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Augmenting the GTAP Database: Are the Data on Intra Institutional Transactions Important?

Yontem Sonmez

Scott McDonald

Terrie Walmsley

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Correspondence Address: University of Central Lancashire, Lancashire Business School, Greenbank 132, Preston, PR1 2HE, email: ysonmez@uclan.ac.uk

1. Introduction

The Global Trade Analysis Project's (GTAP) database is used to calibrate the vast majority of global computable general equilibrium (CGE) models. But all versions of the database have been parsimonious in their coverage of intra institutional transactions within and between regions; consequently domestic institutions – private households, (incorporated) enterprises and government - neither pay income taxes nor save and they are not recipients of incomes or transfers from other regions. Some of the constraints imposed by these limitations of the GTAP database have been partially addressed; McDougall and Hagemejer (2009) seek to include incomes taxes paid by households and enterprises as taxes paid factors, Walmsley et al., (2007) include details on labour incomes from abroad as part of the GMig satellite accounts, and McDonald and Sonmez (2004) augmented the current accounts so as to separate out the non trade balance elements from the balance on the capital account.

The objectives of this study are to augment version 7.1 of the GTAP database and provide a method for augmenting future versions of the GTAP database. The process of augmentation will take place within a Social Accounting Matrix (SAM) representation of the GTAP database and will preserve the majority of the key macroeconomic aggregates that are embedded within version 7.1 of the GTAP database. A longer term objective is to provide a method whereby GTAP can incorporate a wider range of macro economic aggregates into the generation of the database. This aspect of the research will involve the development of a method whereby a complete and consistent global macro (aggregate) SAM can be devised from available and comparable data sources – primarily World Bank and IMF.

The motivation for augmenting the GTAP database comes from two key considerations for policy analyses. First, the limited degree of detail on the external accounts of regions impedes the development of valid policy conclusions. In circumstances, where the inter-regional transactions on the external account of primary income and current transfers are substantial, e.g., aid, workers' remittances, etc., there is the potential for significant distortions. And second, the GTAP databases are increasingly being used for policy analyses where the intra regional transactions data are as important as the inter regional transactions data; hence details on intra institutional transactions are increasingly a potentially important consideration.

In order to illustrate the potential benefits from augmenting the GTAP database two simple policy experiments are implemented. The first focuses upon trade liberalisation with tax replacement in a developing region where official transfers are a large component of

government revenue, while the second examines a tax replacement scenario wherein a direct tax is used to replace revenue lost from an indirect tax. Both experiments indicate that models estimated using this augmentation of the GTAP database may, under certain circumstances, produce substantially different results and hence may enhance the quality of the analysis.

2. Method

The macro SAMs will have the structure detailed in Table 1. Consistent with the immediate objectives the project will, where appropriate, compute control totals for the macro SAM from the existing GTAP database; in Table 1 these totals are indicated by 'GTAP'. Additional data requirements are indicated by 'Derive'. Some of the values are calculated as residuals, these are also indicated by 'Derive'. All other entries are zero.

A major complication is that many of the aggregates that will need deriving are subject to non trivial annual fluctuations whereas private and government consumption and trade volumes are subject to much smaller annual variation. It will therefore be necessary to 'average' data for a number of years around the benchmark year for the GTAP database so as to ensure augmented data are typical.

For the macro SAMs to be useful it is necessary that they are complete and consistent with respect to both the transactions, and national accounts, for each region but also between regions. Since it is highly unlikely that the collected data will be immediately consistent, and even if they were consistent the need to 'average' some of the data, it will be necessary to use some form of estimation procedure to derive complete and consistent macro SAMs. This study will use an entropy metric estimation procedure (Robinson and McDonald, 2004) to assist with this stage of the project.

2.1. Data Sources

The primary additional data sources will be

1. IMF BOP data on inter-regional transactions,i.e. income and current transfers of current account; 'investment income' and 'general government transfers' and 'other current transfers';
2. GMig2 data on bilateral workers' remittances data (based on compensation of employees and remittances data);
3. IMF GFS data on value added tax and IFS data on government saving/deficit; and
4. IMF WEO data on GDP.

Table 1 Macro Social Accounting Matrix

		Commodity	Activity	Factors		Households	Enterprises	Government					Income/Expenditure	Capital Account	Trade Margins	Rest of the World
				Labour	Capital			Import duties	Export taxes	VAT	Other Indirect taxes	Direct taxes				
Commodity		0	GTAP	0	0	GTAP	0	0	0	0	0	0	GTAP	GTAP	GTAP	GTAP
Activity		GTAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Factors	**Labour**	0	GTAP	0	0	0	0	0	0	0	0	0	0	0	0	Derive
	Capital	0	GTAP	0	0	0	0	0	0	0	0	0	0	0	0	Derive
Households		0	0	Derive	Derive	0	Derive	0	0	0	0	0	0	0	0	Derive
Enterprises		0	0		Derive	0	0	0	0	0	0	0	0	0	0	Derive
Government	**Import duties**	GTAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Export taxes	GTAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VAT	Derive	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other Indirect taxes	Derive	GTAP	Derive	Derive	0	0	0	0	0	0	0	0	0	0	0
	Direct taxes	0	0	0	0	Derive	Derive	0	0	0	0	0	0	0	0	0
	Income/Expenditure	0	0	0	0	0	0	GTAP	GTAP	Derive	Derive	Derive	0	0	0	Derive
Capital Account		0	0	0	GTAP	Derive	Derive	0	0	0	0	0	Derive	0	0	Derive
Trade Margins		GTAP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rest of the World		GTAP	0	Derive	Derive	Derive	Derive	0	0	0	0	0	Derive	0	0	0
Total		GTAP	GTAP	GTAP	GTAP	Derive	Derive	Derive	Derive	Derive	Derive	Derive	Derive	GTAP	GTAP	GTAP

2.2 SAM Transactions

2.3 SAM Augmentation

3. A Global Social Accounting Matrix and the GTAP Database

The data for this study are derived from the GTAP database version 7.1, which is benchmarked to the year 2004 (Narayanan and Walmsley, 2008). The form of the database used for this study is a Social Accounting Matrix (SAM) representation of the Global Trade Analysis Project (GTAP) database version 7.1 (McDonald and Thierfelder, 2004). The GTA project produces the most complete and widely available database for use in global computable general equilibrium (CGE) modelling; indeed the GTAP database has become generally accepted as the preferred database for global trade policy analysis and is used by nearly all the major international institutions and many national governments. Hertel (1997) provides an introduction to both the GTAP database and its companion CGE model. The precise version of the database used as the starting point for this study is a reduced form global SAM representation of the GTAP data (McDonald *et al*. 2007).

The analyses are carried out by using a 12-sector, 4-factor and 15-region global computable general equilibrium model -GLOBE CGE - that is implemented in GAMS (McDonald *et al*. 2005). For this study a method for augmenting the GTAP database using additional IMF and GMig2 data on bilateral remittance, differentiated according to the skill type- as skilled and unskilled - have been implemented as an extension to a global representation of the GTAP database (McDonald and Thierfielder, 2004). Due to the availability of bilateral remittance data there was no need for an additional region called "globe". For modelling remittances in the absence of bilateral remittance data one can refer to McDonald and Sonmez (2006).
The accounts in the SAM are detailed below.

Table 2: SAM and Model Accounts

Sectors		**Regions**	
agri	Agriculture	**tur**	Turkey
mins	Minerals	**gbr**	United kingdom
fod	Food products	**fra**	France
text	Textiles	**deu**	Germany
petch	Petroleum and coal products	**ita**	Italy
mets	Metals	**reu**	Rest of the EU15
veh	Vehicles	**swe**	Sweden
omanu	Other manufactures	**grc**	Greece
util	Utilities	**cyp**	Cyprus
serv	Services	**asia**	Asia

trad	Trade and transport	**usa**	USA
cns	Construction	**can**	Canada
		aus	Australia
		row	Rest of the world
		Factors	
		land	Land and nat res
		unsklab	Unskilled labour
		sklab	Skilled labour
		capital	Capital

Source: GTAP Database

3.2. Globe CGE Model

This model is a member of the class of computable general equilibrium (CGE) models that are descendants of the approach to CGE modelling described by Dervis *et al*., (1982). The implementation of this model, using the GAMS (General Algebraic Modeling System) software, is a direct descendant and development of the single country models devised in the late 1980s and early 1990s, particularly the model reported by Robinson et al., (1990), and the multi-country model developed to analyse NAFTA (see Lewis *et al*., 1995, for a later application).

The model is a SAM based CGE model, wherein the SAM serves to identify the agents in the economy and provides the database with which the model is calibrated. Since the model is SAM based it contains the important assumption of the law of one price, i.e., prices are common across the rows of the SAM. The SAM also serves an important organisational role since the groups of agents identified by the SAM structure are also used to define sub-matrices of the SAM for which behavioural relationships need to be defined. As such the modelling approach has been influenced by Pyatt's 'SAM Approach to Modeling' (Pyatt, 1987).

3.2.1. Trade

Trade is modelled using a treatment derived from the Armington 'insight'; namely domestically produced and consumed commodities are assumed to be imperfect substitutes for both imports and exports. Import demand is modelled via a series of nested constant elasticity of substitution (CES) functions; imported commodities from different source regions are assumed to be imperfect substitutes for each other and are aggregated to form composite import commodities that are assumed to be imperfect substitutes for their counterpart domestic commodities The composite imported commodities and their counterpart domestic commodities are then combined to produce composite consumption commodities. These are the commodities demanded by domestic agents as intermediate inputs and for final demand by households, the government, and for investment.

Export supply is modelled via a series of nested constant elasticity of transformation (CET) functions; the composite export commodities are assumed to be imperfect 'substitutes' for domestically consumed commodities, while the exported commodities from a source region to different destination regions are assumed to be imperfect 'substitutes' for each other. The composite exported commodities and their counterpart domestic commodities are then combined to produce composite production commodities. The properties of models using the Armington 'insight' are well known (see de Melo and Robinson, 1989; Deverajan et al., 1990), but it is worth noting here that this model differs from the GTAP model through the use of CET functions for export supply; this ensures that domestic producers adjust their export supply decision in response to changes in the relative prices of exports and domestic commodities, which help to moderate the magnitude of the terms of trade effects in this class of model. Homogeneity can be imposed for all or any subset of commodities and regions.

3.2.2. Production

The production structure is a two stage nest. Intermediate inputs are used in fixed proportions per unit of output – Leontief technology. Primary inputs are combined as imperfect substitutes, according to a CES function, to produce value added.

3.2.3. Final Consumption

Final demand by the government and for investment is modelled under the assumption that the relative quantities of each commodity demanded by these two institutions are fixed – this reflects the absence of a clear theory that defines an appropriate behavioural response by these agents to changes in relative prices. For the household there is however a well developed behavioural theory; hence the model contains the assumption that households are utility maximisers who respond to changes in relative prices and their incomes. In this version of the model the utility functions for the private households are assumed to be Stone-Geary, which yields linear expenditure systems that allow for subsistence consumption, and reduce to Cobb-Douglas utility functions where minimum levels of consumption are not specified.

4. Policy Experiments and Model Closure

4.1. Policy Experiments

Two different policy experiments are analysed for this study in order to compare the differences in results when using an augmented SAM representation of the GTAP database and the existing one. The policy experiments are as follows:

The first focuses upon trade liberalisation with tax replacement in a developing region where official transfers are a large component of government revenue, while the second examines a tax replacement scenario wherein a direct tax is used to replace revenue lost from an indirect tax. Due to the limitations of space, only a subset of possible results will be presented, but references are made to other results, where they provide additional insights.

4.2 Model Closure

The model closures adopted for this study are detailed below:

Foreign Exchange Account Closure

A flexible exchange rate regime not a fixed one is assumed for this study. In the foreign exchange account of the model closures, the current account balance is fixed at the 2004 level so that a specific balance of payments deficit can be maintained but not worsened. Exchange rates are flexible to ensure that the trade balance clears, i.e. balance of payments is maintained via the changes in exchange rate.

Investment – Savings (Capital Account) Closure

Keynesian view of investment driven savings is assumed as the capital account closure. The shares of investment absorption and therefore the share of domestic final demand of investment are fixed. Then, the household savings adjust in an additive mode to equate total savings to total investment. Both the volume and value of investment are free to adjust.

Government Account Closure

The government savings/deficit; internal balance is fixed at the 2004 level together with the shares of government expenditure in final demand. The government budgets are cleared by adjusting the value added tax rates additively. Both the value and the volume of expenditures are free to adjust. The shares of government expenditure in final demand are fixed. Internal balance is fixed. Tax rate adjusters are fixed except the uniform adjustment to value added tax, i.e. the government budgets are cleared by additive changes in the household income tax rates.

Factor Market Closure

For this model, unemployment of unskilled labour in the chosen African economy, Asia and rest of the world is assumed given the unemployment rates in those regions. Therefore, the wage rates are fixed and the total supplies of labour are endogenously determined.

Numéraire

The model is homogenous of degree zero one in prices and it is only the relative prices which are determined, CPI is chosen to be the base. The region specific consumer price indices and the regions in the global numéraire are separately identified OECD countries[1].

For the rest of the countries, flexible exchange rates, investment driven economy, fixed shares of government expenditure in final demand and fixed internal balance is assumed where the government budgets are cleared by additive changes in value added tax rates. Also for the factor market, balanced macroeconomic closure has been assumed with full employment.

5. Results

6. Concluding Comments

7. References

Badri Narayanan G. and Terrie L. Walmsley, Editors (2008). *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

de Melo, J. and Robinson, S., (1989). 'Product Differentiation and the Treatment of Foreign Trade in Computable General Equilibrium Models of Small Economies', Journal of International Economics, Vol 27, pp 47-67.

Dervis, K., J. de Melo, and S. Robinson (1982) General Equilibrium Models for Development Policy, Cambridge University Press.

Devarajan, S., Lewis, J.D. and Robinson, S., (1990). 'Policy Lessons from Trade-Focused, Two-Sector Models', Journal of Policy Modeling, Vol 12, pp 625-657.

Dimaranan, Betina V. and Robert A. McDougall, Editors (2005) *Global Trade,Assistance, and Production: The GTAP 6 Data Base*, Center for Global Trade Analysis, Purdue University.

Hertel, T.W., (1997). Global Trade Analysis: Modeling and Applications. Cambridge: Cambridge University Press.

Lewis, J., Robinson, S. and Wang, Z. (1995) 'Beyond the Uruguay Round: The Implications of an Asian Free Trade Area'. China Economic Review, Vol. 6, No. 1, pp. 35-90.

McDonald, S. and Sonmez, Y., (2004). 'Augmenting the GTAP Database with Data on Inter-Regional Transactions', Sheffield Economics Research Paper 2004:009. The University of

[1] Australia, Canada,, USA, France, Germany, the UK, Italy, Sweden

McDonald, S. and Thierfelder, K., (2004). 'Deriving a Global Social Accounting Matrix from GTAP version 5 Data', Sheffield Economics Research Paper 2004002.

McDonald, S., Robinson, S. and Thierfelder, K., (2005). 'A SAM Based Global CGE Model usingGTAP Data', Sheffield Economics Research Paper 2005:001. The University of Sheffield.

McDonald, S., Thierfelder, K. and Robinson, S., (2007) 'Globe: A SAM Based Global CGE Model using GTAP Data', Economics Working Paper, US Naval Academy, Annapolis, USA.

McDonald, S., Thierfelder, K., Robinson, S. (2008) 'Asian Growth and Trade Poles: India, China and East and Southeast Asia', *World Development*, 36(2), 210-234.

McDougall, R. and Hagemejer, J., (2009). GTAP 7 Data Base Documentation - Chapter 13: Income and Factor Taxes. (www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2939)

Pyatt, G., (1987). 'A SAM Approach to Modelling', Journal of Policy Modeling, Vol 10, pp 327-352.

Robinson, S., Kilkenny, M. and Hanson, K. (1990) 'USDA/ERS Computable General Equilibrium Model of the United States'. Economic Research Services, Staff Report No. AGES 9049, USDA, Washington DC.

Walmsley, T., Winters, A. and Ahmed, S. A. (2007) 'Measuring the Impact of the Movement of Labor Using a Model of Bilateral Migration Flows', GTAP Technical Papers: 2529, Centre for Global Trade Analysis, Department of Agricultural Economics, Purdue University.