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Detailed Trade Policy Simulations Using a Global General Equilibrium Model

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Abstract

For the majority of studies using global general equilibrium models, the sectoral detail provided by the GTAP Data Base would be sufficient. However, analyses aimed at supporting trade negotiations or detailed trade policy regulations often require modeling at the tariff line, or Harmonized System (HS), level. We bridge this gap by providing an automated data and model workflow that allows GTAP-based analyses at the HS level. In this paper, we illustrate and explain the use of this workflow by first carrying out a data procedure where we re-define GTAP sectors related to the auto industry—though the workflow is flexible enough to re-define or disaggregate any GTAP sector into its HS associated components. Then, we use an extended standard GTAP version 7 (GTAP-HS) model to carry out explicit modeling of the additional HS-level detail. Both data and model workflow that accompany this paper are available as supplementary materials. This new framework facilitates simulations of trade policy at the HS level, thereby allowing researchers to capture more nuances on the trade side. This is especially important when tariffs are highly differentiated across the HS components, which is the case for the automotive sector—tariffs may be relatively low on auto parts (intermediate goods), but higher on assembled vehicles (final goods).

JEL codes: C68, D58.
Keywords: Global; General Equilibrium; Data Base; International Trade; Harmonized System.

1 Introduction

Trade policy changes can affect multiple sectors in a country. Because of this, general equilibrium analyses are ideal because they help identify the direct and indirect economic effects that stem from inter-industry linkages. For example, raising aluminum tariffs could be beneficial to domestic aluminum producers, but does not guarantee that domestic industries using aluminium as inputs to production are better off.

There are many global general equilibrium models that rely on the Global Trade Analysis Project (GTAP) Data Base. For the last 30 years, GTAP has lowered the barriers to conduct general equilibrium analyses by maintaining an updated database and publicly-available model. Furthermore,

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the regional representation of the database is ever increasing, and has expanded to 121 countries in its latest release (Aguiar et al., 2019).[1]

The latest release of the GTAP Data Base distinguishes 65 products (i.e, goods and services) and 141 regions of the world (i.e., 121 countries and 20 regional aggregates). For the analysis of trade agreements, however, GTAP's 65-product classification may not be detailed enough if the interest is in tariff changes happening at the international Harmonized System 6-digit (HS6) level.[2]

While the GTAP Data Base provides a consistent economic representation of the global economy for a particular year, going beyond the current 65-product classification requires reconciling each countries' Input Output table data[3] to over five thousand products at the HS6 level.

In this paper, we re-visit seminal papers that disaggregated GTAP sectors into HS6 level components, such as Grant, Hertel, and Rutherford (2009) and Narayanan, Hertel, and Horridge (2010a). Working at the HS6 level would allow us to identify the possible tariff heterogeneity that can exist within HS6 components of a GTAP sector. We improve on these two papers by creating a workflow that automates the data disaggregation process and subsequent model simulation process by using an extended version of the new standard GTAP model (Corong et al., 2017). Chepeliev et al. (2020) further expands the GTAP-HS framework in an application that focuses on fruits and vegetables and which incorporates tariff rate quotas (TRQs)—another trade policy instrument that benefits from the more detailed HS-level classification.

Narayanan, Hertel, and Horridge (2010a) compares results derived from a partial equilibrium model, the standard GTAP model version 6, and a linked partial equilibrium and general equilibrium (PE/GE) version of the GTAP model.[4] We improve on this this work to better explain its capability of disaggregating GTAP commodities at the HS level.

Prior to creating an automated workflow, we replicated the simulation results reported in Narayanan, Hertel, and Horridge (2010b). We then examined all data used in the paper and discovered issues with a supplementary input information, previously calculated in MS Excel. To prevent future data handling issues and to facilitate the implementation of model simulations, we have created an automated data handling procedure— linking the GTAP Data Base with HS6 trade and tariff data obtained from the TASTE utility—using four GEMPACK programs managed via a batch file.

The underlying data in TASTE also comes from the Market Access Maps (MAcMap) Database (ITC, 2017). TASTE makes it easy and quick to extract this information for any GTAP aggregation. In addition, the accompanying programs that we developed are flexible, with no hard coded sets, to facilitate processing of different GTAP aggregations.

In the next section, we disaggregate multiple sectors and define the new sectors. The resulting data base is then used with GTAP-HS model (Aguiar, Corong, and van der Mensbrugghe, 2019), which is an extension of the GTAP version 7 Model (Corong et al., 2017).[5] Besides updating to the latest GTAP model (version 7), this implementation uses the latest GTAP 10 Data Base (Aguiar et al., 2019).[6] Users should use these programs as templates and modify them based on their specific needs.

The following section describes the adjustments to the data base. Section 3 presents the model

[1] Flexible distributions exist so that one need not operate at this scale, but rather focus on the countries of interest.

[2] International tariffs at the HS6 level are a key input in the development of GTAP and is provided by the Market Access Maps (MAcMap) Database (ITC, 2017) and aggregated by GTAP using trade weights.

[3] A typical national Input Output table would have less than 50-products.

[4] An earlier version of Narayanan, Hertel, and Horridge (2010a) is available as GTAP Technical Paper 29, which is available from `https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3192`.

[5] Files accompany this document.

[6] This is the GTAP 10A Data Base.

modifications and last we provide illustrative simulations.

2 Data Development

In this section, we explain how one can disaggregate selected sectors of the GTAP Data Base. GTAP provides a representation of the world economy for a given reference year. One of the key components of the GTAP Data Base is protection information, among which international tariffs, which are originally provided at the HS6 level by the MAcMap data set, then aggregated to match GTAP sectors (ITC, 2017). We use the MAcMap data set, obtained from the TASTE utility to disaggregate GTAP sectors(Horridge and Laborde, 2008).[7]

Rather than operating at the fully disaggregated database, we first narrow our focus by aggregating sectors and regions before disaggregating the sector(s) of interest. The aggregation file used in GTAPAgg is also an input to the TASTE utility that we use. The aggregation in this example identifies 11 sectors including Food, Energy, Manufactures, Services, and 7 GTAP sectors related to the auto industry, which we redefine into auto parts and other. From motor vehicles we extract an additional new sector auto, see Table 1.

Table 1: Sectors of interest

Original sectors	New sectors		
Motor vehicles (mvh)	Auto	APS_mvh	OTH_mvh
Electronics (ele)		APS_ele	OTH_ele
Other machinery (ome)		APS_ome	OTH_ome
Fabricated metal products (fmp)		APS_fmp	OTH_fmp
Rubber and plastic products (rpp)		APS_rpp	OTH_rpp
Other manufacturing (omf)		APS_omf	OTH_omf
Mineral products (nmm)		APS_nmm	OTH_nmm

Table 1 shows that there will be Auto parts derived from each of the initial sectors, for example, auto parts electronics (`APS_ELE`). Sectors not relevant to the auto industry are re-grouped into other sectors, for example other electronics (`OTH_ELE`) or other machinery (`OTH_OME`). The disaggregation procedure then results in 19 sectors (i.e. the original 4 aggregate sectors and the resulting 15 sectors that were disaggregated from the original 7 sectors of interest).

In terms of countries/regions, we consider a 13-region aggregation, namely: the U.S., Canada, Mexico, Brazil, Rest of Latin America, United Kingdom, Germany, Rest of the European Union (EU), China, Japan, Korea, Rest of East Asia, and Rest of the World.[8]

For sector disaggregation, the TASTE utility extracts detailed trade and tariff data at the HS 6-digit level from MAcMap. First, TASTE needs to read the GTAP aggregation file, then with the Split command, we extract the weights with which sectors are disaggregated. The output HAR file contains trade and tariff revenue arrays at the HS level for the selected sectors in your aggregation. The regions are also defined by your aggregation.

Finally, three more inputs are required for the sectors to be disaggregated: the listing of new sectors, their concordance against HS components, and the concordance between the new sectors and the original GTAP sectors.

[7] Dr. Janine Pelikan has been updating TASTE for the last 2 versions of GTAP.

[8] For a different study, you would begin by defining a new GTAP aggregation. When ready, the contents of the aggregated zip file would need to be stored in the "in" folder.

2.1 Data Programs

Four GEMPACK programs help automate the data preparation. The first two programs adjust the sets and parameters for the new model extension. The required extra set definitions are prepared with the file '`prepset.tab`', while the new parameters are prepared by '`prepprm.tab`'. To check and modify the assumptions on parameters to be used in running model simulations, the user could use ViewHAR editing features to alter the starting values (i.e., 'Scalars.prm') that are being read by the program, or the resulting parameters file, or using a text editor (e.g., TABmate) to directly modify the code.[9] For instance, the (top-level) elasticity of substitution for domestic and imported commodities and among importers (second-level) at the disaggregated level are assumed to be the same as that of the GTAP level. One potential source of recent estimates of the Armington elasticities at the HS-level is available in Fontagné, Guimbard, and Orefice (2019).

The other two programs that modify the initial GTAP data are '`calculations.tab`' and '`data_workv7.tab`'. The first of these programs replaces the previous MS Excel sheet available in the original technical paper. It differs from the initial implementation of Narayanan, Hertel, and Horridge (2010a) in that simple average of tariffs and subsequent calibration of tariffs is no longer used.[10] Instead, we make use of TASTE information to derive import flows at basic prices:

$$VMSBK_{k,s,d} = AREV_{k,s,d} + VCIFK_{k,s,d}$$

where $VMSBK$ are the unscaled import flows valued at basic prices for product k from source s into destination d; $AREV$ is the applied tariff revenue retrieved from TASTE; $VCIFK$ are the unscaled import value flows at CIF prices from TASTE. The import flows derived from TASTE are not balanced and therefore cannot be used for general equilibrium modeling. We use these value flows to derive shares that will allow us to disaggregate imports from the GTAP Data Base as follows:

$$VCIF_{k,s,d} = \texttt{TASTE\_SHARES}_{k,s,d} * VCIF_{c,s,d}$$

$$VMSB_{k,s,d} = \texttt{TASTE\_SHARES}_{k,s,d} * VMSB_{c,s,d}$$

where $VCIF$ represents the import value flows at CIF prices of product k, from source region s, into destination region d, and $VMSB$ are the import value flows at basic prices. TASTE shares are used in order to ensure that aggregating the disaggregated k level flows allows us to recover the original GTAP c level flows.

We could then compute the *ad valorem* tariff rates at the disaggregate level with the calibrated data:

$$RTMS_{k,s,d} = \left(\frac{VMSB_{k,s,d}}{VCIF_{k,s,d}} \text{ - } 1\right) \times 100$$

As stated above, Narayanan, Hertel, and Horridge (2010b) calibrated the simple average of the rates and used them in the next data processing. With our new procedure, we do not need to compute the ad-valorem tariffs and instead just use the flows associated with imports at basic and CIF prices: the new tariff can be implied from these two flows. We believe the new treatment is more transparent and therefore easier to understand.

In '`calculations.tab`' we also derive one of the key assumptions utilized by Narayanan, Hertel, and Horridge (2010b) wherein the domestic to import ratio in the disaggregated level is the same

[9] If choosing the latter, remember to recompile the program for the change to take effect in your output.

[10] While not used for this data preparation, the Narayanan, Hertel, and Horridge (2010b) approach is written into the work folder for review.

as in the GTAP level, see below:

$$Dom2Imp_{c,d} = \frac{VDSB_{c,d}}{\sum_{s} VMSB_{c,s,d}}$$

where $VDSB$ are the domestic sales of product c in region d and these are divided by the total imports of product c into d, also valued at basic prices. This computation is a simplifying assumption, that is written before it is used in order to be reviewed and consequently revised when data is available. Provided the data on domestic/import penetration is available at the level of disaggregation that is required, the user should revise this share before proceeding further, for a better representation of the initial equilibrium as illustrated in Chepeliev et al. (2020).

In '`data_workv7.tab`', originally developed by Narayanan, Hertel, and Horridge (2010b), we updated the nomenclature to be consistent with GTAP model version 7. In addition, following the previous paragraph's discussion, the program now reads the domestic to import ratio to estimate the domestic flows at the disaggregated level:

$$VDSB_{k,r} = Dom2Imp_{c,r} \times \sum_{s} VMSB_{k,s,r}$$

where the flows of total domestic supply at the disaggregated k level, in region r, are computed by multiplying the domestic to import share computed at the GTAP level c with the imports at basic prices in r. Next is the allocation of the international margin usage from the GTAP c level to the k components, which is done proportionally, as in:

$$VTWR_{m,k,s,d} = \frac{VCIF_{k,s,d}}{VCIF_{c,s,d}} \times VTWR_{m,c,s,d}$$

where the $VTWR$ flows capture the value of international margin usage, by margin m, freight k, source s, and destination d. Subsequently, exports valued at FOB prices at the k level ($VFOB$) are computed by deducing international transport margins from imports valued at CIF prices:

$$VFOB_{k,s,d} = VCIF_{k,s,d} - \sum_{m} VTWR_{m,k,s,d}$$

We also derive k level exports valued at basic prices ($VXSB$) assuming the same export taxes found at their corresponding GTAP level:

$$VXSB_{k,s,d} = VFOB_{k,s,d} \times \left(1 + \frac{RTXS_{c,s,d}}{100}\right)$$

We calibrate each new value flow to ensure that that aggregating the disaggregated k level flows allows us to recover the original GTAP level value flows.

Note that the data procedure described in this section uses very limited information, thereby facilitating rapid HS-level analyses.[11] In contrast, Dixon, Rimmer, and Tran (2020) implement a comprehensive approach which fully disaggregates the motor vehicle sector based on detailed activity input cost and commodity demand information from various IO tables and data from United Nations Industrial Development Organization (UNIDO).

[11] This is because activities are not disaggregated, with domestic/import penetration ratios at the k level following their associated GTAP commodity.

3 Model Modifications

This section documents the development of a hybrid GTAP with partial equilibrium (hereafter, GTAP-HS) model, which is built on the latest version of the core GTAP trade model (Corong et al., 2017).[12] A key feature of the GTAP-HS model is to take one or more of GTAP's aggregated commodities and disaggregate that commodity at the HS6 level or some aggregation thereof. For example, the motor vehicle and parts (MVH) sector in GTAP, can be split into a set of more disaggregated commodities at the HS6 level that defines that sector. This allows for capturing more nuances on the trade side if tariffs are highly differentiated across the components.

GTAP-HS is a hybrid model that combines general equilibrium with partial equilibrium as in Grant, Hertel, and Rutherford (2006), Grant, Hertel, and Rutherford (2009), Narayanan, Hertel, and Horridge (2010b) and Narayanan, Hertel, and Horridge (2010a). The basic idea is to split a GTAP commodity into two or more HS-based components using a hybrid version of the model. The first part of the effort requires combining HS-level data sets on bilateral trade and import tariffs with the GTAP database including a reconciliation of the flows. The resulting dis-aggregated data from previous section are inputs to the GTAP-HS model.

The model implementation requires changes to the demand and supply side of the standard model. The demand side specification is reflected in Figure 1 while the supply side is reflected in Figure 2.

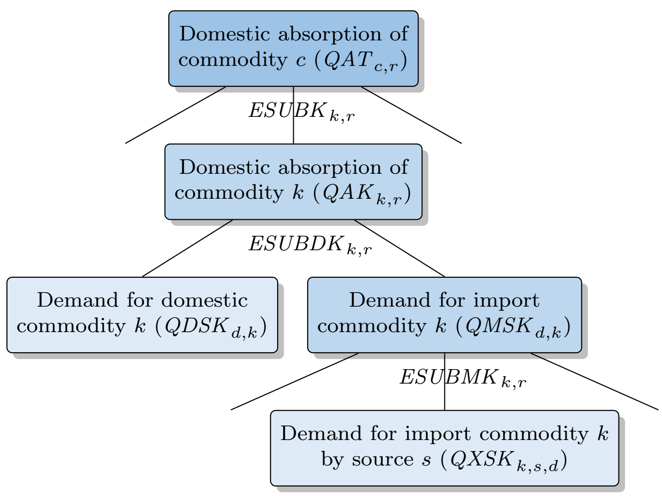

Figure 1: Demand-side CES nest for HS module

The top-level absorption is at the c-level and is determined by summing the level of Armington absorption across all agents in the economy. For this reason, the GTAP-HS model uses a national-level Armington specification to allocate domestic absorption between domestic and imported goods, whereas the standard model, the top-level Armington nest is done at the agent-level.

This section describes the GTAP-HS model's national-level Armington agent specification for the top nest, i.e. the choice of domestic versus imported goods. The TABLO codes in Listing 1 show the equations that implement national-level Armington specification to allocate domestic absorption between domestic ($qds_{c,r}$) and imported ($qms_{c,r}$) goods. Essentially, equations `E_qds` and `E_qms` replace all agent-specific domestic and imported equations (i.e., `E_qfd`, `E_qpd`, `E_qgd`, `E_qid`, `E_qfm`,

[12] The current version of the GTAP-HS model was developed in response to a request from the United States Department of Commerce to revisit and improve on the initial implementation of Narayanan, Hertel, and Horridge (2010b).

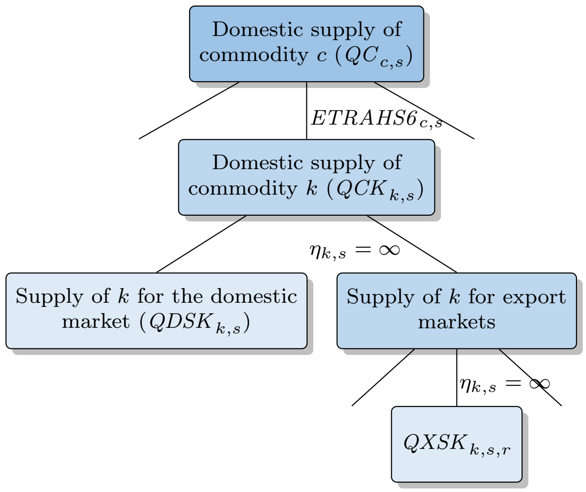

Figure 2: Supply side CET nest for HS module

`E_qpm`, `E_qgm`, `E_qim`) in the standard model.

Equation `E_qat` is a new equation. This is an identity between total domestic absorption ($qat_{c,r}$) of each commodity c in each region, and the sum of all agents' composite domestic and imported commodity demands. The next equation, `E_pat`, calculates the basic price of composite commodity (c), as a share-weighted sum of the domestic and imported goods. The remaining four equations (`E_pfa`, `E_ppa`, `E_pga`, `E_pia`) calculate the agent-specific purchasers' prices based on the basic price of composite commodity c plus agent-specific power of taxes. The slack variables found in Listing 1 are used to activate the HS module and ensure consistency between c-level and k-level commodities when the HS module is active.

Listing 1: GEMPACK equations for national level Armington

```
Equation E_qds
# assures market clearing for domestic sales #
(all,c,COMM)(all,r,REG)
qds(c,r) = qat(c,r) - ESUBD(c,r) * [pds(c,r) - pat(c,r)] + qdsslack(c,r);

Equation E_qms
# assures mkt clearing for imported goods entering each region #
(all,c,COMM)(all,r,REG)
qms(c,r) = qat(c,r) - ESUBD(c,r) * [pms(c,r) - pat(c,r)] + qmsslack(c,r);

Equation E_qat
# market clearing for composite commodity c in region r  #
(all,c,COMM)(all,r,REG)
VAB(c,r) * qat(c,r) = sum{a,ACTS, VCFB(c,a,r) * qfa(c,a,r)}
                              + VCPB(c,r) * qpa(c,r)
                              + VCGB(c,r) * qga(c,r)
                              + VCIB(c,r) * qia(c,r);

Equation E_pat
# purchaser's price of composite commodity c in region r  #
(all,c,COMM)(all,r,REG)
pat(c,r) = VDBSHR(c,r) * pds(c,r) + VMBSHR(c,r) * pms(c,r) + patslack(c,r);

Equation E_ppa
# private consumption price for composite commodities #
(all,c,COMM)(all,r,REG)
ppa(c,r) = pat(c,r) + tpa(c,r);
```

```
Equation E_pga
# government consumption price for composite commodities #
(all,c,COMM)(all,r,REG)
pga(c,r) = pat(c,r) + tga(c,r);

Equation E_pia
# invesment price for composite commodities #
(all,c,COMM)(all,r,REG)
pia(c,r) = pat(c,r) + tia(c,r);
```

3.1 Demand side specification

Each aggregate commodity c from the GTAP database is allocated across k sub-commodities that are derived from the HS6 level data. Figure 1 shows the allocation from the demand side. Aggregate domestic absorption, QAT_c is first split across the k commodities using a CES preference structure governed by the substitution elasticity $ESUBK$ to determine QAK_k, i.e. absorption demand for commodity k. The latter is allocated by source using the standard dual Armington nest. The top Armington nest allocates domestic absorption between domestic goods and an aggregate import bundle, respectively $QDSK$ and $QMSK$ using a substitution elasticity of $ESUBDK$. The second nest subsequently allocates aggregate import demand for k by source region, s, using a CES preference function with elasticity $ESUBMK$ to determine bilateral demand for imports, $QXSK$.

The TABLO codes in Listing 2 show the equations that implement the various nodes in Figure 1. The first equation, `E_qak`, implements $QAK_{c,r}$. This equation states that the demand for composite commodity k is proportional to demand for aggregated GTAP commodity c (from which commodity k was dis-aggregated from—i.e., via the mapping $MAPKC_{c,r}$), and a price term. The latter is composed of the elasticity of substitution between commodity k and the price of commodity k relative to the price of the aggregated GTAP commodity c from which commodity k was dis-aggregated from.

Equations `E_qdsk` and `E_qmsk` determine the domestic and imported demand for commodity k, respectively. The fourth equation, `E_qxsk`, determines the demand for imports of commodity k by destination d coming from source s. The last three equations in Listing 2 determine the domestic, imported and composite prices of commodity k.

Listing 2: GEMPACK equations for national level Armington

```
Equation E_qak
# demand for composite domestic good k #
(all,k,COMMK)(all,r,REG)
qak(k,r) = qat(MAPKC(k),r) - ESUBK(k,r) * [pak(k,r) - pat(MAPKC(k),r)];

Equation E_qdsk
# demand for domestic commodity k #
(all,k,COMMK)(all,r,REG)
qdsk(k,r) = qak(k,r) - ESUBDK(k,r) * [pdsk(k,r) - pak(k,r)];

Equation E_qmsk
# demand for imported commodity k #
(all,k,COMMK)(all,r,REG)
qmsk(k,r) = qak(k,r) - ESUBDK(k,r) * [pmsk(k,r) - pak(k,r)];

Equation E_qxsk
# regional (Armington) demand for imported HS6 com. k by dest. d from source s #
(all,k,COMMK)(all,s,REG)(all,d,REG)
qxsk(k,s,d) = -amsk(k,s,d) + qmsk(k,d)
                - ESUBMK(k,d) * [pmdsk(k,s,d) - amsk(k,s,d) - pmsk(k,d)];

Equation E_pmsk
```

```
# aggregate imports price of HS6k commodity #
(all,k,COMMK)(all,d,REG)
pmsk(k,d) = sum{s,REG, MSHRSK(k,s,d) * [pmdsk(k,s,d) - amsk(k,s,d)]};

Equation E_pak
# price of dom-imp composite commodity k #
(all,k,COMMK)(all,r,REG)
pak(k,r) = VDBKSHR(k,r) * pdsk(k,r) + VMBKSHR(k,r) * pmsk(k,r);
```

3.1.1 Supply side specification

The supply side specification is reflected in Figure 2. The top-level supply is at the c-level and is determined by equilibrium of supply and demand at the c-level. The subsequent levels mimic the allocation of domestic supply from the standard model at the k-level. Similar to the standard model, this implies that all destination markets perceive the same supply price.

Listing 3 shows the equations that implement the various nodes in Figure 2. The first equation, `E_qck`, implements the CET node that determines the supply of commodity k from the c level supply. The next equation, `E_pdsk`, ensures market clearing of commodity k as a share-weighted sum of the supply of commodity k to the domestic and export markets.

Listing 3: GEMPACK equations for national level Armington

```
Equation E_qck
# eq'n distributes the HS6k commodities across COMMD #
(all,k,COMMK)(all,r,REG)
qck(k,r) = qc(MAPKC(k),r)
             - ETRAHS6(MAPKC(k),r) * [pdsk(k,r) - pds(MAPKC(k),r)];

Equation E_pdsk
# market clearing for HS6K commodities #
(all,k,COMMK)(all,r,REG)
qck(k,r) = DBKSHR(k,r) * qdsk(k,r) + sum{d,REG, XSBKSHR(k,r,d) * qxsk(k,r,d)};
```

3.1.2 Trade and transport margins

The trade and transport equations mimic the relevant equations from the standard model—though defined over k instead of over c.

Listing 4 shows the equations that implement the trade and transport margins at the k level. The first equation, `E_ptransk` calculates the price of international trade and transport service by mode m, for the bilateral transport of commodity k from s to d. The next equation, `E_qtmfsdk` calculates the demand for margin services for commodity k. This equation implies that demand for transport and trade services for each commodity k is proportional to the demand for its aggregated GTAP level commodity c counterpart (via the mapping $MAPKC_{c,r}$). The remaining equations in Listing 4 allow for technological improvements in international trade and transport service by mode m, for the bilateral transport of commodity k from s to d.

Listing 4: GEMPACK equations for national level Armington

```
Equation E_ptransk
# flow-specific modal average cost of transport index at HS6-level #
(all,k,COMMK)(all,s,REG)(all,d,REG)
ptransk(k,s,d)
      = sum{m,MARG, VTFSDK_MSH(m,k,s,d) * [pt(m) - atmfsdk(m,k,s,d)]};

Equation E_qtmfsdk
# equation linking qtmfsdk to GTAP-level qtmfsd #
```

```
(all,m,MARG)(all,k,COMMK)(all,s,REG)(all,d,REG)
qtmfsdk(m,k,s,d) = qtmfsd(m,MAPKC(k),s,d);

Equation E_atmfsdk
# flow-specific average rate of tech change for HS6 commodity $\mathit{k}$ #
(all,m,MARG)(all,k,COMMK)(all,s,REG)(all,d,REG)
atmfsdk(m,k,s,d) = atm(m) + ats(s) + atd(d) + atfk(k) + atallk(m,k,s,d);


Equation E_atfk
# equation linking atfk to GTAP-level atf #
(all,k,COMMK)
atfk(k) = atf(MAPKC(k));

Equation E_atallk
# equation linking atallk to GTAP-level atall #
(all,m,MARG)(all,k,COMMK)(all,s,REG)(all,d,REG)
atallk(m,k,s,d) = atall(m,MAPKC(k),s,d);
```

3.1.3 Bridging equations

Listing 5 shows the equations incorporated to minimize the changes to the standard model, via the introduction of slack variables, and to ensure adding up conditions between the c and k level.

Listing 5: GEMPACK equations for national level Armington

```
Equation E_qdsslack1
# equation linking qmsk to GTAP-level qds #
(all,c,COMMD)(all,r,REG)
VDB(c,r) * qds(c,r)
      = sum{k,COMMK:MAPKC(k)=c, VDBK(k,r) * qdsk(k,r)};

Equation E_qxsslack1
# equation linking qxsk to GTAP-level qxs #
(all,c,COMMD)(all,s,REG)(all,d,REG)
VXSB(c,s,d) * qxs(c,s,d)
      = sum{k,COMMK:MAPKC(k)=c, VXSBK(k,s,d) * qxsk(k,s,d)};

Equation E_qmsslack1
# equation linking qmsk to GTAP-level qms #
(all,c,COMMD)(all,r,REG)
VMB(c,r) * qms(c,r)
      = sum{k,COMMK:MAPKC(k)=c, VMBK(k,r) * qmsk(k,r)} ;

Equation E_pfobslack1
# equation linking FOB prices to GTAP-level #
(all,c,COMMD)(all,s,REG)(all,d,REG)
VFOB(c,s,d) * pfob(c,s,d)
      = sum{k,COMMK:MAPKC(k)=c, VFOBK(k,s,d) * pfobk(k,s,d)};

Equation E_pcifslack1
# equation linking CIF prices to GTAP-level #
(all,c,COMMD)(all,s,REG)(all,d,REG)
VCIF(c,s,d) * pcif(c,s,d)
      = sum{k,COMMK:MAPKC(k)=c, VCIFK(k,s,d) * pcifk(k,s,d)};

Equation E_ptransslack1
# equation linking ptransk to GTAP-level ptrans #
(all,c,COMMD)(all,s,REG)(all,d,REG)
ptrans(c,s,d)
      = sum{m,MARG, sum{k,COMMK:MAPKC(k)=c,
            VTFSDK_MSH(m,k,s,d) * ptransk(k,s,d)}};

Equation E_pmdsslack1
# equation linking pmdsk to GTAP-level pmds #
```

```
(all,c,COMMD)(all,s,REG)(all,d,REG)
VMSB(c,s,d) * pmds(c,s,d)
      = sum{k,COMMK:MAPKC(k)=c, VMSBK(k,s,d) * pmdsk(k,s,d)};

Equation E_pmsslack1
# equation linking pmsk to GTAP-level pms #
(all,c,COMMD)(all,r,REG)
VMB(c,r) * pms(c,r)
      = sum{k,COMMK:MAPKC(k)=c, VMBK(k,r) * pmsk(k,r)};

Equation E_patslack1
# equation linking pak to GTAP-level pat #
(all,c,COMMD)(all,r,REG)
VAB(c,r) * pat(c,r) = sum{k,COMMK:MAPKC(k)=c, VABK(k,r) * pak(k,r)};

Equation E_ams1
# equation linking amsk to GTAP-level ams #
(all,c,COMMD)(all,r,REG)(all,s,REG)
VCIF(c,r,s) * ams(c,r,s)
      = sum{k,COMMK:MAPKC(k)=c, VCIFK(k,r,s) * amsk(k,r,s)};

Equation E_tx1
# equation linking txk to GTAP-level tx #
(all,c,COMMD)(all,r,REG)
VXW(c,r) * tx(c,r)
      = sum(k,COMMK:MAPKC(k)=c, VXDFOBK(k,r) * txk(k,r));

Equation E_txs1
# equation linking txsk to GTAP level txs #
(all,c,COMMD)(all,s,REG)(all,d,REG)
VFOB(c,s,d) * txs(c,s,d)
      = sum{k,COMMK:MAPKC(k)=c, VFOBK(k,s,d) * txsk(k,s,d)};

Equation E_tms1
# equation linking tms to GTAP-level #
(all,c,COMMD)(all,s,REG)(all,d,REG)
VMSB(c,s,d) * tms(c,s,d)
      = sum{k,COMMK:MAPKC(k)=c, VMSBK(k,s,d) * tmsk(k,s,d)};

Equation E_tm1
# equation linking tmk to GTAP-level tm #
(all,c,COMMD)(all,r,REG)
VMB(c,r) * tm(c,r)
      = sum{k,COMMK:MAPKC(k)=c, VMBK(k,r) * tmk(k,r)};
```

3.1.4 Model Implementation

The HS module requires two additional set definitions as well as a mapping set. These are summarized in Table 2. The sets COMMD, COMMK and MAPKC are loaded from the 'Sets' file. The GTAP 'basedata' file contains 6 new header arrays that are defined at the k-level aggregation for the commodities being disaggregated. Table 3 summarizes the new header arrays.[13]

The HS module also requires additional parameters, see Table 4. These include three additional demand side elasticities ESUBK, ESUBDK and ESUBMK and one supply side elasticity to transform commodity c supply to k supply. These are all included the model's 'default.prm' file.

[13] N.B. The VTWRK matrix is defined in terms of m0, the initial set of margin commodities. After initial aggregation, m0 is converted to m—the set of modeled margin commodities.

Table 2: Additional sets

Sets & Concordance	Description
`COMMD`	Set of c-level commodities being split into the k-level commodities
`COMMK`	Set of k-level commodities
`MAPKC`	Concordance mapping between the k-level and c-level commodities. Note that each k-level commodity can be mapped to only one c-level commodity

Table 3: Additional header arrays

Coefficient	Description
`VDBK(k,r)`	Domestic supply of commodity k
`VXSBK(k,s,d)`	Bilateral trade at suppliers' price for k sourced in s and sold in d
`VFOBK(k,s,d)`	Bilateral exports at at border, or FOB, price
`VCIFK(k,s,d)`	Bilateral imports at at border, or CIF, price
`VMSBK(k,s,d)`	Bilateral imports at tariff-inclusive price
`VTWRK(m0,k,s,d)`	Value of bilateral trade and transport services by mode

Table 4: Additional parameters

New parameters	Description
`ESUBK(k,r)`	CES elasticity to transform c absorption to k absorption
`ESUBDK(k,r)`	Top-level Armington CES elasticity to allocate k absorption between domestic and aggregate import demand
`ESUBMK(k,r)`	Second-level Armington CES elasticity to allocate k aggregate imports by source region
`ETRAK(k,r)`	CET elasticity to transform c supply to k supply

4 Illustrative Simulations

To illustrate the results of this new model, we run a tariff liberalization scenario for the U.S. motor vehicle sector in the standard GTAP model (i.e., MVH) and contrast it against tariff liberalization of Autos and Auto parts from the motor vehicle sector in the GTAP (i.e., APS_MVH). Table 5 shows the results derived from Equation E_qxsk, which is the percentage change in bilateral imports of sub-sectors in response to the liberalization scenario. For both models, there is an increase in domestic penetration with a larger substitution effect among sources. Here non-NAFTA countries in our aggregation are represented as Rest of the World (ROW). Since the tariff reduction does not affect NAFTA partners already enjoying a zero tariff, we observe a negative substitution effect and a reduction of U.S. imports from NAFTA countries and a positive substitution effect for ROW and an increase in U.S. imports from ROW.

Table 5: US import changes (GTAP-HS and standard GTAP models, % changes post-simulation).

Imports from NAFTA	GTAP-HS Model results				Std. GTAP
	Auto	APS_MVH	OTH_MVH	MVH	MVH
Domestic penetration effect	1.290	0.620	0.400	1.030	1.032
Substitution effect among sources	-3.660	-2.120	-1.560	-3.060	-3.073
Total change in imports	-2.370	-1.500	-1.160	-1.990	-2.041
Imports from ROW	GTAP-HS Model results				Std. GTAP
	Auto	APS_MVH	OTH_MVH	MVH	MVH
Domestic penetration effect	1.330	0.630	0.410	1.030	1.032
Substitution effect among sources	3.050	1.760	3.600	2.670	2.675
Total change in imports	4.380	2.400	4.010	3.740	3.707

Note: MVH results under GTAP-HS are calculated as the aggregate share-weighted change of Auto, APS_MVH and OTH_MVH sectors.

Even though U.S. imports from NAFTA decline, overall U.S. imports rise due to the increase in imports from ROW, see Table 6. The increased competition of imports causes minor reduction in domestic prices of Autos and auto parts under both models. The results show, that even at this small level of disaggregation, there is an heterogeneous response that is not captured by the original aggregate level in the standard GTAP Model.

Table 6: Changes in prices and quantities in US auto sector (in % changes post-simulation).

	US imports from		Aggregate US imports	Aggregate Import prices	Import prices from		Aggregate Domestic US prices
	NAFTA	ROW			NAFTA	ROW	
GTAP-HS							
Autos	-2.370	4.380	1.300	-0.720	-0.063	-1.250	-0.062
APS_MVH	-1.500	2.400	0.620	-0.380	-0.004	-0.690	-0.048
OTH_MVH	-1.160	4.010	0.400	-0.270	0.009	-0.900	-0.041
MVH	-1.990	3.740	1.030	-0.590	-0.040	-1.060	-0.056
Std. GTAP							
MVH	-2.041	3.707	1.032	-0.584	-0.035	-1.061	-0.055

In terms of welfare effects, we find that total welfare effects between models are not considerably different, see Table 7. Table 8 further reports the allocative efficiency effects on imports and welfare due to the tariff reductions. We observe that the welfare gains are driven by the increased imports from ROW due to the reduction of tariffs.

Table 7: Welfare decomposition: an overall comparison of GTAP-HS and standard GTAP.

	Allocative efficiency		Terms of trade		Investment-savings		Total welfare	
	Std. GTAP	GTAP-HS	Std. GTAP	GTAP-HS	Std. GTAP	GTAP-HS	Std. GTAP	GTAP-HS
US	31.95	37.59	-121.08	-106.87	-175.15	-173.45	-264.28	-242.73
NAFTA	-37.41	-23.03	-262.50	-270.51	-22.14	-21.38	-322.05	-314.92
ROW	119.32	98.03	383.51	377.32	197.27	194.80	700.10	670.15
Total	113.86	112.59	-0.07	-0.06	-0.02	-0.03	113.77	112.50

Table 8: Import tax-related allocative efficiency effects for US auto imports at sub-sector-level.

	Imports from NAFTA			Imports from ROW			All auto imports by US	
	Base Tariffs	Change in imports	Change in welfare	Base Tariffs	Change in imports	Change in welfare	imports	welfare
GTAP-HS								
Autos	0	-1865.691	0	1.275	3976.427	25.903	2110.736	25.903
APS_MVH	0	-573.033	0	0.697	1067.148	3.815	494.115	3.815
OTH_MVH	0	-161.256	0	0.903	234.213	1.080	72.957	1.080
MVH	0	-2599.837	0	1.077	5277.858	30.798	2678.021	30.798
Std. GTAP								
MVH	0	-2659.590	0	1.077	5353.238	29.492	2693.648	29.492

Finally, we fully disaggregate motor vehicles into its 62 HS6 components. These are mainly from HS chapters 84 and 87, but not all the elements of these chapters, see them listed in Table 13, which is summarized by Table 9 below, which shows the largest tariffs imposed by the U.S. on Rest of the World. These are trade-weighted tariffs. Within motor vehicles, the majority of the trade weighted tariffs are below 2%.

Table 9: Top US Tariffs (>2%) imposed on HS components of GTAP's Motor Vehicles (MVH)

US Tariffs	HS code	Description
12.44	870423	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. exceeding 20 tonnes), n.e.c. in item no 8704.1
12.44	870431	Vehicles; spark-ignition internal combustion piston engine, for transport of goods, (of a g.v.w. not exceeding 5 tonnes), n.e.c. in item no 8704.1
12.33	870421	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. not exceeding 5 tonnes), n.e.c. in item no 8704.1
12.05	870432	Vehicles; spark-ignition internal combustion piston engine, for transport of goods, (of a g.v.w. exceeding 5 tonnes), n.e.c. in item no 8704.1
9.89	870490	Vehicles; for transport of goods, n.e.c. in heading no. 8704
7.20	870422	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. exceeding 5 tonnes but not exceeding 20 tonnes), n.e.c. in item no 8704.1
2.76	871690	Trailers, semi-trailers and other vehicles not mechanically propelled; parts thereof for heading no. 8716

Notes: Not elsewhere classified (n.e.c.); Gross vehicle weight (g.v.w.).

With fully disaggregated motor vehicles, we run three additional tariff liberalization scenarios. Scenario 2 considers the 62 HS components with the simplifying assumptions of homogeneous domestic to import ratio and trade elasticities of the parent sector (i.e., as in Table 10). Scenario 3 utilizes the estimated elasticities at the HS6 level by Fontagné, Guimbard, and Orefice (2019), and finally Scenario 4 considers different domestic to import ratios. In Scenario 4, the domestic to import ratios were calibrated using the trade weights at the HS6 level so that the higher the import share, the lower the domestic to import ratio, see Table 14. This assumption is not necessarily correct, but provides heterogeneous domestic to import ratios.[14]

Table 10: Initial Assumptions shared by the HS components of motor vehicles

Assumptions	USA	NAFTA	ROW
Domestic to import ratio	2.07	0.50	1.82
Elasticities (ESUBMK=ESUBM)	5.60	5.60	5.60

Summary results for the U.S. motor vehicles is available in Table 11. Although already presented, we include Scenario 1 results to provide context. We can observe that operating at the finer HS

[14] Computing domestic to import ratios with actual data would be preferable but beyond the scope of this paper.

level does provide enhanced results, even when using the aggregate elasticities and the aggregate ratio between domestic and imports across all HS components (Scenario 2). Also, the use of trade elasticities, Scenario 3, at the HS6 level further increases the effect on trade flows following the tariff liberalization, more than the new domestic to import ratio, Scenario 4. Recall, however, that while the calibration provides heterogeneous weights, it is still derived from the aggregate domestic to import ratio and this computation. The allocative efficiency component of welfare, appears to be consistent across the differing assumptions, but the use of HS6 elasticities provides almost double the effect of aggregate elasticities as regards the terms of trade.[15] Change in U.S. imports of motor vehicle imports at the HS6 level is available in Table 12.

From Table 12, we observe that the largest U.S. import, HS code 870323, (i.e., Vehicles; spark-ignition internal combustion reciprocating piston engine, cylinder capacity exceeding 1500cc but not exceeding 3000cc) would increase following tariff liberalization, but depending on the available data, this would be closer to 2%, higher than originally estimated when following the simple assumptions. However, HS code 870490 (i.e., Vehicles; for transport of goods, n.e.c. in heading no. 8704) consistently shows the strongest response to the tariff liberalization scenario under all three different assumptions, ranging from 8.40% and 19.61%.

Table 11: Changes in US auto sector imports and welfare (in % changes unless otherwise stated).

	Aggregate US imports	US imports from NAFTA	ROW	US Welfare (in millions of USD) Allocative efficiency	Terms of Trade	Total
Scenario 1	1.026	-1.989	3.740	37.585	-280.318	-242.73
Scenario 2	1.046	-2.098	3.844	36.759	-297.942	-261.18
Scenario 3	1.997	-4.492	7.726	31.123	-661.009	-629.89
Scenario 4	1.992	-4.477	7.703	31.167	-656.166	-625.00

Notes: Terms of trade here includes Investment Savings.

[15] Investment-savings effects are included in the measure of the terms of trade.

Table 12: US imports and percentage change due to HS components

HS	Base US imports (in millions of USD)	Change in imports (percentage) Scenario 2	Scenario 3	Scenario 4
840731	1.30	-0.20	-0.26	-0.26
840732	24.37	-0.20	-0.22	-0.22
840733	367.12	0.61	1.90	2.03
840734	9,007.47	0.48	0.66	0.69
840820	3,317.73	1.35	2.53	2.66
840991	6,080.86	1.03	1.08	1.13
840999	3,357.04	0.91	1.10	1.15
870110	3.87	-0.20	-0.23	-0.23
870120	5,845.92	-0.27	-0.88	-0.91
870130	545.44	-0.21	-0.30	-0.31
870190	3,161.55	-0.21	-0.53	-0.54
870210	726.01	0.36	0.72	0.76
870290	66.44	0.09	-0.06	-0.05
870310	576.11	0.12	-0.18	-0.18
870321	766.46	1.32	2.73	2.87
870322	6,270.46	1.66	3.18	3.34
870323	83,397.52	1.28	2.20	2.06
870324	64,012.37	1.13	1.55	1.50
870331	1.99	2.13	6.47	6.81
870332	1,226.81	0.48	0.61	0.64
870333	1,400.38	1.81	2.58	2.70
870390	1,001.80	1.25	2.04	2.13
870410	1,105.76	-0.20	-0.35	-0.36
870421	1,937.59	1.96	10.77	11.32
870422	4,727.65	2.36	8.30	8.73
870423	858.52	-0.20	-0.41	-0.42
870431	11,865.01	2.62	10.92	11.40
870432	273.33	-0.07	0.76	0.80
870490	7.78	8.40	18.66	19.61
870510	603.17	-0.21	-0.39	-0.40
870520	39.45	-0.21	-0.31	-0.31
870530	7.49	-0.22	-0.56	-0.58
870540	22.87	-0.24	-0.45	-0.46
870590	269.20	-0.24	-0.29	-0.29
870600	113.90	2.29	2.16	2.26
870710	34.18	1.83	1.21	1.26
870790	884.50	1.00	1.23	1.29
870810	1,043.13	1.07	0.22	0.23
870821	124.25	0.99	0.49	0.51
870829	11,843.43	0.43	0.29	0.30
870830	4,724.49	0.79	1.41	1.49
870840	9,804.09	0.80	1.02	1.07

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Table 12 – continued from previous page				
HS	Base US imports (in millions of USD)	Change in imports (percentage)		
		Scenario 2	Scenario 3	Scenario 4
870850	3,513.31	0.47	0.41	0.43
870870	3,568.60	0.60	1.14	1.21
870880	3,349.34	0.32	0.31	0.34
870891	882.69	0.50	0.47	0.50
870892	876.56	0.49	0.48	0.52
870893	1,407.74	0.47	0.60	0.64
870894	3,869.34	0.26	0.17	0.18
870895	2,290.44	-0.02	-0.19	-0.18
870899	13,592.29	0.32	0.25	0.27
870911	29.42	-0.22	-0.47	-0.48
870919	406.60	-0.25	-0.29	-0.29
870990	263.36	-0.21	-0.33	-0.34
871610	7.01	-0.25	-0.90	-0.94
871620	23.83	-0.26	-0.72	-0.74
871631	155.33	-0.27	-0.61	-0.62
871639	985.90	-0.25	-0.60	-0.61
871640	128.05	-0.23	-0.32	-0.33
871680	445.71	2.17	2.13	2.23
871690	764.38	4.29	6.34	6.66
940120	185.10	-0.23	-0.44	-0.45

5 Summary and conclusions

This paper describes the modifications and extensions to the GTAP framework for the hybrid GTAP-HS model. The GTAP-HS framework requires additional data and changes on the demand and supply side of the standard model. Along with the paper we provide a workflow to facilitate the processing of the data. The new model implements a national-level Armington specification to allocate domestic absorption between domestic and imported goods, whereas the standard model implements a top-level Armington nest at the agent-level. The paper also describes the additional equations needed to implement the HS extension, and the introduction of bridging equations to not only minimize the changes to the standard model but also to ensure consistency between GTAP and HS6 level commodities. The illustrative simulations in this paper showcase the flexibility of the module to re-aggregate (or re-define) sectors differently than originally defined in GTAP. We also show how the analysis could be performed at the HS6 level, improving from the basic assumptions to include elasticities at the HS6 level and detailed domestic to import ratio.

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Table 13: U.S. Tariffs imposed on HS components of GTAP's Motor Vehicles (MVH)

HS code	**Description**
840731	Engines; reciprocating piston engines, of a kind used for the propulsion of vehicles of chapter 87, of a cylinder capacity not exceeding 50cc
840732	Engines; reciprocating piston engines, of a kind used for the propulsion of vehicles of chapter 87, of a cylinder capacity exceeding 50cc but not exceeding 250cc
840733	Engines; reciprocating piston engines, of a kind used for the propulsion of vehicles of chapter 87, of a cylinder capacity exceeding 250cc but not exceeding 1000cc
840734	Engines; reciprocating piston engines, of a kind used for the propulsion of vehicles of chapter 87, of a cylinder capacity exceeding 1000cc
840820	Engines; compression-ignition internal combustion piston engines (diesel or semi-diesel engines), of a kind used for the propulsion of vehicles of chapter 87
840991	Engines; parts, suitable for use solely or principally with spark-ignition internal combustion piston engines (for other than aircraft)
840999	Engines; parts for internal combustion piston engines (excluding spark-ignition)
870110	Tractors; pedestrian controlled
870120	Tractors; road, for semi-trailers
870130	Tractors; track-laying
870190	Tractors; n.e.c. in heading no 8701 (other than tractors of heading no 8709)
870210	Vehicles; public transport type (carries 10 or more passengers), compression-ignition internal combustion piston engine (diesel or semi-diesel)
870290	Vehicles; public transport type (carries 10 or more passengers), other than compression-ignition internal combustion piston engine (diesel or semi-diesel)
870310	Vehicles; specially designed for travelling on snow, golf cars and similar vehicles
870321	Vehicles; spark-ignition internal combustion reciprocating piston engine, cylinder capacity not exceeding 1000cc
870322	Vehicles; spark-ignition internal combustion reciprocating piston engine, cylinder capacity exceeding 1000cc but not exceeding 1500cc
870323	Vehicles; spark-ignition internal combustion reciprocating piston engine, cylinder capacity exceeding 1500cc but not exceeding 3000cc
870324	Vehicles; spark-ignition internal combustion reciprocating piston engine, cylinder capacity exceeding 3000cc
870331	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), cylinder capacity not exceeding 1500cc

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Table 13 – continued from previous page

HS code	**Description**
870332	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), cylinder capacity exceeding 1500cc but not exceeding 2500cc
870333	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), cylinder capacity exceeding 2500cc
870390	Vehicles; for transport of persons (other than those of heading no. 8702) n.e.c. in heading no. 8703, including station wagons and racing cars
870410	Vehicles; dumpers, designed for off-highway use, for transport of goods
870421	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a gvw not exceeding 5 tonnes), n.e.c. in item no 8704.1
870422	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. exceeding 5 tonnes but not exceeding 20 tonnes), n.e.c. in item no 8704.1
870423	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. exceeding 20 tonnes), n.e.c. in item no 8704.1
870431	Vehicles; spark-ignition internal combustion piston engine, for transport of goods, (of a g.v.w. not exceeding 5 tonnes), n.e.c. in item no 8704.1
870432	Vehicles; spark-ignition internal combustion piston engine, for transport of goods, (of a g.v.w. exceeding 5 tonnes), n.e.c. in item no 8704.1
870490	Vehicles; for transport of goods, n.e.c. in heading no. 8704
870510	Vehicles; crane lorries
870520	Vehicles; mobile drilling derricks
870530	Vehicles; fire fighting vehicles
870540	Vehicles; concrete-mixer lorries
870590	Vehicles; break-down lorries, road-sweepers, spraying lorries, mobile workshops, mobile radiological units, and other special purpose vehicles n.e.c. in heading no. 8705
870600	Chassis; fitted with engines, for the motor vehicles of heading no. 8701 to 8705
870710	Vehicles; bodies (including cabs) for the motor vehicles of heading no. 8703
870790	Vehicles; bodies (including cabs) for the motor vehicles of heading no. 8701, 8702, 8704 or 8705
870810	Vehicles; bumpers and parts thereof, for the vehicles of heading no. 8701 to 8705
870821	Vehicles; parts of bodies, safety seat belts
870829	Vehicles; parts and accessories, of bodies, other than safety seat belts
870830	Vehicle parts; brakes, servo-brakes and parts thereof
870840	Vehicle parts; gear boxes and parts thereof

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Table 13 – continued from previous page

HS code	**Description**
870850	Vehicle parts; drive-axles with differential, whether or not provided with other transmission components, and non-driving axles; parts thereof
870870	Vehicle parts; road wheels and parts and accessories thereof
870880	Vehicle parts; suspension systems and parts thereof (including shock-absorbers)
870891	Vehicle parts; radiators and parts thereof
870892	Vehicle parts; silencers (mufflers) and exhaust pipes; parts thereof
870893	Vehicle parts; clutches and parts thereof
870894	Vehicle parts; steering wheels, steering columns and steering boxes; parts thereof
870895	Vehicle parts; safety airbags with inflater system; parts thereof
870899	Vehicle parts and accessories; n.e.c. in heading no. 8708
870911	Vehicles; electrical, self-propelled, (not fitted with lifting or handling equipment), of the type used for short distance transport of goods in factories, warehouses, dock areas or airports
870919	Vehicles; (not electrical), self-propelled, without handling equipment, used for short distance transport of goods in factories, airports and such, and tractors of the type used on railway station platforms
870990	Vehicles; parts of the vehicles of heading no. 8709
871610	Trailers and semi-trailers; of the caravan type, for housing or camping
871620	Trailers and semi-trailers; self-loading or self-unloading, for agricultural purposes
871631	Tanker trailers and tanker semi-trailers
871639	Trailers and semi-trailers; (other than tanker type)
871640	Trailers and semi-trailers; n.e.c. in item no. 8716.3
871680	Vehicles; n.e.c. in heading no. 8716
871690	Trailers, semi-trailers and other vehicles not mechanically propelled; parts thereof for heading no. 8716
940120	Seats; of a kind used for motor vehicles

Table 14: Different domestic to import ratios and HS6 elasiticities

	Import trade weights (percentage)			Calibrated domestic to import ratio			Elasticitity
HS	USA	NAFTA	ROW	USA	NAFTA	ROW	(ESUBMK)
840731	0.00	0.00	0.01	2.07	0.50	1.82	5.71
840732	0.01	0.05	0.04	2.07	0.50	1.82	2.10
840733	0.13	0.08	0.17	2.07	0.50	1.82	19.45
840734	3.25	5.42	1.95	2.00	0.47	1.79	9.11
840820	1.19	3.61	2.42	2.05	0.48	1.78	11.26
840991	2.19	3.39	2.15	2.03	0.48	1.78	6.63
840999	1.21	1.28	2.67	2.05	0.49	1.77	7.38
870110	0.00	0.01	0.04	2.07	0.50	1.82	2.47
870120	2.11	2.14	1.93	2.03	0.49	1.79	23.99
870130	0.20	0.18	0.10	2.07	0.50	1.82	7.64
870190	1.14	1.31	1.59	2.05	0.49	1.79	23.88
870210	0.26	0.53	1.28	2.07	0.50	1.80	12.13
870290	0.02	0.18	0.31	2.07	0.50	1.82	6.79
870310	0.21	0.34	0.10	2.07	0.50	1.82	0.37
870321	0.28	0.54	1.80	2.07	0.50	1.79	12.12
870322	2.25	2.03	6.57	2.02	0.49	1.70	11.69
870323	29.94	15.37	15.99	1.45	0.42	1.53	10.37
870324	22.99	9.35	5.16	1.59	0.45	1.73	8.40
870331	0.00	0.00	2.04	2.07	0.50	1.79	17.42
870332	0.44	0.57	12.04	2.06	0.50	1.60	8.55
870333	0.50	0.73	3.14	2.06	0.50	1.77	8.27
870390	0.36	0.12	0.56	2.06	0.50	1.81	9.51
870410	0.40	0.97	1.08	2.06	0.50	1.80	12.53
870421	0.70	1.20	4.44	2.06	0.49	1.74	16.30
870422	1.69	1.34	1.49	2.04	0.49	1.80	15.22
870423	0.31	0.89	1.52	2.06	0.50	1.79	16.05
870431	4.25	8.07	0.86	1.98	0.46	1.81	15.05
870432	0.10	0.37	0.06	2.07	0.50	1.82	18.75
870490	0.00	0.01	0.09	2.07	0.50	1.82	10.91
870510	0.22	0.27	0.34	2.07	0.50	1.82	14.01
870520	0.01	0.03	0.04	2.07	0.50	1.82	5.41
870530	0.00	0.10	0.17	2.07	0.50	1.82	12.16
870540	0.01	0.04	0.12	2.07	0.50	1.82	6.28
870590	0.10	0.67	0.49	2.07	0.50	1.81	2.08
870600	0.04	0.15	0.35	2.07	0.50	1.82	5.49
870710	0.01	0.01	0.66	2.07	0.50	1.81	3.88
870790	0.32	0.13	0.36	2.06	0.50	1.82	7.61
870810	0.37	0.45	0.47	2.06	0.50	1.81	1.74
870821	0.04	0.19	0.20	2.07	0.50	1.82	3.43
870829	4.27	8.39	4.22	1.98	0.46	1.75	5.78
870830	1.70	2.74	1.92	2.04	0.49	1.79	10.91
870840	3.53	6.16	3.91	2.00	0.47	1.75	7.99
870850	1.27	2.85	1.42	2.04	0.49	1.80	6.47

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Table 14 – continued from previous page							
	Import trade weights (percentage)			Calibrated domestic to import ratio			Elasticitity
HS	USA	NAFTA	ROW	USA	NAFTA	ROW	(ESUBMK)
870870	1.29	1.54	1.16	2.04	0.49	1.80	11.67
870880	1.21	2.36	0.93	2.05	0.49	1.81	7.62
870891	0.32	0.53	0.44	2.06	0.50	1.81	6.52
870892	0.32	0.81	0.59	2.06	0.50	1.81	6.82
870893	0.51	0.70	0.68	2.06	0.50	1.81	8.38
870894	1.40	2.35	1.21	2.04	0.49	1.80	6.39
870895	0.83	1.34	0.48	2.05	0.49	1.81	8.44
870899	4.90	4.95	6.14	1.97	0.48	1.71	6.49
870911	0.01	0.02	0.03	2.07	0.50	1.82	11.85
870919	0.15	0.04	0.07	2.07	0.50	1.82	1.58
870990	0.10	0.01	0.04	2.07	0.50	1.82	9.91
871610	0.00	0.93	0.08	2.07	0.50	1.82	23.36
871620	0.01	0.05	0.06	2.07	0.50	1.82	14.06
871631	0.06	0.15	0.11	2.07	0.50	1.82	8.91
871639	0.36	1.10	0.55	2.06	0.49	1.81	10.86
871640	0.05	0.04	0.14	2.07	0.50	1.82	3.53
871680	0.16	0.16	0.18	2.07	0.50	1.82	5.77
871690	0.27	0.46	0.63	2.07	0.50	1.81	8.68
940120	0.07	0.20	0.21	2.07	0.50	1.82	9.25