Extending the GTAP framework for public procurement analysis

By

Angel Aguiar[1]
Caitlyn Carrico
Thomas Hertel
Zekarias Hussein
Robert McDougall
Badri Narayanan

GTAP Working Paper No. 82
August 2016

[1] Aguiar is corresponding author (aaguiar@purdue.edu). This paper is based on a final report of a project funded by DG TRADE of the European Commission. The authors would like to thank the feedback from participants of the GTAP conferences where this work was presented and that of the European Commission staff, in particular Zornitsa Kutlina-Dimitrova, Senior Economist and also Dominique van der Mensbrugghe, Director of the Center for Global Trade Analysis.

Extending the GTAP framework for public procurement analysis

Abstract

This paper extends the GTAP framework to aid in the analysis of changes to public procurement policies. In terms of data developments, government investment demand data is estimated for each of the 57 GTAP Commodities in the 140 regions of version 9. In addition, the origin of imports by end use (i.e., for firms, private consumption, government consumption, and investment) is determined following the recent literature. Another layer of valuation is also introduced, which captures the preferences towards domestic production. In terms of model extensions, there is a new nest in the production structure that allows for different procurement regimes, and the origin of imports by agents' end use is incorporated. We illustrate this framework by simulating the impact of a hypothetical reduction in the domestic preference in one of the newly introduced procurement regimes. Future work should focus on estimation of these domestic preference margins.

JEL: D58, F13, H57

1. Introduction

Government consumption makes up a significant portion of national economies, ranging from 6-32% of gross domestic product (GDP).[2] In addition, government procurement affects a substantial volume of world trade flows, estimated to be $1000 billion per year.[3] Given the size and the potential implications for trade, employment and prices, government procurement policies have become increasingly prominent in the multilateral negotiations starting with the 1978 Tokyo Round of GATT and leading up to the ratification of the WTO-Government Procurement Agreement (GPA) in 1996. The revised Agreement on Government Procurement entered into force on April 6, 2014. At the core of these negotiations has been the idea of encouraging government procurement from the most efficient suppliers in order to enhance global welfare (Brulhart and Trionfetti, 2001). Government procurement should include current expenditures by the government sector (e.g., public administration, defense, and public enterprises) as well public investment.

Despite its importance in the overall trade reform picture, the analytical tools used to quantify the economic impact of discriminatory government procurement remain underdeveloped. The objective of this study is to improve the quantitative representation of government procurement in global trade policy analysis by enhancing data and modelling tools. In this paper, we document the development of the data and modelling framework, including an illustrative application.

Government procurement agreements involve multiple countries purchasing a wide range of goods and services supplied by many different regions. Therefore, the effect of these agreements is best addressed in a multi-region, general equilibrium framework. Since most contemporary, global CGE models are based on the GTAP Data Base (Aguiar et al., 2016), we have taken this framework as the starting point for our analysis. Despite its merits, the scope for global CGE modelling of any new issue, such as government procurement, is inevitably limited by data availability. For purposes of this study, current purchases by governments of each commodity and service must be identified separately in the data, otherwise, it becomes nearly impossible to estimate the likely impact of government procurement liberalization.

In order to improve the representation of government procurement in the GTAP framework, the standard GTAP Data Base has been supplemented with data that allows for disaggregation of government investment and identification of the country of origin of imports by intermediate and final use. We have also modified the standard GTAP model, according to the new data developments, in order to permit a preliminary analysis of changes to rules and regulations of government procurement, using this new information. This paper discusses the extended data base and analytical framework in order to gain insight into the current state of play with government procurement at a global scale.

[2] Authors computation based on GTAP Data Base version 9, reference year 2011.

[3] Public Procurement, Trade, European Commission: http://ec.europa.eu/trade/policy/accessing-markets/public-procurement

2. Methodology

The GTAP framework is composed of a data base and a standard CGE model of the global economy. The data base has now completed its 9th series of public releases since inception in 1992. There are dozens of variants of the standard model; these are widely used for analyzing trade policies and their effects on the global markets. The regional structure of the GTAP Data Base derives from Input-Output Tables (IOT) and, as such, it fully characterizes the intermediate and final demands of each national economy. At present, the GTAP Data Base allows for just one aggregate sector for the production of public goods: 'OSG' = Other Services (Government). This sector includes the following UN International Standard Industry Classification (ISIC), revision 3 categories:

- 75 = Public administration and defense; compulsory social security
- 80 = Education
- 85 = Health and social work
- 90 = Sewage and refuse disposal, sanitation and similar activities
- 91 = Activities of membership organizations not elsewhere classified
- 99 = Extra-territorial organizations and bodies

The services produced by the OSG sector are destined for final consumption as well as an intermediate input to other activities. The IOT structure underpinning the GTAP Data Base also includes a vector of final demands by government, along with a vector comprising final demand for investment goods. For the purpose of this study, we focus on the OSG sector, which due to its components, typically accounts for the bulk of government consumption expenditure (94 per cent in the GTAP 9 Data Base for reference year 2011).[4] By focusing on the sector that produces the public goods, we capture the effects that changing procurement policy have in the production of public goods that are used as an input for other sectors and represents the main expenditure of final government consumption.[5]

In addition, in the standard GTAP Data Base there is no information available on the origin of imports by use, as this has not been a point of emphasis in the GTAP Data Base construction to date and the data to support such sourcing of imports have not been available. For the purpose of this study, the absence of such sourcing information is problematic, as it holds the key to determining which countries will benefit from a liberalization of government procurement rules. Also, the GTAP Data Base does not distinguish public from private investment, and therefore, this important component of government procurement[6] — namely that associated with infrastructure development — is not available for analysis.

[4] The other 6 per cent varies across regions, but is defined over the other 56 GTAP commodities. For the world as a whole, other business services, recreation and other services, and other transport account for 1 per cent each.

[5] We do not focus on government consumption because being a final demand, it does not appear as an input of other industries and the complete effects of a potential policy change would not be captured.

[6] According to the Organization for Economic Co-operation and Development (OECD), the estimated size of general government procurement is determined by the sum of intermediate consumption by governments, government's gross fixed capital formation, and social transfers in kind via market producers (OECD, 2013). Appendix A computes this statistic using the GTAP Data Base.

In order to identify the current availability of government investment data as well as information regarding government procurement, we undertook a survey of our global network of national IOT contributors. The survey was designed to collect information regarding the availability of government investment and procurement data. We sent out a total of 44 questionnaires to IOT contributors and the response rate was 45 percent.[7] The responses to the survey indicate that there is little information related to government procurement accessible to our IOT contributors. Notable exceptions are found in Japan and Australia. The survey also revealed that foreign versus domestic composition of uses and the origin and destination of imports and exports, respectively, are generally not available in the data from most national IOT frameworks; a notable exception is the information about import available in the EU-IOTs.

In addition, we considered the WTO statistical reports from parties under the Government Procurement Agreement (GPA) to improve the domestic and import composition of the government sector in GTAP. After careful review, it was determined that GPA data only capture a limited component of government procurement (for a detailed explanation, please refer to Appendix C). Due to this limited availability of source data in the IOTs, we have resorted to external data sources to estimate the sourcing of imports and distinguish public from private investment. The next section discusses the external data sources we use and the resulting modifications to the GTAP Data Base.

2.1.1 Data Base Developments

For the purpose of this study, we estimate the sourcing of imports, based on multi-regional input output (MRIO) techniques. In addition, we turn to external macroeconomic data sources to disaggregate private and public investment from GTAP's gross fixed capital formation (i.e., total investment). These are discussed next.

2.1.2 GTAP-MRIO Database

This section discusses the methods used to generate an MRIO database from the standard GTAP Data Base, in order to be able to identify agent purchases of foreign goods by country of origin. An MRIO framework extends the traditional IOT framework by distinguishing imports by country of origin as well as by end use. End use designates the purpose of import demand as intermediate, investment, or final. Imports for intermediate use are inputs for production, imports for investment are goods obtained for investment purposes, and imports for final use are products demanded by government as well as private consumers. In the context of a global MRIO database, all countries have such dimensionality, which permits the emergence of complex source patterns in trade.

A MRIO framework can be derived from the reconciliation of trade data with the cost structure data available in IOTs. In this paper, we build on the standard GTAP Data Base, which is compiled from IOTs and bilateral trade data, among other data sources that are globally reconciled.[8] Following Koopman et al. (2012) and Walmsley et al. (2014), we supplement the standard GTAP Data Base with external bilateral trade data, which we obtain from the Tariff Analytical and Simulation Tool for Economists (TASTE), a reconciled database of UN

[7] Summary responses to each of the seven questions can be found in Appendix B.
[8] For detailed explanation about the GTAP Data Base, please see Aguiar et al. (2016).

COMTRADE data.[9] Because the dimensionality of the trade data in the GTAP Data Base differs from that in TASTE, proper integration requires the implementation of a series of concordances.

In IOTs as well as the standard GTAP Data Base, all commodity demands, including imports, are specified for intermediate use, private consumption, investment, and government purchases; yet, the origin of imports remains unspecified. In contrast, in the UN COMTRADE database and, hence, in TASTE, country sourcing is known for imports; however, imports are not distinguished by end use.[10] Thus, in order to introduce the sourcing information available in UN COMTRADE data to IOTs, the MRIO literature uses concordances to map between product categories at the Harmonized System (HS) classification, the Broad Economic Categories (BEC), and the end use categories of the System of National Accounts (SNA).[11]

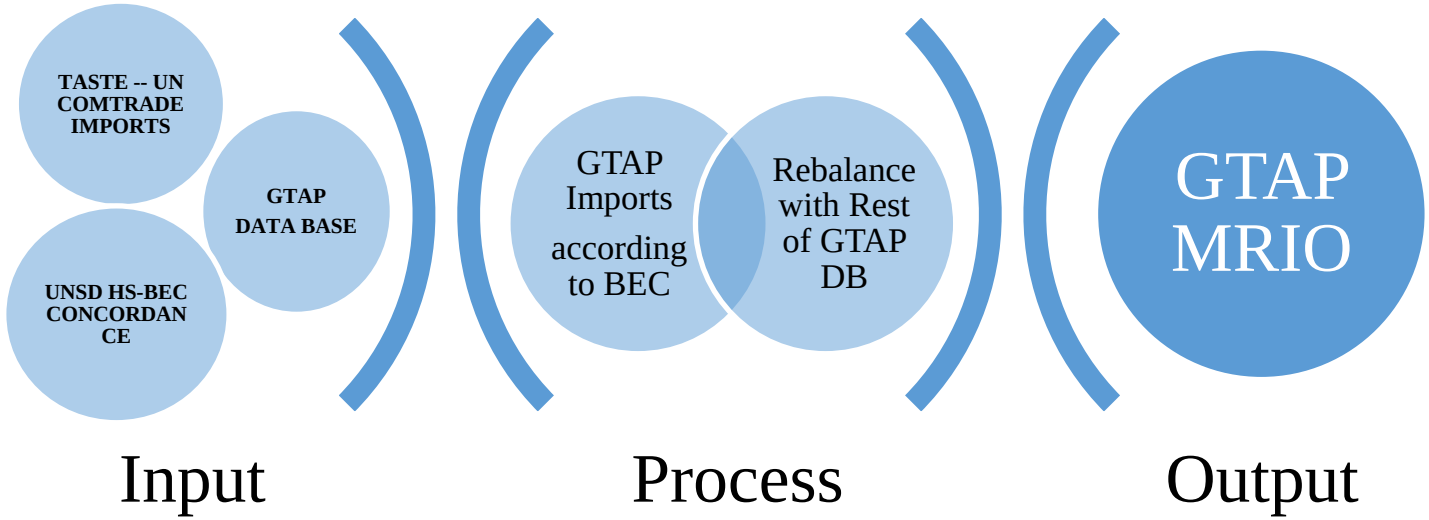
Implementing these concordances, we assimilate the cost structure of each country-agent pair in the GTAP Data Base with the agent specific import demands of the bilateral trade data from TASTE. Next, we rebalance to ensure that this new trade dataset is in accordance with the rest of the GTAP Data Base; the end result is the GTAP-MRIO Database. The overall process of producing the GTAP-MRIO Database is represented in Figure 1 which provides a simple all-encompassing flow chart. In the following paragraphs, we describe in further detail the characteristics of our data sources as well as the methodology of MRIO construction.

[9] For more information about TASTE data please refer to:
https://www.gtap.agecon.purdue.edu/resources/taste/taste.asp

[10] The distribution of imports for intermediate use across industries remains unknown in both the standard GTAP Data Base and the TASTE database.

[11] This concordance is publicly available from the United Nations Statistics Division (UNSD), as is a reference for a concordance between the BEC and SNA end use categories. The HS to BEC concordance is available from: http://unstats.un.org/unsd/cr/registry/regdnld.asp?Lg=1

Figure 1. Work flow of building a GTAP-MRIO Data Base



Implementation of Procedures to obtain the GTAP-MRIO Data Base

We build on the GTAP 9 Data Base, which consists of bilateral trade, private and government consumption, as well as industrial production data for the year 2011 (Aguiar et al., 2016). In Version 9, there are 140 regions across the standard 57 GTAP sectors. Specifically, we use: total bilateral imports by commodity and countries of origin and destination, contained in header VIMS; intermediate imports by commodity, industry, and region, contained in header VIFM; government imports by commodity and region, contained in header VIGM; and private household imports by commodity and region, contained in header VIPM.

We obtain trade data for the year 2011 from the TASTE for GTAP 9 (Pelikan, 2014). This database contains trade data from UN COMTRADE Database, based on the 2007 Harmonized System (HS) classification at the 6 digit level. The trade data was originally compiled by CEPII in collaboration with the International Trade Centre (Pichot et al., 2014; Guimbard et al. 2012). The authors use a combination of cost-insurance-freight (CIF) and free-on-board (FOB) values from UN COMTRADE data. The benefit of this database is that it was developed for the GTAP community and, hence, contains a concordance which perfectly maps each HS line to a GTAP commodity.

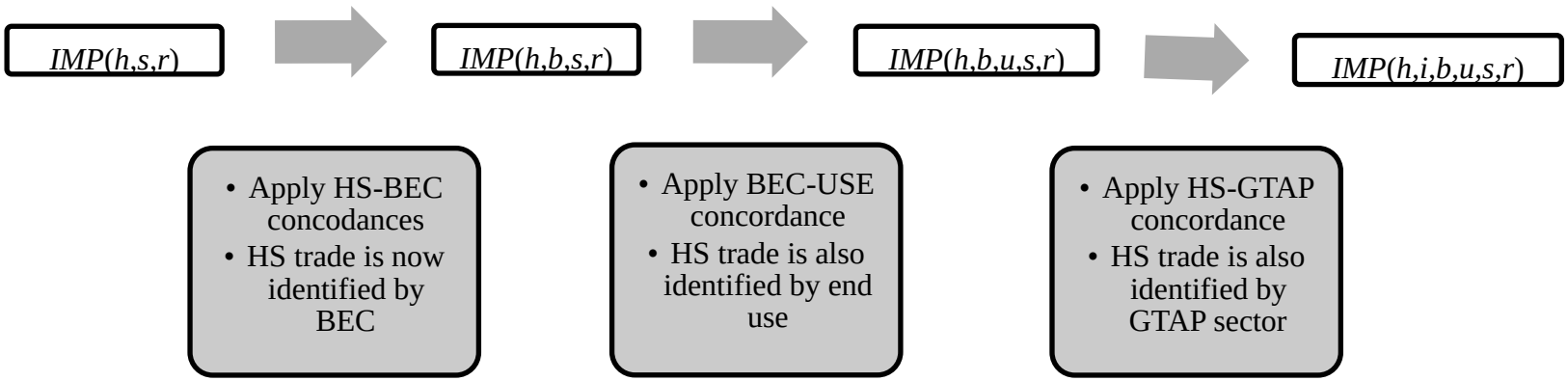
As previously mentioned, we use two concordances from the UNSD. The first is a concordance between HS and BEC revision 4. This concordance maps from 5052 HS codes at the six digit level to 19 BEC categories. The second concordance we use, maps these 19 BEC categories to the three SNA end use classes (i.e., capital goods, intermediate use, and final consumption), as seen in Table 1. It should be noted that the BEC-SNA concordance is only explicitly given for 16 of the BEC categories. For BEC categories "51" defined as "Transport equipment - Passenger motor cars" and "7" defined as "Goods not elsewhere specified", the UNSD official publication on the BEC, "Classification by Broad Economic Categories" (UNSD, 2003), reports that these goods may be considered a mix of the SNA end use classes. Specifically, category "51" is specified to be used for intermediate use and final consumption, whereas category "7" is specified for a general mix of all three end uses. We additionally specify BEC category "32" defined as "Fuels and lubricants - Processed" to be used for intermediate use and final consumption.

Processing the UN COMTRADE data from the TASTE database can be broken into two steps: the application of concordances and the reformatting of the trade data for compatibility with the GTAP Data Base. We apply the HS-BEC concordance by mapping bilateral imports data $IMP(h,s,r)$ indexed on HS line h, source country s, and importer r to BEC code b, giving us $IMP(h,b,s,r)$. Then we apply the BEC-SNA concordance, mapping to SNA end use u. Finally, we implement the HS-GTAP concordance to map to GTAP sector i. This process is depicted in Figure 2 and further detailed below. Then as shown in Figure 3, the reformatting of the data prepares the newly sourced trade data by agent to be rebalanced according to the standard GTAP Data Base.

Table 1. Mapping between the BEC and SNA End Use

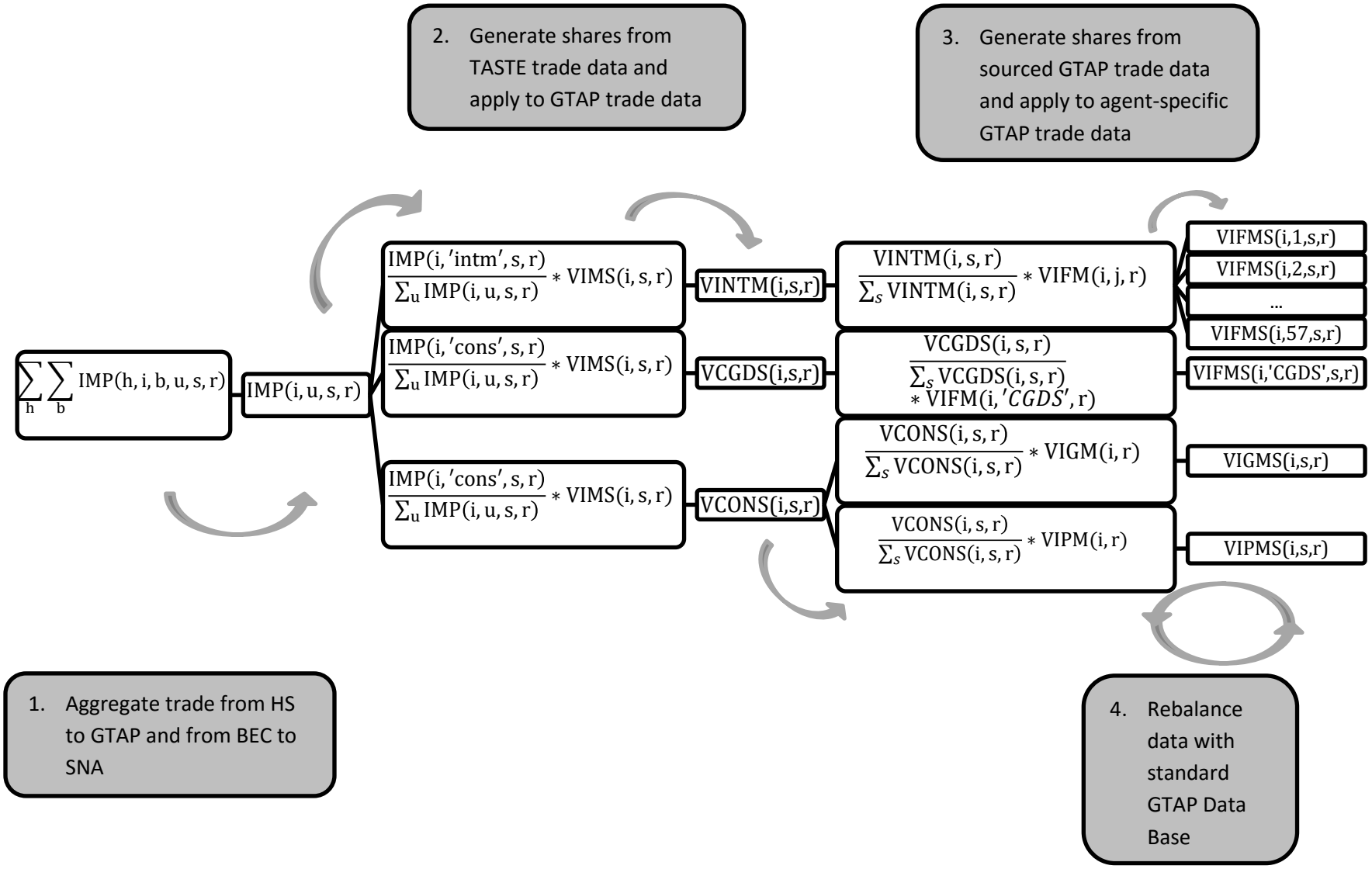
No.	BEC	BEC Description	SNA End Use
1	111	Food and beverages - Primary - Mainly for industry	Intermediate
2	112	Food and beverages - Primary - Mainly for household	Final
3	121	Food and beverages - Processed - Mainly for industry	Intermediate
4	122	Food and beverages - Processed - Mainly for household	Final
5	21	Industrial supplies not elsewhere specified – Primary	Intermediate
6	22	Industrial supplies not elsewhere specified - Processed	Intermediate
7	31	Fuels and lubricants – Primary	Intermediate
8	32	Fuels and lubricants - Processed - Motor spirit	Final, Intermediate
9	322	Fuels and lubricants - Processed - Other	Intermediate
10	41	Capital goods (except transport equipment)	Capital goods
11	42	Capital goods - Parts and accessories	Intermediate
12	51	Transport equipment - Passenger motor cars	Final, Capital goods
13	521	Transport equipment - Other - Industrial	Capital goods
14	522	Transport equipment - Other - Non-industrial	Final
15	53	Transport equipment - Parts and accessories	Intermediate
16	61	Consumer goods not elsewhere specified - Durable	Final
17	62	Consumer goods not elsewhere specified - Semi-durable	Final
18	63	Consumer goods not elsewhere specified - Non-durable	Final
19	7	Goods not elsewhere specified	Final, Intermediate, Capital goods

Figure 2. Application of the HS-BEC, BEC-SNA, and HS-GTAP concordances to the UN COMTRADE data



Note: *IMP*(*h,s,r*) represents the UN COMTRADE imports data from the TASTE Database. This data is indexed on HS line *h*, source country *s*, and reporting country *r*. Index *b* represents BEC codes, introduced through the HS to BEC concordance. The index *u* represents the SNA end use categories included through the BEC to SNA concordance. Finally, the index *i* represent the GTAP commodity, which is introduced through the HS to GTAP concordance.

Figure 3. Reformatting the UN COMTRADE data and application to the GTAP Data Base



For the BEC category "32" defined as "Fuels and lubricants - Processed", we assume a proportional split of trade value between intermediate and final consumption uses. That is to say that half of the trade value at a given HS category mapped to BEC category "32" would be allocated to intermediate use and the other half would be allocated to final consumption.[12] BEC Category 32 maps solely to GTAP sector 32, Petroleum and Coke products. For the Petroleum and Coke Products sector, about 88 percent of the trade value, on average across importers, comes from BEC Category 32. The remaining percentage comes from other BEC categories, which map uniquely to intermediate use. Thus, on average, we allocate about 44 percent of the total trade value of Petroleum and Coke products to final consumption, across importers.[13]

Similarly, for BEC Category 51 defined as "Transport equipment - Passenger motor cars", we assume a proportional split of trade value between capital goods (investment) and final consumption uses. BEC Category 51 maps solely to GTAP sector 38, Motor vehicles and parts, comprising 46 percent of the trade value in GTAP 38, on average across importers. BEC Category 522, "Transport equipment - Other - Non-industrial", is the only other BEC category mapped to GTAP 38 which maps to the final consumption, but it only accounts for 0.4 percent of the trade value in GTAP 38, on average across importers. Therefore, the assignment of half of the trade value mapped from BEC Category 51 accounts for the majority of the trade value allocated to final consumption in GTAP sector 38, which comes out to 23 percent, on average across importers.

For the BEC category "7" defined as "Goods not elsewhere specified", we allocate one third of the trade value to intermediate goods, one third to capital goods, and one third to final consumption goods. This amounts to 0.13 percent of global trade.

Then, as described above, each HS category in the UN COMTRADE Data from TASTE maps uniquely to an HS category in the GTAP-HS concordance. Thus, the application of this concordance does not require any splitting of trade values. Now, we are ready to aggregate the data into a matter compatible with the GTAP Data Base.

The process of reformatting the trade data, as depicted in Figure 2, begins with aggregation of the value of imports indexed on the HS line *h*, GTAP sectors *i*, the BEC code *b*, SNA end use categories *u*, source country *s*, and reporting country *r* (*IMP*(*h,i,b,u,s,r*)). We sum over all HS lines to aggregate to the GTAP commodities. Simultaneously, we sum over each Broad Economic Category to each SNA end use category, respectively. This gives us the value of imports indexed on GTAP commodity *i*, SNA end use category *u*, source country *s*, and reporting country *r* (*IMP*(*i,u,s,r*)).

We then generate shares of intermediate imports and consumption imports from *IMP*(*i,u,s,r*). We apply these shares to the value of imports in a given country from all regions (header VIMS(i,s,r) in the GTAP Data Base). The resulting data represents the value of imports indexed on GTAP commodities, end use categories of intermediate and consumption goods, source country *s*, and reporting country *r*. This procedure returns three new 'BEC-informed' bilateral

[12] Consider the example of German imports from Russia at the HS line 271019, petroleum oils. BEC category 32 is a dual use product, meaning that it is used for both intermediate use as well as final consumption. When the BEC-SNA concordance is applied, the HS-BEC mapping of 271019-32, with a value of 2.166 billion, is now mapped to both intermediate and final SNA categories such that each category is allocated a value of 1.083 billion USD.

[13] This allocation is necessary because without splitting the BEC category 32 between end uses, no Petroleum and Coke would be designated for final consumer use which is not realistic.

trade-value coefficients: the value of imports for intermediate use (VINTM(i,s,r)), investment (VCGDS(i,s,r)), and consumption goods (VCONS(i,s,r)), each indexed by GTAP commodity *i*, source country *s*, and reporting country *r*.

These three newly defined coefficients are used to generate sourcing shares to apply to agents-specific trade values in the GTAP Data Base. For imports to producers excluding investment (VIFM(i,j,r) where j ≠ 'CGDS'), sourcing shares are determined by the value of imports for intermediate use (VINTM(i,s,r)). In the case of imports for investment purposes (VIFM(i,j,r) where j = 'CGDS'), sourcing shares are determined by the value of imports for investment (VCGDS(i,s,r)). For imports to the government (VIGM(i,r)), and to the private household (VIPM(i,r)), sourcing shares are determined by the value of imports to consumption goods (VCONS(i,s,r)). The output of this procedure yields the value of imports to producers (VIFMS(i,j,s,r) where j ≠ 'CGDS'), to investment (VIFMS(i,j,s,r) where j = 'CGDS'), to the government (VIGMS(i,s,r)), and to the private household (VIPMS(i,s,r)), each indexed by GTAP commodity *i*, source country *s*, and reporting country *r*.[14]

These import values by agent and by source must be balanced with the rest of the GTAP Data Base. For each commodity in each region, the source-specific import usage data should be consistent with standard GTAP data for imports, from all sources, in each use, and for imports, for all uses, from each source. This can be achieved through a constrained optimization problem where values for VIFMS(i,j,s,r), VIGMS(i,s,r), and VIPMS(i,s,r) are adjusted to satisfy the four constraints as depicted in Figure 4.

[14] Appendix D provides a detailed numerical example.

Figure 4. Rebalancing the BEC-informed data with the standard GTAP Data Base

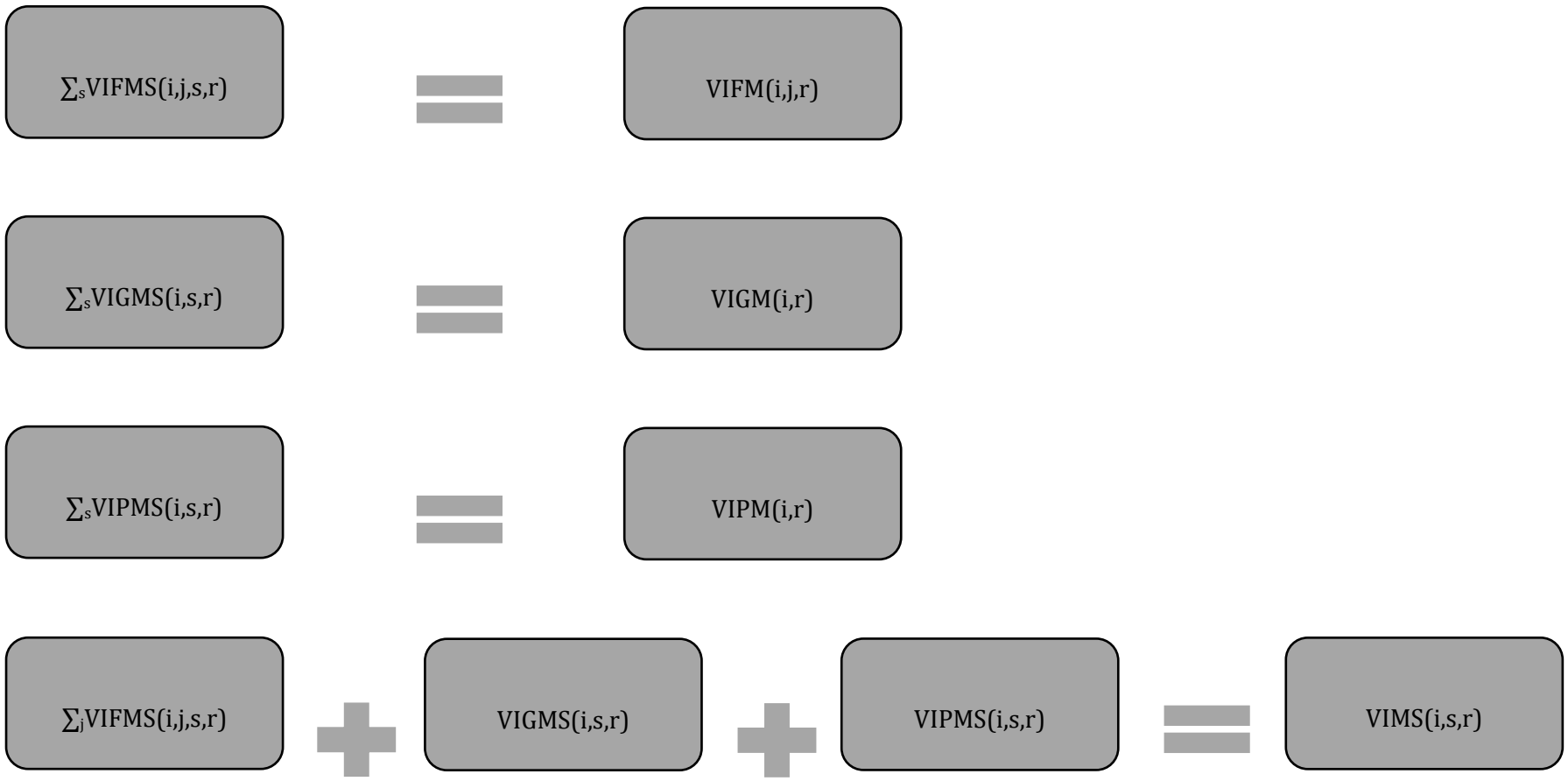


Table 2 shows the world interrelations for an aggregation of regions and selected industries based on these newly developed GTAP MRIO data. The 3 regions in Table 2 are the EU (EU28), Canada, and the Rest of the world (ROW). For each of these 3 regions we present all traded products (aggregated into five categories) demanded by two sectors: government services and capital goods services. The input sectors have been aggregated into primary (PRIM), manufactures (OMF), construction (CNS), other services (Osvcs), and government services (Gsvcs). The two industries we display in Table 2 further distinguish two policy regimes, which are explained later in this document. These policy regimes are (1) subject to local preference and (2) not subject to local preference. This aggregate global inter-industry matrix shows the imported inputs needed by each region's industries from the rest of the regions.

Table 2. Import demand by government services and investment (in millions of USD)

	EU28				Canada				ROW			
	Gsvcs		CGDS		Gsvcs		CGDS		Gsvcs		CGDS	
Supply\ Demand	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.
EU28-PRIM	2881	8049	447	0	12	27	24	2	1338	2931	1441	533
EU28-OMF	30596	83885	315885	6098	698	1572	7510	149	25357	44940	398743	26348
EU28-CNS	238	678	14264	3336	1	3	11	3	689	1147	14278	5310
EU28-Osvcs	11624	33149	27245	2082	641	1443	766	43	13431	22751	18423	2774
EU28-Gsvcs	310	766	5571	0	83	186	46	0	1235	1991	2303	0
Canada-PRIM	62	156	8	0	0	0	0	0	524	619	242	13
Canada-OMF	385	1009	2940	104	0	0	0	0	5102	5881	43264	1173
Canada-CNS	3	7	136	30	0	0	0	0	2	5	124	53
Canada-Osvcs	295	817	827	66	0	0	0	0	1545	1968	1179	174
Canada-Gsvcs	7	17	78	0	0	0	0	0	135	168	155	0
ROW-PRIM	1844	4727	762	0	173	391	92	7	4653	9185	5631	1521
ROW-OMF	18141	48967	202745	5000	4768	10739	52739	934	62420	117665	1023764	50258
ROW-CNS	241	653	13416	3223	8	17	59	15	703	1230	18679	7224
ROW-Osvcs	8906	24800	17806	1387	1080	2433	1423	63	18710	30904	21572	3320
ROW-Gsvcs	369	913	5678	0	539	1214	299	0	2233	3648	7982	0

2.1.3 Investment Decomposition

The GTAP Data Base reports Gross Fixed Capital Formation (GFCF) for 120 countries and 20 regions. In order to determine how much of this corresponds to government investment, we compute shares based on data from the OECD, the United Nations (UN) and EUROSTAT.

The OECD data presents GFCF data by institutional sectors (general government, households and non-profit institutions serving households, and corporations) by asset group (but not by asset group and institution). "For government this typically means investment in transport infrastructure and public buildings such as schools and hospitals. For households, this generally equates to dwellings." (OECD, 2010).

The six assets the OECD presents are: Dwellings (excluding land); Other buildings and structures (roads, bridges, airfields, dams, etc.); Transport equipment (ships railway, aircraft, etc.); Other machinery and equipment (office machinery and hardware, etc.); Cultivated assets (managed forests, livestock raised for milk production, etc.); and Intellectual property type fixed assets (mineral exploration, software and databases and literary and artistic originals, etc.).

The integrated economic accounts data from the United Nations identifies data for the total economy and the five institutional sectors of the SNA system, i.e., the non-financial corporations, financial corporations, general government, households, and non-profit institutions serving households. For 2011, the UN offers data for 63 countries see Appendix E. From EUROSTAT, we can obtain GFCF data for the total economy, government, business, and household sectors for 30 European countries.

In general, there is consistency among data sources in terms of the monetary value of government investment. Table 3 shows the 2011 investment by institutional sector for EU countries. We rely on EUROSTAT for government investment data for EU countries. Outside of the European countries, we allow the OECD to take precedence over the UN source.[15]

After these data sources are combined, we have investment data by household, corporations, and government for 65 countries.[16] Since the GTAP data construction process lists 244 countries, we map every single available country to the regional aggregates and compute investment-weighted splits to fill in missing observations. Appendix E shows public investment data for the 140 regions represented in GTAP. The product composition of government investment is available for GTAP 57 products, based on the structure as the original total investment in GTAP. For five countries (i.e., Australia, Japan, France, the U.S. and Canada), we have obtained detailed information that allowed us to better distribute government investment demand across goods and services purchases. Based on these five countries, a weighted average is used based on time series data and is applied to all countries. This is a necessary simplifying assumption due to the absence of a centralized source of public investment by product; see Appendix F for further discussion.

[15] The standard GTAP model incorporates investment by treating it as a fictitious industry of capital goods. This is equivalent to having a Leontief expenditure function for investment expenditures. In all static models, including standard GTAP, investment is savings driven. For this study, we distinguish between private and government investments. The modelling section will explain how this information is implemented.

[16] The list of 65 countries include the 63 country data from the UN plus United Kingdom and China data retrieved from the OECD.

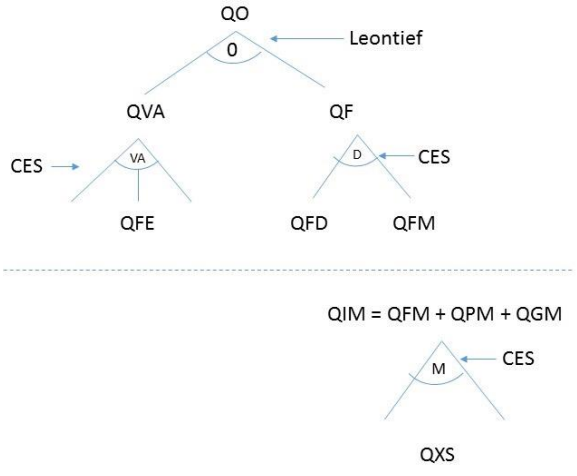
Table 3. EU's 2011 Gross Fixed Capital Formation (in millions of USD)

No.	Country Name	Corporate	Government	Household	Total
1	Austria	57,093	12,022	21,591	90,706
2	Belgium	73,617	11,549	31,746	116,912
3	Bulgaria	9,802	2,338	637	12,776
4	Croatia	8,128	2,153	2,166	12,447
5	Cyprus	2,086	967	1,532	4,585
6	Czech Republic	34,271	8,131	9,780	52,182
7	Denmark	33,421	10,653	14,119	58,192
8	Estonia	4,081	1,199	896	6,177
9	Finland	28,019	8,957	15,469	52,444
10	France	307,742	98,850	152,978	559,570
11	Germany	388,496	75,129	201,003	664,627
12	Greece	18,052	7,455	21,902	47,409
13	Hungary	16,556	4,201	3,866	24,622
14	Ireland	12,294	3,185	4,229	19,709
15	Italy	225,503	60,251	142,768	428,521
16	Latvia	4,794	1,661	904	7,359
17	Lithuania	4,885	2,203	1,569	8,657
18	Luxembourg	11,439	2,917	3,987	18,343
19	Malta	1,220	403	516	2,139
20	Netherlands	82,694	29,533	37,507	149,734
21	Poland	55,321	31,994	23,382	110,697
22	Portugal	25,265	8,202	9,824	43,291
23	Romania	28,935	9,812	9,884	48,632
24	Slovakia	14,740	3,279	4,412	22,431
25	Slovenia	6,293	2,108	2,061	10,463
26	Spain	185,740	53,379	70,882	310,000
27	Sweden	69,051	19,882	12,673	101,606
28	United Kingdom	207,938	61,620	102,469	372,027

3. Model

The model used for this study, is a modified version of the standard GTAP model which is a comparative static, multi-region, multi-sector, computable general equilibrium model, with perfect competition and constant returns to scale (Hertel, 1997). In the standard GTAP model, the production structure characterizes output as a Leontief composite of each commodity input and factors of production (or value added), and each commodity is a constant elasticity of substitution (CES) composite of an imported and a domestically produced commodity, see the technology tree in Figure 5.

Figure 5. Production structure in the standard GTAP model



Source: Based on Figure 2.6 in Hertel (1997)

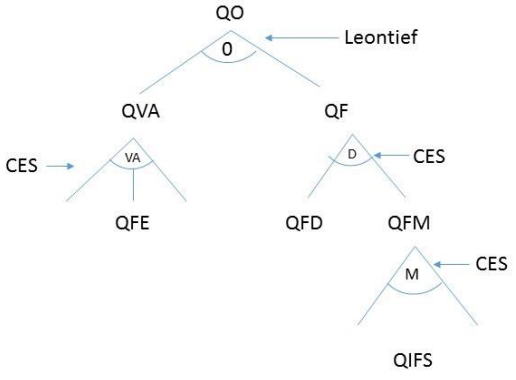
In Figure 5, QO represents quantity produced by industries, QVA represents the composite value added quantity purchased by industries, QFE is the quantity of individual factor endowments (e.g., Land, Labor, and Capital), QF is the quantity of intermediates purchased by industries, which is composed of domestic and imported intermediates. QIM are total imports composed of imports destined to intermediates (QFM), to private household (QPM), and to the government (QGM). Total imports are matched with exports coming from all other regions (QXS). Figure 5 describes that the sourcing decision for imports in the standard GTAP model is made at the aggregate level and not at the agent level. This was done mainly due to the original lack of detailed import sourcing data at the agent level (Walmsley et al. 2014).

The modified GTAP model presented here permits us to exploit the data developments described in the previous section. In the extended model, the sourcing of imports is determined at the agent level (i.e., for firms, private consumption, government consumption, private investment, and government investment). Household behavior is modified to accommodate for the addition of sourcing information. Private and government imports used to contain total imports per product and region, now they also reflect the origin of such imports. The information is contained in the GTAP Data Base under the same headers VIPA and VIGA for private and government agents, respectively. These import demands are modelled following the Armington approach.[17] The following paragraphs illustrate the modifications focusing on the firms by expanding Figure 5, one modification at a time.

For firms, modelling the sourcing of imports consists on incorporating a new nest level between the composite commodity and the source-specific varieties, see bottom of Figure 6, which represents the alternative production structure with firms' imports (QIFS) indexed by their country of origin.

[17] For a detailed discussion, please refer to chapter 2 of Hertel (1997).

Figure 6. Alternative production structure with origin of imports



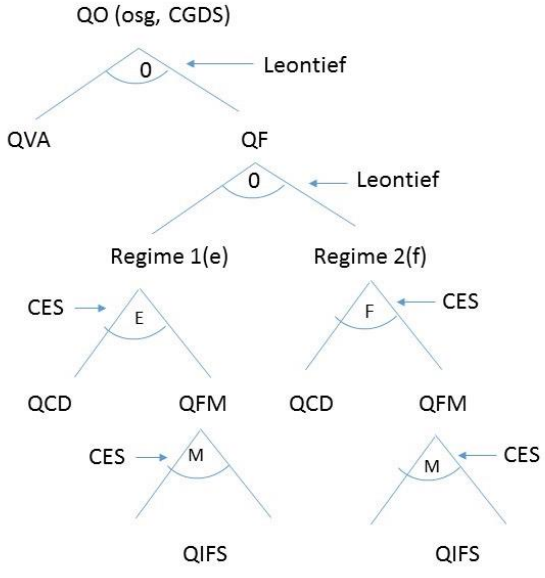
Source: Authors' illustration.

In addition, the extended model accounts for different government procurement regimes, see Figure 7.[18] The new composite commodities are Leontief aggregates of inputs purchased under different procurement policy regimes, and each of these is a CES composite of domestic and imported varieties.

Note that what we say here about intermediate usage of the government related sector in GTAP (OSG), applies equally to gross fixed capital formation, which in GTAP is treated as a fictitious industry (CGDS) and handled together with current production in the data base and theory.

[18] In Figure 7, quantity of domestic intermediate products purchased by industries (formerly QFD) is renamed QCD.

Figure 7. Alternative production structure with origin of imports and procurement regimes



Source: Authors' illustration.

Two procurement policy regimes are considered, purchases **exempt** from procurement policy or not subject to local preference (see Regime 1(**e**) in Figure 7), and purchases subject to **finite** local preference (see Regime 2(**f**) in Figure 7).[19] Purchases subject to finite local preference are those government purchases that can be subject to some kind of bias (e.g., home bias). Purchases not subject to local preference could also be considered competitive purchases or fully liberalized purchases.

In order to introduce the procurement regime where some bias exists (regime 2(f) in Figure 7), a new layer of taxes on intermediate inputs are considered. In the standard GTAP model, the variable *tfd* represents the percentage change in the power of the tax on intermediate usage of domestic product, and *tfm* is the percentage change in the corresponding power of the tax for imports. In standard GTAP, *tfd* is typically an exogenous variable, which links market prices with firms prices, see Equation 1.

```
pfd(i,j,r) = tfd(i,j,r) + pm(i,r)                    (1)
```

where *pfd* is the percentage change in the price index that industry *j* in region *r* pays for domestic purchases of product *i*; if *tfd* does not change, any changes to the market price of commodity *i* in region *r* (*pm*) will have an effect on the price index that the industry pays for inputs.[20]

[19] The new set, CURE, is used in the model and data base. It consists of two elements, "e" for purchases exempt from procurement policy, and "f" for purchases subject to finite local preference. This can be found in the sets file.
[20] In the GTAP model, lower case variable represent percent change variable and upper case the level variable. For example, PFD is the price index that industry j pays for domestic purchases in each region and pfd is the associated percentage change variable after linearization.

To introduce local preference, we introduce new tax variables that account for the percentage change in *veridical* and *phantom* taxes for domestic and imported inputs (*tcd* and *tics*, respectively). By *veridical* taxes, we mean taxes in the model that represent taxes in reality (i.e., what is accounted for by variables *tfd* and *tfm* in the standard model). *Phantom* taxes are used to model the effects of non-tax policy instruments. Phantom taxes are zero for inputs into all current production other than that of "other government services" and capital goods. They are also zero for purchases exempt from procurement policy (Regime 1(e) in Figure 7). These phantom taxes only exist for "other government services" and capital goods purchases under finite local preference. Therefore, in the extended model, the new tax variables (*tcd*) and (*tics*) are regime-specific variable calculated from its veridical and phantom components; see Equations 2 and 3.

```
tcd(i,j,c,r) = tcdv(i,j,c,r) + tcdp(i,j,c,r)                    (2)
```

where the new index '*c*' represents the policy regime; *tcd* is the tax on domestic commodity *i* purchased by sector *j* in region *r*; *tcdv* is the veridical tax on domestic commodity *i* purchased by sector *j* in region *r*; and *tcdp* is the phantom tax on domestic commodity *i* purchased by sector j in region r.[21]

```
tics(i,j,c,s,r) = tcmv(i,j,c,s,r) + tcmp(i,j,c,s,r)             (3)
```

where variable *tics* is the tax on imported commodity *i* purchased by sector *j* in region r from source region s; *tcmv* is the veridical tax on imported commodity *i* purchased by sector *j* in region *r* from region *s*; and *tcmp* is the phantom tax on imported commodity *i* purchased by sector j in region *r* from region *s*.

Equations 4 and 5 show the new price linkage equations, which take into account the new tax variables (*tcd* and *tics*).

```
pcd(i,j,c,r) = tcd(i,j,c,r) + pm(i,r)                           (4)
```

where variable *pcd* is the percentage change of the price index for domestic purchases of product *i* by industry *j* under policy regime *c* in region *r*; *tcd* is the new tax on domestic commodity *i* purchased by sector *j* in region *r* that accounts for veridical and phantom taxes; and *pm* is, as before, the market price of commodity *i* in region *r*.

```
pics(i,j,c,s,r) = tics(i,j,c,s,r) + pcms(i,j,c,s,r)             (5)
```

where *pics* is the percentage change of the price index for imported purchases of product *i* by industry *j* under policy regime *c* from region *s* in region *r*; *tics* is the new tax on imported commodity *i* purchased by sector *j* from region *s* in region *r* that accounts for veridical and phantom taxes; and *pcms* is the market price of imported commodity *i* from region *s* in region *r*.

A requirement is imposed on the phantom taxes affecting domestic and imported inputs, the tax on any flow of domestic product and the corresponding flow of imports should sum to

[21] Variables and coefficients indexed by regime have the letter 'C' in place of the standard GTAP 'F' for Firm. For instance, the regime-generic quantity of a composite intermediate input is qf, as in standard GTAP, and the corresponding regime-specific quantity is qc.

zero.[22] This ensures that phantom taxes cannot affect government revenue or industry costs, or lead to substitution between one composite commodity and another.[23] Local preference is represented as a tax on imports and an equal and opposite subsidy on domestic product. Therefore, between two corresponding components of *tcdp* and *tcmp* (phantom taxes on domestic product and on imports), there is only one degree of freedom. We absorb that with a variable *tclp* representing the power of local preference (Equation 6).

```
tclp(i,j,c,r) = tcmp(i,j,c,r) - tcdp(i,j,c,r)                    (6)
```

The new variable *tclp* is typically exogenous. Therefore, typically the powers of the phantom tax on domestic product and imports are determined by the extent of local preference and the zero revenue condition. Shocking variable *tclp* affects both phantom taxes, which affect the domestic and imported commodities through *tcdp* and *tcmp*, respectively. Through equations 2 and 3, the new tax on domestic and imported commodities would be updated (*tcd* and *tics*). In turn, via equations 4 and 5, the new taxes alter the prices for domestic and imported inputs (*pcd* and *pics*) that the affected industries pay.

Implementation of modifications

In dividing usage values between procurement regimes, we assume that all inputs are exempt, except for part of the intermediate usage of the "Other Services (Government)" sector, (OSG), and part of gross fixed capital formation. The "other government services" industry is treated distinctly because it includes public administration and defense, and because it accounts for the bulk of government consumption expenditure (94 per cent in GTAP Standard Data Release 9). In fact, the component sectors of OSG were disaggregated according to the 2 digit ISIC category based on EUROSTAT data for the EU. For lack of better data, we assume that for each country, the share of purchases of inputs subject to local preference in Public Administration and Defense, Education, and Health is set equal to the share of government consumption in sales of domestically produced "other government services". On average for the world, 65 per cent of domestic government output is sold to final government consumption. This means that, on average for the world, 35 per cent is assumed to be procured competitively. For gross fixed capital formation, the initial value assigned to be subject to local preference is set to equal the share of public investment in total investment developed in the previous section (on average, 13 per cent). This means that, 87 per cent of total investment is procured competitively (private investment).[24]

The GTAP framework considers several levels of valuation: Agent, Market, or World prices. To accommodate the more complex structure of taxes on intermediate usage, for the data base we define a new level of valuation, in which prices for the new level include veridical but not phantom taxes. In data array and coefficient names, we use the symbol 'V' for veridical; so, for instance, corresponding to the standard GTAP intermediate usage of domestic product at market and agents' prices (headers VDFM and VDFA, respectively), we now have the regime-specific

[22] For example, for a country A that produces and imports product B, the phantom tax requirement establishes a subsidy on the domestic product and a tax on the imported product. The combined tax/subsidy revenue is equal to zero.

[23] The exception would be second-order effects arising from allocative inefficiency.

[24] Note that in this framework, the role of public corporations is not clearly identified, because these are not distinguishable from the underlying data used for construction of the GTAP Data Base.

VDCM, VDCA, and VDCV, the last of which represents value at veridical prices, to which phantom taxes or subsidies may be added or subtracted to obtain the value VDCA at agents' prices.

We set the new veridical value arrays for domestic and imported usage (VDCV and VICV) equal in aggregate to the old agents' value arrays VDFA and VIFA (that is, summing over regimes, from new VDCV we recover old VDFA, and likewise for VICV and VIFA). The new agents' values arrays VDCA and VICA incorporate phantom taxes and subsidies, which we set so that:

- Phantom taxes are zero for inputs into all current production other than that of "other government services", and capital goods. Further, for inputs into "other government services" and capital goods, phantom taxes are also zero for exempt purchases (i.e., phantom taxes only affect purchases under finite local preference).
- For remaining purchases, that is, for the portion of inputs into "other government services" and gross fixed capital formation subject to local preference, we assume a hypothetical scenario where there is a 20 percent margin of local preference in the European Union, and 50 per cent elsewhere.
- The total value of phantom taxes and subsidies on corresponding domestic product and import flows are equal in and opposite in sign.

This set up allows us to explore the implications of the conjecture that local preference is substantial in most jurisdictions, but lower in the European Union than elsewhere. In the existing literature on public procurement, home bias is suggested by comparing the total import shares in final government consumption versus private consumption (Shingal, 2015). If this definition is correct, in the context of this work, we should compare import shares of the government sector with that of non-government sectors. Furthermore, within this new framework, home bias could be differentiated across products.[25]

4. Illustrative application

For purposes of illustration we aggregate the global economy into 14 regions and 22 sectors (see Table 4 for sectoral correspondence to GTAP sectors). The regional aggregates include: the EU 28 member countries, Canada, the USA, China, Japan, Korea, India, Brazil, Russia, Turkey, Rest of America, Africa, Rest of Asia, and the Rest of the World.

For the illustrative scenario, we will remove the initial hypothetical bias that we introduced. The simulation will reduce the Canadian bias to the same level of that is hypothesized for the EU. In the rest of the world, the power of local preference remains 1.5.[26] In terms of the closure for this model, full-employment of factor endowments (e.g., capital and labor) is assumed. Investment is allowed to move across regions in order to equate the change in the expected rates of return.

[25] Another possible source of preference estimates could be the Global Trade Alert (GTA) report (see www.globaltradealert.org). The notifications from the GTA report indicate the description of measure, the country implementing the measure, the countries directly affected, date when the measure was announced or implemented, the affected sector and products, and the duration of the measure if available.

[26] More elaborate specifications (monopolistic competition, oligopoly and Melitz-style firm heterogeneity) could be added, but would simply serve to complicate the main additions provided by this study.

Table 4. Aggregation and correspondence to GTAP sectors

No	Aggregated Sectors	GTAP Sectors
1	Agriculture	1-12
2	Extraction (forestry, fishing, coal, oil, gas and other mining)	13-18
3	Food, beverage and tobacco products	19-26
4	Textiles, wearing apparel, and leather products	27-29
5	Wood and paper, printing and publishing	30-31
6	Petroleum and coke products	32
7	Chemical, rubber, and plastic products	33
8	Metal and metal products	34-37
9	Motor vehicles and transport equipment	38-39
10	Electronic equipment	40
11	Other machinery	41
12	Other manufactures	42
13	Utilities	43-45
14	Construction	46
15	Trade	47
16	Transportation	48-50
17	Communication	51
18	Finance	52
19	Insurance	53
20	Business services	54
21	Consumer services	55, 57
22	Government services	56

4.1 Simulation results

In this section we present the results of the illustrative simulation.[27] Table 5 reports the welfare consequences of this reform to public procurement in billions of US dollars. We observe that Canada gains from liberalization of the public procurement policy regime. Canada suffers terms-of-trade losses, but it more than makes up for these through improvements in allocative efficiency as government agencies now obtain goods and services at lower cost from foreign suppliers. The non-liberalizing regions, the EU and the rest of the world, enjoy terms-of-trade gains due to the lower priced imports received from Canada, as well as the higher prices received for sales to those two governments.

Table 5: Equivalent variation (2011 USD billion)

Region	Allocative Efficiency	Terms of trade[28]	Total
European Union	0.05	0.16	0.21
Canada	1.94	-0.94	0.99
Rest of the World	0.02	0.79	0.81

Table 6 shows the effect of the policy scenario on real GDP, exports, and imports. We observe that the hypothetical reduction of Canada's government local preference bias, from 50 to 20 percent, has a small positive effect on Canada's GDP. Table 7 shows the changes in the volume of output. For all but 7 of the industries there is a decrease in production, the exceptions are Agriculture, Extraction, Food, beverage and tobacco products, Metal and metal products, Motor vehicles, Insurance, and Government services. The decrease of production is driven by the loss of domestic sales, in particular those originally destined for intermediate use subject to finite local procurement regime.

Table 6. Effect of reducing government local preference in Canada on Real GDP, Exports, and Imports (in percentages)

	Real GDP	Exports	Imports
Canada	0.109	1.123	0.935
EU	0.0003	0.002	0.003
ROW	0.00004	0.013	0.020

[27] This RunGTAP application is available from: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5146

[28] Including the effects of changes in relative prices of investment and saving.

Table 7. Changes in volume of output in Canada (in percentages unless noted)

Sectors	Base (Millions of 2011 USD)	Reduction of local preference in Canada
Agriculture	48,424	0.45
Extraction	164,270	0.94
Food, beverage and tobacco products	127,428	0.08
Textiles, wearing apparel, and leather	18,549	-0.39
Wood and paper printing and publishing	107,827	-0.46
Petroleum and coke products	82,561	-0.07
Chemical, rubber, and plastic products	117,060	-1.06
Metal and metal products	154,674	0.32
Motor Vehicles and transport equipment	122,334	0.20
Electronic Equipment	23,548	-1.44
Other machinery	69,888	-0.57
Other manufactures	19,418	-0.41
Utilities	56,625	-0.15
Construction	263,700	-0.04
Trade	365,295	-0.08
Transport	108,092	-0.35
Communications	76,262	-0.27
Financial	134,310	-0.13
Insurance	38,529	0.04
Business services	332,331	-0.21
Consumer services	192,922	-0.11
Government services	549,051	0.21

Table 8 shows the percentage change in imports due to the reduction of government's finite local preference. As expected, the reduction of Canadian local preference in the government services and investment sectors increases Canadian imports from the EU by a considerable amount for the products that are being traded (mostly double digit percentage changes, as shown in the Canada, Gsvcs, local preference column of Table 9). The reduction of Canadian local preference in government procurement also increases the imports from the rest of the world.

5. Concluding remarks

This paper presents the analytical data base designed to improve the public procurement representation in the GTAP framework. Improving the data base is central to making progress in this area of research. Surveying our IOT contributors provided confirmation that improving this area of global economic analysis is a non-trivial pursuit. In order to improve the government investment decomposition we relied on time series IOTs for selected countries. Detailed

information for more countries is desirable, but unfortunately this is not available. Future inter-governmental initiatives should focus on improving these data. Finally, estimates of local preference margins will be essential to taking such analyses beyond illustrative simulations into the domain of policy relevant applications.

Table 8. Percentage change in imports after local preference reduction

	EU28				Canada				ROW			
	Gsvcs		CGDS		Gsvcs		CGDS		Gsvcs		CGDS	
Supply\ Demand	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.	no local pref.	local pref.
EU28-PRIM	0%	0%	0%	0%	0%	65%	-1%	47%	0%	0%	0%	0%
EU28-OMF	0%	0%	0%	0%	0%	27%	0%	19%	0%	0%	0%	0%
EU28-CNS	0%	0%	0%	0%	0%	52%	0%	52%	0%	0%	0%	0%
EU28-Osvcs	0%	0%	0%	0%	0%	44%	0%	48%	0%	0%	0%	0%
EU28-Gsvcs	0%	0%	0%	0%	-1%	48%	-1%	0%	0%	0%	0%	0%
Canada-PRIM	2%	2%	1%	1%					1%	1%	1%	1%
Canada-OMF	1%	1%	1%	1%					1%	1%	1%	1%
Canada-CNS	1%	1%	1%	1%					1%	1%	1%	1%
Canada-Osvcs	1%	1%	1%	1%					1%	1%	1%	1%
Canada-Gsvcs	2%	2%	2%	0%					2%	2%	2%	0%
ROW-PRIM	0%	0%	0%	0%	0%	68%	-1%	47%	0%	0%	0%	0%
ROW-OMF	0%	0%	0%	0%	0%	29%	0%	19%	0%	0%	0%	0%
ROW-CNS	0%	0%	0%	0%	0%	52%	0%	52%	0%	0%	0%	0%
ROW-Osvcs	0%	0%	0%	0%	0%	45%	0%	48%	0%	0%	0%	0%
ROW-Gsvcs	0%	0%	0%	0%	-1%	48%	-1%	0%	0%	0%	0%	0%

REFERENCES

Aguiar, Angel, B. Narayanan and R. McDougall (2016) "An Overview of GTAP 9 Data Base," Journal of Global Economic Analysis 1(1), pp 181-208. Available at: <https://jgea.org/resources/jgea/ojs/index.php/jgea/article/view/23>. doi:http://dx.doi.org/10.21642/JGEA.010103AF.

Brulhart, Marius and Federico Trionfetti (2001) "Industrial Specialization and Public Procurement: Theory and Empirical Evidence," Journal of Economic Integration 16(1), pp 106-127.

Carrico, Caitlyn (2014) "Developing a GTAP-Based MRIO Ready for Use via FlexAgg2" Unpublished manuscript.

EU-Canada Joint Study (2008) "Assessing the Costs and Benefits of a Closer EU-Canada Economic Partnership" Available online from: http://trade.ec.europa.eu/doclib/docs/2008/october/tradoc_141032.pdf

"EUROPA - PRESS RELEASES - Press Release - External Public Procurement Initiative - Frequently Asked Questions." Accessed September 6, 2013. http://europa.eu/rapid/press-release_MEMO-12-201_en.htm.

"European Commission: Market Access Database: Trade Barriers." Accessed September 6, 2013. http://madb.europa.eu/madb/barriers_details.htm?barrier_id=970031&version=4.

EUROSTAT (2014) Investment by institutional sectors, Government, Retrieved from http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdec210

EUROSTAT (2015). EU27 Input Output Tables for 2011. Available for download from http://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/workbooks

Guimbard, H., S. Jean, M. Mimouni, and X. Pichot (2012) "MAcMap-HS6 2007, An Exhaustive and Consistent Measure of Applied Protection in 2007." International Economics 130 (February 2012): 99–121.

Hertel, Thomas. W., ed. (1997) Global Trade Analysis: Modeling and Applications, New York; Cambridge University Press, 1997.

Horridge, Mark (2008). "SplitCOM: Manual to disaggregate GTAP sectors". Available for download at http://www.copsmodels.com/splitcom.htm

Horridge, J.M. and Laborde, D. (2008) "TASTE: a program to adapt detailed trade and tariff data to GTAP-related purposes." GTAP Resource No. 3192, Centre for Global Trade Analysis, Purdue University.

Hussein, Zekarias, (2014) "Documentation on WTO-GPA Government Procurement Data" Unpublished manuscript.

Johnson, Robert and Guillermo Noguera (2012) "Accounting for Intermediates: Production Sharing and Trade in Value Added." *Journal of International Economics* 82(2): 224-36.

Koopman, Robert, Zhi Wang and Shang-Jin Wei (2012) “Tracing Value-added and Double Counting in Gross Exports.” NBER Working Paper No. 18579.

McDougall, Robert (2014) “An Extension of the GTAP Model for Analysis of Public Procurement” Unpublished manuscript.

Narayanan, G., Badri, Angel Aguiar and Robert McDougall, Eds. (2015) *Global Trade, Assistance, and Production: The GTAP 8 Data Base*, Center for Global Trade Analysis, Purdue University.

OECD (2009), National Accounts of OECD Countries 2009, Volume I, Main Aggregates, OECD Publishing, http://dx.doi.org/10.1787/na_vol_1-2009-en-fr. Online databases

OECD (2013), Government at a Glance 2013, OECD Publishing. http://dx.doi.org/10.1787/gov_glance-2013-en

Pelikan, J. (2014). "TASTE Add-on for GTAP 9 Data Base: based on ITC-MacMAP applied tariffs." Thünen Institute, Braunschweig.

Pichot, X., M. Mimouni, B. Narayanan, and J. Pelikan (2014). "Construction of ITC Tariff Dataset: Methodology and Comparisons across Versions." GTAP Resource No. 4419, Center for Global Trade Analysis, Purdue University.

“Public Procurement Indicators 2010” (2011) EU Commission, Brussels. Available at: http://ec.europa.eu/internal_market/publicprocurement/docs/modernising_rules/public-procurement-indicators-2011_en.pdf

Shingal, A. (2015), Econometric Analyses of Home Bias in Government Procurement. Review of International Economics, 23: 188–219. doi: 10.1111/roie.12164

Timmer, Marcel, Ed. (2012) “The World Input-Output Database (WIOD): Contents, Sources and Methods.” WIOD Working Paper No. 10.

Tsigas, Marinos, Zhi Wang and Mark Gehlhar (2012) “How a Global Inter-Country Input-Output Table with Processing Trade Account Can be constructed from GTAP Database” GTAP Resource #3784, Centre for Global Trade Analysis, Purdue University.

United Nations Statistical Division (2008) System of National Accounts (SNA 2008). Available at http://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

United Nations Statistics Division (2014) National Accounts Official Country Data, Retrieved from http://data.un.org/

Walmsley, Terrie and Robert McDougall (2007) “Using Entropy to Compare IO Tables.” GTAP Research Memorandum No. 9, Center for Global Trade Analysis, Purdue University.

Walmsley, Terrie, Thomas Hertel and David Hummels (2014) “Developing a GTAP-Based Multi-Region, Input-Output Framework for Supply Chain Analysis.” in Asia and Global Production Networks-Implications for Trade, Incomes and Economic Vulnerability. Benno Ferrarini and David Hummels (eds). Asian Development Bank and Edgar Elgar Publishing.

Appendix A: Estimates of the size of government procurement

According to the Organization for Economic Co-operation and Development (OECD, 2013), the estimated size of general government procurement (GP) is determined as:
GP = ICG + GGFCF + STIK

- where ICG is the sum of intermediate consumption by governments,
- GGFCF is the government's gross fixed capital formation (i.e., government investment), and
- STIK are the social transfers in kind via market producers.

Table A1 presents the components of this indicator using GTAP data for 129 GTAP regions/countries in 2007. For the intermediate consumption by governments, we take GTAP's intermediate use of products by the public sector, which is captured by sector 'osg: Other services (Government)', which accounts for the production account of public administration, defense, health and education.[29] Government's gross fixed capital formation has been developed as part of this project and social transfers in kind (STIK) is data not separately distinguished in the GTAP Data Base.

Table A1. Government Procurement Indicator for 2007

Region/Country Name	Intermediate Government Consumption	Government Investment	Government Procurement (in millions USD)	Government Procurement (% of GDP)
Australia	54,557	20,396	74,953	8.75%
New Zealand	11,080	2,779	13,859	10.02%
Rest of Oceania	3,063	645	3,708	11.65%
China	268,022	158,431	426,453	12.21%
Hong Kong	4,632	5,326	9,958	4.81%
Japan	392,500	139,794	532,294	12.16%
Korea	80,978	50,441	131,419	12.53%
Mongolia	470	189	659	16.77%
Taiwan	15,703	10,411	26,114	6.63
Rest of East Asia	3,165	1,523	4,688	14.22
Cambodia	324	215	539	6.45
Indonesia	18,454	13,355	31,809	7.36
Lao People's Democratic Republic	134	187	321	7.48
Malaysia	2,281	4,649	6,930	3.71
Philippines	5,978	2,710	8,688	6.03
Singapore	19,298	16,179	35,477	20.07
Thailand	5,227	7,866	13,093	5.30
Viet Nam	2,687	3,567	6,254	9.14
Rest of Southeast Asia	993	518	1,511	5.28

[29] We use header NVFA in the GTAP Data Base and exclude factor payments (e.g., payments to capital or labor).

Region/Country Name	Intermediate Government Consumption	Government Investment	Government Procurement (in millions USD)	Government Procurement (% of GDP)
Bangladesh	2,272	2,277	4,549	6.65
India	15,781	60,729	76,510	6.21
Nepal	479	294	773	7.52
Pakistan	7,811	4,284	12,095	8.45
Sri Lanka	2,094	1,109	3,203	9.90
Rest of South Asia	628	500	1,128	9.39
Canada	149,216	43,362	192,578	13.52
United States of America	1,440,599	346,375	1,786,974	12.71
Mexico	25,753	21,189	46,942	4.58
Rest of North America	2,202	276	2,478	30.22
Argentina	16,531	7,533	24,064	9.23
Bolivia	1,012	1,131	2,143	16.33
Brazil	116,387	29,148	145,535	10.65
Chile	7,819	3,776	11,595	7.06
Colombia	15,926	5,297	21,223	10.23
Ecuador	1,456	1,226	2,682	5.86
Paraguay	432	265	697	5.70
Peru	4,616	2,826	7,442	6.92
Uruguay	1,553	536	2,089	8.72
Venezuela	7,699	6,849	14,548	6.41
Rest of South America	680	213	893	15.08
Costa Rica	899	746	1,645	6.26
Guatemala	1,119	1,137	2,256	6.61
Honduras	597	344	941	7.59
Nicaragua	365	271	636	11.33
Panama	858	813	1,671	8.44
El Salvador	493	1,202	1,695	8.32
Rest of Central America	100	36	136	10.66
Caribbean	24,320	1,738	26,058	9.88
Austria	24,471	4,082	28,553	7.67
Belgium	40,095	8,145	48,240	10.52
Cyprus	1,882	702	2,584	12.05
Czech Republic	13,432	6,931	20,363	11.69
Denmark	28,484	5,943	34,427	11.08
Estonia	1,843	1,143	2,986	13.96
Finland	20,887	6,352	27,239	11.05
France	176,959	88,143	265,102	10.05
Germany	215,333	50,057	265,390	7.97
Greece	17,118	8,720	25,838	8.34
Hungary	6,110	5,121	11,231	8.09
Ireland	14,288	10,845	25,133	9.68
Italy	161,166	49,629	210,795	9.96

Region/Country Name	Intermediate Government Consumption	Government Investment	Government Procurement (in millions USD)	Government Procurement (% of GDP)
Latvia	2,106	1,805	3,911	13.60
Lithuania	2,670	2,224	4,894	12.51
Luxembourg	3,300	2,589	5,889	11.48
Malta	589	341	930	12.49
Netherlands	73,723	26,246	99,969	12.84
Poland	23,189	18,817	42,006	9.88
Portugal	16,525	6,316	22,841	9.89
Slovakia	5,561	1,648	7,209	8.56
Slovenia	4,334	2,156	6,490	13.72
Spain	79,164	58,731	137,895	9.57
Sweden	42,543	14,507	57,050	12.33
United Kingdom	302,645	54,143	356,788	12.75
Switzerland	28,412	8,977	37,389	8.61
Norway	23,969	12,410	36,379	9.39
Rest of EFTA	1,833	851	2,684	10.82
Albania	114	400	514	4.75
Bulgaria	4,609	2,349	6,958	16.52
Belarus	3,863	2,586	6,449	14.24
Croatia	204	2,395	2,599	4.44
Romania	11,731	9,593	21,324	12.60
Russian Federation	89,888	47,511	137,399	10.57
Ukraine	12,580	5,663	18,243	12.78
Rest of Eastern Europe	544	157	701	15.92
Rest of Europe	4,974	2,901	7,875	8.57
Kazakhstan	8,679	5,839	14,518	13.85
Kyrgyzstan	386	116	502	13.21
Rest of Former Soviet Union	3,220	1,057	4,277	11.06
Armenia	597	424	1,021	11.10
Azerbaijan	1,469	1,660	3,129	9.47
Georgia	934	645	1,579	15.52
Bahrain	357	1,258	1,615	8.74
Slovak Republic	9,139	5,684	14,823	5.18
Israel	23,475	3,039	26,514	15.88
Kuwait	1,653	5,020	6,673	5.82
Oman	1,097	2,916	4,013	9.58
Qatar	1,494	7,405	8,899	11.02
Saudi Arabia	5,756	21,717	27,473	7.15
Turkey	8,807	31,669	40,476	6.25
United Arab Emirates	2,000	14,504	16,504	7.95
Rest of Western Asia	9,063	6,164	15,227	11.43
Egypt	13,015	4,742	17,757	13.61

Region/Country Name	Intermediate Government Consumption	Government Investment	Government Procurement (in millions USD)	Government Procurement (% of GDP)
Morocco	23,118	2,288	25,406	33.77
Tunisia	1,528	1,474	3,002	8.43
Rest of North Africa	5,434	8,357	13,791	6.63
Cameroon	948	434	1,382	6.68
Cote d'Ivoire	696	740	1,436	7.26
Ghana	1,824	2,006	3,830	15.55
Nigeria	84	68	152	3.61
Senegal	305	455	760	6.70
Rest of Western Africa	1,034	1,850	2,884	15.08
Central Africa	2,372	1,594	3,966	9.59
South Central Africa	3,607	1,881	5,488	7.93
Ethiopia	951	570	1,521	7.93
Kenya	5,223	656	5,879	21.64
Madagascar	166	405	571	7.78
Malawi	108	111	219	6.11
Mauritius	225	220	445	5.92
Mozambique	439	145	584	7.28
Tanzania	933	628	1,561	9.28
Uganda	889	289	1,178	9.91
Zambia	449	348	797	6.91
Zimbabwe	113	145	258	5.82
Rest of Eastern Africa	515	1,679	2,194	3.98
Botswana	1,247	561	1,808	14.60
Namibia	577	363	940	10.67
South Africa	27,861	9,376	37,237	13.01
Rest of South African Customs Union	294	86	380	8.39
Rest of the World	7	3	10	8.00

Appendix B: The GTAP IOT Contributors' Survey Questionnaire

Questions	Answers
1. What countries' IOT (or SAM) have you worked with? Which of these have been contributed to the GTAP Data Base?	The first question of the survey is designed to identify the contributors and the IOTs they have worked on and contributed to GTAP. While there are several contributors for Latin and Asian countries, there are fewer contributors for African countries, and a single respondent for the EU countries.[30]
2. In the IOT sources upon which you have drawn, are you able to locate data on public (vs. private) investments?	75% of respondents indicated that they were not able to locate private from public investment data. The exception to this are the IO tables from Japan, Australia, and Taiwan where contributors were able to identify a verifiable source.
3. Are you aware of other sources of data on government procurement in the countries which you have contributed? If yes, please list them here.	Australia publishes tender results in AusTender, all the other contributors said that they are not aware of any other source of government procurement data.[31] Other respondents for Thailand, Latin America, and the Middle East indicated their awareness of government data being available.
4. Does your IOT display foreign vs. domestic composition of inputs used within each industry/activity?	60% of respondents answered that their IOT does not display foreign vs. domestic composition of inputs. Only one of the remaining 40% responded that this distinction is available through the pro-rate computation that GTAP recommends when a table's imports is a vector in the matrix. All of the EU tables, however, do make this distinction.
5. Does the IOT indicate the origin and destination of your country's imports and exports?	All respondents, except for Taiwanese table contributor, say that the IOTs do not indicate the origin of imports or the destination of exports. Also, the EU tables provide extra-EU and intra-EU information for imports and exports.
6. Does the original IO table distinguish between imports for intermediate use and those for final demand?	Question six received the largest number of positive answers. 50% of respondents indicate that the original IOTs distinguished import use between intermediate and final demand. The geographic distribution of the response includes countries in Asia (Mongolia, Thailand, and Taiwan) and Latin America (Mexico, Brazil, and Ecuador). None of the African IO table contributors were able to indicate such distinction of the use of imports.
7. Do you know if your country restricts government purchases of imported goods? If yes, please indicate the study or data source.	The last question on the IO survey was designed to inquire further into the extent to which government procurement affects imported goods. 65% of the respondents indicated that they were not aware of any restrictions. 20% confirmed that there are no restrictions (Philippines, Thailand, New Zealand, and Australia). For Brazil, on the other hand, certain government programs do give preference to domestic suppliers. Some Middle Eastern countries (Bahrain, Oman, Kuwait, United Arab Emirates, Qatar, and Saudi Arabia) have a system of government procurement that gives a ten percent price advantage to local producers.

[30] The EU contributor is new, but currently working on the next EU contribution.

[31] The contributor for the Thai table, as well as Martin Cicowiez for Latin American countries, mention that basic government data is available but is not always well systematized.

Appendix C: Government Procurement Agreement (GPA) Data

There are two specific issues related to the data from GPA statistical reports. The two issues, which are discussed in detail in the following pages, are:

1. The GPA statistical reports present a direct measure of government purchases that fall above a certain threshold; leaving the below threshold purchases unaccounted for. This issue is addressed in the Section 1, where we compare three different indicators related to the size of public procurement based on data from the Organization for Economic Co-operation and Development (OECD), GTAP, and GPA.
2. The GPA statistical reports do not follow a standard format, which requires additional standardization of the data. Furthermore, GPA statistical reports do not distinguish whether public procurement was used for intermediate consumption and/or for public investment. Section 2 explains the discrepancies between GTAP and GPA by way of a 'per product' comparison. This will highlight the discrepancies between countries in the reported GPA data.

Given the issues presented, GTAP proposes the use of country data in the GTAP Data Base. These data, consistent with SNA guidelines, covers all government expenditures, allowing for comprehensive results of simulations affecting public procurement.

Indicators of Public Procurement

According to the Organization for Economic Co-operation and Development (OECD), the estimated size of general government procurement is determined by the sum of intermediate consumption by governments, government's gross fixed capital formation, and social transfers in kind via market producers (OECD, 2013)[32]. Table C1 presents three indicators based on OECD data, GTAP data, and GPA data for a subset of countries for which data exists in all three data sources.

The OECD indicator is based on National Accounts Data from the OECD Statistics (http://stats.oecd.org/).[33] This measure ranges between 10 and 20 percent of GDP and may overestimate government procurement, as the above categories may include certain expenditures not carried out through government procurement (OECD, 2013).[34]

Next we compute a public procurement indicator using GTAP Data. The GTAP indicator of public procurement uses total intermediate costs of the government sector (OSG)[35], excluding factor costs, plus government gross fixed capital formation.[36] Social transfers in kind are not

[32] OECD (2013), *Government at a Glance 2013*, OECD Publishing. http://dx.doi.org/10.1787/gov_glance-2013-en

[33] More specifically, this data was collected from the General Government Accounts, item 12: "Government deficit/surplus, revenue, expenditure and main aggregates".

[34] The general government component includes the values of procurement by central, state and local governments, and social security funds, but exclude public corporations, such as state-owned utilities.

[35] We use the proportion of OSG that is consumed by final government consumption.

[36] Government gross fixed capital formation is not available in the standard GTAP Data Base, but it has been estimated for this project.

separately identified in GTAP, therefore we would expect that the GTAP indicator is smaller than the one computed with OECD data.

Table C1. Indicators of Public Procurement as a percentage of GDP for 2007

Countries	OECD	GTAP	GPA
Austria	11%	7%	2%
Belgium	12%	10%	3%
Czech Republic	15%	10%	4%
Germany	13%	7%	1%
Denmark	12%	11%	2%
Estonia	13%	13%	5%
Spain	12%	9%	3%
Finland	14%	10%	1%
France	14%	10%	2%
Greece	13%	8%	5%
Hungary	13%	8%	4%
Ireland	12%	10%	2%
Italy	10%	10%	2%
Luxembourg	11%	11%	1%
Netherlands	20%	12%	1%
Poland	12%	9%	3%
Portugal	11%	10%	2%
Sweden	15%	11%	3%
Slovenia	12%	13%	10%
United Kingdom	13%	13%	5%
Japan	13%	12%	0.47%
United States	11%	13%	10%

The third indicator in Table C1 uses data from the GPA statistical reports. GPA data reflect central and local government procurement. This indicator reflects above-threshold[37] purchases made as a percentage of GDP, which leads to a much smaller indicator than that reported by the OECD and GTAP. The smaller reach of GPA data, provides an incomplete portrayal of public procurement and the associated policy issues.

Comparability of the per product information in the GPA reports against GTAP

Each member of the GPA uses a different product classification that needs to be homogenized to match the 57 products of the GTAP data base. For example, the US uses a 102 product and service classification, which is a combination of the product service codes (PSCs) and the federal supply

[37] The threshold value is determined by each member country, but it generally is set at 130,000 SDRs for each products and services. The threshold value for construction services is typically different and usually higher than that for products and services.

codes (FSCs), the EU uses a 61 product and service classification called common procurement vocabulary (CPV), and Japan uses a 51 product and service classification.

For the purpose of this per product comparison, using US, France, and Japan as examples, it is necessary to note that:

- From GTAP we used intermediate government consumption per product, sector (OSG), which being based on Input Output (IO) tables, must account for all purchases made by all government entities.[38] These include total (above and below threshold) central and local government purchases.
- From GPA we use central and local government purchases when these are available for a common product classification. In the case of Japan, local procurement is not used in the comparison because the data reported has a much aggregate classification of products and services (i.e., goods, technical services, construction services, and other services). In the case of the US, local procurement is also not used in the comparison because it is broken down by state and not by product.
- GPA allows for certain government entities to be excluded; therefore their information is not reported and the data reported by product is available for contracts valued above the threshold.
- GPA data makes no distinction whether purchases are destined for intermediate consumption, gross fixed capital formation, or for social transfers in kind.

Table C2 displays the US GTAP and GPA data. For the US, GTAP 2007 data are compared against GPA 2008 data because the GPA 2007 data for US did not break down procurement by product. In Table C3, above threshold values for the central and local government purchases (GPA Annexes 1 and 2, respectively) are compared against GTAP data. In order to be able to compare against GTAP we develop a different classification than the one used for the US because France provides above threshold government purchases by product for a classification of 61 products and services.

As expected, GPA's total above threshold procurement is smaller than intermediate government consumption in GTAP. According to the GPA and GTAP data, for US and France, the main government procurement items are 'Construction' and 'Other business services'. For the US, the dollar value of 'Construction' according to GPA is larger than that reported in GTAP. This also happens for France in Table C3, for Coal, Oil and Gas, and Other mining because GPA data may also include procurement that is separately accounted for as public investment in the GTAP framework. This, in turn, is one of the difficulties that we encounter with the use of GPA data. For incorporation in the GTAP data and modeling framework, we need to be able to allocate between intermediate government consumption and government investment.

For Japan, as reported in Table C4, we develop another mapping to be able to compare GPA with GTAP. According to GPA, the most important government purchase for Japan is also 'Construction' at 42%. In GTAP, the dollar value for construction is larger than GPA, but its

[38] Scaled for actual purchases to final government consumption, which is above 90% for the countries used in this clarification note.

relevance is only 3% because of the larger base for computation given that GTAP data is a more comprehensive measure of public procurement.

The commodity composition of GPA data for the US, France, and Japan can be compared when looking at the shares of public purchases. For all three countries, 'construction services' are an important component of government purchases, for US and Japan this is the main purchase, representing 42% for each country. The top government purchase for France is for 'Manufactures', which is an aggregated classification that captures maintenance, repair, and installation services. 'Other business services' is another important government purchase for all three countries, but for the US (30%) this is larger than for Japan (25%) and France (15%). Therefore, to the extent possible, we can use GPA's information for product composition, while maintaining GTAP data for total government purchases. We can also use GPA information to distinguish different contracting regimes such as above threshold government purchases from below threshold government purchases.

Conclusion

This appendix note shows that GPA data are unlikely to be an effective substitute for direct use of the GTAP data base in estimating flows of public procurement. The main difficulties of working with GPA data derive from two core problems: (1) it includes only above threshold purchases, and (2) it does not identify whether purchases are destined for intermediate or final consumption. Additionally, each country reports in a different format, which requires individualized treatment. This makes it difficult to develop and maintain GPA-sourced public procurement for the GTAP data base over time. Some countries like the EU include a detailed per product purchase of local procurement, but that is not the case for the US or Japan.

Table C2: US product composition of intermediate government consumption in GTAP versus procurement purchases in GPA statistical reports (in millions of USD and shares)

No.	Product or Service	GTAP (2007)		GPA (Annex 1, 2008)	
1	Agriculture, forestry, and fishing	3,118	0%	N/A	-
2	Coal, Oil, Gas, and Other Mining	589	0%	N/A	-
3	Wood and paper, printing and publishing	65,218	5%	609	0%
4	Mineral products nec	4,962	0%	2,366	0%
5	Machinery and equipment nec	68,419	5%	123,808	**19%**
6	Ferrous metals	502	0%	3	0%
7	Metals	497	0%	N/A	-
8	Electronic equipment	15,836	1%	1,727	0%
9	Manufactures	6,525	0%	213	0%
10	Fabricated Metal Products	6,320	0%	259	0%
11	Chemical, rubber, plastic products	100,539	7%	2,475	0%
12	Motor vehicles and parts	7,150	0%	1,608	0%
13	Construction	149,834	10%	273,401	**42%**
14	Communications	36,658	3%	14,634	2%
15	Leather, textiles and wearing apparel	7,101	0%	1,174	0%
16	Food products	36,135	3%	2,036	0%
17	Petroleum, coal products	4,562	0%	13,375	2%
18	Transportation	108,754	8%	1,581	0%
19	Other business services	401,868	28%	194,360	**30%**
20	Recreation and other services	31,314	2%	2,041	0%
21	Other government (services)	96,012	7%	14,058	2%
22	Utilities	80,522	6%	N/A	-
23	Trade	93,190	6%	N/A	-
24	Other financial services nec	96,683	7%	N/A	-
25	Insurance services	16,199	1%	N/A	-
26	Miscellaneous products	N/A	-	8,655	1%
	Total	**1,438,505**		**658,384**	

Table C3. France's product composition of intermediate government consumption in GTAP versus procurement purchases in GPA statistical reports (in millions of USD and shares)

No	Product or service	GTAP (2007)		GPA (Annexes 1 and 2, 2007)	
1	Agriculture	2,056	1%	-	0%
2	Forestry	83	0%	0.5	0%
3	Fishing	112	0%	3	0%
4	Coal	0.3	0%	3	0%
5	Oil and Gas	1	0%	63	0%
6	Other Mining	19	0%	242	1%
7	Food products	8,328	5%	568	2%
8	Textiles	561	0%	106	0%
9	Wearing apparel and leather products	1,196	1%	321	1%
10	Wood products	171	0%	52	0%
11	Paper, printing and publishing	6,644	4%	752	2%
12	Petroleum and coke products	753	0%	539	1%
13	Chemicals, rubber, and plastics	10,983	7%	4,687	13%
14	Mineral products nec	1,212	1%	20	0%
15	Ferrous metals and metals nec	78	0%	31	0%
16	Manufactures	27,935	**17%**	12,395	**34%**
17	Other manufactures nec	2,047	1%	304	1%
18	Utilities	8,423	5%	-	0%
19	Construction	7,743	5%	6,891	**19%**
20	Recreation and other services	2,114	1%	-	0%
21	Other transport	6,272	4%	1,141	3%
22	Water transport	11	0%	-	0%
23	Air transport	2,214	1%	124	0%
24	Communications	7,186	4%	622	2%
25	Financial services and insurance	7,7712	5%	646	2%
26	Other business services	43,201	**26%**	5,458	**15%**
27	Other services (Government)	15,932	10%	1,252	3%
28	Services Misc.	N/A	-	236	1%
29	Misc./Combined/Not Available	N/A	-	143	0%
30	Supplies Misc.	N/A	-	87	0%
	Total	**163,046**		**36,688**	

Table C4. Japan's product composition of intermediate government consumption in GTAP versus procurement purchases in GPA statistical reports (in millions of USD and shares)

No.	Product or service	GTAP (2007)		GPA (Annex 1, 2007)	
1	Agriculture, forestry, and fishing	2,730	1%	4	0%
2	Coal, Oil, Gas, and Other Mining	2,785	1%	144	1%
3	Chemicals, rubber, leather, textiles and wearing apparel[39]	66,542	17%	127	1%
4	Wood and paper, printing and publishing	13,221	3%	40	0%
5	Mineral products	1,259	0%	-	0%
6	Ferrous metals	35	0%	5	0%
7	Metals and fabricated metals	2,308	1%	2	0%
8	Other machinery	6,721	2%	181	1%
9	Electrical machinery	2,898	1%	1,988	**16**%
10	Motor vehicles	268	0%	187	2%
11	Other transportation	7,147	2%	331	3%
12	Manufactures nec	9,458	2%	47	0%
13	Construction	12,014	3%	5,219	**42**%
14	Other business services	110,215	28%	3,155	**25**%
15	Other transportation	25,208	6%	40	0%
16	Water transport	325	0%	9	0%
17	Air transport	1,845	0%	5	0%
18	Communications	9,622	2%	42	0%
19	Other government (services)	19,473	5%	73	1%
20	Miscellaneous products	N/A	-	858	7%
21	Food products	8,197	2%	N/A	
22	Petroleum and coke products	11,306	3%	N/A	
23	Utilities	24,587	6%	N/A	
24	Trade	37,092	9%	N/A	
25	Other financial services	9,564	2%	N/A	
26	Insurance services	891	0%	N/A	
27	Recreation and other services	6,305	2%	N/A	
	Total	**392,017**		**12,456**	

[39] The aggregation may seem strange but it was based on the classification used by GPA for government purchases.

Table D5. Available GPA Statistical Reports for 2007

No.	Countries	2007 report	Central procurement per product	Above or below threshold	Local procurement per product	Above or below threshold	Cross border
1 - 27	EU (Austria, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Estonia, France, Finland, Germany, Greece, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, United Kingdom)	Yes	61 CPV	Above	Yes	Above	Yes(10)**
28	Japan	Yes	51 CPC	Above	Yes, different product classification	Above	Yes(5)
29	US	2008	102 PSC and FSC	Both	Yes, not per product	Above	No
30	Canada	Yes	49 class	Above	N/A		No
31	Hong Kong-China	Yes*	N/A		N/A		
32	Korea	2003	49	Above	Yes	Above	Yes(15)
33	Norway	Yes	50 CPV	Both	Yes	Both	No
34	Singapore	Yes	N/A	Both	N/A		No
35	Switzerland	2003	24	Above	N/A		Yes(3)
36	Chinese Taipei	2009	131	Above	Yes, different product classification	Above	Yes(4)

Source: WTO-GPA webpage: http://www.wto.org/english/tratop_e/gproc_e/gpstat_e.htm
Note: Members of the GPA that have no available data are: Armenia, Iceland, Israel, and the Netherlands with respect to Aruba. Liechtenstein is not listed because it is not available in the GTAP Data Base.
*Report exists but it states that it is available on the WTO Members' site, but link is not provided.
** For the EU as a whole, not for individual EU countries. Number of trading partners in parenthesis.

Table D6. Available GPA Statistical Reports for 2011

No.	Countries	2011	Central procurement per product	Above or below threshold	Local procurement per product	Above or below threshold	Cross border*
1 - 27	EU (Austria, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Estonia, France, Finland, Germany, Greece, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, United Kingdom)	Yes	45 CPV	Above	Yes	Above	No
28	Japan	Yes	51 CPC	Above	Yes, different product classification	Above	Yes (6)
29	US	2008	102 PSC and FSC	Both	Yes, not per product	Above	No
30	Canada	2009	49 class	Above	N/A		No
31	Hong Kong-China	Yes	3	Both	N/A		No
32	Korea	2003	49	Above	Yes	Above	Yes (15)
33	Norway	2009	50 CPV	Both	Yes	Both	No
34	Singapore	2009	N/A	Both	N/A		No
35	Switzerland	2003	24	Above	N/A		Yes (3)
36	Chinese Taipei	2009	131	Above	Yes, different product classification	Above	Yes (4)

Source: WTO-GPA webpage: http://www.wto.org/english/tratop_e/gproc_e/gpstat_e.htm

Note: Members of the GPA that have no available data are: Armenia, Iceland, Israel, and the Netherlands with respect to Aruba. Liechtenstein is not listed because it is not available in the GTAP Data Base.

* Number of trading partners in parenthesis

Appendix D: Numerical Example

Consider the numerical example of imports of motor vehicles and parts (GTAP sector 38) to the U.S. from Germany. In 2011, this was reported to amount to 28 billion USD, according to the UN Comtrade based TASTE Data. Thus $\sum_u \text{IMP}(38, u, \text{DEU}, \text{USA})$=28 billion USD. From the HS-BEC and the BEC-SNA concrodances, this was mapped to capital goods, intermediate, and final consumption end uses: The amount was delegated such that IMP(38,cgds,DEU,USA)=10.8 billion USD, IMP(38,cons,DEU,USA)=10.3 billion USD, and IMP(38,cgds,DEU,USA)=6.8 billion USD. Now this data is used to compute shares to break out the imports data from the standard GTAP model, VIMS(38,DEU,USA), which amounts to 27.4 billion USD.

To generate the value of imports for investment, consumption goods, and intermediate uses, we apply shares $\frac{\text{IMP(38,cgds,DEU,USA)}}{\sum_u \text{IMP(38,u,DEU,USA)}}$ =0.39, $\frac{\text{IMP(38,cons,DEU,USA)}}{\sum_u \text{IMP(38,u,DEU,USA)}}$ =0.37, and $\frac{\text{IMP(38,intm,DEU,USA)}}{\sum_u \text{IMP(38,u,DEU,USA)}}$ =0.24 to VIMS(38,DEU,USA), respectively. This give us VCGDS(38,DEU,USA)=10.6 billion USD, VCONS(38,DEU,USA)=10.1 billion USD, and VINTM(38,DEU,USA)=6.7 billion USD. Now we use these source- and agent-specific import values to generate the sourcing shares to apply to the agent-specific values of the standard GTAP Database (i.e. VIFM(38,j,DEU,USA), VIGM(38,DEU,USA), and VIPM(38,DEU,USA)).

From the value of imports for investment, VCGDS(38,DEU,USA), we generate $\frac{\text{VCGDS(38,DEU,USA)}}{\sum_s \text{VCGDS(38,s,USA)}}$=0.12. This share indicates that, across sources, the U.S. imports 12 percent of cars intended for investment from Germany. We apply this share to VIFM(38,'CGDS',USA)=78 billion USD to generate VIFMS(38,'CGDS',DEU,USA)=9.7 billion USD.

From the value of imports for intermediate use, VINTM(38,DEU,USA), we generate $\frac{\text{VINTM(38,DEU,USA)}}{\sum_s \text{VINTM(38,s,USA)}}$=0.09. This share indicates that, across sources, the U.S. imports 9 percent of cars intended for intermediate or industrial use from Germany. Due to lack of further data on industry specific sourcing, we apply this share to VIFM(38,j,USA) to generate VIFMS(38,j,DEU,USA), across all 57 sectors. As one might expect, the motor vehicles and parts sector in the U.S. is the largest importer of the commodity motor vehicles and parts, across sectors so we will consider this as a specific example. Applying the above described sourcing share of 0.09 to VIFM(38,38,USA)=39 billion USD, we find that the U.S. imports 3.5 billion USD of the commodity motor vehicles and parts from Germany (i.e. VIFM(38,38,DEU,USA)=3.5 billion USD).

From the value of imports for consumption, VCONS(38,DEU,USA), we generate $\frac{\text{VCONS(38,DEU,USA)}}{\sum_s \text{VCONS(38,s,USA)}}$=0.15. This share indicates that, across sources, the U.S. imports 15 percent of cars intended for final consumption from Germany. Without further information available, we apply this share to both VIGM(38,USA)=227 thousand USD and VIPM(38,USA)=87 billion USD to generate VIGMS(38,DEU,USA)=35 thousand USD and VIPMS(38, DEU,USA)=13 billion USD, respectively.[40]

[40] Please be aware that both shares and trade values are rounded, so simple accounting of the numbers above may not total as anticipated.

Appendix E: Table E1. 2011 Gross Fixed Capital Formation by institutional sector (Authors estimation based on data from EUROSTAT, OECD and UN data)

		Gross Fixed Capital Formation, in millions of USD			
No.	**Region/Country name**	**Corporate**	**Government**	**Household**	**Total**
1	Australia	215,269	46,984	107,844	370,097
2	New Zealand	20,791	5,125	4,730	31,689
3	Rest of Oceania	8,320	1,852	3,954	7,337
4	China	2,165,328	366,732	843,328	1,423,233
5	Hong Kong	38,283	7,242	13,123	41,557
6	Japan	820,384	183,393	200,083	1,009,586
7	Korea	245,854	60,751	65,863	296,057
8	Mongolia	2,728	516	935	1,475
9	Taiwan	56,148	10,621	19,246	81,238
10	Rest of East Asia	10,120	1,914	3,469	11,881
11	Brunei Darussalam	1,855	567	861	1,705
12	Cambodia	1,193	365	554	105,772
13	Indonesia	155,032	47,411	71,988	1,479
14	Lao People's Democratic Republic	1,280	391	594	36,822
15	Malaysia	39,506	12,082	18,344	21,465
16	Philippines	25,238	7,718	11,719	41,897
17	Singapore	44,197	18,871	11,692	62,298
18	Thailand	52,865	16,167	24,548	28,253
19	Viet Nam	23,938	7,321	11,115	4,105
20	Rest of Southeast Asia	9,596	2,935	4,456	17,213
21	Bangladesh	9,882	4,288	13,205	424,268
22	India	229,304	99,500	306,405	2,226
23	Nepal	1,661	721	2,220	32,383
24	Pakistan	10,469	4,543	13,989	8,386
25	Sri Lanka	6,083	2,639	8,128	3,779
26	Rest of South Asia	1,855	805	2,479	329,496
27	Canada	200,018	74,647	137,342	2,685,577
28	United States of America	1,517,678	609,585	747,335	219,053
29	Mexico	140,973	30,120	75,140	2,176
30	Rest of North America	985	1,280	507	61,866
31	Argentina	60,841	14,329	28,853	2,295
32	Bolivia	2,933	691	1,391	242,241
33	Brazil	267,923	64,846	142,047	32,903
34	Chile	40,147	5,244	10,325	45,250
35	Colombia	49,309	10,759	18,751	10,069
36	Ecuador	11,502	6,163	3,765	2,174
37	Paraguay	2,656	626	1,260	23,208
38	Peru	23,995	5,651	11,379	4,402

No.	Region/Country name	Gross Fixed Capital Formation, in millions of USD			
		Corporate	Government	Household	Total
39	Uruguay	5,287	1,245	2,507	56,249
40	Venezuela	35,433	8,345	16,804	1,750
41	Rest of South America	2,019	476	958	5,188
42	Costa Rica	4,773	1,119	1,366	6,453
43	Guatemala	3,853	1,183	1,883	4,044
44	Honduras	3,346	425	94	1,779
45	Nicaragua	1,119	373	480	5,655
46	Panama	8,410	1,972	2,406	3,112
47	El Salvador	1,963	838	519	251
48	Rest of Central America	109	26	31	46,314
49	Dominican Republic	5,048	1,544	2,344	81,544
50	Jamaica	1,694	518	786	113,355
51	Puerto Rico	7,334	2,243	3,406	5,155
52	Trinidad and Tobago	1,514	463	703	44,885
53	Caribbean	10,542	3,224	4,895	68,809
54	Austria	57,093	12,022	21,591	8,036
55	Belgium	73,617	11,549	31,746	55,540
56	Cyprus	2,086	967	1,532	569,405
57	Czech Republic	34,271	8,131	9,780	623,633
58	Denmark	33,421	10,653	14,119	68,777
59	Estonia	4,081	1,199	896	30,466
60	Finland	28,019	8,957	15,469	59,107
61	France	307,742	98,850	152,978	458,039
62	Germany	388,496	75,129	201,003	10,818
63	Greece	18,052	7,455	21,902	12,029
64	Hungary	16,556	4,201	3,866	16,283
65	Ireland	12,294	3,185	4,229	1,947
66	Italy	225,503	60,251	142,768	158,064
67	Latvia	4,794	1,661	904	97,403
68	Lithuania	4,885	2,203	1,569	51,912
69	Luxembourg	11,439	2,917	3,987	23,084
70	Malta	1,220	403	516	14,172
71	Netherlands	82,694	29,533	37,507	445,741
72	Poland	55,321	31,994	23,382	92,600
73	Portugal	25,265	8,202	9,824	504,785
74	Slovakia	14,740	3,279	4,412	97,231
75	Slovenia	6,293	2,108	2,061	88,982
76	Spain	185,740	53,379	70,882	7,049
77	Sweden	69,051	19,882	12,673	3,282
78	United Kingdom	207,938	61,620	102,469	12,839
79	Switzerland	97,156	18,589	24,966	16,143

No.	Region/Country name	Gross Fixed Capital Formation, in millions of USD			
		Corporate	Government	Household	Total
80	Norway	61,538	14,000	24,759	16,446
81	Rest of EFTA	1,471	1,677	636	51,113
82	Albania	2,279	667	937	287,765
83	Bulgaria	9,802	2,338	637	42,796
84	Belarus	18,497	1,654	3,697	1,778
85	Croatia	8,128	2,153	2,166	24,742
86	Romania	28,935	9,812	9,884	34,123
87	Russian Federation	275,887	62,986	76,923	837
88	Ukraine	25,402	3,230	3,204	6,209
89	Rest of Eastern Europe	1,483	105	182	3,409
90	Rest of Europe	13,020	2,881	4,368	7,510
91	Kazakhstan	29,624	8,426	3,072	2,901
92	Kyrgyzstan	1,858	76	402	5,659
93	Rest of Former Soviet Union	19,250	5,286	2,084	78,511
94	Armenia	1,840	485	295	31,880
95	Azerbaijan	6,293	6,309	1,173	22,576
96	Georgia	1,171	2,412	93	13,113
97	Bahrain	3,696	1,643	608	33,298
98	Iran Islamic Republic of	50,154	21,763	67,018	76,335
99	Israel	12,895	36,039	4,446	142,409
100	Jordan	2,544	5,242	201	65,219
101	Kuwait	19,461	4,359	15	27,717
102	Oman	5,693	11,730	451	28,319
103	Qatar	17,251	35,545	1,366	25,191
104	Saudi Arabia	103,664	50,580	1,468	8,686
105	Turkey	41,242	129,486	3,265	60,906
106	United Arab Emirates	32,316	66,587	2,559	3,440
107	Rest of Western Asia	21,356	44,005	1,691	1,917
108	Egypt	26,239	7,256	8,713	5,196
109	Morocco	18,777	3,723	10,232	14,755
110	Tunisia	4,682	2,376	3,180	3,600
111	Rest of North Africa	44,561	12,026	19,844	5,313
112	Benin	1,359	580	359	12,623
113	Burkina Faso	664	643	232	14,898
114	Cameroon	2,799	856	1,300	4,517
115	Cote d'Ivoire	1,177	503	311	5,194
116	Ghana	6,907	2,949	1,827	3,211
117	Guinea	420	240	324	881
118	Nigeria	40,649	17,356	10,754	1,744
119	Senegal	2,100	642	975	1,152
120	Togo	580	248	153	4,973

No.	Region/Country name	Gross Fixed Capital Formation, in millions of USD			
		Corporate	Government	Household	Total
121	Rest of Western Africa	7,596	2,452	1,868	2,289
122	Central Africa	13,734	4,200	6,377	2,759
123	South Central Africa	8,909	2,724	4,137	1,146
124	Ethiopia	4,953	1,515	2,300	13,779
125	Kenya	4,087	1,250	1,898	3,430
126	Madagascar	866	265	402	2,218
127	Malawi	418	128	194	57,342
128	Mauritius	1,614	494	749	526
129	Mozambique	2,229	682	1,035	31
130	Rwanda	730	223	339	32
131	Tanzania	4,845	1,482	2,250	33
132	Uganda	1,893	579	879	34
133	Zambia	2,383	729	1,107	35
134	Zimbabwe	1,151	352	534	36
135	Rest of Eastern Africa	8,456	2,434	4,399	37
136	Botswana	2,933	815	414	38
137	Namibia	1,069	1,517	151	39
138	South Africa	57,385	12,256	8,105	40
139	Rest of South African Customs Union	481	134	68	41
140	Rest of the World	27	6	13	42

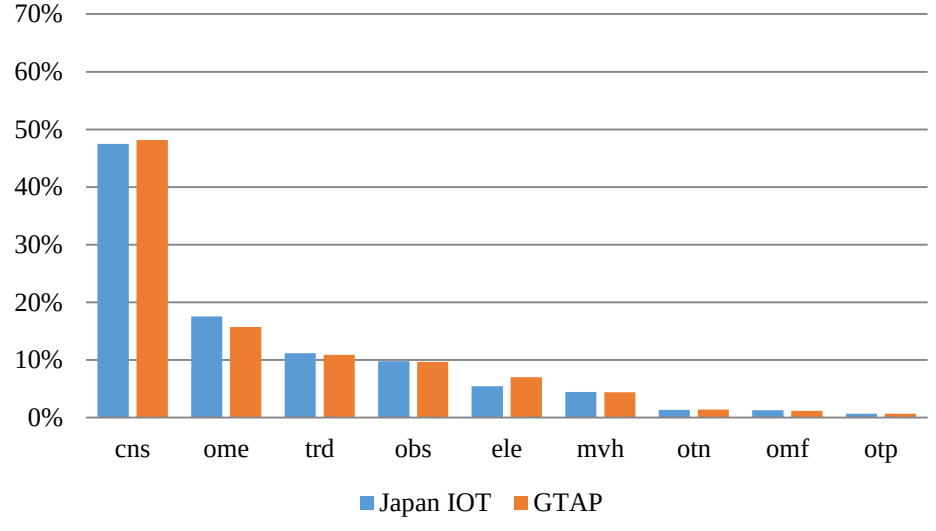
Appendix F: Investment Decomposition

The GTAP Data Base reports Gross Fixed Capital Formation (GFCF) for 120 countries and 20 regions. In order to determine how much of this corresponds to government investment, we compute shares based on data from the OECD, the United Nations (UN) and EUROSTAT as reported in the Interim Report of this project.

While we have been able to obtain data to distinguish private from government investment, this has been at the aggregate level. Investment by product is not readily available for many countries in major data providers. Government investment by product is also not readily available. IO tables, however, do decompose total investment by products and this is captured in the GTAP Data Base. Therefore, for the interim report, we have proceeded under the assumption that the product decomposition for government and private investment is the same as total investment in GTAP. In order to get a sense of the simplifying assumption, we obtained detailed information for four countries with actual data on the composition of government investment, these are: Australia, Canada, France, US, and Japan.[41]

The data for each country was processed separately, meaning that each country has its own data aggregation. We match the aggregation for each country using the GTAP Data Base. Figure F1 shows the decomposition of investment based the Input Output table for Japan and Japan information from the GTAP Data Base version 8 (Narayanan et al. 2012). Other countries' figures are included at the end of this appendix note.

Figure F1. Japan's investment decomposition[42]



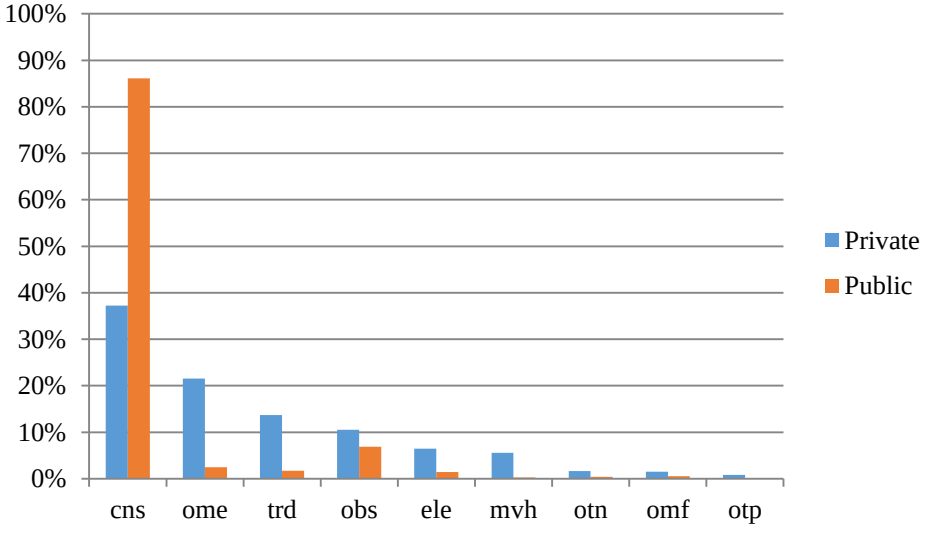
[41] We also searched for this kind of data from the German National Statistical Office website and contacted EUROSTAT's staff working on EU-IO tables, but the data were not available.

[42] Only the top commodities are listed. We are using GTAP three-letter sector codes. Detailed description of the 57 GTAP sectors can be found at: https://www.gtap.agecon.purdue.edu/databases/contribute/detailedsector.asp

Discrepancies are expected between GTAP data and the detailed IO tables information because GTAP data was constructed with earlier data, except for Japan. For example, GTAP 9 was constructed with a Canadian IO table with reference year 2003, France's IO table of 2000, and Australian IO table of 2005-2006, and we are comparing against more recent data for Canada (2010), France (2007), and Australia (2009-2010). For Japan we are using the same data contributed to GTAP; the small discrepancies, less than 2%, that are observed in Construction (cns), Machinery and equipment (ome), and Electronic equipment (ele) can be attributed to differences in data processing.

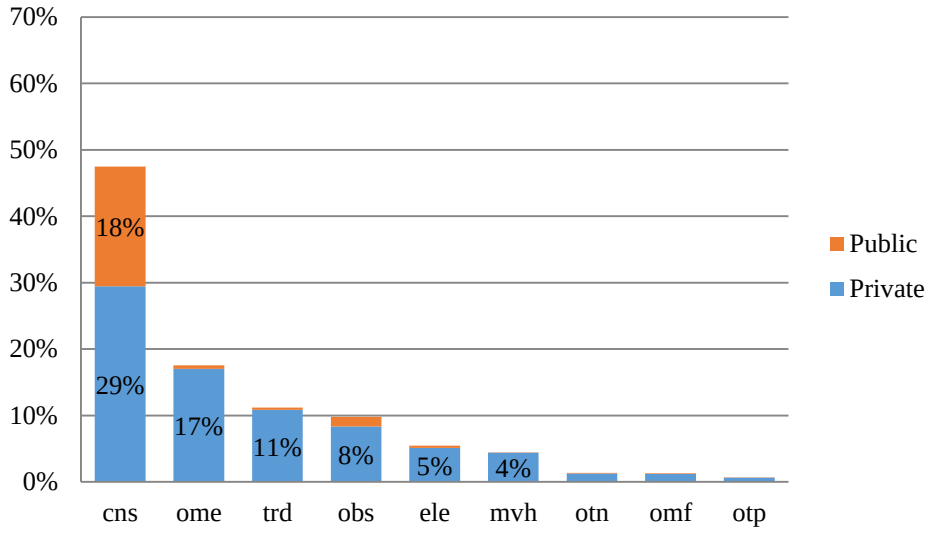
The figures show that Construction is the main component of total investment. Other important products for total investment in all four countries are: Machinery and equipment (ome), Trade (trd), and Other business services (obs). Initially, we assumed that the composition of total investment holds for private and public investment. Figure F2, however, shows that the relevance of Construction in public investment in Japan is higher than originally assumed. Other countries' figures are included at the end of the note.

Figure F2. Japan's private and public investments decomposition



Note that private investment composition is computed with respect to total private investment. Similarly, public investment composition is computed with respect to total public investment. In Figure F2, public investment on construction represents 86 per cent of public investment in Japan, however, with respect to total investment, it accounts for 18 per cent. Figure F3 shows Japan's investment by products as in Figure F1 and it further distinguishes between private and public investment.

Figure F3. Japan's investment decomposition by commodity and institution



Given that these detailed data provide valuable information, we used it to supplement our modifications to the GTAP Data Base. For all GTAP countries, we use a weighted average allocation based on time series data. We use time series data for these countries in order to prevent the possibility of bias of one year observation (i.e., diminish the possibility of picking a year with atypical high investment).[43] We believe this approach is better than our initial assumption, but still far from perfect. The structure of these five developed economies would be applied on less developed economies. Given the scarcity of data, however, the proposed approach would provide a setup to be used as better data for other countries become available.

Revised Data References

Data for Australia includes the following years: 1998-1999, 2001-2002, 2004-2005, 2005-2006, 2006-2007, 2007-2008, 2008-2009, 2009-2010, and 2012-2013. Retrieved from: http://www.abs.gov.au/

Data for Canada includes the years 2009, 2010, and 2011. Retrieved from: http://www.statcan.gc.ca/

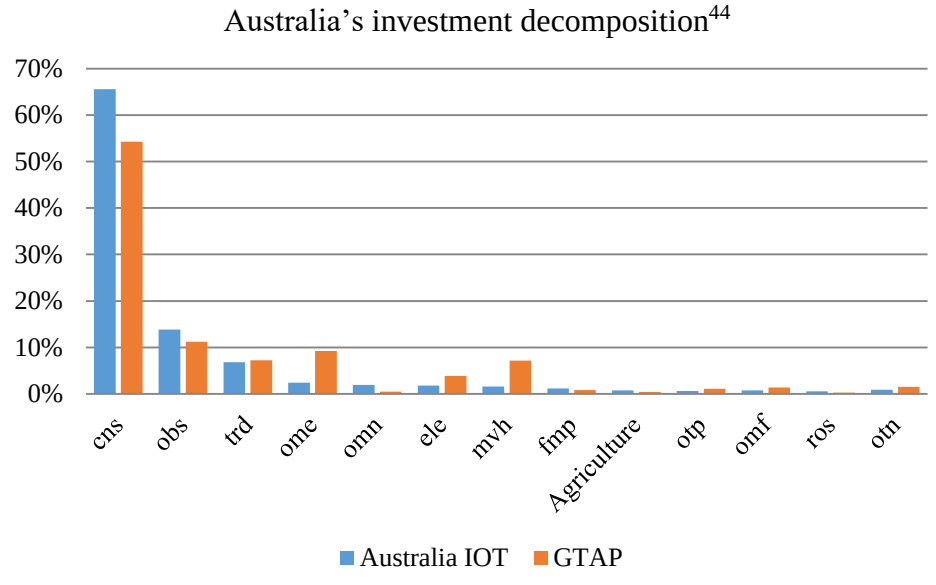
Data for France spans 34 years from 1978 to 2011. Retrieved from: http://www.insee.fr/en/

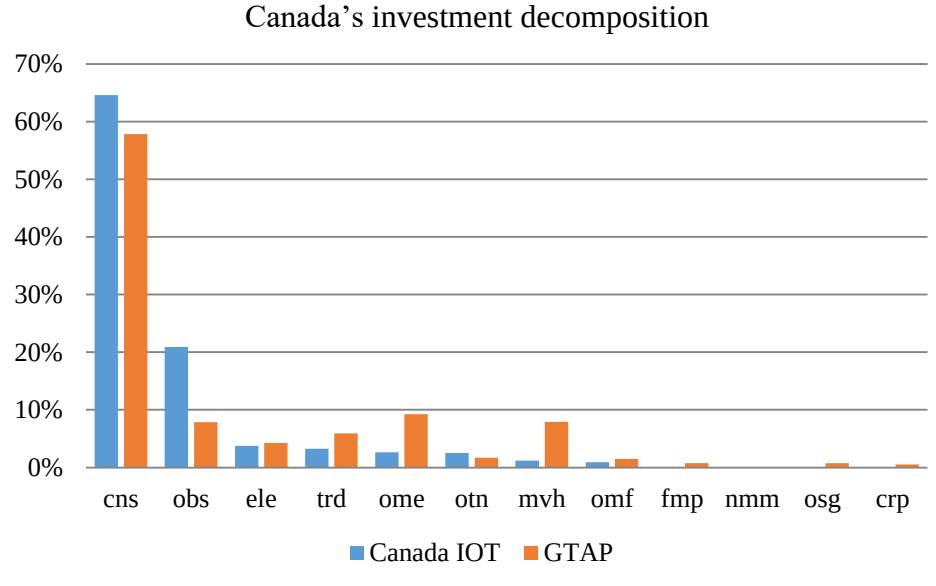
Data for Japan includes the following years: 1995, 2000, 2005 and 2011. Retrieved from: http://www.soumu.go.jp/english/dgpp_ss/data/io/index.htm

Narayanan, G., Badri, Angel Aguiar and Robert McDougall, Eds. 2012. *Global Trade, Assistance, and Production: The GTAP 8 Data Base*, Center for Global Trade Analysis, Purdue University

[43] Although the analysis of this appendix note was prepared using GTAP Data Base version 8, its conclusions also apply for the use of GTAP version 9, which is the data that was used in this paper.

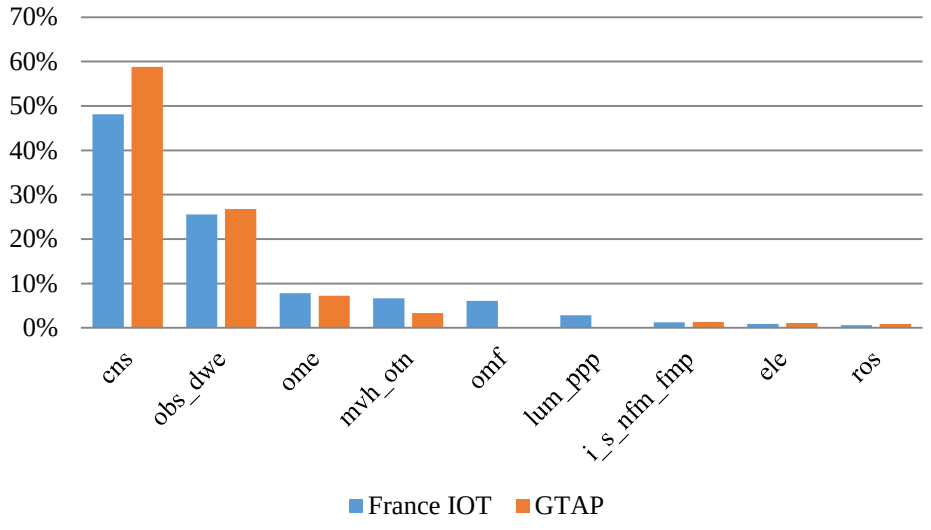
Other Figures



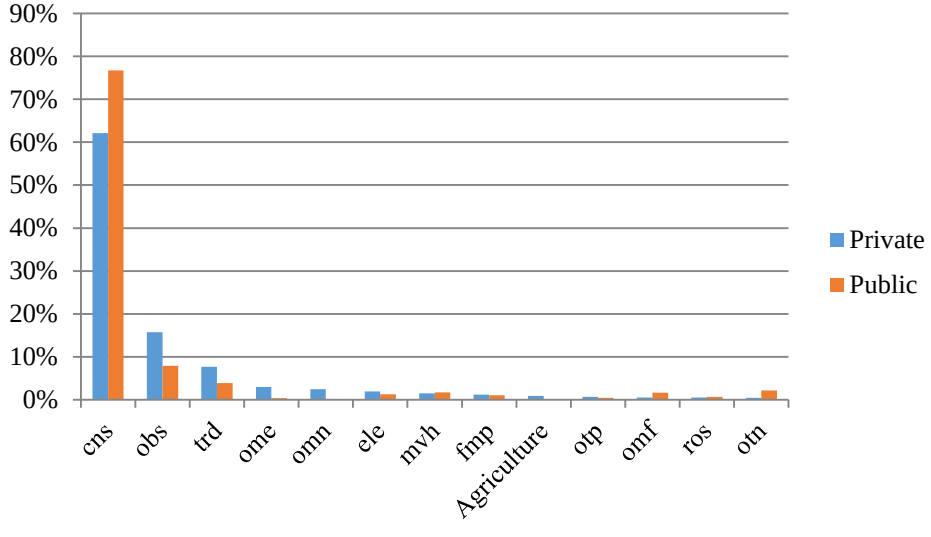


[44] For Australia Agriculture includes GTAP sectors: pdr, wht, gro, ocr, ctl, rmk, wol.

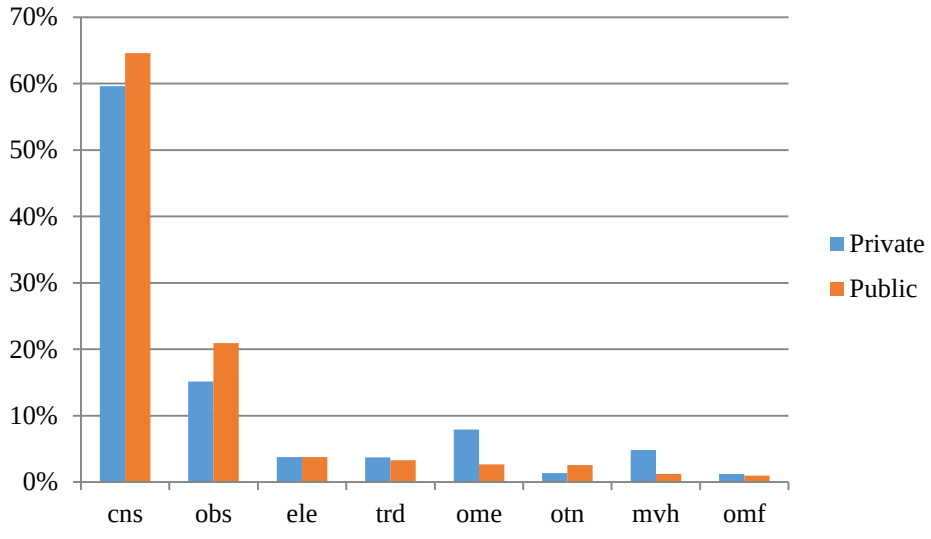
France's investment decomposition



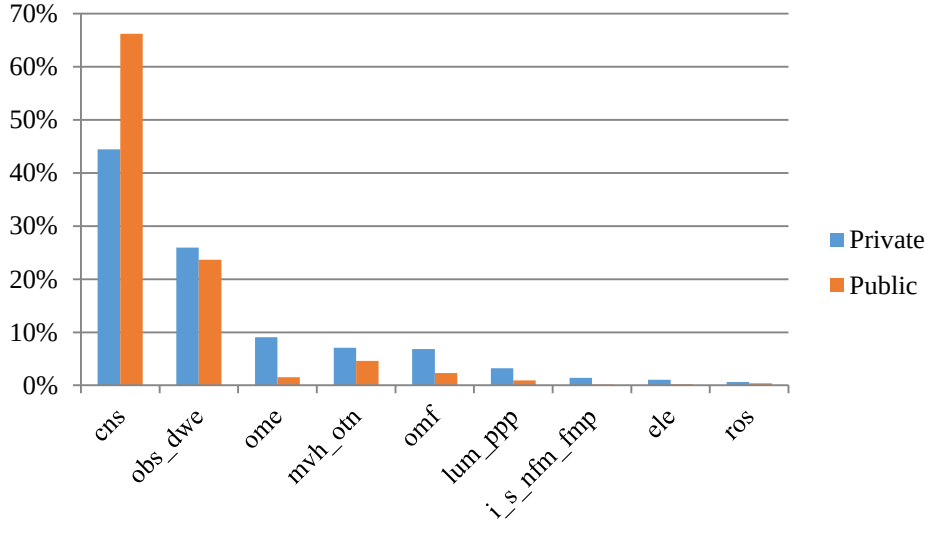
Australia's private and public investments decomposition



Canada's private and public investments decomposition



France's private and public investments decomposition



6. Glossary of Technical Terms

BEC-SNA	Concordance for trade data under the Broad Economic Categories by the end use specified by the System of National Accounts (SNA).
CGE	Computable General Equilibrium type of model.
CGDS	Represents capital goods in the GTAP Data Base.
HS	Harmonized System (Harmonized Commodity Description and Coding System).
HS-BEC	Concordance for trade data between the Harmonized System (HS) classification and the Broad Economic Categories (BEC). This is available for three different years (1996, 2002, and 2007).
IMP	Value of imports for the construction of GTAP-MRIO
Leontief	Here it represents a production function under the assumption of fixed proportions.
MRIO	A multiregional input-output (MRIO) framework extends the traditional IO framework by distinguishing imports by country of origin as well as by end use. End uses may include both imported products used in the production of another product (also called intermediate use) as well as imports for final demands, including investment, government consumption and private demands.
OSG	Represents Other services (Government) sector in the GTAP Data Base.
VCGDS	Data coefficient for GTAP MRIO construction that captures the portion of VIMS that goes into investment uses.
VCONS	Data coefficient for GTAP MRIO construction that captures the portion of VIMS that goes into final consumption uses.
VIFM	Data coefficient in the GTAP Data Base that accounts for firms' imports in region r, valued at market prices.
VIFMS	New data coefficient in GTAP MRIO that accounts for firms' imports from region s to region r, valued at market prices.
VIGM	Data coefficient in the GTAP Data Base that accounts for government's imports in region r, valued at market prices.
VIGMS	New data coefficient in GTAP MRIO that accounts for governments' imports from region s to region r, valued at market prices.
VIMS	Data coefficient in the GTAP Data Base that accounts for total imports i from region s to r, valued at market prices for GTAP commodities and regions.
VINTM	Data coefficient for GTAP MRIO construction that captures the portion of VIMS that goes into intermediate uses.
VIPM	Data coefficient in the GTAP Data Base that accounts for private households' imports in region r, valued at market prices.
VIPMS	New coefficient in GTAP MRIO that accounts for private households' imports from region s to region r, valued at market prices.