Journal of Global Economic Analysis, Volume 1 (2016), No. 1, pp. 181-208.

An Overview of the GTAP 9 Data Base

BY ANGEL AGUIAR[a], BADRI NARAYANAN[b] AND ROBERT MCDOUGALL[c]

This paper provides an overview of the Global Trade Analysis Project (GTAP) Data Base and its latest release, version 9. The GTAP Data Base has been used in thousands of economy-wide analyses over the past twenty-five years. While initially focused on supporting trade policy analysis, the addition of satellite accounts pertaining to greenhouse gas emissions and land use has resulted in a surge of applications relating to climate change as well as other environmental issues. The Data Base comprises an exhaustive set of accounts measuring the value of annual flows of goods and services with regional and sectoral detail for the entire world economy. These flows include bilateral trade, transport, and protection matrices that link individual country/regional economic datasets. Version 9 disaggregates 140 regions, 57 sectors, 8 factors of production, for 3 base years (2004, 2007 and 2011). The great success enjoyed by this Data Base stems from the collaboration efforts by many parties interested in improving the quality of economic analysis of global policy issues related to trade, economic development, energy and the environment.

1. Introduction

The GTAP Data Base is the centerpiece of the Global Trade Analysis Project. It's latest version, version 9, represents the world economy as 140 regions and 57 economic sectors for three benchmark year: 2004, 2007 and 2011 (Narayanan, Aguiar, and McDougall, 2015).[1] The Data Base includes bilateral trade in goods and services, intermediate inputs among sectors, as well as taxes and subsidies imposed by governments. First created for global applied general equilibrium models, the GTAP Data Base is also used by other modeling communities such as Multi-region Input Output analysis (Hertel, Hummels, and Walmsley, 2013), Global Social Accounting Matrix modeling (Thierfelder and McDonald, 2012), Integrated Assess-

[a] Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, West Lafayette, IN, 47906 (aaguiar@purdue.edu). Corresponding author.
[b] McKinsey and Company and Center for International Trade in Forestry, University of Washington, Seattle, WA, 98195, (badrig@uw.edu).
[c] Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, West Lafayette, IN, 47906, (rmcdougall@purdue.edu).
[1] Previous versions documentation are available at https://www.gtap.agecon.purdue.edu/databases/archives.asp.
References for data inputs for various data versions are available from https://www.gtap.agecon.purdue.edu/resources/citations.asp.

ment Modeling (Elliott et al., 2010) and complex network science (Ukkusuri et al., 2016).[2] The Data Base underpins thousands of economic model applications and to date, the GTAP website contains 1013 studies on International Trade, 893 on Growth and Development, and 521 on Climate and the Environment. The GTAP Data Base documentation has attracted more than 2600 scholarly citations.[3]

The production of the GTAP Data Base relies on the contributions from many individuals and organizations throughout the world. Individuals contribute the best available input-output table for their country, while other experts contribute the macro-economic, trade, protection and other data required. The Center for Global Trade Analysis, the home of GTAP, coordinates these contributions and produces one usable, globally consistent, database which is a fully documented, publicly available, and regularly updated. The benefits of the centralized construction begin with the specification of a set of common standards, concordances and reference years. For many countries, Input-Output Table (IOT) statistics are only produced sporadically. Furthermore, each country has its own sectoral breakdown, while the international data sets use their own classifications, all of which must be harmonized during the construction process. Once produced, data contributors and leading national and international organizations play a role in reviewing the database before it is made public, providing an extra layer of quality assurance.

Complementing the core GTAP Data Base are several extensions designed to make the Data Base more relevant to contemporary policy issues. For example, GTAP-E conveniently combines the GTAP Data Base with energy volume and carbon dioxide (CO_2) emissions data for ease of use with the GTAP-E model aimed at analysis of climate mitigation and energy policies (McDougall and Golub, 2009). The migration extension of the GTAP Data Base (GMig) contains additional data on labor force by country of origin, wages and remittances, as well as additional parameters required by the GMig2 model which focuses on international migration and policy responses (Walmsley, Winters, and Ahmed, 2007). The Land Use Data Base (GTAP-AEZ) contains disaggregated land use data by type of land cover (cropland, forests and pasture) and 18 Agro-Ecological Zones (AEZs) (Hertel et al., 2008). The Dynamic GTAP (GDyn) Data Base contains additional data on foreign income flows, reference economic growth rates, rates of return, as well as additional convergence parameters, all of which are required for running the Dynamic GTAP model (Ianchovichina and Walmsley, 2012). The GTAP-Power Data Base disaggregates GTAP's single electricity sector into: transmission & distribution and generation activities, whereby the latter is further broken into nuclear, coal, gas (base and peak load), oil (base and peak load), hydroelectric (base and peak load), wind, solar, and other power technologies (Peters, 2015). The GTAP Non-

[2] For a list of models that use the GTAP Data Base, see https://www.gtap.agecon.purdue.edu/about/data_models.asp.

[3] Based on Google Scholar calculations of all nine GTAP versions.

CO_2 Emissions Data Base complements GTAP-E providing information on other greenhouse gas (GHG) emissions such as Methane (CH_4), Nitrous Oxide (N_2O), and Fluorinated gases (FGAS) (Irfanoglu and Mensbrugghe, 2016). Together, these data bases have become core inputs into many of the Integrated Assessment Models used to evaluate the economic costs and benefits of climate regulations.

The remainder of the paper is divided into five sections. A brief overview of the structure of the GTAP Data Base is provided in Section 2. Section 3 discusses the methodology used in producing the Data Base. Section 4 identifies the updates specific to the latest release, version 9, made available to the public in May 2015. Section 5 illustrates some of the data included in the Data Base. The final section concludes.

2. Structure of the Data Base

The GTAP Data Base presents globally consistent data on consumption, production, and international trade (including transportation and protection data), energy data and CO_2 emissions for 140 regions and 57 commodities for three benchmark years (2004, 2007 and 2011).[4] At its core, the GTAP Data Base is composed of Input Output Tables statistics, which are contributed by members of the GTAP Network.[5] These are of utmost importance because they provide the inter-sectoral linkages within each country. The GTAP 9 Data Base includes separate IOTs for 120 individual countries representing 98% of global gross domestic product (GDP) and 92% of the world's population, along with 20 composite regions which are mainly aggregations of smaller economies. Countries represented as individual regions are illustrated with blue coloring in Figure 1, while the red denotes countries which are aggregated into 'rest of' regions and represented with combinations of the known IOTs. A complete list regions is provided in Table A.1.[6]

Although the GTAP 9 Data Base covers all but 2% of the world's GDP at the individual country level, Figure 1 shows that country coverage in Africa needs to be improved. This gap would have been much larger were it not for two prior successful projects funded by the Netherlands Partnership Program and the World Bank that have facilitated a significant increase the number of African countries for which IOTs are available. The resulting data bases focused on Africa are freely

[4] It is important to note that the data sources and methods used to build these three benchmark years are fully consistent, thereby allowing for meaningful comparisons of developments over time. This would not be the case if the user took data from GTAP Data Bases 7 (2004), 8 (2007) and 9 (2011) because both the core source data and the methods for processing these data change between releases.

[5] To learn how to contribute to the GTAP Data Base, see https://www.gtap.agecon.purdue.edu/databases/contribute/default.asp.

[6] For a detailed description of regions represented in the database, see https://www.gtap.agecon.purdue.edu/databases/regions.asp?Version=9.211.

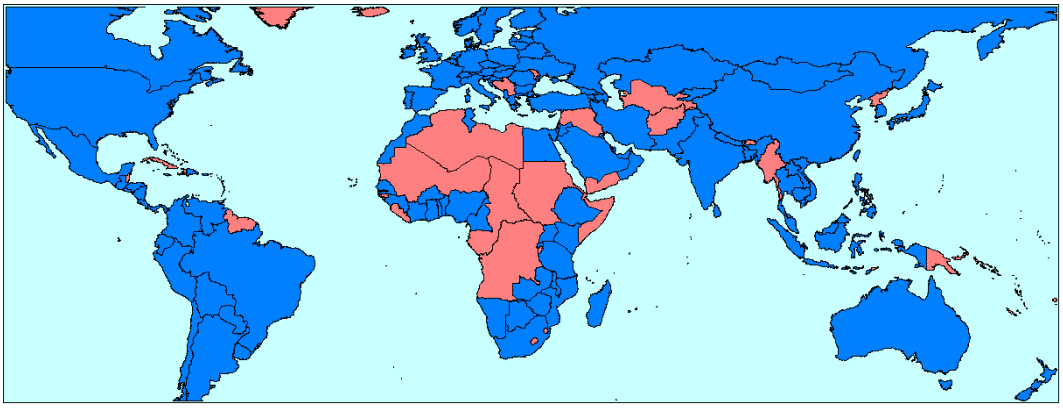

Figure 1. Countries represented as individual regions (in blue) and included in composite regions (in red).

Notes: Figure 1 has been developed using Shademap, a free utility developed by Mark Horridge, accessible at http://www.copsmodels.com/shademap.htm.

Source: GTAP 9 Data Base.

available on the GTAP website.[7] The latest Africa data base, designed to enhance the depth and breadth of analysis conducted on this region, is an aggregation of the GTAP Data Base. It provides all the country detail available for Africa (i.e., 32 African regions) along with ten non-Africa region aggregates.

Since version 5, released in 2001, all economic activity is accounted for by 57 products and services. These are mapped to the United Nations Central Product Classification (CPC) and the International Standard Industrial Classification (ISIC). The sectoral aggregation of the data base, detailed in Table A.2, represents 14 agricultural sectors (including forestry and fishing), four mineral extraction sectors, eight food processing sectors, 16 manufacturing sectors, three utility distribution sectors, construction, wholesale and retail trade, three transportation sectors, six service sectors, and dwellings.[8]

For each country/region, the Data Base distinguishes the following factor endowments: capital, land, natural resources, and five labor categories consistent with the International Labor Organization's grouping of employment by occupation. The five labor categories in the GTAP 9 Data Base include (1) officials and managers, (2) technicians, (3) clerks, (4) service/shop workers, and (5) agricultural and unskilled workers, which provide a more detailed labor disaggregation than the two labor types identified in versions 4 through 8 of the GTAP Data Base. Prior to that, there was just a single labor category represented in versions 1 through 3. Walmsley and Carrico (2016) provide a detailed representation of labor categories

[7] The GTAP Africa Data Bases can be accessed at https://www.gtap.agecon.purdue.edu/databases/Africa/default.asp.

[8] A detailed description is available from https://www.gtap.agecon.purdue.edu/databases/v9/v9_sectors.asp.

represented in the GTAP 9 Data Base.

Due to the very large size of the full GTAP Data Base, the associated files are distributed with two alternative aggregation packages (FlexAgg and GTAPAgg), which allow users of the data base to tailor sectoral and regional aggregation to their needs. FlexAgg is a command line data aggregation program described in Villoria and McDougall (2015). GTAPAgg is a Windows program with a convenient, graphical user interface that also aggregates the GTAP Data Base and is described in Horridge (2015). Both of these aggregation packages include additional programs that reformat the GTAP Data Base. The GTAPView format provides a more intuitive and user friendly way to look at the GTAP Data Base (Bacou, Hertel, and Yu., 1999). Another widely used format is the global social accounting matrix (SAM), which is consistent with the GTAP model and is explained in McDonald and Thierfelder (2004).

The GTAP Data Base comprises four files: sets, parameters, core data, energy volumes, and CO_2 emissions. The core data consist of economic value flows valued in millions of current US dollars (i.e., valuation differs according to the reference year). Energy volumes are measured in million tons of oil equivalent (Mtoe). All the files are binary header array (HAR) files, to keep the size of the files small (Harrison and Pearson, 1998). The HAR files are designed to work with the General Equilibrium Modeling PACKage (GEMPACK), a suite of economic modeling software products specifically designed for computable general equilibrium (CGE) modeling. Utilities exist for readily converting these HAR files to the General Algebraic Modeling System (GAMS) data exchange file (GDX) format, as well as to CSV files.[9]

Table 1 shows the arrays in the sets file. These sets are designed to allow the data base to fully parameterize the standard GTAP model (Hertel, 1997), which can be run with any aggregation of the GTAP Data Base. The array H1 is a list of regions. H2 lists goods and services that can be traded between regions. Primary factors/endowment commodities are listed in H6. Capital endowments are specified as a separate array for convenience in implementing the investment theory of the GTAP model. The arrays H7 and H8 divide the endowment commodities into two groups. In the standard GTAP model, the mobile endowment commodities (H8) are perfectly mobile across industries within each region; and the sluggish endowment commodities (H7) are imperfectly mobile, with the degree of mobility governed by an elasticity of transformation function in the GTAP model. In the standard data base, the five labor categories, as well as capital, are mobile, and land and natural resources are sluggish. This is suitable for long-run simulations. For

[9] The standard GTAP model is written in GEMPACK but it has also been implemented in GAMS (Rutherford, 2005). However, because there are a few substantive differences between the GEMPACK and GAMS implementations of the GTAP model, an exact replication of the standard GTAP model in GAMS is underway (van der Mensbrugghe, 2016).

short-run simulations, users may wish to alter this treatment, for example moving capital from H8 to H7, to treat it as sluggish rather than mobile.

Table 1. Arrays in the GTAP Sets File.

Name	Dimension	Description
H1	*r*	Regions
H2	*t*	Traded commodities
H3	*s+m+t+1*	Non-saving commodities
H4	*s+m+t*	Demanded commodities
H5	*t+1*	Produced commodities
H6	*s+m*	Endowment commodities
H7	*s*	Sluggish endowment commodities
H8	*m*	Mobile endowment commodities
H9	*1*	Capital endowment commodity
MARG	*g*	Margin commodities
TARS	*2*	Types of tariffs

Notes: *r* is the number of regions, *t* is the number of traded commodities, *s* is the number of primary factors not perfectly mobile across industries, *m* is the number of primary factors perfectly mobile across industries, and *g* is the number of margins commodities (sectors).

Source: Contents of GTAP's sets file.

The remaining arrays are provided for convenience in implementing the theoretical structure of the standard GTAP model. The non-savings commodities, array H3, comprise the endowment commodities, the traded commodities, and an investment good. The demanded commodities, H4, comprise endowment and traded commodities; the produced commodities, H5, comprise traded commodities and services, as well as the investment good which is a composite of intermediate inputs contributing to the accumulation of capital goods in the economy. Finally, array MARG lists the margin commodities which are used to assign the international trade and transport margins in the GTAP model.[10]

Table 2 shows the behavioral parameters provided with the GTAP Data Base (Hertel et al., 2016). These include the source-substitution or Armington elasticities (used to differentiate goods by country or origin), the factor substitution elasticities, the factor transformation elasticities affecting the sluggish factors, the investment parameters, and the parameters governing the consumer demand elas-

[10] Users of the data base who are employing the GTAP Model should note that the derived arrays H3, H4, and H5 are obsolete as of 'gtap.tab' release 5.1 (they are now derived internally in the model's program). Also obsolete are the sluggish and mobile endowment commodity arrays H7 and H8; the sluggish/mobile distinction is indicated with a parameter, see SLUG header located in the parameters file. The header TARS was introduced in the GTAP 8 Data Base, showing the components of tariff available in the dataset in the new additional data header VTSS.

ticities. The first three sets of parameters are independent of the data construction process. The investment parameters are also required to run the GTAP model and offer additional flexibility to the users of the model in specifying the mobility of international investment in response to expected regional rates of return. The consumer demand parameters relate to the Constant Difference of Elasticities (CDE) demand system and are re-calibrated for every new version of the Data Base using expenditure elasticities that are calculated from estimates of an implicit, directly additive demand system (AIDADS) model based on the version of GTAP in current use. This approach is reported in Reimer and Hertel (2004) and discussed in Hertel et al. (2016).

Table 2. Arrays in the GTAP Parameters File.

Name	Dimension	Description
ESBD	t	elasticity of substitution between domestic and imported products
ESBM	t	elasticity of substitution between imports from different regions
ESBT	t	elasticity of substitution between comp. intermediates and value added
ESBV	t	elasticity of substitution between primary factors
ETRE	s	elasticity of transformation for sluggish primary factor endowments
RDLT	*1*	binary switch mechanism of allocating investment funds
RFLX	r	flexibility of expected net rate of return on capital stock w.r.t. Investment
INCP	$t \times r$	expansion parameter in the CDE consumer demand system
SUBP	$t \times r$	substitution parameter in the CDE consumer demand system
SLUG	e	sluggish-mobile switch parameter

Notes: t is the number of tradable commodities (sectors), s is the number of primary factors not perfectly mobile between industries, r is the number of regions, and e is the number of factor endowments.

Source: Contents of GTAP's parameters file.

The elements of the main data file are outlined in Table 3. These flows include both input-output flows within each region and bilateral international trade flows. Most flows are measured at both tax-free and tax-paid prices (i.e., taxes are implicitly accounted for). Figure 2 offers a simplified view of the GTAP Data Base, excluding commodity taxes within each region – see Walmsley, Aguiar, and Narayanan (2012) for a comprehensive overview. In Figure 2, each region's economy is summarized by sales of domestic and imported commodities (rows I and II respectively) and of factors of production (row III) across the domestic activities, final

domestic uses (investment, private and government consumptions) and abroad by other countries (intermediate and final uses). The inputs into commodities' production are captured by column I. The naming convention matches that used in the GTAP Data Base and model, and follows the format "V" for value; "D" or "I" for domestic or imports; "P", "G", "F" or "X" for private, government, firm/intermediate or export demand respectively; and "M" for market prices. In Figure 2, all values are at domestic market prices, which are exclusive of taxes but inclusive of domestic margins.[11]

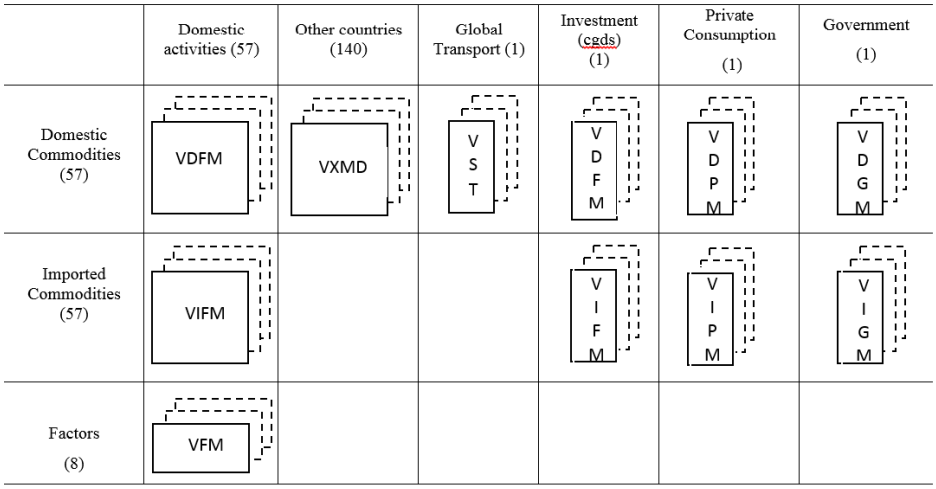

Figure 2. Simplified view of the GTAP Data Base Structure.

Notes: Excludes commodity taxes.

Source: Walmsley, Aguiar, and Narayanan (2012).

Sales of transport or margin commodities to the global transportation services pool (VST), which are used to supply international transportations services for exporting goods from one country to another are included in Figure 2.[12] Figure 3, also taken from Walmsley, Aguiar, and Narayanan (2012), illustrates how the value of exports at market prices by destination (VXMD where "D" signifies destination) are linked to the value of imports at market prices by source country (VIMS where "S" signifies source) by export taxes/subsidies (XTAXD, shown in

[11] Domestic sales of domestic and imported goods and factors are also valued inclusive of commodity and factor use taxes in the Data Base, as signified by "A" for agent prices (e.g., VDFA).

[12] Three of the 57 GTAP commodities are also modes of transport or margin commodities in the GTAP Data Base: air (atp), water (wtp) and other (otp) transport corresponding to the three margins accounted for margin demand (VTWR) in Figure 3 (margin supply (VST) in Figure 2).

Table 3. Data Arrays in the GTAP 9 Data File.

Name	Dimension	Description
ADRV	$t \times r \times r$	anti-dumping duty
DPSM	r	sum of distribution parameters in the household demand system
EVFA	$e \times p \times r$	primary factor purchases, at agents' prices
EVOA	$e \times r$	primary factor sales, at agents' prices
FBEP	$e \times p \times r$	factor-based subsidies
FTRV	$e \times p \times r$	factor employment tax revenue
ISEP	$t \times p \times r \times d$	intermediate input subsidies
MFRV	$t \times r \times r$	export tax equivalent of Multi-fiber agreement (MFA) quota premium
OSEP	$t \times r$	ordinary output subsidy
POP	r	Population
PURV	$t \times r \times r$	export tax equivalent of price undertakings
SAVE	r	net saving, by region
TFRV	$t \times r \times r$	ordinary import duty
TVOM	$t \times r$	sales of domestic product, at market prices
VDEP	r	capital depreciation
VDFA	$t \times p \times r$	domestic purchases, by firms, at agents' prices
VDFM	$t \times p \times r$	domestic purchases, by firms, at market prices
VDGA	$t \times r$	domestic purchases, by government, at agents' prices
VDGM	$t \times r$	domestic purchases, by government, at market prices
VDPA	$t \times r$	domestic purchases, by households, at agents' prices
VDPM	$t \times r$	domestic purchases, by households, at market prices
VFM	$e \times p \times r$	primary factor purchases, by households, at market prices
VIFA	$t \times p \times r$	import purchases, by firms, at agents' prices
VIFM	$t \times p \times r$	import purchases, by firms, at market prices
VIGA	$t \times r$	import purchases, by government, at agents' prices
VIGM	$t \times r$	import purchases, by government, at market prices
VIMS	$t \times r \times r$	imports, at market prices
VIPA	$t \times r$	import purchases, by households, at agents' prices
VIPM	$t \times r$	import purchases, by households, at market prices
VIWS	$t \times r \times r$	imports, at world prices
VKB	r	capital stock
VRRV	$t \times r \times r$	export subsidy equivalent of voluntary export restraints
VST	$t \times r$	margin exports
VTWR	$m \times t \times r \times r$	margins by margin commodity
VXMD	$t \times r \times r$	non-margin exports, at market prices
VXWD	$t \times r \times r$	non-margin exports, at world prices
XTRV	$t \times r \times r$	ordinary export tax
VTSS	$2 \times t \times r \times r$	value of specific and *ad-valorem* tariff revenue

Notes: t is the number of tradable commodities (sectors), r is the number of regions, e is the number of endowment commodities (primary factors), p is the number of produced commodities, d is the number of trade directions (exports, imports), and m is the number of margin commodities (sectors).

Source: Contents of GTAP's data file.

the header XTRV of the data file), transportation margins (VTWR) and import duties (MTAXD, shown in the header TFRV of the data file). Since GTAP was initially introduced as a trade model each of these 'wedges' is separately identified in the GTAP Data Base by commodity, country of origin and destination, along with trade valued both free on board (f.o.b.) and including cost, insurance, and freight (c.i.f.).

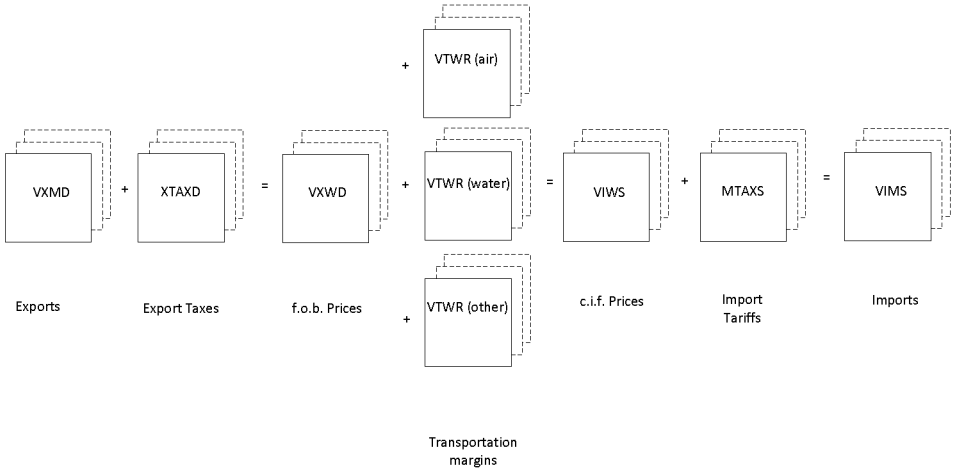

Figure 3. The Link between Exports and Imports.

Source: Walmsley, Aguiar, and Narayanan (2012).

The value of imports by commodity, source and destination at market prices by source (VIMS) are equal to the sum of Imports purchased for intermediate and final uses, that is Firms (VIFM), Government (VIGM), Investment (VIFM) and Private consumption (VIPM). The GTAP Data Base will soon be extended to distinguish the country of origin of imports into intermediate and final uses. Although there is currently relatively limited information globally about the sourcing of imports by different users, this is an area attracting considerable attention and we hope that adding this feature to the data base will encourage further contributions along these lines.

The main data file also includes arrays summarizing the value of revenue generated from protection measures and the subsidy expenditures related to support measures. The protection data is available in the GTAP data file both implicitly and explicitly. Implicitly, the rates of different protection instruments may be calculated from the different valuations of the same economic flow (e.g., value of output at agent prices, VOA, and value of output at market prices, VOM). Table 4 shows the protection measures that may be calculated from the data base and the arrays associated with these measures. The import and export duties calculated from the data base are the comprehensive measures, described in detail in Narayanan, Aguiar, and McDougall (2015).

Table 4. Implicit Protection in the GTAP Data File.

Protection Measures	Formula[a]	Description
Import Duties	VIMS / VIWS	power of import tax (comprehensive)
Export Duties	VXMD / VXWD	power of export tax (comprehensive)
Output Subsidies	VOA / VOM	power of output tax
Domestic Inputs	VDFA / VDFM	power of domestic and imported
Imported Inputs	VIFA / VIFM	intermediate inputs tax, respectively
Factor-Based Payments	EVFA / (VFM + FTRV)	power of factor-based subsidies

Notes: [a] The difference between the two value flows gives the value of revenue or subsidy expenditure.

Source: GTAP 9 Data Base.

The protection data explicitly declared in the GTAP data file are the revenue values or expenditure values associated with the protection measures. The revenues/-expenditures from the different types of import and export instruments are given in separate arrays. These explicit arrays are TFRV, XTRV, MFRV, ADRV, PURV, VRRV, OSEP, ISEP, and FBEP, each of which is defined in Table 3. VTSS is a new header introduced in GTAP 9, showing the value of the tariff revenue data by its two components, namely, specific and *ad-valorem* measures.

In addition to observations on input-output flows, trade margins, trade taxes and commodity taxes, the GTAP Data Base also includes income taxes, savings (SAVE), capital stocks (VKB), depreciation (VDEP), and population (POP) data for each country/region.[13]

Tables 5 and 6 show the format of the energy volumes and CO_2 emissions data files. There are six energy commodities in GTAP: coal, oil, natural gas, petroleum and coke products, electricity, and gas distribution. The Data Base includes three arrays reporting the volume of energy purchases by firms and by households and the government and also the volume of bilateral trade in energy, in Mtoe. Detailed documentation about the energy volumes tracked in the GTAP Data Base is available at McDougall and Lee (2006). Mirroring energy volumes, the data base also tracks CO_2 emissions associated with firms, household and government purchases of energy commodities.

[13] Savings absorb a host of omissions such as foreign income payments and/or remittances flows and are accounted for to obtain macroeconomic balance. In each region, the capital stock in the benchmark year is used to determine the investment to capital ratio and depreciation, which are used by the model to determine net investment. Depreciation is set at 4% of capital stocks. Population data is measured in millions and is not read in by the current standard version of the GTAP model, but it is useful for post-simulation calculations.

Table 5. Arrays in the Energy Volumes Data File.

Name	Dimension	Description
EC	n	energy commodities
EDF	$n \times p \times r$	volume of domestic input purchases by firms (Mtoe)
EDP	$n \times r$	volume of domestic purchases by households (Mtoe)
EDG	$n \times r$	volume of domestic purchases by government (Mtoe)
EIF	$n \times p \times r$	volume of imported input purchases by firms (Mtoe)
EIP	$n \times r$	volume of imported purchases by households (Mtoe)
EIG	$n \times r$	volume of imported purchases by government (Mtoe)
EXI	$n \times r \times r$	volume of bilateral trade (Mtoe)

Notes: n is the number of energy commodities (sectors), p is the number of produced commodities (sectors), and r is the number of regions.

Source: Contents of GTAP's energy data file.

Table 6. Arrays in the CO2 Emissions Data File.

Name	Dimension	Description
FC	f	fuel commodities
MDF	$f \times p \times r$	emissions from domestic input purchases by firms (Mt CO_2)
MDP	$f \times r$	emissions from domestic purchases by households (Mt CO_2)
MDG	$f \times r$	emissions from domestic purchases by government (Mt CO_2)
MIF	$f \times p \times r$	emissions from imported input purchases by firms (Mt CO_2)
MIP	$f \times r$	emissions from imported purchases by households (Mt CO_2)
MIG	$f \times r$	emissions from imported purchases by government (Mt CO_2)

Notes: f is the number of fuel commodities, p is the number of produced commodities (sectors), and r is the number of regions.

Source: Contents of GTAP's CO_2 data file.

3. Summary of the construction methodology

Constructing the GTAP Data Base requires integrating and reconciling more than a hundred IOTs contributed by GTAP network members across the world and international datasets contributed by several international organizations. After receiving an IOT from a contributor, it is checked to ensure that it satisfies certain formal requirements. If there are serious deviations from these requirements, we advise the contributor and request changes. As described by Huff, McDougall, and Walmsley (2000), the contribution process consists of reformatting the IOT and checking that the transformations did not affect balance conditions. We flag any negative use values, because we require that all uses be non-negative, except for changes in stocks; the latter are subsequently removed in the data construction process. We also flag excessively large taxes or subsidy rates in the contributed table. We compare the cost structure of the IOT against a *representative* table and the previous IOT for that country, if it exists. Finally, we report these checks to the contributor for verification and correction if necessary.

Once accepted, the IOTs go through a number of stages before they can be integrated into the GTAP Data Base. First, agricultural production targets are applied to certain IOTs before the main data construction phase. Since GTAP 6 Data Base, agricultural production in IOTs is adjusted to target the Organization for Economic Co-operation and Development (OECD) database on Producer and Consumer Support Estimates for Agriculture.[14]

Second, many tables contain inappropriate treatment of government services. Under standard national accounting conventions, government consumption includes the outputs of "non-market processes of production" and excludes their inputs, which are instead included as intermediate inputs by various industries, notably, public administration and defense. Most IOTs contributed to GTAP apply this convention, but some do not. For those that do not, modifications are made in the construction process to rectify the problem.

Third, IOTs that represent fewer than the 57 sectors in the GTAP Data Base are disaggregated to conform to the current sector listing. For GTAP 9, 105 IOTs did not contain all 57 sectors and required disaggregation, of which 74 required agricultural disaggregation and 102 required disaggregation of non-agricultural sectors. Disaggregation of agricultural and food sectors draws on a dataset constructed from Food and Agriculture Organization of the United Nations (FAO) data and previously contributed IOTs (Peterson, 2016). This dataset is constructed by regressing IOTs coefficients of agricultural and food sectors for the countries that have full agricultural disaggregation in their contributed IOTs, against production, consumption and trade from the FAO dataset. The coefficients estimated in such a regression are then used to extrapolate the IOT coefficients of all other countries us-

[14] The country files data is available at http://www.oecd.org/tad/agricultural-policies/producerandconsumersupportestimatesdatabase.htm.

ing the FAO statistics on production, consumption and trade. The disaggregation routine then employs these disaggregated IOT coefficients in place of the aggregate food and agricultural IOT coefficients in the IOTs.

For the non-agricultural commodities, contributed IOTs that represent the full 57 GTAP sectors are weighted by GDP and combined to create a representative IOT. This representative table is then used to calculate production and input shares for aggregated sectors in cases where the non-agricultural detail is insufficient. Finally, for each region where we have no contributed table, a composite table, calculated as a linear combination of IOTs for selected regions, mapped to the missing countries, is calculated. A different selection of regions is made for each composite region, matching as closely as possible the composite region's income level and production pattern.

With this global collection of IOTs in hand, our task is to ensure consistency amongst the different datasets contributed. In general, we adjust the IOTs to the international data sets rather than the other way around. The reason for this is that international data sets are generally more up-to-date and in some cases, such as for the energy and trade data sets, they are subjected to international balance conditions, which the country IOTs do not collectively satisfy. We call the adjustment procedure, the *FIT process*. This is used to fit the IOTs to the international data sets using entropy theoretic methods (James and McDougall., 1993).[15] This means, for example, that for any given country, the GDP reported in GTAP must be adjusted to match that reported in the World Bank (Aguiar, 2013). Similarly, the merchandise export and import data matches the consistent bilateral trade matrices which our contributor, Mark Gehlhar of the US Department of Interior has pre-processed to ensure global consistency (Gehlhar, 1996). With GDP fixed, this requires us to adjust other GDP expenditures, including Private Consumption, Government, and Investment expenditures.

A key component of the GTAP Data Base is the treatment of protection and domestic support. The International Trade Centre (ITC) provides a rich a dataset on different types of tariffs on imports, including specific tariffs, *ad-valorem* tariffs, tariff rate quotas, compound tariffs and mixed tariffs, all converted into *ad-valorem* basis at Harmonized System (HS) 6 level. We make these data available at this disaggregated (HS6) level, along with trade flows, in the form of a tool called Tariff Analysis and Simulation Tool for Economists (TASTE) developed by Horridge and Laborde (2008), so that users can construct disaggregate shocks in tariffs (i.e. starting from the HS 6 level and aggregating to GTAP sectors). In GTAP, we aggregate this data base to 57 sectors. The agricultural domestic support dataset in GTAP is contributed by the OECD and this follows the Producer Support Estimate ap-

[15] The extent of the changes depends on the age and quality of the underlying IOT. Good quality tables generally match the macro data and therefore any changes in these tables are small.

proach, with both coupled and decoupled payments handled separately. Payments coupled to production primarily include the single-commodity transfers, while decoupled payments may come under group commodity payments, all commodity payments and other transfer payments. We convert all domestic support payments into subsidy rates at the GTAP sector and regional level. These are available for all OECD countries and 10 non-OECD countries.

4. Updates in version 9

The GTAP 9 Data Base builds heavily on earlier work at Purdue University, as well as research and data base development efforts at a number of national and international agencies. Indeed, the earliest versions of the GTAP Data Base built very heavily on the Sectoral Analysis of Liberalising Trade in the East Asian Region (SALTER) Project which was undertaken at the Australian Industry Commission during the 1980s and early 90s. Table 7 shows the gradual expansion of regional and sectoral coverage since 1990 when the first version was released, along with some of the other major improvements in the database.

Each new version of the GTAP Data Base has increased the regional coverage. The inclusion of a new country into the data base is driven by the needs of the users of the GTAP Data Base. Country IOTs are prepared by contributors who have a particular interest in including the country in the GTAP Data Base. There are 11 new countries added to GTAP 9: Benin (contributed by Badri Narayanan), Burkina Faso, Guinea and Togo (Lacina Balma), Rwanda (Zekarias Hussein), Brunei Darussalam (Ken Itakura), Jordan (Hedi Bchir), Dominican Republic, Jamaica, Trinidad and Tobago and Puerto Rico (Carlos Ludea).

Equally important are the 20 other IOTs which were updated in version 9, these include IOTs for: Australia (Daniel Marshall), China (Liu Yu), Colombia (Gabriel Piraquive Galeano), Japan (Suzumu Suzuki), Korea (Jong-Hwan Ko), New Zealand (Anna Strutt), Nigeria (Khalid Siddig), Norway (Glen Peters), Pakistan (Dario Debowicz), Paraguay (Martin Cicowiez), Senegal (Angel Aguiar), Singapore (Nhi Tran), Taiwan (Hsing-Chun Lin), Turkey (Mustafa Acar), Malawi, Mozambique, Tanzania and Zambia (Zekarias Hussein). Besides the 31 new/updated IOTs, two tables, Belarus (Csilla Lakatos) and Brazil (Joaquim Bento), were subject to minor adjustments by the contributors.

In version 9, we consider thee reference years: 2004, 2007 and 2011. Therefore, the IOTs of several countries, especially the OECD members, are pre-adjusted to match 2004, 2007 and 2011 agricultural production statistics by sector.[16] This was done initially for the EU countries to more accurately reflect the shares of each member to total agricultural production the EU domestic support payments. The 2004, 2007 and 2011 agricultural production targets for the EU were contributed

[16] We do this because of new IOTs that need to be adjusted or the agricultural production statistics by sector have been updated.

Table 7. Timeline of GTAP Data Base Releases.

Version	Released	Regions	Sectors	Reference year(s)	Other improvements
GTAP 1	1993	15	37	1990	
GTAP 2	1994	24	37	1992	
GTAP 3	1996	30	37	1992	
GTAP 4	1998	45	50	1995	• Increased number of agricultural products. • Physical energy flows underlying the GTAP Data Base obtained from the International Energy Agency (IEA). • Labor divided into skilled and unskilled, based on occupational splits.
GTAP 5	2001	66	57	1997	• More services sectors added. • Tariffs obtained from Agriculture Market Analysis Database (AMAD) supplied by the Economic Research Service of the US Department of Agriculture (ERS/USDA) and World Integrated Trade Software (WITS) provided by World Bank and the United Nations Conference on Trade and Development.
GTAP 6	2005	87	57	2001	• Market Access Map (MAcMap) data base for tariffs and import protection provided by the Centre d'Etudes Prospectives et d'Information Internationales (CEPII) and ITC, covering tariff preferences for the first time. • Disaggregated land use and non-CO2 emissions data made available as satellite data bases. • First release of GMIG and GDYN satellite data bases.
GTAP 7	2008	113	57	2004	• Bilateral Services trade data contributed by the Netherlands Central Plan Bureau (CPB). • Agricultural export subsidy data contributed by Aziz Elbehri. • More comprehensive domestic support data from OECD, contributed by Hsin Huang and Hans Jensen. • In addition to satellite data bases released in version 6, GTAP-E data, TASTE, and time costs in trade.
GTAP 8	2012	129	57	2004 2007	• More comprehensive export subsidy data contributed by David Laborde, IFPRI. • Inclusion of CO2 emissions into the standard data base. • All prior satellite data bases.
GTAP 9	2015	140	57	2004 2007 2011	• Five labor categories represented. • Decomposition of tariff (into *ad-valorem* and specific.) • All prior satellite data bases.

by the Institute for Prospective Technological Studies (IPTS) team in Seville. The IOTs for the EU27, Australia, New Zealand, Japan, Korea, USA, Canada, Mexico, Switzerland, Turkey and Norway are now pre-adjusted to match 2004, 2007 and 2011 agricultural production data. The OECD supplied GTAP with the agricultural production targets for the non-EU27 OECD countries as well as some non-OECD countries (Brazil, China, Indonesia, Kazakhstan, Russia, Ukraine, South Africa, Israel and Chile). Agricultural production targeting is documented in the detailed documentation available online (Haqiqi et al., 2016).

Macroeconomic aggregates (GDP, private consumption, government consumption, and investment) are used in updating the IOTs to common reference years 2004, 2007 and 2011. The primary source of macroeconomic data used in GTAP 9 is the World Bank World Development Indicators. As in previous versions of the GTAP Data Base, reconciled bilateral merchandise trade data, based on the United Nations Commodity Trade Statistics Data Base have been utilized. For version 9, the IEA energy volume, taxes and prices data has been included for the years 2004, 2007 and 2011.

Significant improvements that were made to the bilateral services trade data in GTAP 7 as a result of the efforts of Nico van Leeuwen and Arjan Lejour from the CPB, have been further carried forward to GTAP 9, for all three years: 2004, 2007 and 2011. In the past, bilateral services trade was estimated based on unilateral data obtained from the International Monetary Fund (IMF). Since GTAP 7, bilateral data on services trade were obtained for the OECD countries from the CPB and these are now combined with the IMF data to significantly improve the quality of the estimated bilateral services trade data.[17]

Domestic support data are now available for the following OECD countries: Australia, Canada, European Union (EU27), Iceland, Japan, Korea, Mexico, Norway, Switzerland, Turkey, and the US. The non-OECD member economies covered in the domestic support dataset for all three years are: Brazil, China, Indonesia, Kazakhstan, Russia, Ukraine, South Africa, Israel and Chile. One significant improvement in the domestic support dataset is that for all countries except the EU27, the data sources (i.e., OECD) as well as country coverage are identical for all the three reference years.

Agricultural export subsidy data for 2004, calculated from country notifications to the WTO and the "Financial report on the European Agricultural Guidance and Guarantee Fund (EAGGF)" were contributed by Aziz Elbehri of the FAO, with inputs from David Laborde of the International Food Policy Research Institute (IFPRI) and Hans Jensen.[18] Agricultural export subsidies are identified for the year 2004 for Canada, Switzerland and the European Union. Data is still for 2003 for

[17] Detailed information on trade is services data in the GTAP Data Base is available at https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3397.
[18] The EAGGF financial report is available from: http://aei.pitt.edu/40621/.

Panama and Israel, for 2002 for the US, Tunisia and Morocco, and for 2001 for Norway. We continue to use a common agricultural export subsidy rate for the EU member countries. For 2007, David Laborde contributed a much richer export subsidy data, based on a bilateral export subsidy and bilateral trade dataset for 36 exporting countries, 15 GTAP sectors (in agriculture and manufacturing) and 230 importing countries.[19]

Estimates of the export tax equivalent (ETE) of the export quotas on textiles and clothing (wearing apparel) exports under the Agreement on Textiles and Clothing were provided by Francois, Wörz, and Narayanan (2013). For Canada and the EU15, the ETE estimates are for 2003 and for the US ETE estimates are for 2004. For 2007, all of these ETE's are set to zero, given the phase-out of MFA quotas. However, in keeping with their WTO accession agreement, quotas on Chinese exports remain in place for the US, Canada and the EU. We extrapolated ETEs from the 2004 data to 2007 for China, based on the extent to which the quotas for Chinese exports were allowed to grow in each of these countries.

For reference years 2007 and 2011, we obtained tariff data directly from MAcMap, which compiles primary national customs information.[20] For 2004, we continue to use the dataset contributed for version 7 by David Laborde through the joint efforts of ITC and CEPII. Detailed documentation of Version 9 of the GTAP Data Base is provided by Narayanan, Aguiar, and McDougall (2015).

5. Numerical illustration

There are many aspects of the Data Base value flows that can be highlighted. In this section, we chose to focus on imports for intermediate use, which as a share of total imports have risen over time as seen in Table 8.

The share of imports used by the agricultural sector is small relative to that of other sectors. This in contrast to the share of imports into the manufacturing sectors, which represents the largest share of total imports for intermediate use. The importance of the energy sector, relative to other sectors is increasing over time. In fact, Figure 4, which shows the import share of total imports by sector and all sectors for the three reference years in GTAP 9, indicates that the energy sector is the most import intensive and that this import dependency has increased over time.

Focusing on importing countries, between 2004 and 2011, the Rest of the world aggregate region has increased its participation by about 2%, see Figure 5, which shows the share of global intermediate imports by region. On the other hand, the 28 members of the European Union have decreased their share of global intermediate imports over the same period. US intermediate imports have increased, but as a

[19] Unfortunately, we have not been able to secure a contributor to update export subsidies for 2011.

[20] The tariff data used in the GTAP Data Base is documented at http://www.macmap.org.

Table 8. Global imports by use in GTAP 9 (millions of *nominal* USD).

	2004		2007		2011	
	Value	Share	Value	Share	Value	Share
Intermediate uses	**6,944,414**	**63.72**	**10,258,463**	**65.37**	**13,747,933**	**66.63**
Agricultural	106,517	0.98	145,225	0.93	214,875	1.04
Energy	845,632	7.76	1,547,050	9.86	2,326,507	11.28
Manufactures	3,699,757	33.95	5,252,245	33.47	6,950,474	33.69
Services	2,292,508	21.03	3,313,943	21.12	4,256,077	20.63
Final uses	**3,954,181**	**36.28**	**5,435,273**	**34.63**	**6,885,391**	**33.37**
Investment	1,366,285	12.54	1,944,031	12.39	2,349,721	11.39
Private Consumption	2,475,139	22.71	3,328,960	21.21	4,313,228	20.9
Government Consumption	112,757	1.03	162,282	1.03	222,442	1.08
Total Imports	**10,898,595**		**15,693,736**		**20,633,324**	

Source: GTAP 9 Data Base.

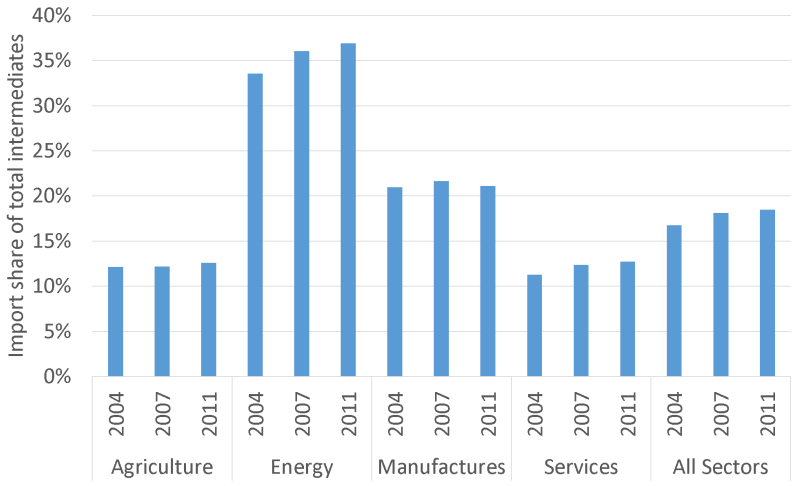

Figure 4. Imports share of total intermediates by sector.

Source: Author calculations based on the GTAP 9 Data Base.

share of total intermediate imports, US participation has remained around 14% in all three years (i.e., 2004, 2007 and 2011).

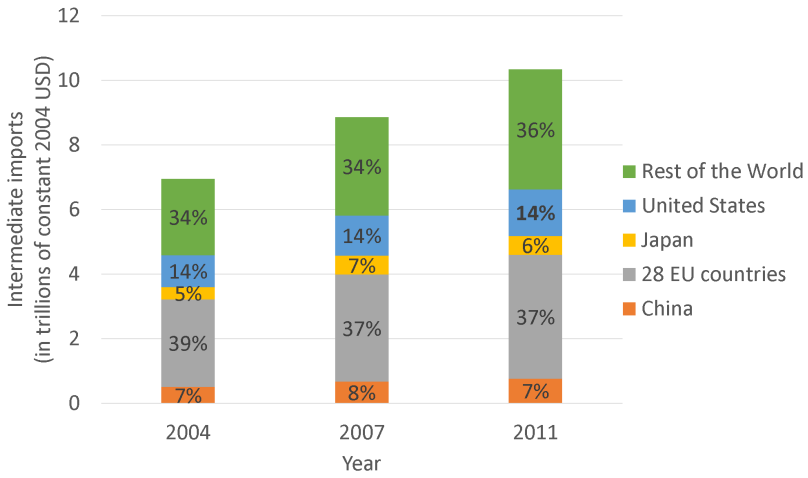

Figure 5. Imported intermediate inputs over time.

Notes: In trillions of *constant* 2004 USD.

Source: Author calculations based on the GTAP 9 Data Base.

6. Summary and conclusion

Version 9 of the GTAP Data Base includes IOTs for 140 regions and bilateral trade data for 57 products and services which, together, exhaust global economic activity. The Data Base presents globally consistent data on consumption, production, and international trade (including transportation and protection data), energy data and carbon dioxide (CO_2) emissions for three benchmark years (2004, 2007 and 2011). The Data Base includes tariff information converted into *ad-valorem* and domestic support payments as subsidy rates. The core data consist of economic value flows valued in millions of current US dollars (i.e., valuation differs according to the reference year). Several satellite extensions complement the GTAP Data Base. There is an energy extension (GTAP-E), a migration satellite (GMig), a land use satellite (GTAP-AEZ), an extension for the Dynamic GTAP model (GDyn), an extension to represent the electricity sector in detail (GTAP-POWER) and a non-CO_2 emissions dataset.

One of the reasons for the success and longevity of the data base is the fact that it relies on the contributed datasets from a large network of individuals, Board member agencies and institutions from around the world. No individual agency or Center could accomplish this task and the GTAP Data Base would not exist, absent this network and the commitment of individuals to making this high quality product publicly available.

The Network of GTAP Contributors also provides an excellent resource for improvement of the Data Base. Those who identify areas for improvement or extension of the data base are free to share their suggestions with GTAP Staff, as well

as the GTAP Advisory Board. This Consortium of more than two dozen leading national and international agencies provides the resources and long term guidance and direction which are key to the longevity of this data base. Individuals interested in accessing the GTAP Data Base are referred to the web site: https://www.gtap.agecon.purdue.edu/databases/default.asp where older versions can be downloaded for free. The most recent versions of the Data Base are free to contributors (both data contributors and consortium members). Others are charged a fee, the revenue from which goes to support ongoing development of the Data Base.

Acknowledgements

The authors acknowledge the valuable comments from two anonymous reviewers.

References

Aguiar, A. 2013. "GDP Consistency in GTAP 8." Center for Global Trade Analysis, Purdue University, GTAP Research Memorandum No. 25. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4290.

Bacou, M., T. Hertel, and W. Yu. 1999. "Data viewing software." In *Global Trade, Assistance, and Production: The GTAP 4 Data Base*, edited by R. McDougall, A. Elbehri, and T. P. Truong. Center for Global Trade Analysis, Purdue University, chap. 10. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=444.

Elliott, J., I. Foster, S. Kortum, T. Munson, F.P. Cervantes, and D. Weisbach. 2010. "Trade and Carbon Taxes." *The American Economic Review*, 100(2): 465–469. http://www.jstor.org/stable/27805040.

Francois, J., J. Wörz, and B. Narayanan. 2013. "ATC Export Tax Equivalents." In *Global Trade, Assistance, and Production: The GTAP 8 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. chap. 10.F. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4298.

Gehlhar, M. 1996. "Reconciling Bilateral Trade Data for Use in GTAP." GTAP Technical Paper No. 10. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=313.

Haqiqi, I., R. McDougall, , and B. Narayanan. 2016. "Agricultural Production Targeting." In *Global Trade, Assistance, and Production: The GTAP 9 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. chap. 8.C.

Harrison, W., and K. Pearson. 1998. "An Introduction to GEMPACK." Centre of Policy Studies and Impact Project, Monash University, GEMPACK Document No. GPD-1, 4th ed.

Hertel, T., ed. 1997. *Global Trade Analysis: Modeling and Applications*. Cambridge University Press. https://www.gtap.agecon.purdue.edu/products/gtap_book.asp.

Hertel, T., D. Hummels, and T. Walmsley. 2013. "Developing a Multi-region Input-Output Framework from GTAP for Analyzing the Vulnerability of the Asia-Pacific Supply Chain to Natural Disasters." http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4140.

Hertel, T., H.L. Lee, S. Rose, and B. Sohngen. 2008. "Modeling Land-use Related Greenhouse Gas Sources and Sinks and their Mitigation Potential." GTAP Working Paper No. 44. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2605.

Hertel, T., R. McDougall, B. Narayanan, and A. Aguiar. 2016. "Behavioral Parameters." In *Global Trade, Assistance, and Production: The GTAP 9 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. chap. 14.

Horridge, M. 2015. "GTAPAgg Data Aggregation Program." In *Global Trade, Assistance, and Production: The GTAP 9 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. Center for Global Trade Analysis, Purdue University, chap. 5. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4822.

Horridge, M., and D. Laborde. 2008. "TASTE a program to adapt detailed trade and tariff data to GTAP-related purposes." http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2666.

Huff, K., R. McDougall, and T. Walmsley. 2000. "Contributing Input-Output Tables to the GTAP Data Base." GTAP Technical Paper No. 01. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=304.

Ianchovichina, E., and T. Walmsley, eds. 2012. *Dynamic Modeling and Applications for Global Economic Analysis*. Cambridge University Press. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3169.

Irfanoglu, Z.B., and D.v.d. Mensbrugghe. 2016. "Non-CO2 documentation V9." http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4868.

James, M., and R. McDougall. 1993. "FIT: An input-output data update facility for SALTER." Industry Commission, Canberra, SALTER working paper No. 17. http://www.pc.gov.au/research/supporting/salter-model/workingpaper17.

McDonald, S., and K. Thierfelder. 2004. "Deriving a Global Social Accounting Matrix from GTAP Versions 5 and 6 Data." http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1645.

McDougall, R., and A. Golub. 2009. "GTAP-E: A Revised Energy-Environmental Version of the GTAP Model." Center for Global Trade Analysis, Purdue University, GTAP Research Memorandum No. 15. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2959.

McDougall, R., and H.L. Lee. 2006. "An Energy Data Base for GTAP." In *Global Trade, Assistance, and Production: The GTAP 6 Data Base*, edited by B. V. Dimaranan. chap. 17. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1951.

Narayanan, B.G., A. Aguiar, and R. McDougall, eds. 2015. *Global Trade, Assistance, and Production: The GTAP 9 Data Base*. Center for Global Trade Analysis, Purdue University. https://www.gtap.agecon.purdue.edu/databases/v9/v9_doco.asp.

Peters, J.C. 2015. "The GTAP-Power Data Base: Disaggregating the Electricity Sector in the GTAP Data Base." http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4619.

Peterson, E. 2016. "Food and Agricultural Data Base." In *Global Trade, Assistance, and Production: The GTAP 9 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. chap. 8.A. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4877.

Reimer, J., and T. Hertel. 2004. "International Cross Section Estimates of Demand for Use in the GTAP Model." GTAP Technical Paper No. 23. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1647.

Rutherford, T. 2005. "GTAP6inGAMS: The Dataset and Static Model." http://www.mpsge.org/gtap6/gtap6gams.pdf.

Thierfelder, K., and S. McDonald. 2012. "Globe v1: A SAM Based Global CGE Model using GTAP Data." United States Naval Academy Department of Economics, Departmental Working Papers No. 39, Dec. https://ideas.repec.org/p/usn/usnawp/39.html.

Ukkusuri, S.V., R. Mesa-Arango, B. Narayanan, A.M. Sadri, and X. Qian. 2016. "Evolution of the Commonwealth Trade Network." International Trade Working Paper 2016/07, Commonwealth Secretariat, London. doi:http://dx.doi.org/10.14217/5jm3mbfw26jg-en. http://www.oecd-ilibrary.org/commonwealth/trade/evolution-of-the-commonwealth-trade-network_5jm3mbfw26jg-en.

van der Mensbrugghe, D. 2016. "The Standard GTAP model in GAMS, version 6.2." Unpublished.

Villoria, N., and R. McDougall. 2015. "FlexAgg2.0: An Improved Version of the Data Aggregation Program FlexAgg." In *Global Trade, Assistance, and Production: The GTAP 9 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. Center for Global Trade Analysis, Purdue University, chap. 4. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4821.

Walmsley, T., A. Aguiar, and B. Narayanan. 2012. "Introduction to the Global Trade Analysis Project and the GTAP Data Base." http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3965.

Walmsley, T., and C. Carrico. 2016. "Disaggregating Labor Payments." In *Global Trade, Assistance, and Production: The GTAP 9 Data Base*, edited by B. G. Narayanan, A. Aguiar, and R. McDougall. chap. 12.B. http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4867.

Walmsley, T., A. Winters, and S.A. Ahmed. 2007. "Measuring the Impact of the Movement of Labor Using a Model of Bilateral Migration Flows." Center for Global Trade Analysis, Department of Agricultural Economics, Purdue Uni-

versity, GTAP Technical Paper No. 28. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2529.

Appendix A.

Table A.1. The 140 regions in GTAP 9.

No.	Code	Name	No.	Code	Name
1	aus	Australia	27	can	Canada
2	nzl	New Zealand	28	usa	United States of America
3	xoc	Rest of Oceania	29	mex	Mexico
4	chn	China	30	xna	Rest of North America
5	hkg	Hong Kong	31	arg	Argentina
6	jpn	Japan	32	bol	Bolivia
7	kor	Korea	33	bra	Brazil
8	mng	Mongolia	34	chl	Chile
9	twn	Taiwan	35	col	Colombia
10	xea	Rest of East Asia	36	ecu	Ecuador
11	brn	Brunei Darussalam	37	pry	Paraguay
12	khm	Cambodia	38	per	Peru
13	idn	Indonesia	39	ury	Uruguay
14	lao	Lao People's Democratic Republic	40	ven	Venezuela
15	mys	Malaysia	41	xsm	Rest of South America
16	phl	Philippines	42	cri	Costa Rica
17	sgp	Singapore	43	gtm	Guatemala
18	tha	Thailand	44	hnd	Honduras
19	vnm	Viet Nam	45	nic	Nicaragua
20	xse	Rest of Southeast Asia	46	pan	Panama
21	bgd	Bangladesh	47	slv	El Salvador
22	ind	India	48	xca	Rest of Central America
23	npl	Nepal	49	dom	Dominican Republic
24	pak	Pakistan	50	jam	Jamaica
25	lka	Sri Lanka	51	pri	Puerto Rico
26	xsa	Rest of South Asia	52	tto	Trinidad and Tobago

Continued ...

. . . Continued

No.	Code	Name	No.	Code	Name
53	xcb	Caribbean	82	alb	Albania
54	aut	Austria	83	bgr	Bulgaria
55	bel	Belgium	84	blr	Belarus
56	cyp	Cyprus	85	hrv	Croatia
57	cze	Czech Republic	86	rou	Romania
58	dnk	Denmark	87	rus	Russian Federation
59	est	Estonia	88	ukr	Ukraine
60	fin	Finland	89	xee	Rest of Eastern Europe
61	fra	France	90	xer	Rest of Europe
62	deu	Germany	91	kaz	Kazakhstan
63	grc	Greece	92	kgz	Kyrgyzstan
64	hun	Hungary	93	xsu	Rest of Former Soviet Union
65	irl	Ireland	94	arm	Armenia
66	ita	Italy	95	aze	Azerbaijan
67	lva	Latvia	96	geo	Georgia
68	ltu	Lithuania	97	bhr	Bahrain
69	lux	Luxembourg	98	irn	Iran, Islamic Republic of
70	mlt	Malta	99	isr	Israel
71	nld	Netherlands	100	jor	Jordan
72	pol	Poland	101	kwt	Kuwait
73	prt	Portugal	102	omn	Oman
74	svk	Slovakia	103	qat	Qatar
75	svn	Slovenia	104	sau	Saudi Arabia
76	esp	Spain	105	tur	Turkey
77	swe	Sweden	106	are	United Arab Emirates
78	gbr	United Kingdom	107	xws	Rest of Western Asia
79	che	Switzerland	108	egy	Egypt
80	nor	Norway	109	mar	Morocco
81	xef	Rest of EFTA	110	tun	Tunisia

Continued . . .

...Continued

No.	Code	Name	No.	Code	Name
111	xnf	Rest of North Africa	135	xec	Rest of Eastern Africa
112	ben	Benin	136	bwa	Botswana
113	bfa	Burkina Faso	137	nam	Namibia
114	cmr	Cameroon	138	zaf	South Africa
115	civ	Cote d'Ivoire	139	xsc	Rest of South African Customs
116	gha	Ghana	140	xtw	Rest of the World
117	gin	Guinea			
118	nga	Nigeria			
119	sen	Senegal			
120	tgo	Togo			
121	xwf	Rest of Western Africa			
122	xcf	Central Africa			
123	xac	South Central Africa			
124	eth	Ethiopia			
125	ken	Kenya			
126	mdg	Madagascar			
127	mwi	Malawi			
128	mus	Mauritius			
129	moz	Mozambique			
130	rwa	Rwanda			
131	tza	Tanzania			
132	uga	Uganda			
133	zmb	Zambia			
134	zwe	Zimbabwe			

Table A.2. The 57 sectors in GTAP 9.

No.	Code	Description	No.	Code	Description
1	pdr	Paddy rice	31	ppp	Paper products, publishing
2	wht	Wheat	32	p_c	Petroleum, coal products
3	gro	Cereal grains, not elsewhere classified (n.e.c.)	33	crp	Chemical, rubber, plastic products
4	v_f	Vegetables, fruit, nuts	34	nmm	Mineral products n.e.c.
5	osd	Oil seeds	35	i_s	Ferrous metals
6	c_b	Sugar cane, sugar beet	36	nfm	Metals n.e.c.
7	pfb	Plant-based fibers	37	fmp	Metal products
8	ocr	Crops n.e.c.	38	mvh	Motor vehicles and parts
9	ctl	Cattle, sheep, goats, horses	39	otn	Transport equipment n.e.c.
10	oap	Animal products n.e.c.	40	ele	Electronic equipment
11	rmk	Raw milk	41	ome	Machinery and equipment n.e.c.
12	wol	Wool, silk-worm cocoons	42	omf	Manufactures n.e.c.
13	frs	Forestry	43	ely	Electricity
14	fsh	Fishing	44	gdt	Gas manufacture, distribution
15	coa	Coal	45	wtr	Water
16	oil	Oil	46	cns	Construction
17	gas	Gas	47	trd	Trade
18	omn	Minerals n.e.c.	48	otp	Transport n.e.c.
19	cmt	Meat: cattle, sheep, goats, horse	49	wtp	Sea transport
20	omt	Meat products n.e.c.	50	atp	Air transport
21	vol	Vegetable oils and fats	51	cmn	Communication
22	mil	Dairy products	52	ofi	Financial services n.e.c.
23	pcr	Processed rice	53	isr	Insurance
24	sgr	Sugar	54	obs	Business services n.e.c.
25	ofd	Food products n.e.c.	55	ros	Recreation and other services
26	b_t	Beverages and tobacco products	56	osg	PubAdmin/Defense/Health/Educat
27	tex	Textiles	57	dwe	Dwellings
28	wap	Wearing apparel			
29	lea	Leather products			
30	lum	Wood products			