.6	1.2
CAN	CAN	US	0.9	0.0	0.9	2.9	2.9	13.4	4.4	4.0	7.4
CAN	CAN	ROW	-4.4	-0.7	-7.3	-9.3	-2.8	-8.1	-6.3	-5.0	-4.0
CAN	US	CAN	3.3	2.4	4.5	5.7	4.1	10.2	6.7	3.0	3.4
CAN	US	US	-0.8	-0.2	-0.9	-0.4	-0.3	-2.1	-1.8	-1.1	-0.2
CAN	US	ROW	-0.5	0.0	-0.2	-0.1	0.0	0.7	0.4	-0.2	-0.3
CAN	ROW	CAN	3.3	2.4	4.3	5.0	4.0	9.3	6.0	2.7	3.1
CAN	ROW	US	-1.2	0.0	-1.1	-1.1	-1.0	-2.9	-3.0	-0.9	-0.7
CAN	ROW	ROW	-0.9	-0.6	-1.0	-0.7	-0.3	-0.1	-0.3	-1.1	-0.6
US	CAN	CAN	1.3	2.4	2.1	0.4	2.2	-1.5	1.1	1.7	1.6
US	CAN	US	0.9	0.0	0.9	2.9	2.9	13.4	4.4	4.0	7.5
US	CAN	ROW	-3.6	-0.5	-6.3	-8.6	-2.6	-8.0	-5.8	-4.4	-3.5
US	US	CAN	5.0	2.5	5.3	6.1	4.0	4.8	5.0	3.4	4.0
US	US	US	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
US	US	ROW	0.4	0.2	0.6	0.3	0.1	0.2	0.3	0.3	0.2
US	ROW	CAN	4.8	2.5	5.1	5.8	3.9	4.5	4.6	3.3	3.9
US	ROW	US	-0.2	0.0	-0.3	-0.2	-0.4	-0.5	-0.8	-0.2	-0.2
US	ROW	ROW	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
ROW	CAN	CAN	1.3	2.4	2.1	0.4	2.2	-1.6	1.1	1.7	1.6
ROW	CAN	US	0.9	0.0	0.9	2.9	2.9	13.4	4.4	4.0	7.5
ROW	CAN	ROW	-3.6	-0.5	-6.3	-8.6	-2.6	-8.0	-5.8	-4.4	-3.5
ROW	US	CAN	5.0	2.5	5.3	6.1	4.0	4.6	5.0	3.4	4.0
ROW	US	US	0.0	0.0	-0.1	0.0	0.0	0.2	0.1	-0.1	0.0
ROW	US	ROW	0.4	0.2	0.6	0.3	0.1	0.3	0.3	0.3	0.2
ROW	ROW	CAN	4.8	2.5	5.1	5.8	3.9	4.3	4.7	3.3	3.9
ROW	ROW	US	-0.2	0.0	-0.3	-0.2	-0.4	-0.3	-0.7	-0.2	-0.2
ROW	ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Sectoral output - Impact of Scenario 4 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.1	1.3	0.5	1.2	2.6	7.6	5.1	0.4	1.2
CAN	US	-0.5	0.0	-0.7	-0.3	-0.1	-1.5	-1.4	-0.9	-0.1
CAN	ROW	-0.8	-0.4	-0.9	-0.6	-0.3	-0.4	-0.5	-1.0	-0.5
US	CAN	0.4	1.5	1.4	1.6	2.6	5.4	5.2	1.2	1.5
US	US	0.1	0.1	0.0	0.1	0.2	0.4	0.4	0.0	0.1
US	ROW	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
ROW	CAN	0.4	1.5	1.5	1.6	2.6	7.1	5.3	1.3	1.5
ROW	US	0.1	0.1	0.0	0.1	0.2	0.4	0.5	0.0	0.1
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0

Source: Simulation results

Physical capital stock - Impact of Scenario 4 (in %)

Nationality	Location	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	-0.1	0.9	0.2	0.5	1.4	3.8	2.1	0.5	0.8
CAN	US	-1.5	-1.0	-1.7	-1.5	-1.4	-2.2	-2.2	-1.8	-1.4
CAN	ROW	-1.7	-1.2	-1.8	-1.6	-1.5	-1.5	-1.6	-1.8	-1.6
US	CAN	1.4	1.9	2.1	2.1	2.7	3.9	3.6	2.3	2.3
US	US	0.0	0.1	0.0	0.0	0.1	0.2	0.2	0.0	0.0
US	ROW	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
ROW	CAN	1.5	2.0	2.1	2.1	2.8	5.0	3.7	2.4	2.4
ROW	US	0.1	0.1	0.0	0.1	0.1	0.2	0.3	0.0	0.1
ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results

Sectoral trade flows by nationality of firms [Domestic production for domestic use on the diagonal (CAN.CAN, US.US, ROW.ROW)] - Impact of Scenario 4 (in %)

Nationality	From:	To:	AGRI	RESO	FOOD	TEXT	MANU	TECH	AUTO	SERV	TRAN
CAN	CAN	CAN	0.7	2.0	0.8	-0.3	2.1	1.3	2.0	0.6	1.2
CAN	CAN	US	0.9	0.0	0.9	2.9	2.9	13.4	4.4	4.0	7.4
CAN	CAN	ROW	-4.4	-0.7	-7.3	-9.3	-2.8	-8.1	-6.3	-5.0	-4.0
CAN	US	CAN	3.7	2.4	4.9	6.9	5.4	16.1	8.6	4.6	6.5
CAN	US	US	-0.8	-0.2	-0.9	-0.4	-0.3	-2.1	-1.8	-1.1	-0.2
CAN	US	ROW	-0.5	0.0	-0.2	-0.1	0.0	0.7	0.4	-0.2	-0.3
CAN	ROW	CAN	3.3	2.4	4.3	5.0	4.0	9.3	6.0	2.7	3.1
CAN	ROW	US	-1.2	0.0	-1.1	-1.1	-1.0	-2.9	-3.0	-0.9	-0.7
CAN	ROW	ROW	-0.9	-0.6	-1.0	-0.7	-0.3	-0.1	-0.3	-1.1	-0.6
US	CAN	CAN	1.3	2.4	2.1	0.4	2.2	-1.5	1.1	1.7	1.6
US	CAN	US	0.9	0.0	0.9	2.9	2.9	13.4	4.4	4.0	7.5
US	CAN	ROW	-3.6	-0.5	-6.3	-8.6	-2.6	-8.0	-5.8	-4.4	-3.5
US	US	CAN	5.4	2.5	5.7	7.3	5.2	10.4	6.8	5.0	7.1
US	US	US	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
US	US	ROW	0.4	0.2	0.6	0.3	0.1	0.2	0.3	0.3	0.2
US	ROW	CAN	4.8	2.5	5.1	5.8	3.9	4.5	4.6	3.3	3.9
US	ROW	US	-0.2	0.0	-0.3	-0.2	-0.4	-0.5	-0.8	-0.2	-0.2
US	ROW	ROW	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
ROW	CAN	CAN	1.3	2.4	2.1	0.4	2.2	-1.6	1.1	1.7	1.6
ROW	CAN	US	0.9	0.0	0.9	2.9	2.9	13.4	4.4	4.0	7.5
ROW	CAN	ROW	-3.6	-0.5	-6.3	-8.6	-2.6	-8.0	-5.8	-4.4	-3.5
ROW	US	CAN	5.4	2.5	5.7	7.3	5.2	10.2	6.8	5.0	7.1
ROW	US	US	0.0	0.0	-0.1	0.0	0.0	0.2	0.1	-0.1	0.0
ROW	US	ROW	0.4	0.2	0.6	0.3	0.1	0.3	0.3	0.3	0.2
ROW	ROW	CAN	4.8	2.5	5.1	5.8	3.9	4.3	4.7	3.3	3.9
ROW	ROW	US	-0.2	0.0	-0.3	-0.2	-0.4	-0.3	-0.7	-0.2	-0.2
ROW	ROW	ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Simulation results