Working Paper

Trade Policy Analysis at a Sub-national Level: Replacing Canada by its Provinces in the GTAP Model

Dmitry Lysenko, Dan Ciuriak, and Jingliang Xiao
14 April 2015

CIURIAK CONSULTING INC.

Trade Policy Analysis at a Sub-national Level: Replacing Canada by its Provinces in the GTAP Model

Dmitry Lysenko, Dan Ciuriak, and Jingliang Xiao

14 April 2015

Abstract: This paper develops a new version of the GTAP database in which Canada is replaced by its provinces in order to allow the analysis of international trade agreements at a subnational level. The methodology in effect treats the individual provinces as separate trading entities, much like the individual Member States within the European Union, with common external trade barriers and minimal internal trade barriers. We document the procedure to develop this dataset and apply it in a demonstration simulation of the Canada-EU Comprehensive Economic and Trade Agreement. While we emphasize the naïve nature of the policy shock used to demonstrate the model – full tariff elimination and non-tariff factors not taken into account – the overall impact of the CETA appears to be reasonable both in terms of scale and in terms of sectoral impacts. Importantly, the results demonstrate that Canada's provinces are affected very differently by a preferential trade agreement where geography and sectoral specialization favour some and disfavour others.

Keywords: CGE model, GTAP, sub-national impact, provincial trade, trade policy, Canada

JEL Codes: F14, F15, F17

Acknowledgements: This paper has been prepared for submission to the GTAP 18th Annual Conference on Global Economic Analysis, "Information for the Policy Maker: Practical Economic Modelling for Tomorrow". Corresponding author is Dmitry Lysenko, dlysenk@gmail.com.

1. Introduction

Empirical analysis of trade policy impacts has been mainly focused on country-level impacts. Changes in trade policy however may have very different impacts on regions within countries depending on regions' economic structure and geography. It is often of great interest to sub-national levels of government to understand the impacts on their region.

Analysis in this area, particularly general equilibrium analysis, is however virtually non-existent. This reflects a lack data availability at a sub-national level but also a lack of models that incorporate sub-national regions. Standardi, Bosello and Eboli (2014) is one recent exception. It replaces Italy with a number of Italian regions in the Global Trade Analysis Project (GTAP) database while using regional data on production and transportation. Ciuriak, Lysenko and Xiao (2014), in a Canadian context, demonstrate how sub-national impacts can be derived from national-level general equilibrium model results using partial equilibrium model trade results and an allocation method for general equilibrium/income effects.

The purpose of this paper is to modify the GTAP database replacing Canada with its provinces to analyse impacts of international trade agreements at a province-level ("provinces" refer to both territories and provinces of Canada). This is an easier task for Canada as compared to other countries because Statistics Canada has constructed province-level Input-Output (I-O) tables that are linked with each other by a table of interprovincial trade flows. We embed this framework in the standard GTAP model. This paper describes the methodological issues that must be addressed to accomplish this.

To demonstrate the extended database, we conduct a simplified analysis of the Canada-EU Comprehensive Free Trade Agreement (CETA) using the GTAP static model and analyze how its impact differs across Canadian provinces. We aggregate our original database into 16 regions — Korea, US, EU, Rest of the World and twelve Canadian regions — and 19 sectors. We anticipate that the sectoral impacts are very different across Canadian provinces. For example, while the fish sector of Nova Scotia, a province on the East coast of Canada, stands to benefit from the agreement, Quebec's food manufacturing will likely be hurt by dairy imports from the EU. Overall, the extended database can be used to analyze a variety of important issues related to Canadian international and interprovincial trade policies.

The paper is organized as follows: Section 2 sets out the procedure for developing the GTAP-PROV dataset. Section 3 provides a demonstration of the dataset applied in the context of the Canada-EU Comprehensive Economic and Trade Agreement. Section 4 concludes.

2. Constructing a GTAP database with Canadian provinces: Methodology

To create the provincial GTAP database involves the following major steps:

1) Disaggregation of provincial I-O tables: this is required because available I-O tables are too aggregated from the perspective of policy analysis;
2) Calculation of a Canadian I-O table consistent with the disaggregated provincial I-O tables and calculation of provincial share matrices, based on the Canadian I-O table;
3) Allocation of provincial international exports and imports in I-O tables by market; this is required because there is no market dimension in the international trade component of the provincial I-O tables;
4) Splitting the Canadian data in the GTAP database into provinces based on provincial shares.

2.1. Canadian symmetric I-O tables

Statistics Canada produces symmetric I-O tables that delineate intermediate inputs sourced from domestic producers or through interprovincial and international trade. Thus, there are three types of tables available for each Canadian province: a domestic I-O table, an interprovincial imports I-O table, and an international imports I-O table. The tables are obviously related: in domestic tables international and interprovincial imports appear as rows; each number in these rows are the sums of columns in the interprovincial and international I-O tables.

The domestic I-O table includes the following GDP elements: taxes on products; subsidies on products; subsidies on production; taxes on production; wages and salaries; supplementary labour income; gross mixed income; and gross operating surplus.

Inter-industry transactions in the domestic I-O table are valued at modified basic prices: that is, subsidies are included in these values and then are subtracted in the two additional rows (subsidies on products and subsidies on production).

The final demand categories include: household consumption; government consumption; investment; international re-exports; additions to inventories; withdrawals from inventories; international exports; interprovincial exports; international imports; and interprovincial imports. Columns for imports in the domestic table are all zeros (because imports are in the rows) except that they include taxes on imported products.

Tables are available for 12 Canadian regions. While there are 13 Canadian provinces/territories, two of them (Northwest Territories and Yukon) are aggregated to preserve confidentiality of data.

2.2. Reconciling sector classifications and disaggregation of provincial I-O tables

There are two key challenges in constructing provincial symmetric industry-by-industry I-O tables to introduce into the GTAP model.

First, the aggregation level of the provincial I-O tables is much higher than that of the national table. Provincial symmetric industry-by-industry tables include 32 industries but most of them are quite detailed services industries while agriculture is represented by just two industries and manufacturing is represented as a whole, by one industry.

Second, while the provincial I-O tables include quite detailed services industries, the industry classification does not align well with the sector classification in the GTAP database.

Therefore, we start by defining the finest level of aggregation that would reconcile differences between GTAP and provincial I-O classifications. This can be accomplished by aggregating the provincial I-O tables into 12 categories: crop and animal production; forestry; fishing; mining, oil and gas; utilities; construction; manufacturing; trade; transportation; other business services; dwellings; and public services.

Final demand is first aggregated into the following categories: household consumption; government consumption; investment; international exports; international re-exports; interprovincial exports; international imports; interprovincial imports; inventory additions; and inventory withdrawals. The alignment of these categories with GTAP final demand categories is effected at a later stage.

From the perspective of trade policy, the major issue emerging from this initial result is that the manufacturing sector is represented as a whole. It is desirable to have greater detail on manufacturing because most cross-border trade is accounted for by trade in goods and manufactured products account for a large portion of trade in goods.

Therefore, we disaggregate the manufacturing sector into eight industries, namely: food; textiles; wood; petroleum; minerals and metals; chemicals, plastic and rubber; transportation equipment; electronic equipment and machinery; and other manufacturing. With this disaggregation of the manufacturing sector, we obtain a provincial GTAP database covering 19 sectors.

We disaggregate the sector in domestic, international-imports, and interprovincial-imports I-O tables. The disaggregation procedure involves the following steps

2.2.1. Disaggregation of the manufacturing row in the provincial symmetric I-O table

Intermediate and final demand for the manufacturing sector is disaggregated into the eight-industry classification, based on the information on intermediate and final demand for the corresponding manufacturing commodities in the industry-by-commodity I-O tables. The commodity classification used by Statistics Canada is quite detailed as opposed to the industry classification and our disaggregation exploits the fact that industry-by-commodity tables include a number of manufacturing commodities. Essentially, we assume that commodities are identical to industries; this appears to be a reasonable assumption because the eight sectors are quite highly aggregated.

We split intermediate demand for internationally imported, inter-provincially imported and domestically supplied commodities in the industry-by-commodity I-O tables based on the conventional proportionality assumption. We then calculate commodity shares within the total demand for all manufacturing commodities, for domestic and imported commodities separately. We then use these shares to disaggregate intermediate and final demand (except for exports and re-exports) for manufacturing in the domestic, international-imports, and interprovincial-imports symmetric I-O tables. International exports and re-exports are disaggregated based on corresponding shares in the industry-by-commodity tables.

2.2.2. Disaggregation of the manufacturing column in the provincial symmetric I-O table

Disaggregation of the manufacturing sector row gives us sales of each manufacturing industry calculated as a sum of corresponding rows. Looking from the other perspective, we obtain costs incurred by these industries, as sums over columns. A challenge at this step is to disaggregate the column of manufacturing sector, i.e. the cost structure of the sector, by manufacturing industry. Essentially, we need to figure out which manufacturing industry purchases intermediate inputs from other industries and from itself as well as supplies of primary factors of production. We obtain this information from more detailed Canada-level I-O tables. Essentially we assume that sales of each industry to the manufacturing sector have the same market shares in provincial economies as in Canada. For example, if Canadian tables show that the crop and animal production industry sells 90% to food manufacturing within total sales to manufacturing sector, we assume that the same takes places in provinces. This is a reasonable assumption given that we disaggregate into broad manufacturing industries.

We use Canadian domestic I-O table to calculate manufacturing industry market shares and apply them to the manufacturing sector column in the provincial domestic I-O tables. In the provincial interprovincial-imports and international-imports I-O tables, we apply Canadian market shares calculated using the Canadian international-imports I-O table.

We disaggregate the elements of GDP of the manufacturing sector (taxes, subsidies and primary factor incomes) using information on direct multipliers. Statistics Canada produces I-O multipliers at the provincial level, at a very detailed level, although some industries remain confidential. The tables include direct and indirect multipliers; for our purpose, we use direct multipliers. We aggregate the multipliers over detailed industries for which data are available up to the required manufacturing industries as weighted averages using outputs as

weights. It should be safe to exclude industries with confidential data because these tend to be smaller industries while data for key industries are available. We apply calculated multipliers to industry output available from CANSIM and then calculate shares of GDP elements within an estimate of GDP obtained by application of total GDP multiplier to the output. Then, we calculate GDP in the I-O tables as the difference between total costs (which we know as a result of disaggregation of the manufacturing sector row) and the sum of intermediate demand (which is obtained on the basis of Canadian market shares). We then allocate the GDP estimate into GDP elements based on their shares calculated using multipliers.

2.2.3. Adjustments to the disaggregated I-O tables

The above steps generate a balanced I-O table of a province. However, in some cases (typically small sectors in some provinces, such as textiles in BC), we unrealistic estimates of GDP when calculated as the difference between output and intermediate demand, prior to allocating it by GDP elements using multipliers. To address these cases, we rescale the data. The steps are as follows:

1) We obtain an approximate GDP estimate as output multiplied by the manufacturing sector GDP over output ratio.
2) To preserve the intermediate cost structure, we calculate shares of purchases from each industry within total intermediate input purchases and then apply these shares to the new estimate of intermediate input purchases calculated as a difference between the new GDP estimate and output.
3) We then calculate the difference between our new and old estimates of intermediate input purchases and we reallocate these difference to other industries based on Canadian market shares (calculated excluding industries for which the adjustment is being implemented).

2.2.4. Reconciling other minor differences between provincial I-O tables and GTAP

Before we split Canada into provinces, we make several additional changes in the provincial I-O tables.

1) Taxes and subsidies are summed up into one row.
2) The inventories column is eliminated by allocating change in inventories among other final demand categories (final consumption by household and government, investments and international exports). This assumes that changes in inventories were not related to intermediate demand. This may not be completely accurate but this allows us to preserve the balance of the table in a relatively easy way.
3) Re-exports of transportation margin is added to international exports. Other re-exports are essentially subtracted from international imports, in the sense that we simply use international imports net of re-exports.
4) Negative operating surplus is included in taxes.
5) Capital is split into capital, natural resources and land based on Canadian GTAP shares.
6) Labour is split into skilled and unskilled labour based on Canadian GTAP shares assuming that proportions of skilled and unskilled labor in each province are the same as in Canada.
7) In the provincial I-O tables, government sector final consumption involves purchases only of services from the public sector. In the Canadian GTAP table, however, government sector final consumption includes purchases of products from many other sectors. Accordingly, we reallocate provincial investment and government final consumption calculating their sum and then splitting among the two categories based on GTAP shares.

Thus, we disaggregate provincial I-O tables and realign its categories with GTAP database categories.

2.3. Market shares of provincial international trade

In order to split Canadian data within GTAP into provinces, we need data on international trade of provinces by market. As previously noted, the market dimension of international trade is not available within the I-O accounts. However, for goods, this information is available within merchandise trade databases. That being said, while information on destination markets of provincial exports is reliable, sources of international imports are not reliable. Accordingly, caution is required in this area.

Imports are recorded in the province in which they clear customs; this generates a major trans-shipment problem. For the present study, we rely on provinces' customs-based international imports data to allocate each province's adjusted product data by country of origin. Insofar as provinces source their imports through logistics chains that result in direct entry from abroad, this method of allocation will be accurate. Insofar as the logistics chain for a particular product results in bulk shipments to one point of entry into Canada, followed by internal distribution post-customs clearance, this method will overstate the source country's share in the province of entry and understate it in all other provinces. We note that this is an issue in particular with imports of cars: EU-sourced autos are overstated in Nova Scotia while Korean-sourced autos are overstated in Ontario. An adjustment in this respect will be done in the next version of the database (see Ciuriak, Lysenko and Xiao, 2014, for a discussion of this issue and an adjustment for Korean-sourced autos in the context of the Canada-Korea FTA analysis in that study).

Merchandise trade data is classified according to the HS nomenclature. In order to construct GTAP product aggregates, HS codes are matched to GTAP codes. We use trade data from Ciuriak, Lysenko and Xiao (2014) to calculate market shares of provincial international trade.

While we can calculate market shares in merchandise trade, there is no information on market dimension of international trade in services. Canadian market shares in the GTAP database are used as proxies of market shares of provincial trade in services. We anticipate being able to improve on this allocation using gravity model results for international goods shipments, taking into account the general correlation between goods and services trade by destination.

2.4. Split of Canadian data within the GTAP database

Once international trade market shares and I-O tables are calculated, we use these data to split Canada into provinces within the GTAP database.

First, we calculate the domestic Canadian I-O table as a sum of provincial domestic and interprovincial-imports tables across provinces. It should be noted that the interprovincial imports row and the interprovincial exports column in this table are left empty because interprovincial trade data are taken into account by including interprovincial-imports table in this sum. The Canadian international-imports I-O table is obtained as a sum of provincial international-imports I-O tables. We then calculate provincial share matrices in which each number is the provincial share within the Canadian total. Thus, 24 cells correspond to one cell in the Canadian domestic matrix: 12 provincial domestic cells and 12 interprovincial imports cells.

Second, we use these shares to replace Canada with provinces in the GTAP database. To implement this, we modify the Splitreg program introduced by Horridge (2011) that is used to split composite regions in GTAP into separate regions. At a first step, the program converts the original GTAP database into a "normalized" format. Most importantly, the normalized dataset has two arrays: NATIONAL and TRADE, which replace a number of arrays in the original GTAP database. The array NATIONAL includes domestic and international-imports I-O tables at basic values as well as taxes tables, except that international trade columns are not included in the array.

We split Canada into provinces within the NATIONAL array based on the I-O share matrices. Thus, provincial interprovincial imports and international imports within the NATIONAL array sum to the Canada equivalent. Shipments are split on the same basis. To split taxes, we assume that provincial shares within Canadian taxes are the same as within tax-free transactions. This is a reasonable assumption but in future it can be relaxed using provincial I-O tax matrices.

We split Canada into provinces within the TRADE array through the following steps:

1) Canadian international trade data at basic values in the TRADE array are first allocated by province using provincial exports and imports in provincial I-O tables as shares within total Canadian exports and imports in Canadian I-O table. Then, provincial trade is allocated market using market shares obtained as discussed above.
2) Canadian export and import tax rates as well as margin rates are calculated using data on trade in basic value and levels of taxes and margins. The rates are then applied to provincial trade at basic values to get provincial taxes and margins.
3) We calculate the share of provincial interprovincial exports within total interprovincial exports across provinces using original I-O data and apply these shares to interprovincial trade in the GTAP NATIONAL array split into provinces. We multiply the resulting total interprovincial export of a product by export market shares. The latter are calculated from interprovincial trade matrices produced by Statistics Canada and available at commodity, not industry, level. The resulting trade flows are recorded as interprovincial trade in the TRADE array.
4) We assume that import and export taxes as well as transportation margins are zero in interprovincial trade.

A number of other arrays in the "normalized dataset" are also allocated across provinces. These include: VKB (capital stock), EVOA, SAVE, VDEP, DPARSUM, and VST.

At this stage, the reconstructed provincial I-O tables are no longer balanced. Imbalances come from several factors:

1) When disaggregating provincial I-O tables and when splitting Canada into provinces, we do not constrain total interprovincial imports in Canada to be equal to total interprovincial exports of Canada.
2) There are zeros in Canadian data and positive numbers in provincial data and vice versa.

These imbalances are eliminated using the GTAPAdjust program. Because of the imbalances and subsequent rescaling of the data by the GTAPAdjust, it is not possible to reconstruct original GTAP Canada data. However, we check that sums over provinces are close to the original Canadian numbers.

2.5. Summary

Through the above steps, we create an extended GTAP database that replaces Canada with 12 Canadian regions and includes 19 sectors. We check that the new database satisfies GTAP accounting identities. For this demonstration project, we use the most recent 2010 provincial I-O tables and the GTAP Version 7 database with a base year of 2004. It would be preferable to use 2004 provincial I-O tables to split 2004 Canadian data so that changes in structure of Canadian economy between 2004 and 2010 do not affect our results. However, the 2004 tables are not readily available. This improvement will be implemented in the next version of this paper.

Table 1 below provides the provincial GDPs in the GTAP-PROV database.

Table 1: Provincial Gross Domestic Product in the GTAP-PROV database

	GTAP value	GTAP share (%)	2010 share based on original Canadian data (%)	Difference: GTAP share - 2010 share
Provincial GTAP				
AB	144,598	14.79	16.25	-1.46
BC	120,180	12.29	12.39	-0.10
MB	30,638	3.13	3.18	-0.05
NB	18,817	1.92	1.81	0.11
NL	14,095	1.44	1.75	-0.31
NS	21,935	2.24	2.23	0.01
NU	1,018	0.10	0.12	-0.01
ON	381,849	39.05	37.88	1.18
PE	3,005	0.31	0.31	-0.01
QC	204,605	20.93	19.84	1.09
SK	33,853	3.46	3.81	-0.35
YTNT	3,153	0.32	0.43	-0.10
Total (Canada)	977,746	100.00	100.00	0.00
GTAP Original Canada	979,130			

Source: Calculation by the authors.

3. Demonstration Simulation: Canadian Provincial Impacts of CETA

3.1. CETA Background

Canada and the European Union have concluded and are in the process of ratifying the Comprehensive Economic and Trade Agreement (CETA). Implementation is expected for 2016.

The 28 countries that form the European Union have a combined population of about 507.5 million people (60% larger than that of the United States), and a combined GDP of US$17.3 trillion (3% larger than that of the United States), thus forming the single largest economy in the world. For Canada, the EU represents a huge market: imports of goods totalled US$5.7 trillion (US$2.5 trillion excluding intra-EU28 trade) in 2013 and imports of commercial services were approximately US$1.5 trillion in 2012. As a source of FDI, it accounts for 42% of the global outward FDI stock (US$9.8 trillion of the global total of US$23.6 trillion 2012).

The EU is Canada's second largest trade and investment partner, after the United States. In 2013, the EU absorbed $32 billion worth of Canadian goods, or 7% of Canada's worldwide goods exports. Meanwhile, Canada's goods imports from the EU amounted to $51.6 billion, or 11% of Canada's worldwide imports, resulting in a $19.6 billion trade deficit. As regards services trade, in 2012, the EU purchased $15.4 billion worth of services from Canada, or 20% of Canada's worldwide exports of services. Canada, meanwhile, imported $25.7 billion worth of services from the EU, or 24% of Canada's worldwide services imports. In 2012, EU economies accounted for $171 billion of FDI into Canada, which amounts to 24% of total FDI into Canada. Canada has approximately $181 billion in FDI in European economies, which represents 28% of Canada's total outward FDI stock.

Given the realities of geography, the Canadian provinces on the Atlantic seaboard are more exposed to EU trade than are the western provinces. At the same time, given the realities of economic specialization within the provinces, the exposure to the EU in terms of trade – and particularly in terms of trade facing tariffs that are slated for elimination – also varies considerably. Tables 2 and 3 provide summary data of the provinces' exports to and imports from the EU for the 19 sectors in the GTAP-PROV Model.

Table 2: Provincial exports to the EU in GTAP-PROV database (VXWD array)

	AB	BC	MB	NB	NL	NS	NU	ON	PE	QC	SK	YTNT	CDA	CDA-GTAP
Farming	74	9	68	2	5	21	0	264	2	179	214	1	839	1,273
Forestry	1	1	0	2	0	0	0	1	0	2	0	0	7	20
Fishing	0	1	0	1	1	26	0	0	0	13	0	1	43	85
Mining	10	231	18	40	443	0	3	182	0	280	1	657	1,865	2,572
Food	59	28	10	23	68	104	0	87	20	162	9	0	570	652
Textiles	0	23	11	0	25	3	0	79	0	234	0	0	375	262
Wood	100	678	23	42	15	109	0	146	1	583	0	1	1,698	2,274
Petroleum, metals & minerals	167	14	39	142	291	40	1	5,156	0	741	0	0	6,591	3,679
Chemicals, Rubber & Plastic	84	40	36	3	1	11	2	1,322	7	437	7	1	1,951	1,643
Transport Equipment	26	36	21	1	1	79	3	1,062	8	2,233	0	1	3,471	2,552
Machinery & electrical	102	367	55	8	3	67	1	1,856	1	1,176	46	0	3,682	3,966
Other Mfg	7	18	7	17	0	1	0	127	0	38	2	0	217	285
Utilities	1	10	11	3	0	0	0	19	0	35	0	0	79	79
Business Services	3	1	1	0	0	1	0	14	0	1	0	0	21	22
Trade	50	41	20	26	5	10	0	330	1	113	38	1	635	634
transportation	444	475	103	68	18	43	0	619	6	377	162	4	2,319	2,318
Other Services	642	1,246	112	75	67	128	2	4,200	14	1,749	77	20	8,332	8,330
Public Services	22	57	6	6	3	10	0	233	2	70	5	1	415	417
Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,793	3,277	541	458	947	654	12	15,698	62	8,423	560	688	33,113	31,063

Source: Calculation by the authors.

Table 3: Provincial imports from the EU in provincial GTAP database (VXWD array)

	AB	BC	MB	NB	NL	NS	NU	ON	PE	QC	SK	YTNT	CDA	CDA-GTAP
Farming	9	15	1	0	1	4	0	99	0	54	0	0	183	193
Forestry	0	1	0	0	0	1	0	4	0	1	0	0	7	3
Fishing	0	0	0	0	0	0	0	6	0	4	0	0	10	6
Mining	2	1	0	125	1	25	0	24	0	643	0	0	821	983
Food	125	120	12	12	31	33	0	530	4	763	9	0	1,639	1,921
Textiles	125	38	6	3	85	27	0	292	15	241	43	0	875	1,212
Wood	80	76	6	1	38	74	0	198	0	441	4	9	927	1,283
Petroleum, metals & minerals	166	71	17	120	255	143	0	1,197	1	2,111	44	0	4,125	3,033
Chemicals, Rubber & Plastic	283	125	53	14	59	93	1	2,703	20	2,615	151	54	6,171	5,705
Transport Equipment	281	223	69	26	261	1,114	3	890	1	3,173	16	0	6,057	4,918
Machinery & electrical	1,424	613	152	116	387	727	0	2,254	19	3,113	113	0	8,918	7,837
Other Mfg	70	22	9	2	4	11	43	118	0	99	3	5	386	466
Utilities	12	35	4	0	0	0	0	51	0	32	4	0	138	103
Business Services	8	8	2	2	1	1	1	26	1	14	2	1	67	52
Trade	68	59	14	9	6	10	0	291	1	128	15	1	602	545
transportation	165	190	37	32	14	29	1	918	5	335	32	3	1,761	1,732
Other Services	522	503	119	70	41	78	3	2,670	7	961	137	11	5,122	5,137
Public Services	64	60	11	6	1	7	0	251	0	121	12	1	534	404
Dwellings	2	2	2	2	2	2	2	2	2	2	2	2	24	0
Total	3,407	2,159	515	541	1,185	2,379	55	12,524	77	14,851	587	88	38,368	35,534

Source: Calculation by the authors.

3.2. Simulation Framework

We use a very simple simulation approach for this demonstration project.

First, a static model is used. It underestimates the impacts reflecting only efficiency gains and ignoring expansion of productive capacity of the economy in the long-run. Provincial dynamic variables will be included in the next revision of the paper.

Second, for simplicity, in the policy shock, we assume that all tariffs in goods sectors are fully eliminated; clearly this over-estimates the impact of the CETA since agricultural products are not facing full liberalization. Tariffs are shows in Table 4.

Third, we do not take into account all other elements of the trade agreement. .

For these reasons, we do hold our results as a realistic assessment of the CETA; rather, the simulations serve only to demonstrate the possibility of modelling the CETA at this level and to underscore that provinces will be impacted differently, based on their exposure to EU trade and their product specialization.

Table 4: Tariffs in the Baseline Data

Sector	Sector Description	Tariffs Canada faces in the EU	Tariffs the EU faces in Canada
1	Farming	6.46	2.38
2	Forestry	1.08	1.02
3	Fishing	8.84	0.03
4	Mining	0.00	0.01
5	Food	15.29	17.82
6	Textiles	8.24	10.59
7	Wood	0.13	1.57
8	Petroleum, metals and minerals	0.97	2.34
9	Chemicals, Rubber & Plastic	2.03	1.93
10	Transport Equipment	2.09	3.30
11	Machinery & electrical	1.09	1.22
12	Other Mfg	1.18	3.75
13	Utilities	0.00	0.00
14	Business Services	0.00	0.00
15	Trade	0.00	0.00
16	transportation	0.00	0.00
17	Other Services	0.00	0.00
18	Public Services	0.00	0.00
19	Dwellings	0.00	0.00

Source: Calculations by the authors.

We use a long-run microeconomic closure in which the rate of return to capital and wages are set exogenously and labour and capital supply are allowed to change. The macroeconomic closure is the standard one, i.e. current accounts can vary. Using the long-run microeconomic closure is important. The GTAP model assumes that labour and capital are not mobile across regions. In the context of modelling impacts on Canadian provinces this is a significant constraint that should reduce gains from trade because most of the provinces do not have diversified economies. Growth of a sector in a province is typically based on accessing resources from other provinces. While we do not relax the assumption of immobile resources across regions in the theoretical structure of the economy as this is done for example by Standardi, Bosello and Eboli (2014), we may mitigate this constraint by assuming that supply of factors can change in response to prices on the factor markets. Essentially, we assume that these changes are possible primarily because labour and capital are moving from losing provinces to winning provinces. Experimentation showed that simulated impacts of CETA become negligible if a standard closure if used.

3.3. Results

Overall Canadian GDP increases by 0.24% but impacts on individual provinces vary considerably, as expected. Provinces that experience large gains include Newfoundland, Nova Scotia, Quebec, Prince Edward Island and Ontario; Alberta, Manitoba and Saskatchewan sustain losses. British Columbia and New Brunswick make relatively small gains. Changes in several key sectors drive these results – namely, food, wood and paper, transportation equipment, machinery and equipment. These are the sectors in which trade between Canada and the EU has a significant value and which experience economically meaningful changes in tariffs. As noted, these preliminary results do not take into account the actual CETA agreement and we limit our comments accordingly. A shock file reflecting the CETA as negotiated will be implemented in a revised version of this working paper.

Table 5: Impacts of the CETA by Province

	Real GDP (%)	Household income (%)	Real GDP (USD million)	Export volume	Import volume	Trade Balance	Terms of Trade	Skilled Labour	Unskilled Labour	Capital
NL	0.795	0.783	112	1.26	1.33	-16	0.054	0.83	1.19	0.63
QC	0.654	0.57	1,337	1.35	1.38	-138	-0.141	0.57	0.67	0.59
NS	0.562	0.484	123	1.13	1.1	-40	0.023	0.45	0.64	0.49
PE	0.356	0.306	11	0.55	0.46	-1	0.054	0.27	0.35	0.35
ON	0.237	0.22	905	0.46	0.49	-58	-0.04	0.23	0.25	0.19
YTNT	0.107	0.101	3	0.13	0.14	-1	0.029	0.1	0.12	0.11
NU	0.028	-0.053	0	0.47	0.17	0	0.01	-0.07	0.03	0.06
BC	0.018	0.023	22	0.03	0.07	-22	0.001	0.01	0.01	-0.03
NB	0.017	0.018	3	-0.08	-0.04	-4	0.007	0	0	-0.01
AB	-0.047	-0.056	-68	-0.02	0.03	-29	0.004	-0.07	-0.06	-0.06
MB	-0.165	-0.124	-51	-0.16	-0.11	-2	0.016	-0.13	-0.14	-0.25
SK	-0.177	-0.145	-60	-0.21	-0.14	-3	0.052	-0.2	-0.22	-0.17
Canada	0.239		2,338	0.49	0.52	-314				
EU_25	0.181	0.181	23,159	0.21	0.21	-96	0.001	0.18	0.18	0.18

Source: Calculation by the authors.

Table 6: Change in volume of exports to EU caused by CETA, goods sectors, USD millions

		AB	BC	MB	NB	NL	NS	NU	ON	PE	QC	SK	YTNT
1	Farming	27	3	24	1	2	7	0	94	1	63	75	0
2	Forestry	0	0	0	0	0	0	0	0	0	0	0	0
3	Fishing	0	0	0	0	0	6	0	0	0	3	0	0
4	Mining	0	1	0	0	1	0	0	-1	0	-1	0	0
5	Food	61	29	10	23	70	105	0	91	20	170	9	0
6	Textiles	0	19	9	0	23	2	0	68	0	199	0	0
7	Wood	1	8	0	1	0	1	0	2	0	8	0	0
8	Petroleum, metals and minerals	11	1	2	9	19	3	0	339	0	52	0	0
9	Chemicals, Rubber & Plastic	12	6	5	0	0	2	0	199	1	69	1	0
10	Transport Equipment	4	5	3	0	0	13	0	152	1	370	0	0
11	Machinery & electrical	10	37	6	1	0	8	0	189	0	130	5	0
12	Other Mfg	1	2	1	2	0	0	0	13	0	4	0	0

Source: Calculation by the authors.

Table 7: Table 6: CETA-Induced Change in imports from the EU, goods sectors, USD Millions

		AB	BC	MB	NB	NL	NS	NU	ON	PE	QC	SK	YTNT
1	Farming	1	2	0	0	0	1	0	11	0	7	0	0
2	Forestry	0	0	0	0	0	0	0	0	0	0	0	0
3	Fishing	0	0	0	0	0	0	0	0	0	0	0	0
4	Mining	0	0	0	0	0	0	0	0	0	4	0	0
5	Food	146	141	14	15	37	40	1	601	5	803	10	0
6	Textiles	126	41	7	3	55	27	0	304	11	251	40	0
7	Wood	8	8	1	0	4	8	0	20	0	44	0	1
8	Petroleum, metals and minerals	25	11	3	16	32	20	0	181	0	291	6	0
9	Chemicals, Rubber & Plastic	35	16	7	2	7	12	0	325	2	289	18	6
10	Transport Equipment	60	47	15	6	48	102	1	197	0	596	4	0
11	Machinery & electrical	136	61	15	11	31	50	0	232	2	302	11	0
12	Other Mfg	20	7	3	1	1	3	12	36	0	30	1	2

Source: Calculation by the authors.

Table 8: CETA-Induced Changes in Output by Sector, % change

		AB	BC	MB	NB	NL	NS	NU	ON	PE	QC	SK	YTNT
1	Farming	0.06	-0.16	0.23	0.23	2.38	2.52	0.37	0.61	0.56	1.08	0.44	0.85
2	Forestry	-0.01	-0.01	0.01	0.01	0.44	0.24	1.69	0.09	0.32	0.38	-0.02	0.34
3	Fishing	0.05	0.03	0.09	0.32	0.57	1.03	0.33	0.25	0.31	0.89	0.18	2.32
4	Mining	0.01	0.01	0.02	0.03	0.02	0.06	0.04	0.11	1.84	0.06	0	0.04
5	Food	-1.33	-1.7	-1.88	-0.78	6.5	4.82	-0.63	-1.55	0.5	-0.56	-2.13	0.6
6	Textiles	-1.69	1.27	1.49	-0.51	19.82	-2.08	-0.33	1.66	-3.99	3.17	-2.6	-0.45
7	Wood	0	-0.02	-0.14	-0.02	0.85	0.29	0.43	0.16	0.35	0.35	-0.23	0.16
8	Petroleum, metals and minerals	-0.11	-0.06	-0.05	-0.29	1.11	0.04	0.5	0.84	0.19	0.65	-0.32	0.14
9	Chemicals, Rubber & Plastic	-0.14	0.03	-0.02	0.02	0.99	0.24	2.3	0.71	1.2	1.18	-0.41	0.88
10	Transport Equipment	0.04	0.09	-0.12	-1.71	-0.33	0.86	3.3	0.25	1.22	3.56	-0.62	1.37
11	Machinery & electrical	0.04	0.9	0.11	0.3	1.68	2.88	1.32	0.8	0.21	1.78	-0.19	0.26
12	Other Mfg	-0.35	-0.16	-0.05	0.5	1.23	0.74	1.13	0.24	0.59	0.63	-0.65	0.14
13	Utilities	-0.05	-0.02	-0.08	0.01	0.91	0.33	0.02	0.29	0.33	0.49	-0.1	0.1
14	Business Services	0.01	0.05	-0.15	0.11	1.16	1.36	0.26	0.3	0.49	0.96	-0.1	0.18
15	Trade	-0.06	0.02	-0.1	0.05	0.71	0.51	0.09	0.24	0.3	0.6	-0.15	0.1
16	transportation	0.01	0.04	0.06	0.21	0.71	0.68	0.05	0.2	0.19	0.59	0.01	0.2
17	Other Services	-0.03	0.01	-0.07	0.09	0.69	0.54	0.04	0.21	0.31	0.6	-0.13	0.12
18	Public Services	-0.11	-0.04	-0.15	-0.02	0.67	0.33	-0.1	0.17	0.22	0.44	-0.18	0.08
19	Dwellings	-0.11	-0.04	-0.16	-0.02	0.63	0.34	-0.08	0.18	0.25	0.46	-0.18	0.08
	Total	0.02	0.06	-0.16	0.13	1.22	1.55	0.27	0.31	0.53	1.03	-0.11	0.18

Source: Calculation by the authors.

4. Discussion and Conclusions

This paper introduces the new GTAP-PROV model which replaces Canada in the GTAP dataset with 12 Canadian provinces and territories. The paper explains the methodology followed to create the GTAP dataset and demonstrates the database by simulating an impact of CETA on Canadian provinces. This is first attempt to apply a multi-country CGE model to analyze an impact on Canadian provinces. While we emphasize the naïve nature of the policy shock used to demonstrate the model – full tariff elimination and non-tariff factors not taken into account – the overall impact of the CETA appears to be reasonable both in terms of scale and in terms of sectoral impacts. The aim at this stage is to demonstrate proof of concept; we believe this has been accomplished.

Generally, international trade agreements look very differently from different provinces' perspectives. There are provinces that stand to benefit more than others but there are also provinces that will face significant challenges. This is determined primarily by sectoral structure, exposure of sectors to trade with other countries and in particular with the partner of a trade agreement, determined to a large extent by geographic location of a province. The situation of Canadian provinces is undoubtedly mirrored in other large geographic regions such as the United States and China. Accordingly, we see this as a contribution towards a better understanding of regional impacts of trade agreements more generally.

Simulations based on the GTAP-PROV model can provide important policy insight for provincial policy-makers. This has become particularly important in the context of CETA negotiations because several provincial governments requested compensation for potential losses. Empirical analysis can help understand distribution of gains and losses across provinces and within provinces. The simple application to CETA implemented in

this paper demonstrates the varying impact of CETA across provinces; accordingly, this empirical work seems eminently worthwhile.

Further work on the GTAP-PROV database will be focused on the following:

(a) Further adjustments aimed to improve the quality of the database in a variety of dimensions by drawing on additional sources of data, including to introduce internal transportation margins that could be used to simulate the impact of reduction of non-tariff barriers under a strengthened Agreement on Internal Trade.
(b) Developing a simulation of the CETA based on the agreement as negotiated, based on the refined dataset.
(c) Updating the GTAP-PROV database to the GTAP 9.0 dataset.
(d) Incorporating the database into a model suitable for dynamic analysis.
(e) In the longer-run, further disaggregation of sectors.

References

Ciuriak, Dan, Dmitry Lysenko and Jingliang Xiao. 2014. "Province-Level Impacts of Canada's Trade Agreements: Ontario and the Canada-Korea FTA," 24 December 2014, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2542568

Horridge, Mark. 2011. Splitreg program archived at the Centre for Policy Studies (CoPS), http://www.copsmodels.com/archivep.htm

Standardi, Gabriele, Francesco Bosello, and Fabio Eboli. 2014. "A Sub-national CGE Model for Italy," Nota di Lavoro 4.2014, Fondazione Eni Enrico Mattei, Milan, Italy.