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ABSTRACT

This paper describes the construction of the East Asia inter-regional social accounting matrix (EA-IRSAM). The first section describes the basics of the social accounting matrix. The next section presents procedures to construct EA-IRSAM based on the Global Trade Analysis Project (GTAP) Power version 9 database. The last section describes two extensions of IRSAM analyses used in this paper, namely inter-regional constrained fixed price multiplier (IR-CFPM) and microsimulation of household income.

Keywords: Climate change, social accounting matrix, East Asian economy

INTRODUCTION

This paper describes the construction of the East Asia inter-regional social accounting matrix (EA-IRSAM). East Asia region, in this paper, is defined based on the Energy Market Integration (EMI) declaration in 2005 during the East Asian Summit (EAS) in Kuala Lumpur, Malaysia. In the 2005 EAS, ASEAN countries and six partner countries, namely Australia, China, India, Japan, South Korea, and New Zealand, agreed to initiate EMI (Wu, Shi and Kimura 2011). Therefore, there are 12 countries in EA-IRSAM: Australia, China, Japan, India, South Korea, Indonesia, Malaysia, Singapore, the Philippines, Thailand, Vietnam, and the rest of ASEAN Malaysia. Also, the selection of the countries in EA-IRSAM is in line with the objective of this paper. The main objective of this paper is to observe the socio-economic and environmental impacts of the integrated electricity market, renewable electricity development, and decarbonisation in the East Asia region[1].

This paper has two-fold objectives. First, this paper aims to provide details on the EA-IRSAM construction. The details will enable replication or modification of EA-IRSAM in future research. Second, this paper describes two extensions of IRSAM analyses, namely inter-regional constrained fixed price multiplier (IR-CFPM) and microsimulation of household income using IRSAM.

This paper consists of four main sections that are divided into several subsections as follows. The first section, on social accounting matrix, briefly explains the basic structure of social accounting matrix (SAM), structure of East Asia inter-regional social accounting matrix (EA-IRSAM), and various data sources to construct EA-IRSAM. The second section describes the steps

[1] Even though New Zealand was one of a country that signed EMI in 2005, this paper excludes New Zealand from EA-IRSAM because the economy size of New Zealand in 2011 was relatively small compared to Australia and other East Asia countries.

to construct EA-IRSAM: extraction of the GTAP Power 9 database, construction of global SAM, and construction of EA-IRSAM. Then, the next section explains two extensions of this paper: inter-regional constrained fixed price multiplier (IR-CFPM) and microsimulation of household income using IRSAM. Finally, the last section concludes.

SOCIAL ACCOUNTING MATRIX

Basic structure of the social accounting matrix

The social accounting matrix (SAM) is a square matrix that represents an economy in a particular year (Pyatt and Round 1985). There are two basic features of SAM: balanced account and segregation of endogenous and exogenous accounts. First, the balanced account feature implies that accounts in SAM should have equal corresponding total rows and columns. In other words, the income and expenditure of an account in SAM should be exactly similar in a country (King, 1985; Pyatt, 1988).

Second, segregation of the endogenous and exogenous accounts emphasises the interaction of production activities and households through factors and commodities markets (Round 2003). In a policy context, the endogenous account is the policy objectives, while exogenous accounts are the policy instruments directed by the policymakers (Bellù 2012). Therefore, the accounts in SAM are disaggregated into endogenous and exogenous accounts. The endogenous accounts cover production activities, factors, and institutions (usually households), while exogenous accounts consist of government, capital, and the rest of the world (Defourny and Thorbecke 1984).

Figure 1 presents a simplified schematic of SAM. In Figure 1, incomes correspond to the row's total, while expenditures correspond to the column's total. In SAM, the balanced accounts imply that incomes should always be equal to expenditure. Therefore, the total row value should be equal to the corresponding column value, such that $y_i = y_i{}'$ where $i = 1,2,3$. Also, the exogenous accounts values should be equal ($y_x = y_x{}'$).

Figure 1. Simplified Schematic SAM

			Expenditures				
			Endogenous Account			Exogenous Account	Total
			Production Activities	Factors	Institutions		
Incomes	Endogenous Accounts	Prod.	T_{11}		T_{13}	x_1	y_1
		Fact.	T_{21}			x_2	y_2
		Ins.		T_{32}	T_{33}	x_3	y_3
	Exogenous Account		I_1	I_2	I_3		y_x
	Total		y_1'	y_2'	y_3'	y_x'	

Source: Defourny & Thorbecke (1984)

The square matrix of SAM in Figure 1 consists of several submatrices. T_{11} is the intermediate input requirements and similar to the input-output transaction matrix. T_{13} represents the pattern of expenditure for each institution. In this submatrix, the institutions consume commodities that are produced by production activities. T_{21} is the value-added matrix, in which the production activities generate value-added, and it is recorded as income for production factor. T_{32} is income distributions from the production factors into institutions and T_{33} is inter-institutional transfers among government, firm, and household. The exogenous accounts are represented by x_i where $i = 1,2,3$, while leakages are represented by I_i where $i = 1,2,3$.

Structure of East Asia inter-regional social accounting matrix

The inter-regional social accounting matrix (IRSAM) is a combination of two or more single regions SAM. Several features of IRSAM, similar to single region SAM, are balanced accounts and interaction of production activities and households through factors and commodities markets. Nonetheless, IRSAM has a trade matrix between regions that do not exist in a single region SAM.

Table 1. List of EA-IRSAM account Set

Production Sectors		**Regions**
Agriculture	Gas manufacture distribution	Australia
Farming	Water	China
Forestry	Construction	Japan
Fishing	Trade	India
Coal	Transportation	South Korea
Oil	Communication	Indonesia
Gas	Financial services	Malaysia
Minerals *nec*	Public administration, defence, health, and education	Philippines
Food and beverages		Singapore
Textile and leather products		Thailand
Wood and paper products	Dwellings and other services	Vietnam
Petroleum products		Rest of ASEAN
Chemical, rubber, and plastic products		Rest of the World
Mineral products *nec*	**Factors**	
Metal products	Capital	**Institutions**
Manufacturing	Land	Firm
Wind power electricity	Natural resources	Government
Hydropower electricity	Skilled Labour	Rural household
Solar power electricity	Unskilled Labour	Urban household
Coal power electricity		
Oil power electricity	**Other Accounts**	
Gas power electricity	Import Tax	
Other power electricity	Indirect Tax	
Transmission and Distribution	Savings-Investment	

Table 1 describes the sets of EA-IRSAM accounts. EA-IRSAM consists of 33 production activities. There are four agricultural sectors, four mineral extraction sectors, eight manufacturing sectors, eight disaggregated electricity sectors, and nine services sectors. The production factors cover capital, land, natural resources, skilled labour, and unskilled labour. Also, there are four types of institutions: firm, government, rural household, and urban household. Finally, other accounts consist of import tax, indirect tax, and savings investment.

Each country in EA-IRSAM has a similar SAM structure, as presented in Figure 2. However, the rest of the world (ROW) region has slightly different features. The ROW contains production activities, indirect and import taxes, and other account. Other account covers aggregated institutions as it is almost impossible to identify income distribution among institutions in the ROW.

Figure 2. Simplified Schematic of EA-IRSAM

			Expenditure									
			Region 1				**Region 2**				**ROW**	**TOTAL**
			Prod.	**Fact.**	**Ins.**	**O.A.**	**Prod.**	**Fact.**	**Ins.**	**O.A.**		
Income	**Region 1**	**Production Activities**	T_{11}^{11}		T_{13}^{11}	T_{14}^{11}	T_{11}^{12}		T_{13}^{12}	T_{14}^{12}	x_1^1	y_1^1
		Factors	T_{21}^{11}									y_2^1
		Institutions		T_{32}^{11}	T_{33}^{11}	T_{34}^{11}						y_3^1
		Other Accounts	T_{41}^{11}		T_{43}^{11}		T_{41}^{12}			T_{44}^{12}	x_4^1	y_4^1
	Region 2	**Production Activities**	T_{11}^{21}		T_{13}^{21}	T_{14}^{21}	T_{11}^{22}		T_{13}^{22}	T_{14}^{22}	x_1^2	y_1^2
		Factors					T_{21}^{22}					y_2^2
		Institutions						T_{32}^{22}	T_{33}^{22}	T_{34}^{22}		y_3^2
		Other Accounts	T_{41}^{21}			T_{44}^{21}	T_{41}^{22}		T_{43}^{22}		x_4^2	y_4^2
	Rest of the World		I_1^1		I_3^1		I_1^2		I_3^2			y_x
	TOTAL		$y_1^{1'}$	$y_2^{1'}$	$y_3^{1'}$	$y_4^{1'}$	$y_1^{2'}$	$y_2^{2'}$	$y_3^{2'}$	$y_4^{2'}$		

Figure 2 describes the simplified structure of EA-IRSAM into two regions (Region 1 and Region 2). In Figure 2, there are two distinct activities: within-country activities and cross-country activities. The activities within-country are indicated by similar superscripts on each term. In region 1, term T_{11}^{11} represents intermediate input production activities, T_{21}^{11} represents input factor payment for its use in production activities, T_{32}^{11} represents income distribution from production factor to institutions, T_{41}^{11} represents intermediate input payment for indirect tax. Meanwhile, T_{32}^{11} represents factor income distribution into institutions, namely rural household, urban household, firm, and government. Next, T_{13}^{11} represents demand on commodities by institutions, T_{33}^{11} represents transfer among institutions, i.e. transfer from government to the household, T_{43}^{11} represents institutional savings. Finally, T_{14}^{11} represents purchases of commodities for investment purposes, while T_{34}^{11} represents government income from tax, namely indirect tax and import tax. Similarly, in region 2, terms T_{11}^{22} to T_{34}^{22} represent similar interaction among accounts as in Region 1.

Cross-country activities are indicated by different superscript values on each notation in Figure 2. In Region 1, T_{11}^{21} represents imported commodities from Region 2, purchased by production activities as an intermediate input in Region 1. T_{41}^{21} represents import tariff paid by Region 1 to Region 2 for commodities exported from Region 1 to Region 2. In Region 1, import tariff is computed as a ratio of T_{41}^{21} divided by the summation of T_{11}^{12}, T_{13}^{12}, and T_{14}^{12}. Similarly, in Region 2, import tariff is computed as a ratio of T_{41}^{12} divided by the summation of T_{11}^{21}, T_{13}^{21}, and T_{14}^{21}.

Next, T_{13}^{21} represents imported commodities from Region 2 purchased by institutions, while T_{14}^{21} represents imported commodities from Region 2 purchased for investment purposes. Finally, T_{44}^{21} represents net payment transfer. The transfer payment in this term is in the form of capital that is different from the capital of the production factor. The transfer payment amount balances the balance of payment because of the trade deficit between the two regions. In Region 2, terms T_{11}^{12} to T_{44}^{12} represent similar interaction among accounts as in Region 1.

Finally, terms I_1^1 and I_3^1 are leakages of Region 1 to the rest of the world. Similarly, I_1^2 and I_3^2 are leakages of Region 2 to the rest of the world. Terms x_1^1, x_4^1, x_1^2, and x_4^2 are exogenous accounts.

DATA SOURCES

EA-IRSAM construction needs two main data sources. First, the main dataset is the Global Trade Analysis Project Power version 9 database (GTAP-Power). GTAP-Power is an extension of the GTAP database. GTAP is a global database that combines linkages among regions through bilateral trade data and individual country input-output databases (Aguiar, Narayanan, and McDougall 2016). GTAP has a highly disaggregated economy sector with 57 sectors and five production factors: unskilled labour, skilled labour, capital, land, and natural resources.

The main difference between GTAP-Power and GTAP is that GTAP-Power has a highly disaggregated electricity sector: wind, hydroelectric, solar, coal, oil, gas, nuclear and others, and transmission and distribution. Further, hydroelectric, oil, and gas are disaggregated into the base and peak load (Peters, 2016**)**.

There are three common reference years in GTAP-Power: 2004, 2007, and 2011 (Aguiar, Narayanan, and McDougall 2016). This paper uses the common reference year of 2011 as it is the latest one in a million United States dollars currency.

The second data source is various household survey datasets and SAM of each East Asian country. The second data source is needed for disaggregates regional household account in the original GTAP-Power into private households (urban household and rural household) and firms in EA-IRSAM. In GTAP-Power, all incomes from the indirect taxes, direct taxes, and factor incomes in each country are assumed to belong to the regional household account. In turn, the regional household allocates the income into three different accounts such as private expenditure, government expenditure, and savings-investment (Delpiazzo & Standardi, 2014; McDonald & Thierfelder, 2004).

The main disadvantage of the regional household account concept is that there is no direct connection between private household and government accounts to capital account. Thus, the private household does not save and pay income tax. Also, the government has no surplus or deficit in their account (McDonald and Thierfelder 2004). The elimination of the regional household account allows for richer specification in the model, particularly inter-institutional transfer in each region (McDonald and Sonmez 2004).

There are three data sources to disaggregate regional household account. First, the ideal data source to disaggregate the regional household account into private households and firms in each country is based on social accounting matrix (SAM). Second, disaggregating income urban and rural households need data on income distribution between urban and rural households from either SAM or other sources. Finally, disaggregating private households expenditure into urban households and rural households in EA-IRSAM needs a data source on the share of urban and rural household expenditures on each commodity from household surveys and other studies.

The list of data sources needed to disaggregate the regional household account in this paper is as follows.

Australia

1. 1996-1997 SAM (Pang, Meagher, and Lim 2007)

2. 2009-2010 Household Expenditure Survey
3. Gross household income per week, between states and territory with the balance of state (Australian Bureau of Statistics 2013).

China

1. 2007 SAM (Zhang & Diao 2013).
2. 2012 China Family Panel Survey (CFPS)
3. Urban-rural income ratio (Kanbur and Zhuang 2013).

Japan

1. 2011 income by institutional sector (Statistics Japan 2015).
2. 2009 Family Income and Expenditure Survey.
3. Family income and expenditure survey 2009 (Statistics Japan 2011).

India

1. 1998-1999 SAM (Polaski et al. 2008)
2. 2011-2012 Household Consumer Expenditure NSS-68th Round.
3. Urban-rural income ratio (Kanbur and Zhuang 2013).

South Korea

1. 2000 SAM (Noh 2007)
2. Average income of urban and rural households (Song-hyun 2014).

Indonesia

1. 2008 SAM (Statistics Indonesia 2010).
2. 2011 socio-economic survey (SUSENAS).

Malaysia

1. 2014 SAM (Department of Statistics Malaysia 2017).

The Philippines

1. 2000 SAM (Cororaton and Corong 2009).
2. 2011 Annual Poverty Indicators Survey (APIS)
3. Urban-rural income ratio (Kanbur and Zhuang 2013).

Singapore

1. 1995 SAM (Akkemik 2009).

Thailand

1. 1998 SAM (Li 2002).
2. 2011 Household Socio-Economic Survey (SES).
3. The income per household by the source of income (National Statistical Office 2011).

Vietnam

1. 1997 SAM (Nielsen 2002).
2. 2014 Vietnam Household Living Standards Survey (VHLSS)
3. Urban to rural income ratio from (McCaig 2009)

This paper makes two adjustments in government account: fiscal balance and social spending to the household. The adjustment is needed because the construction of EA-IRSAM mimics a country-specific condition. Unfortunately, GTAP-Power does not provide fiscal balance and social spending to the household. The fiscal balance in the government account is defined as a percentage of government surplus or deficit to GDP. This paper extracts the fiscal balance from ASEAN Statistical Yearbook 2012 (ASEAN 2016) for ASEAN member countries. For India, the fiscal balance is obtained from the Planning Commission of India (2019). Other regions' fiscal balances are obtained from OECD (2019a). The government's transfer to the household is defined as social expenditure that is a percentage of total public social spending to GDP. Australia, Japan, and South Korea are based on OECD (2019b). For the rest of East Asia countries, this paper extracts the share from ILO (2019).

The last dataset is carbon emissions by sector and country. This paper extracts data on carbon emissions from the GTAP Power 9 database. The data covers carbon emissions due to consumption of electricity, coal, oil, gas, petroleum products, and gas manufactured distribution by each production activity and household in each country. The unit of carbon emissions is in a million tonnes of carbon dioxide.

CONSTRUCTION OF EAST ASIA INTER-REGIONAL SOCIAL ACCOUNTING MATRIX (EA-IRSAM)

This section describes in detail the process of constructing EA-IRSAM by following Nurdianto (2011) closely. The first step is to extract the Global Trade Analysis Project Power 9 (GTAP-Power) database. The next step is to reconstruct the structure of each SAM for each country from the GTAP-Power before being merged into EA-IRSAM. The last step is to combine all submatrices into EA-IRSAM.

Extraction of GTAP Power 9 database

The extraction of the GTAP-Power database is conducted by utilising GTAPAgg2 software. The GTAPAgg2 creates an aggregated database of the GTAP-Power database. By default, GTAPAgg2, there is no aggregation of production activities in each country. However, GTAPAgg2 aggregates the labour types from five types into two types: skilled and unskilled labour. Thus, there are 57 sectors for each country, with production factors aggregated into five types (capital, land, natural resource, skill labour, and unskilled labour) (GTAP 2019).

After the GTAP-Power database extraction, the next step is to transform the database into the SAM structure by utilising General Algebraic Modeling System (GAMS) software. This paper uses a GAMS programme available in McDonald and Thierfelder (2004) to translate the extracted GTAP database into SAM. Several modifications are needed in the original program since the program only supports the GTAP version 8 database, while this paper uses the GTAP-Power version 9 database. The adjustments are mainly on adjusting labelling on several variables.

The conversion process of GTAP-Power into SAM is as follows. The program converts the extracted database of the GTAP-Power database into a balanced SAM. The main database from GTAPAgg2 originally is in HAR format. Now it is transformed into a GDX format that is compatible with GAMS. Further, the program checks whether the constructed SAM for each country is balanced or not.

The next step is to aggregate countries using a GAMS programme available in McDonald and Thierfelder (2013). The program aggregates countries and SAM accounts simultaneously. This step aggregates from 140 regions into 13 regions, namely Australia, China, Japan, India, South Korea, and seven Association of Southeast Asian Nations (ASEAN) countries plus the rest of the world region (ROW). After the regions are aggregated, the next step is to prepare the structure of each country SAM into a global SAM, as presented in detail in the following section.

Construction of a global SAM

There are several steps to construct a global SAM for each region. The global SAM is a SAM in which each region is ready to be merged. Each region SAM is defined ready to merged if all the accounts are balanced. The detail of each step as follows.

1. Incorporating transportation cost and margin into imports and exports, respectively.

The transportation cost is added to import value from other countries. On the exports side, trade margin is added into related transportation sectors. For example, the trade margin from ocean transportation mode is added to the domestic ocean transportation sector. It is then distributed evenly to all regions. Similar treatments are done for water and air transportations. The adjustment is conducted by adjusting foreign savings.

2. Aggregating several taxes into indirect taxes;

   The next step is to aggregate several types of taxes into indirect taxes. There are five taxes: import sales taxes, domestic sales taxes, factor taxes, production taxes, and export tax aggregated. The aggregation is conducted by combining these five blocks into one block by row and column.

3. Creating production activities

   Production activities in EA-IRSAM are an aggregation of domestic commodities and activities that can be aggregated similarly to indirect taxes. Imported commodities are not aggregated since it is needed to compute the trade among regions. It is also necessary to eliminate the supplied matrix. In the GTAP, the supplied matrix implies that each commodity is made by single activity, vice versa (Go et al. 2014). There is no implication in calculating both total row and column since the supply matrix is a diagonal matrix.

4. Disaggregating regional household account

   The regional household is eliminated by distributing the row and column of the regional household into the private household and government accounts. Following Nurdianto (2011) and Delpiazzo and Standardi (2014), the row component of income factors is distributed to the private household, while income from tax is mainly going to the government.

The next step is to impose a fiscal balance for the government. This paper computes the government savings as a percentage of GDP in 2011. It subtracts the equivalent values of fiscal balance from the regional household's savings account. Then the rest value of the regional household savings is allocated to the private households. The last step is to compute the transfer from the government to the private household as a residual. Therefore, for now, this paper assumes that the transfer is a net government transfer to the household. Later on, the government transfer to the household will be adjusted accordingly.

5. Constructing firms account

   The construction of the firm account is based on the percentage of income distribution from the private household. The percentage can be obtained from SAM in each country. It can be done by taking a particular percentage from the private household accounts by row and column.

6. Eliminating direct taxes

   The elimination of direct tax simplifies the payment of production factor to the government directly. The production factors pay to the direct tax account in the global SAM before redistributing to the government account. It is more convenient to ensure that direct payment of direct tax goes directly to the government.

7. Transferring indirect taxes

   Similar to direct tax, indirect taxes also need to be adjusted. In the EA-IRSAM, it is assumed that only the production activities pay indirect taxes. Thus, the indirect taxes that are paid by the private household, government and capital should be returned to each account.

However, returning indirect taxes by assuming equal distribution across commodities is not suitable since there is a possibility that certain commodities in production activities do not pay indirect tax. Thus, this paper uses the percentage of each commodity expenditure to total demand. Then this percentage is used to adjust the value of returned indirect taxes to demand by each commodity. The first step is to compute total commodities demand by the private household. Then a ratio of each commodity demand to total commodities demand is constructed. Finally, existing commodity demand for the household is adjusted by multiplying the ratio with the indirect taxes' payment. A similar treatment can be done to the government and capital as well. The gaps in the total column and row of commodities are incorporated into the indirect tax row.

8. Transferring labour payments transfer

   The next step is to transfer the labour payments from the government to the private household. It is assumed that labour as a production factor is owned by the household only. Thus, it is done by adding the labour payment from the government row account into the private household row account. In this paper, there are two types of labour payments, skilled and unskilled labour. Both of them are transferred into the private household's row.

9. Transferring depreciation

   The minor adjustment is to transfer depreciation to factor payment for the firm account. The capital account pays depreciation in the production factor to the savings-investment account. Thus, depreciation is added to the firm accounts as factor payments.

10. Creating inter-institutional transfer

   In terms of inter-institutional transfer, a transfer from the government to the household is feasible. However, it is relatively difficult to obtain transfer within households in survey data. Thus, EA-IRSAM only allows for inter-institutional transfer from the government to private household accounts.

The value of the government transfer to the household is based on the percentage value of social expenditure by each country's government. The balancing is done by adjusting the savings-investment account for the government and private households. Similar to the elimination of the regional household, the savings-investment account is treated as a residual account.

11. Disaggregating the private household account

    The next step is to disaggregate the private household account into rural and urban household accounts. Based on the household survey, this paper disaggregates the column based on expenditure share on each commodity. In contrast, row disaggregation is based on the share of income from SAM and other sources. Also, this paper assumes that there are no rural areas in Singapore.

    Three areas need disaggregation, namely private household's demand, savings, and factor income distributions. The balancing is done by adjusting the savings account. It is also assumed that there is a similar pattern of consumption for both domestic and imported commodities. This assumption has to be made since there is a lack of data since the household survey does not identify the origin of goods and services consumed by the household.

Construction of EA-IRSAM

At this stage, each country in the global SAM should be balanced and ready to be merged. Then, the next step combines each country global SAM into EA-IRSAM. The main diagonal matrix of

EA-IRSAM consists of a square matrix of each country global SAM. The off-diagonal matrices are mostly dealing with imported commodities among regions as follows.

In each global SAM, there are two components of trade, namely exports and imports. Exports value is a final demand on commodities of other countries, including the rest of the world, while imports are inputs from other countries to a particular sector. Since trade is a symmetric transaction, i.e., in terms of imports by one country is and exports by another country. The inter-diagonal matrices values can be obtained from either exports or imports values. This paper constructs the inter-region matrices from the import side as the imports side has more sectoral disaggregation than the exports side.

Three blocks use imported commodities, such as production activities, institutions, and savings investment. Adjustments are conducted for these three blocks in several steps. The first step is to compute a ratio of imports from each country in a particular region. That is done by computing the total imports value from other countries by each commodity. Then the ratio is constructed by dividing the imports value from the origin country to total import values. After that, the ratio is multiplied by the total value of imports for each country. Similar routines are done for each block. As a result, the blocks of production activities, institutions, and savings-investment are expanded.

As pointed out by Nurdianto (2011), this assumption implies that the consumer cannot differentiate the origin of the imported goods. Also, utilising the institutions' final demand ratio implies a similar percentage of imported goods consumed by the institutions.

The final adjustment is to adjust the value of indirect tax and import taxes in a particular region. Since imported commodities pay indirect taxes, the indirect taxes should be disaggregated in each inter-regions matrices. The ratio of import and the ratio of imported commodities to total commodities are utilised to disaggregate indirect tax. Then, the disaggregated indirect tax is combined with import taxes as the new value of import taxes. The balancing of indirect tax is done by subtracting the value of each country from the diagonal matrices.

After constructing inter-region SAM for each country, the final step is to combine SAM with all inter-region SAM into the EA-IRSAM. The final check is to ensure that the EA-IRSAM is balanced.

EXTENSIONS OF IRSAM ANALYSES

Inter-regional constrained fixed price multiplier method

The first extension of IRSAM analysis is the inter-regional constrained fixed price multiplier method (Resosudarmo and Thorbecke, 1996 and 1998)[2]. Figure 3 describes two regions (Region 1 and Region 2) inter-regional Social Accounting Matrix (IRSAM). Each region consists of production activities, factor inputs, and institutions such as households. Outputs of some productions in Region 1 are constrained (Y_C^1) and others are unconstrained (Y_{NC}^1 and Y_{NC}^2). Also, exogenous accounts such as government, savings, and taxes are included in the rest of the world (ROW) column and row accordingly.

Figure 3. Structure of IRSAM with Constrained Sector

	Region 1		Region 2	ROW	TOTAL
Region 1	A_C^{11}	R^{11}	R^{12}	X_C^1	Y_C^1

[2] The inter-regional CFPM approach is relatively different from standard IRSAM multiplier. The explanation and derivation of standard IRSAM multiplier, for example, can be found in Resosudarmo et al. (2009).

	Q^{11} A_{NC}^{11}	A_{NC}^{12}	X_{NC}^{1}	Y_{NC}^{1}
Region 2	Q^{21} A_{NC}^{21}	A_{NC}^{22}	X_{NC}^{2}	Y_{NC}^{2}
ROW	l^{1}	l^{2}	t	Y_E
TOTAL	$(Y_C^1)'$ $(Y_{NC}^1)'$	$(Y_{NC}^2)'$	$(Y_E)'$	

Terms A_C^{11}, A_{NC}^{11}, R^{11}, and Q^{11} are matrices of expenditures among sectors within Region 1. A_C^{11} is matrices of expenditures among constrained sectors (electricity sectors in this paper), A_{NC}^{11} is matrices of expenditures among non-constrained sectors, R^{11} is matrices of expenditures from non-constrained sectors to constrained sectors, and Q^{11} is matrices of expenditures from constrained sectors to non-constrained sectors. The term A_{NC}^{22} is a matrix of expenditures among sectors within Region 2.

The terms A_{NC}^{12} and R^{12} are matrices of expenditures from sectors in Region 2 to sectors in Region 1. However, Q^{21} and A_{NC}^{21} are matrices of expenditures from Region 1 to those in Region 2. The terms l^1 and l^2 are leakages to the ROW, while X_C^1, X_{NC}^1, and X_{NC}^2 are vectors of injection from the ROW. Finally, t is a vector of exogenous not related to Region 1 nor Region 2. Figure 3. can be expressed mathematically as follows.

$$d\begin{bmatrix} Y_C^1 \\ Y_{NC}^1 \\ Y_{NC}^2 \end{bmatrix} = \begin{bmatrix} A_C^{11} & R^{11} & R^{12} \\ Q^{11} & A_{NC}^{11} & A_{NC}^{12} \\ Q^{21} & A_{NC}^{21} & A_{NC}^{22} \end{bmatrix} d\begin{bmatrix} Y_C^1 \\ Y_{NC}^1 \\ Y_{NC}^2 \end{bmatrix} + d\begin{bmatrix} X_C^1 \\ X_{NC}^1 \\ X_{NC}^2 \end{bmatrix} \quad (1)$$

The matrices in equation (1) can be rearranged, following Hartono and Resosudarmo (2008) and Resosudarmo and Thorbecke and Jung (1996), and elaborated to depict the relationship in equation (2). This equation shows the impact of changes in outputs of the constrained sectors in

Region 1 (Y_C^1) as well as the changes of injections from the ROW to the non-constrained sectors in both Regions 1 and 2 to the outputs of the non-constrained sectors in both Regions 1 and 2 (Y_{NC}^1 and Y_{NC}^2) as well as the injection to Region 1.

$$d\begin{bmatrix} Y_{NC}^1 \\ X_C^1 \\ Y_{NC}^2 \end{bmatrix} = \begin{bmatrix} -R^{11} & I & -R^{12} \\ (I - A_{NC}^{11}) & 0 & -A_{NC}^{12} \\ -A_{NC}^{21} & 0 & (I - A_{NC}^{22}) \end{bmatrix}^{-1} \begin{bmatrix} -(I - A_C^{11}) & 0 & 0 \\ Q^{11} & I & 0 \\ Q^{21} & 0 & I \end{bmatrix} d\begin{bmatrix} Y_C^1 \\ X_{NC}^1 \\ X_{NC}^2 \end{bmatrix} \tag{2}$$

where $\begin{bmatrix} -R^{11} & I & -R^{12} \\ (I - A_{NC}^{11}) & 0 & -A_{NC}^{12} \\ -A_{NC}^{21} & 0 & (I - A_{NC}^{22}) \end{bmatrix}^{-1} \begin{bmatrix} -(I - A_C^{11}) & 0 & 0 \\ Q^{11} & I & 0 \\ Q^{21} & 0 & I \end{bmatrix}$ is called inter-regional constrained fixed price multiplier (IR-CFPM). Analysing the impact of a change in constrained outputs on the non-constrained outputs using this multiplier is called the IR-CFPM method.

There are several assumptions in this method. Firstly, this paper assumes that prices are fixed and unchanged in any simulation. Secondly, integrating the electricity market or generating more electricity causes no additional costs to any country. In other words, this paper assumes that there is excess capacity on each type of electricity, following the assumption in the work by Thorbecke and Jung (1996).

Household income microsimulation

The second extension of IRSAM analysis is the microsimulation of household income. The microsimulation establishes a link between macroeconomic indicators in the IRSAM to the incomes of several different household groups. Using this microsimulation, this paper can estimate several household microeconomic indicators, such as changes in household income and changes in poverty incidence.

In the computable general equilibrium (CGE) model literature, the household microsimulation method usually has been utilised to construct the top-down CGE approach, that is, linking results from a CGE model to household micro indicators (Bourguignon and Bussolo, 2013; Nurdianto and Resosudarmo, 2016; Yusuf and Resosudarmo, 2015).

This paper offers a novel household income microsimulation approach to link an IRSAM to household incomes for different category groups. The two principles adopted are as follows. First, the total payment of production activities to production factors should be equal to all institutions' total income, such as households, government, and firms. Second, it is assumed that the average propensities to consume are unchanged. Hence, the value of any element in IRSAM at row i and column j can be obtained by multiplying a particular element of average propensity to consume matrix with a total value of the corresponding column.

Given new total values of outputs after a simulation, these two assumptions allow this paper computes new total income values for different production factors (labour and non-labour incomes) related to urban and rural households available in the IRSAM. After computing new values of labour and non-labour income and utilising equation (3), total incomes for different household percentile c in urban or rural (ur) areas can be defined.

$$H_c^{ur} = \sigma_c^{ur} sl^{ur} \sum_v \sum_q \frac{N_c^{q,v}}{\sum_c N_c^{q,v}} lb^{q,v} + \varsigma_c^{ur} sh^{ur}\, inc\_sh_c^{ur} \sum_w \sum_q nlb^{q,w} \quad (3)$$

Equation (3) can be explained as follows. In each country, households are grouped into 100 household groups, based on the percentile of their incomes from the poorest to the richest, in urban areas and another 100 household groups in rural areas (Nurdianto and Resosudarmo, 2016). The index ur identifies whether a household group is in an urban or rural area. H_c^{ur} denotes the total income of households in percentile c in the urban/rural areas.

Superscripts q and v denote production sectors in a region and labour types (skilled and unskilled labour). Term $N_c^{q,v}$ denotes the number of labour type v by sector q in household c. Therefore, term $\frac{N_c^{q,v}}{\sum_c N_c^{q,v}}$ is a sectoral labour share of household percentile c in sector q.

Furthermore, $lb^{q,v}$ is the total labour income type v in sector q and sl^{ur} is the share of the total labour income of urban or rural households. Therefore, $\sigma_c^{ur} sl^{ur} \sum_v \sum_q \frac{N_c^{v,q}}{\sum_c N_c^{v,q}} lb^{v,q}$ is the total labour income of household group c in *ur* areas. Note that σ_c^{ur} is a constant scaling factor to adjust the value of total labour income from the household survey data, where all parameters in equation (3) are estimated from, into IRSAM value.

Superscript w denotes non-labour income types (land, natural resources, and capital). The term $nlb^{q,w}$ is non-labour income type w in sector q, and sh^{ur} is the share of total non-labour factor incomes for urban and rural households. Hence, $\varsigma_c^{ur} sh^{ur}\ inc\_sh_c^{ur} \sum_w \sum_q nlb^{q,w}$ is the total non-labour income of household group c in *ur* areas. Note that ς_c^{ur} is a constant scaling factor to adjust the value of total non-labour income from the household survey data into IRSAM value.

FINAL REMARKS

This paper has demonstrated the process of constructing EA-IRSAM from the GTAP Power 9 Database. It started from the raw data of the GTAP Power 9 Database. Then this paper converts the GTAP Power 9 database into GDX format that can be used in GAMS software. Finally, the structure of the extracted data is adjusted accordingly to the EA-IRSAM structure.

Several assumptions have to be made. In particular, there is no available data on the government surplus or deficit, government transfer to the households, and factor incomes distribution among institutions. The assumptions are extracted from various data sources, namely household survey datasets and other publicly available data.

Finally, there are two extensions of traditional SAM analyses in this paper: inter-regional constrained fixed price multiplier and microsimulation of household income.

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APPENDIX

Derivation of the inter-country constrained fixed price multiplier (IC-CFPM)

This section explains in detail the derivation of the inter-country constrained fixed price multiplier (IC-CFPM) following Lewis and Thorbecke (1992), Resosudarmo and Thorbecke (1996 and 1998) and Hartono and Resosudarmo (2008). Table 2 can be expressed in the matrices operation as follow.

$$\begin{bmatrix} Y_C^1 \\ Y_{NC}^1 \\ Y_{NC}^2 \end{bmatrix} = \begin{bmatrix} A_C^{11} & R^{11} & R^{12} \\ Q^{11} & A_{NC}^{11} & A_{NC}^{12} \\ Q^{21} & A_{NC}^{21} & A_{NC}^{22} \end{bmatrix} \begin{bmatrix} Y_C^1 \\ Y_{NC}^1 \\ Y_{NC}^2 \end{bmatrix} + \begin{bmatrix} X_C^1 \\ X_{NC}^1 \\ X_{NC}^2 \end{bmatrix} \quad \text{(A1)}$$

The matrices in equation A1 can be transformed into a linear equation system as presented in Equations A2, A3, and A4.

$$Y_C^1 = A_C^{11}.Y_C^1 + R^{11}.Y_{NC}^1 + R^{12}.Y_{NC}^2 + X_C^1 \quad \text{(A2)}$$

$$Y_{NC}^1 = Q^{11}.Y_C^1 + A_{NC}^{11}.Y_{NC}^1 + A_{NC}^{12}.Y_{NC}^2 + X_{NC}^1 \quad \text{(A3)}$$

$$Y_{NC}^2 = Q^{21}.Y_C^1 + A_{NC}^{21}.Y_{NC}^1 + A_{NC}^{22}.Y_{NC}^2 + X_{NC}^2 \quad \text{(A4)}$$

Rearranging equation (A2), Equation (A3), and Equation (A4)

$$X_C^1 = -R^{11}.Y_{NC}^1 + (I - A_C^{11}).Y_C^1 - R^{12}.Y_{NC}^2 \quad \text{(A2a)}$$

$$(I - A_{NC}^{11}).Y_{NC}^1 = Q^{11}.Y_C^1 + A_{NC}^{12}.Y_{NC}^2 + X_{NC}^1 \quad \text{(A3a)}$$

$$(I - A_{NC}^{22}).Y_{NC}^2 = Q^{21}.Y_C^1 + A_{NC}^{21}.Y_{NC}^1 + X_{NC}^2 \quad \text{(A4a)}$$

Rearranging equation A2a, A3a, and A4a:

$$-R^{11}.Y_{NC}^1 - X_C^1 - R^{12}.Y_{NC}^2 = -(I - A_C^{11}).Y_C^1 \quad \text{(A2b)}$$

$$(I - A_{NC}^{11}).Y_{NC}^1 - A_{NC}^{12}.Y_{NC}^2 = Q^{11}.Y_C^1 + X_{NC}^1 \quad \text{(A3b)}$$

$$-A_{NC}^{21}.Y_{NC}^1 + (I - A_{NC}^{22}).Y_{NC}^2 = Q^{21}.Y_C^1 + X_{NC}^2 \quad \text{(A4b)}$$

Translate equation A2b, A3b, and A4b into matrices form:

$$\begin{bmatrix} -R^{11} & I & -R^{12} \\ (I - A_{NC}^{11}) & 0 & -A_{NC}^{12} \\ -A_{NC}^{21} & 0 & (I - A_{NC}^{22}) \end{bmatrix} \begin{bmatrix} Y_{NC}^{1} \\ X_{C}^{1} \\ Y_{NC}^{2} \end{bmatrix} = \begin{bmatrix} -(I - A_{C}^{11}) & 0 & 0 \\ Q^{11} & I & 0 \\ Q^{21} & 0 & I \end{bmatrix} \begin{bmatrix} Y_{C}^{1} \\ X_{NC}^{1} \\ X_{NC}^{2} \end{bmatrix} \tag{A5}$$

$$\begin{bmatrix} Y_{NC}^{1} \\ X_{C}^{1} \\ Y_{NC}^{2} \end{bmatrix} = \begin{bmatrix} -R^{11} & I & -R^{12} \\ (I - A_{NC}^{11}) & 0 & -A_{NC}^{12} \\ -A_{NC}^{21} & 0 & (I - A_{NC}^{22}) \end{bmatrix}^{-1} \begin{bmatrix} -(I - A_{C}^{11}) & 0 & 0 \\ Q^{11} & I & 0 \\ Q^{21} & 0 & I \end{bmatrix} \begin{bmatrix} Y_{C}^{1} \\ X_{NC}^{1} \\ X_{NC}^{2} \end{bmatrix} \tag{A6}$$