Journal of Indonesian Economy and Business
Volume 26, Number 3, 2011, 287 – 309

REGIONAL ECONOMIC MODELLING FOR INDONESIA: IMPLEMENTATION OF IRSA-INDONESIA5*

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ABSTRACT

Ten years after Indonesia implemented a major decentralisation policy, regional income per capita disparity and excessive rate of natural resource extraction continue to be pressing issues. There are great interests in identifying macro policies that would reduce regional income disparity and better control the rate of natural extraction, while maintaining reasonable national economic growth. This paper utilises an inter-regional computable general equilibrium model, IRSA-INDONESIA5, to discuss the economy-wide impacts of various policies dealing with the development gap among regions in the country, achieving low carbon growth, and reducing deforestation. The results of simulations conducted reveal that, primarily, the best way to reduce the development gap among regions is by creating effective programs to accelerate the growth of human capital in the less developed regions. Secondly, in the short-term, the elimination of energy subsidies and/or implementation of a carbon tax is effective in reducing CO_2 emission and producing higher economic growth, while in the long-run, however, technological improvement, particularly toward a more energy efficient technology, is needed to maintain a relatively low level of emission with continued high growth. Thirdly, if reducing deforestation means reducing the amount of timber harvested, it negatively affects the economy. To eliminate this negative impact, deforestation compensation is needed.

Keywords: *computable general equilibrium, development planning and policy, environmental economics*

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* Budy P. Resosudarmo, Arief A. Yusuf and Djoni Hartono built the inter-regional computable general equilibrium (IRCGE) model and gathered the inter-regional social accounting matrix (IRSAM) data utilised in this paper for the Analysing Pathways to Sustainability in Indonesia project, a collaborative project between Bappenas, AusAID, CSIRO and the World Bank. All mistakes in this paper, however, are the authors' responsibility.

INTRODUCTION

Indonesia is the world's largest archipelagic state and one of the most spatially diverse nations on earth in its resource endowments, population settlements, location of economic activity, ecology, and ethnicity. The disparity in socio-economic development status and environmental conditions has long been a crucial issue in this country (Hill *et al.* 2008; Resosudarmo and Vidyattama, 2006; Resosudarmo and Vidyattama, 2007). In 2007, the gross domestic product (GDP) of the two richest provinces outside Java—Riau and East Kalimantan—was more than 36 times that of the poorest province, Maluku. Based on GDP per capita, East Kalimantan outstripped the rest of the country by far, Java included. East Kalimantan was almost twice as rich as the runner-up, Riau, and more than 16 times richer than Maluku in terms of per capita regional GDP. Some regions in the country are richly endowed with natural resources, such as oil, gas, coal and forests, while others are not. The range of poverty incidence also varies widely, from 4.6 percent of the population in Jakarta to 40.8 percent in Papua. Table 1 shows the economic indicators of several Indonesian regions.

It is well known that Indonesia has abundant natural resources such as oil, gas and minerals as well as rich and very diverse forestry and marine resources. These resources, however, are not equally distributed across regions in the country. Oil and gas are found in Aceh, Riau, South Sumatra and East Kalimantan. Mineral ores such as copper and gold are abundant in Papua, coal in most of Kalimantan and West Sumatra, tin on the island of Bangka, nickel in South Sulawesi and North Maluku. Forests are mostly located in Sumatra, Sulawesi, Kalimantan and Papua, and marine resources in Eastern Indonesia. The two major criticisms with regard to natural resource extraction in Indonesia are the skewed distribution of benefits and the unsustainability of the rate of extraction (Resosudarmo, 2005).

Due to the demands of disadvantaged regions for larger income transfers and greater authority in constructing their development plans, and from rich natural resource regions to control their own natural endowments, rapid political change took place a few years after the economic crisis of 1997: Indonesia drastically shifted from a highly centralistic government system to a highly decentralised one in 2001. Greater authority was delegated to more than 400 districts and municipalities, in the areas of education, agriculture, industry, trade and investment as well as infrastructure (Alm *et al.* 2001). Only security, foreign relations, monetary and fiscal policies remain the responsibility of the central government (PP No. 25/2000).

Suddenly leaders of district and city levels of government acquired vast authority and responsibility, including receiving a huge transfer of civil servants from sectoral departments within their jurisdiction. Provincial governments, however, generally remained relatively weak. In the new structure, regional governments received a much larger proportion of taxes and revenue sharing from natural extraction activities in their regions, with it being typical for budgets to triple after decentralisation. Yet the issues of regional income per capita disparity and the excessive rate of natural resource extraction remain (Resosudarmo and Jotzo, 2009).

There is great interest in identifying the macro policies that would reduce regional income disparity and better control the rate of natural extraction, while maintaining reasonable national economic growth; i.e. policies that will enable Indonesia to pursue a path of sustainable development. The question is what kind of economic tool is appropriate to analyse the impact of any macro policy on regional and national performances as well as environmental conditions. This paper would like to

Table 1. Indonesia's Regional Outlook

	GDP (2007) (Rp. trillion)	GDP per Capita (2007) (Rp. million)	Growth of GDP per Capita (87-07) (%)	Percentage of Poor People (2007) (%)
Aceh	73.87	17.49	0.1	26.7
North Sumatra	181.82	14.17	4.7	13.9
West Sumatra	59.80	12.73	4.2	11.9
Riau	210.00	41.41	-0.3	11.2
Jambi	32.08	11.70	3.8	10.3
South Sumatra	109.90	15.66	2.5	19.2
Bengkulu	12.74	7.88	3.2	22.1
Lampung	61.82	8,481	5.3	22.2
Sumatra	**742.02**	**17.98**	**2.8**	**18.5**
Jakarta	566.45	62.49	5.4	4.6
West Java	528.45	13.10	3.2	13.6
Central Java	310.63	9.59	4.2	20.4
Yogyakarta	32.83	9.56	3.7	19.0
East Java	534.92	14.50	4.1	20.0
Bali	42.34	12.17	4.5	6.6
Java-Bali	**2,015.62**	**16.05**	**4.1**	**16.5**
West Kalimantan	42.48	10.17	4.5	12.9
Central Kalimantan	27.92	13.77	2.9	9.4
South Kalimantan	39.45	11.61	4.5	7.0
East Kalimantan	212.10	70.12	1.1	11.0
Kalimantan	**321.94**	**25.49**	**2.8**	**10.3**
North Sulawesi	23.45	10.72	5.7	11.4
Central Sulawesi	21.74	9.07	4.5	22.4
South Sulawesi	69.27	9.00	4.8	14.1
Southeast Sulawesi	17.81	8.77	3.8	21.3
Sulawesi	**132.28**	**9.24**	**4.7**	**16.1**
West Nusa Tenggara	32.17	7.49	4.9	25.0
East Nusa Tenggara	19.14	4.30	3.7	27.5
Maluku	5.70	4.32	4.2	31.1
Papua	55.37	58.63	13.6	40.8
Eastern Indonesia	**112.37**	**10.21**	**4.8**	**28.1**
Indonesia (total)	**3,324.23**	**16.23**	**3.8**	**16.6**

Note: GDP and GDP per capita are in current prices, and growth is calculated in 1993 constant prices
Source: BPS (2008)

suggest that an inter-regional computable general equilibrium model, in particular IRSA-INDONESIA5 which was developed under the Analysing Path of Sustainable Indonesia (APSI) project, is one of the most appropriate tools to analyse these issues. This paper aims to explain IRSA-INDONESIA5 and to discuss the economy-wide impacts of various policies dealing with the development gap among regions in the country, achieving low carbon growth, and reducing deforestation.

THE COMPUTABLE GENERAL EQUILIBRIUM MODEL

Market equilibrium represents a market condition such that the quantity of goods demanded equals the quantity supplied at a price at which suppliers are prepared to sell and consumers to buy. Thus, it is the current state of exchange between buyers and sellers persists. When all markets in an economy are in equilibrium, this is known as a condition of general equilibrium. A computable general equilibrium (CGE) model uses realistic economic data to model the necessary criteria for an economy to attain a condition of general equilibrium. The CGE consists of a system of mathematical equations representing all agents' behaviour; i.e. consumers' and producers' behaviours and the market clearing conditions of goods and services in the economy. This system of equations is usually divided into five blocks of equations, namely:

- The Production Block: Equations in this block represent the structure of production activities and producers' behaviour.
- The Consumption Block: This block consists of equations that represent the behaviour of households and other institutions.
- The Export-Import Block: This block models the country's decision to export or import goods and services.
- The Investment Block: Equations in this block simulate the decision to invest in the economy, and the demand for goods and services used in the construction of the new capital.
- The Market Clearing Block: Equations in this block determine the market clearing conditions for labour, goods, and services in the economy. The national balance of payments also falls within this block.

An inter-regional CGE model is one that models multi-region economies within a country. In this model, regions which consist of multiple sectors are typically inter-connected through trade, movements of people and capital, and government fiscal transfers. In general there are two approaches to constructing an inter-regional CGE model: the top-down and the bottom-up approaches. The top-down model solves the general equilibrium condition at the national level, which means the optimisation is done at this level. National results for quantity variables are broken down into regions using a share parameter. This approach, therefore, recognises regional variations in quantity but not in price.

The bottom–up model on the other hand, consists of independent sub-regional equilibrium models that are inter-linked and aggregated at the national level as an economy-wide system. With this approach, optimisations are done at the regional level. The results of these regional models are then combined to produce an aggregate economy-wide outcome. This approach, therefore, allows for both price and quantity to vary independently by region. By implication, it enables one to analyse the impact of a region-specific shock to an economy. The downside, however, is that the approach requires more data and computing resources than the top-down approach. Therefore, sectoral or regional details often need to be sacrificed in order to compensate for this drawback. IRSA-INDONESIA5 falls into this category of inter-regional CGE model.

1. CGE on Indonesia

The CGE model of the Indonesian economy became available at the end of the 1980s. Included among the first generation of Indonesian CGEs are those developed by BPS, ISS and CWFS (1986), Behrman, Lewis and Lotfi (1988)[1], Ezaki (1989), and Thorbecke (1991). They were developed in close collaboration with the Indonesian National Planning and Development Agency (Bappenas), the Ministry of Finance and the Central Statistics Agency (BPS or *Badan Pusat Statistik*). They were all static CGE models. The models of Behrman *et al*. (1988) and Ezaki (1989) were based on the Indonesian input-output (IO) tables, meaning their classifications of labour and household were limited and their models of household consumption were not complete. The models by BPS, ISS and CWFS (1986) and Thorbecke (1991) were based on the Indonesian social accounting matrix (SAM) which is generally a more complete system of data than an input-output table. The models by Behrman *et al*. (1988) and Thorbecke (1991) were written using GAMS software, while BPS, ISS and CWFS (1986) and Ezaki (1989) used other computer languages. The models of Ezaki (1989) and Thorbecke (1991), in addition to the real sector, also include the financial sector in order to determine absolute prices endogenously. All of these CGE models were developed to analyse the structural adjustment program implemented by Indonesia as a response to the decline in the oil price in the early 1980s.

The second generation models of Indonesian CGEs came out in the 2000s. Among others are the following: Abimanyu (2000) in collaboration with the Centre of Policy Studies (CPS) at Monash University developed an INDORANI CGE model based on the Indonesian IO table. It is an application of the Australian ORANI model for Indonesia (Dixon *et al.* 1982), and so works on the platform of GEMPACK Software. There are two other derivatives of the ORANI model for Indonesia, which are the Wayang model by Warr (2005) and the Indonesia-E3 by Yusuf (Yusuf and Resosudarmo, 2008). The advantage of Wayang over INDORANI is that Wayang is based on the Indonesian social accounting matrix and so has more household classifications. The Indonesia-E3 disaggregated the Indonesian SAM households even further into 100 urban and 100 rural households so as to produce gini and poverty indexes. All of these CGE models are static in nature. INDORANI includes pollution emission equations for NO_2, CO, SO_2, SPM and BOD, and Indonesia-E3 for CO_2 emissions.

In the GAMS software environment, Azis (2000) combined the models by Lewis (1991) and Thorbecke (1991) to develop a new dynamic financial CGE model for Indonesia and analysed the impact of the 1997–98 Asian financial crisis on the Indonesian economy. The advantage of this CGE is the inclusion of the financial sector, so it can simulate financial policies. The Indonesian Central Bank currently utilises this model for their policy analysis. Another dynamic CGE model for Indonesia was developed by Resosudarmo (2002 and 2008). It omits the financial sector, but does include close-loop relationships between the economy and air pollutants such as NO_2, SO_2 and SPM (2002) and between the economy and pesticide use (2008).

Concerning inter-regional models, one of the first such CGEs (IRCGE) for Indonesia was developed by Wuryanto (Resosudarmo *et al.* 1999). On the production side, it divides Indonesia into Java and non-Java, while households comprise those in Sumatra, Java, Kalimantan, Sulawesi and the rest of Indonesia. It is a static CGE, based on the Indonesian inter-regional SAM (IRSAM), and runs on GAMS platform software. Another model was developed by Pambudi (Pambudi and Parewangi, 2004) in collaboration with the

[1] See Lewis (1991) for detail specification of the CGE utilized.

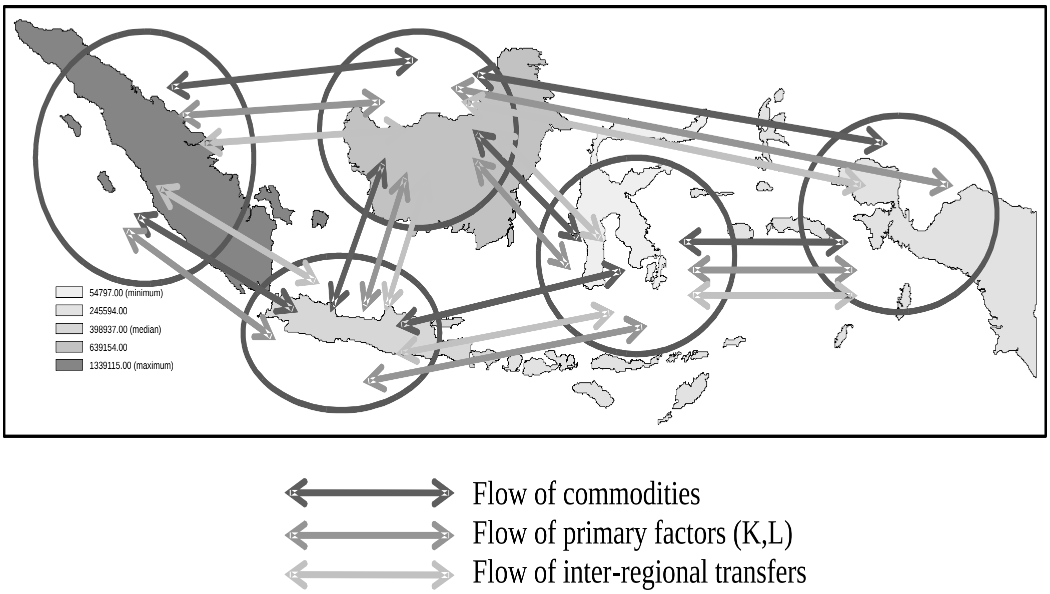
CPS at Monash University. It is a provincial level CGE, static in nature, a derivative of the inter-regional version of the ORANI model, based on the Indonesia IO table, and utilises GEMPACK Software. The models by Wuryanto and Pambudi are both bottom-up IRCGE models.

Note that other CGE models for Indonesia of equal importance to the ones mentioned above are available. They have not been mentioned simply because the authors of this paper are not that familiar with them.

2. IRSA-INDONESIA5: Main Features

IRSA-INDONESIA5 is a multi-year (dynamic) CGE dividing Indonesia into five regions: Sumatra, Java-Bali, Kalimantan, Sulawesi and Eastern Indonesia. Figure 1 illustrates these divisions. The connections between regions are due to the flow of goods and services (or commodities), flow of capital and labour (or factors of production) and flows of inter-regional transfers which can be among households, among governments, or between governments and households. It is important to note that each region is also connected with the rest of the world; i.e. they conduct import and export activities with other countries as well as sending money to and receiving it from friends and relatives abroad.

In each region there are 35 sectors of production, 16 labour classifications, accounts for capital and land, two types of households (rural and urban households) and accounts for regional government and corporate enterprise. The 35 sectors, as seen in Table 2, are based on an inter-provincial input-output table developed by the Indonesian statistical agency (BPS) for the national planning and development agency (Bappenas). There are four types of labour—agricultural, manual, clerical and professional workers—who are part of formal and informal sectors and are located in rural and urban areas.



Source: Resosudarmo *et al*. (2009)

Figure 1. Inter-Regional CGE Model

Table 2. Sectors in the Indonesian Inter-Regional CGE

SECTOR		SECTOR	
1	Rice	19	Cement
2	Other Food Crops	20	Basic Metal
3	Estate Crops / Plantations	21	Metal Products
4	Livestock	22	Electrical Equipment and Machinery
5	Forestry	23	Vehicle
6	Fishery	24	Other Industries
7	Oil, Gas and Geothermal Mining	25	Electricity, Gas and Clean Water
8	Coal and Other Mining	26	Construction
9	Oil Refinery	27	Trade
10	Palm Oil Processing	28	Hotel and Restaurant
11	Marine Capture Processing	29	Land Transportation
12	Food and Beverage Processing	30	Water Transportation
13	Textile and Textile Products	31	Air Transportation
14	Footwear	32	Communication
15	Wood, Rattan and Bamboo Products	33	Financial Sector
16	Pulp and Paper	34	Government and Military
17	Rubber and Rubber Products	35	Other Services
18	Petrochemical Products		

Source: Resosudarmo *et al*. (2009)

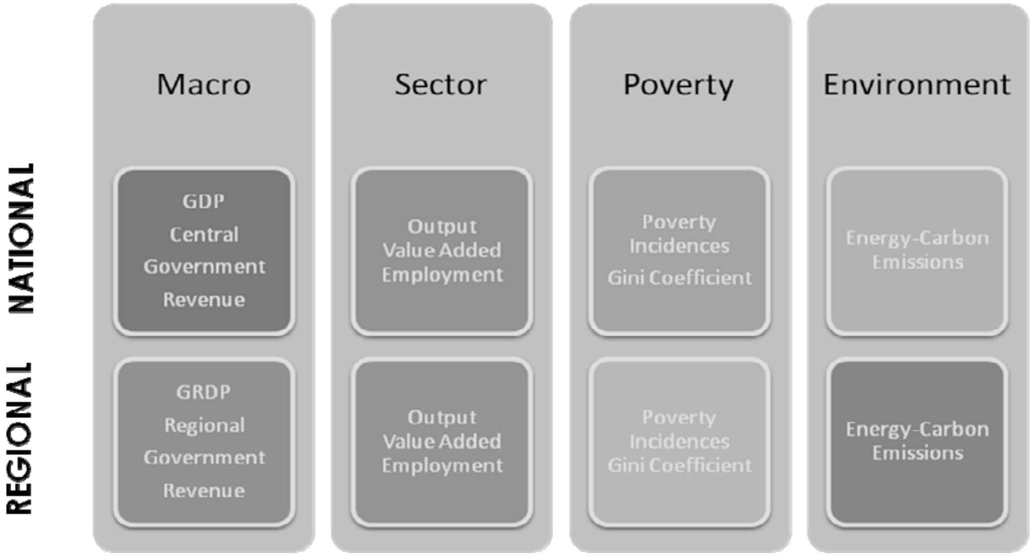
Both rural and urban households in each region are disaggregated using a top-down income-distribution model to become 100 representative households. CO_2 emission from energy use by both production activities and households is modelled, but not that due to deforestation and land conversion. Hence, not only is IRSA-INDONESIA5 able to present the typical macro indicators such as regional gross domestic product (GDP) as well as labour and household consumption, but also gini and poverty indexes as well as CO_2 emission for each region. Figure 2 summarises indicators available in IRSA-INDONESIA5 and which will apply until 2020.

Information capturing all these inter-regional dynamics is available in the 2005 Indonesian inter-regional social accounting matrix (Indonesia IRSAM) developed under the APSI project as well (Resosudarmo, *et al.* 2009a; 2009b).

3. IRSA-INDONESIA5: Basic Systems of Equation

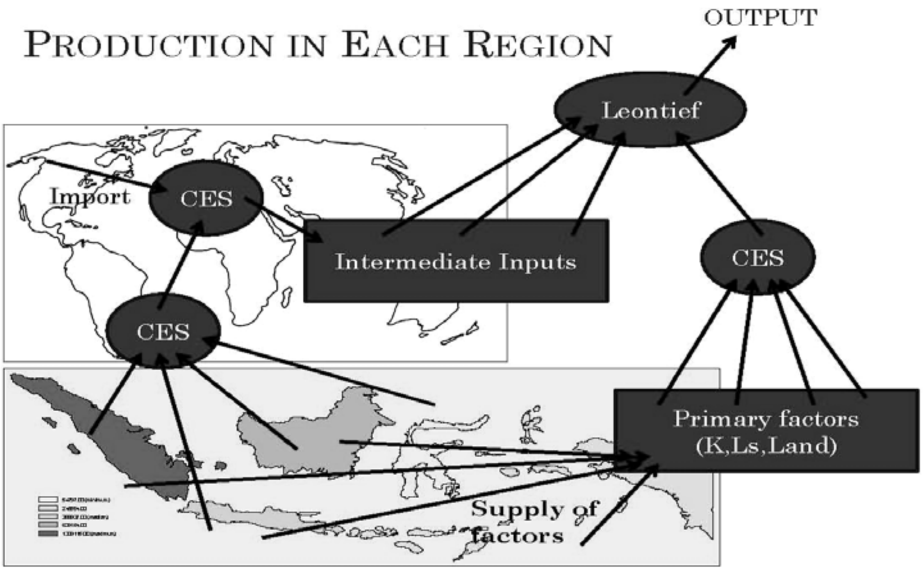
The summary of mathematical equations within IRSA-INDONESIA5 is as follows. On the production side, a nested production function is utilised. At the top level of the production function model for each commodity is a Leontief production function between all intermediate goods needed for production and a composite of value added (Figure 3), which is a constant elasticity of substitution (CES) function between capital, labour and land.

Each intermediate good utilised in the production of a particular commodity is a CES combination between imported and composite domestic goods. Domestic goods come from all regions with a constant elasticity of substitution among them.



Source: Resosudarmo *et al*. (2009)

Figure 2. Economic Indicators



Source: Resosudarmo *et al*. (2009)

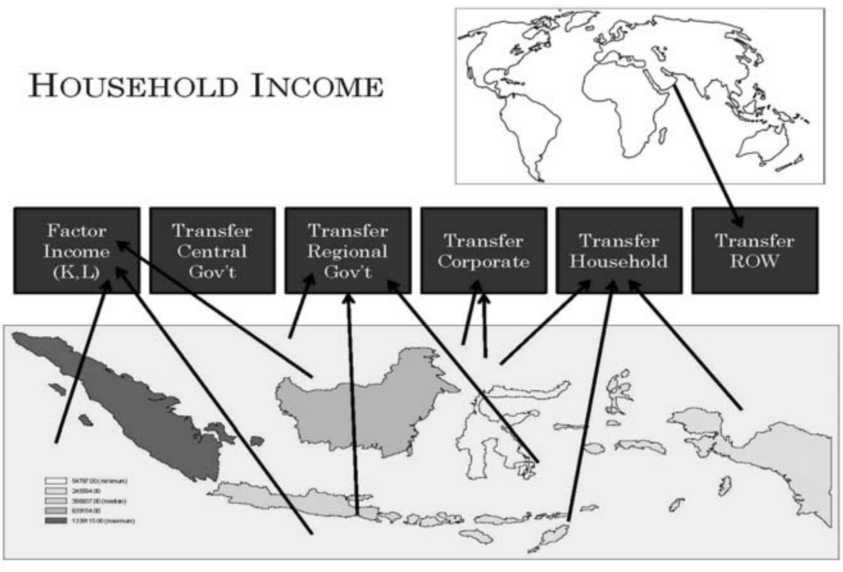
Figure 3. Production Side

At each level of this nested production function, firms maximise their profits subject to the production function at that level. A zero profit condition is assumed to represent a fully competitive market. Firms then distribute their products domestically and abroad. An export demand function and domestic demand system determines the amount of goods sent abroad or retained for domestic consumption.

Household demand for each commodity is a Linear Expenditure System (LES) model obtained from a model where households maximise a Stone-Geary utility function subject to a certain budget constraint. Sources of household income are their income from providing labour and capital in production activities in various regions, transfers from national and regional governments, transfers from other households and remittances from abroad (Figure 4). Meanwhile commodities consumed by households (as well as regional government and industries) in each region are a composite of domestic products and imports with a constant elasticity of substitution according to the usual Armington function. Composite domestic products are products from various regions which also have a constant elasticity of substitution. The consumption of households, government and industries creates a system of demand functions. (Figure 5).

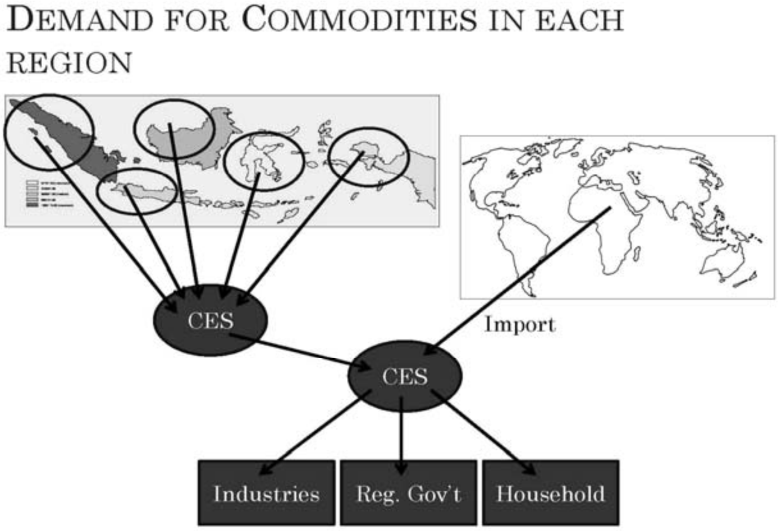
Household demand equations mentioned above are connected to a top-down income-distributional module which disaggregates each household group (urban and rural households) in each region into 100 household groups. The income of these 100 households is determined by a share parameter distributing the income of the original household. Expenditure for each of these 100 households is calculated using an LES demand function derived from a Stone-Geary utility function.

Market clearing requires that all markets for commodities and factors of production are in a state of equilibrium; i.e. supply matches demand. The inter-temporal part of the model consists mainly of two equations: first, an equation representing capital accumulation from one year to the next; and second, the growth of the country's labour force.



Source: Resosudarmo *et al*. (2009)

Figure 4. Sources of Household Income



Source: Resosudarmo *et al*. (2009)

Figure 5. Commodity Market

IMPLEMENTATION

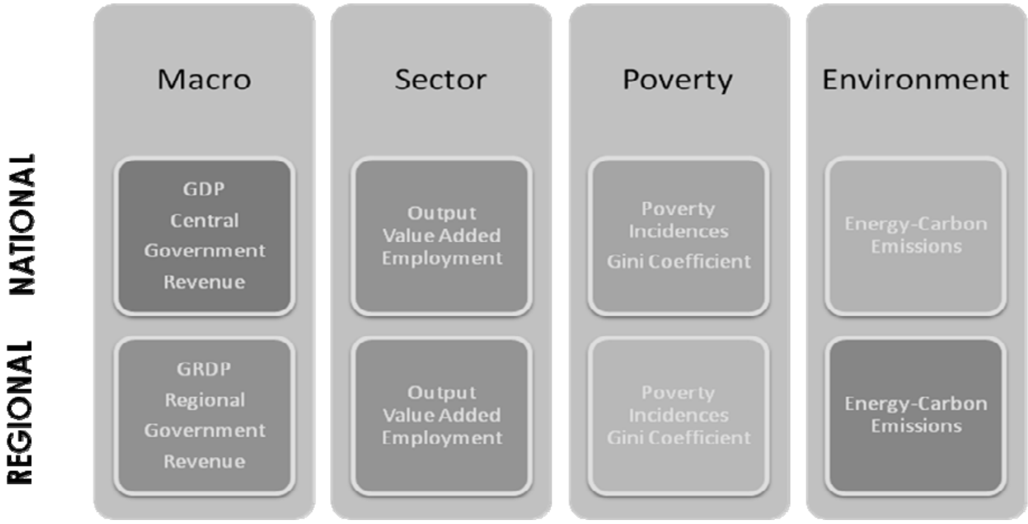
This section provides several basic analyses utilising IRSA-INDONESIA5. As an analysing tool, it could well illustrate the impact economic policy has on various national and regional economic indicators, such as gross domestic product (GDP), sectoral output, household consumption, the poverty level, income distribution typically represented by the gini index, and CO_2 emitted by combustion. Figure 6 illustrates the various indicators that IRSA-INDONESIA5 can produce. These economic indicators in general fall into four major categories, namely macroeconomic, sectoral, poverty, and environmental. They are available both at national and regional levels.

IRSA-INDONESIA5 can be utilised to analyse impacts on various national and regional economies. For example (Figure 7), the model can illustrate the impact of national policies or international shocks—such as fluctuations in the international oil price, the reduction of import tariffs, and changes in nation-wide indirect taxes or subsidies—on regional economic indicators. On the other hand, this model can also perform a reverse-causality analysis. In other words, it can be used to analyse nation-wide impacts due to region-specific shocks, such as changes in regional taxes, and regional productivity shocks due to drought, tsunami, or other natural disasters. Lastly, it can also reflect impacts due to changes in national and regional relationships, for example changes in the formula of inter-regional fiscal transfers.

The following sub-sections illustrate more specific implementations of IRSA-INDONESIA5. Several broad different policy simulations are conducted. The period under observation is from 2005 to 2020. To simplify the presentation, only results for 2020 are given. The aim of these simulations is to shed some light on solving the issues of (1) reducing the development gap among regions in the country, (2) achieving low carbon growth and (3) reducing deforestation.

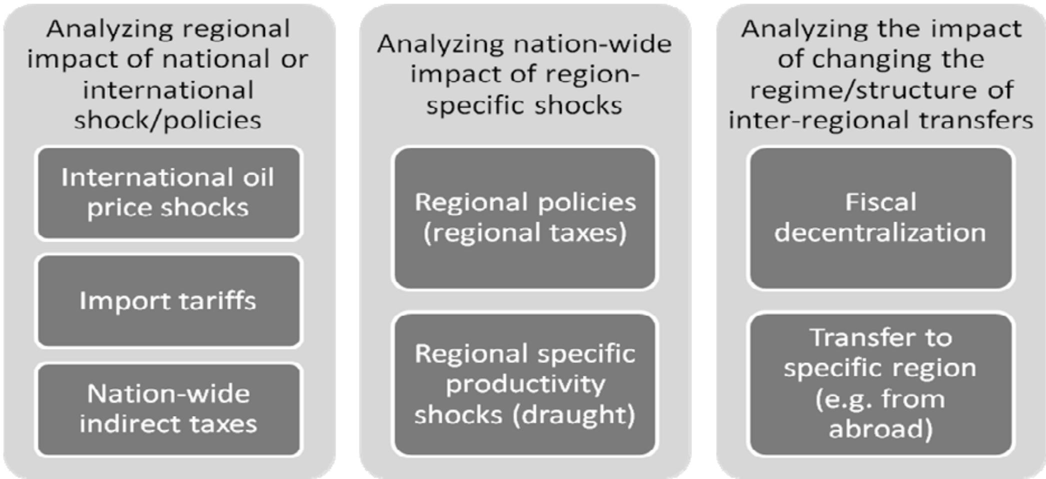
1. Designing Baseline (Sim0)

Before applying any sort of policy simulations of shocks, a baseline simulation is



Source: Resosudarmo *et al*. (2009)

Figure 7. Economic Indicators



Source: Resosudarmo *et al*. (2009)

Figure 7. Implementation of IRSA-INDONESIA5

needed to act as a benchmark from which to compare all other simulations. The baseline also makes several basic assumptions, the most fundamental one being the assumption that the structure of the economy does not change much during the simulation period. From 2006 until 2010 the GDP grew approximately according to the actual numbers reported by the Indonesian central statistical agency (BPS). For the remaining years up to 2020, GDP growth is assumed to be at approximately 6 percent following the (lower bound) prediction of the Government's Master Plan for Economic Expansion and Acceleration 2011-2025.

Table 3. Several Indicators in the Baseline Scenarios

Region	Indicators	2005	2020	% change
National	GDP (Rp trillion)	2,666.2	6,245.1	134.2
	Consumption per capita			
	- Urban household (Rp million)	8.7	12.7	45.0
	- Rural household (Rp million)	4.7	7.2	51.8
	Poverty			
	- Urban area (%)	12.3	1.0	-91.5
	- Rural area (%)	20.3	3.4	-83.3
	CO_2 Emission (Mt)*	341.0	928.1	172.2
Sumatra	GDP (Rp trillion)	579.7	1,305.5	125.2
	Consumption per capita			
	- Urban household (Rp million)	10.3	15.5	49.8
	- Rural household (Rp million)	3.9	6.7	71.3
	Poverty			
	- Urban area (%)	14.9	3.1	-79.1
	- Rural area (%)	18.6	*.*	-100.0
	CO_2 Emission (Mt)*	55.5	145.0	161.3
Java-Bali	GDP (Rp trillion)	1,605.6	3,797.3	136.5
	Consumption per capita			
	- Urban household (Rp million)	8.4	11.9	41.9
	- Rural household (Rp million)	5.9	8.4	43.1
	Poverty			
	- Urban area (%)	12.0	0.5	-96.0
	- Rural area (%)	20.7	3.1	-85.1
	CO_2 Emission (Mt)*	247.1	678.0	174.4
Kalimantan	GDP (Rp trillion)	258.7	673.8	160.4
	Consumption per capita			
	- Urban household (Rp million)	8.6	14.4	67.2
	- Rural household (Rp million)	3.3	6.2	88.2
	Poverty			
	- Urban area (%)	8.0	*.*	-100.0
	- Rural area (%)	13.0	1.1	-91.5
	CO_2 Emission (Mt)*	18.4	51.8	181.0
Sulawesi	GDP (Rp trillion)	107.7	237.5	120.5
	Consumption per capita			
	- Urban household (Rp million)	7.8	11.1	42.5
	- Rural household (Rp million)	2.1	3.6	70.5
	Poverty			
	- Urban area (%)	7.8	*.*	-99.9
	- Rural area (%)	20.9	4.4	-79.1
	CO_2 Emission (Mt)*	14.5	41.3	184.4
E. Indonesia	GDP (Rp trillion)	99.0	230.0	132.3
	Consumption per capita			
	- Urban household (Rp million)	11.6	17.8	54.2
	- Rural household (Rp million)	2.9	4.3	45.2
	Poverty			
	- Urban area (%)	22.3	8.1	-63.5
	- Rural area (%)	32.0	22.8	-28.8
	CO_2 Emission (Mt)*	5.4	12.1	123.3

Note: * = CO_2 emission from energy combustion; *.* = a trivial number.
Source: results of model calculations with the software GAMS

Table 3 provides several general indicators as a result of this baseline scenario. It demonstrates the Indonesian GDP in 2020 will be approximately 134 percent higher than in 2005. Of the Indonesian regions, it is expected that Kalimantan will grow the fastest. Urban poverty at the national level goes down to 1 percent, while rural poverty is 3 percent in 2020. The poverty level in rural Sumatra, urban Java, urban Kalimantan and urban Sulawesi is expected to be zero or close to zero by then. The level of total CO_2 emission from energy combustion is predicted to be 172 percent higher than in 2005.

2. Fiscal Decentralisation (Sim1)

A fiscal decentralisation policy simulation scenario is where local governments receive a greater fiscal transfer allocation from the central government. In this type of policy scenario the central government is asked to increase its fiscal transfer to local governments through a central-to-regional fiscal transfer, which consists of four types of fund allocation, i.e. tax revenue shared funds, natural resource revenue shared funds, specific allocation funds (DAK or *Dana Alokasi Khusus*), and general allocation funds (DAU or *Dana Alokasi Umum*). Typically, the central government increases its transfers to local governments through the general allocation fund or specific allocation fund. In doing so, the central government could increase each regional government's budget proportionally to its current budget; or it could increase transfers to each regional government by giving certain amounts of additional lump-sum funds. The implication is that central government expenditure will be reduced by an equal amount in both scenarios.

The hypothesis of the two policy options above is as follows. When central government expenditure on goods and services is expected to decrease, this tends to have a contractionary effect on the economy through the decline in demand for commodities. On the other hand, after receiving a larger fiscal transfer from the central government, regional governments will increase their consumption expenditure. This tends to have an expansionary effect on the economy. Whether or not the national demand will decline depends on which force is stronger. The impact on each region also depends on the nature of inter-regional trade. The regions that supply a considerable amount of goods and services to the central government will be more affected.

Another possible scenario (policy option) is that the central government increases its fiscal transfer to some regions, typically the regions that lag behind, and decreases the amount of fiscal transfer to the more advanced regions. The main hypothesis for this policy option is that those regions that lag behind will grow faster and close the development gap among regions in the country. It is important to note that the more advanced regions will be negatively affected and so it is not that clear what the impact of this policy will be on the national economy.

The simulation run for this paper adopts the third option; in this simulation, Eastern Indonesia receives an additional central government transfer of 5 percent compared to the base line situation, from 2010 until the end of the simulation year. In this simulation, all the additional budget received by Eastern Indonesia will be used for consumption expenditures. The consumption pattern of Eastern Indonesia's government does not change, just the amount of each expenditure increases. The additional funds for Eastern Indonesia are acquired from an equal amount of fiscal transfer reduction for Java-Bali. The main argument for doing this is that Eastern Indonesia is the least developed region in the country and that increased fiscal transfers from the central government will enable the region to catch up.

3. Regional Productivity (Sim2)

The second simulation deals with regional productivity. Productivity can arise from either or both capital and labour. Capital productivity can improve due to, among other things, equipment maintenance and the adoption of new technology. Labour productivity can increase due to labour quality improvements resulting from better education or new knowledge.

In this second simulation it is assumed that the rate of improvement in labour quality in Eastern Indonesia is higher than that of the other islands. Please note that by 2020, labour quality in Eastern Indonesia could still be lower than in the rest of Indonesia. The main reasons for Eastern Indonesia's faster labour quality growth are that it starts from a lower base, there is a movement of labour with higher skills into the area and the quality of education in the area is improved. Better labour quality, in turn, translates, in this paper, into an increase in both labour and capital productivity by as much as 1 percent higher than the baseline between 2010 and the end of the simulation year.

With this acceleration of labour and capital productivity it is expected that Eastern Indonesia will develop faster than it would under the baseline scenario and this will benefit the nation as a whole in terms of poverty reduction and higher growth.

4. Energy Efficiency (Sim3)

With increasing global concern regarding climate change, adaptation and mitigation strategies become very important. Indonesia faces a variety of climate change impacts, from sea-level rise to a changing hydrological cycle and more frequent droughts and floods, to greater stresses on public health. These will require attention and corrective action if development is to be safeguarded in the face of changes in the natural world. Indonesia itself is a significant emitter of greenhouse gases, especially connected to deforestation. However, reducing these emissions creates its own challenges; particularly in calculating how these activities will affect the economy and the people.

The third simulation relates to the improvement in efficiency of energy use. There are many forms energy efficiency can take, albeit mostly related to maintenance and technological improvements. Energy efficiency can also occur both in the private and industrial sectors. Households deciding to use more energy efficient light bulbs and heaters is an example of private sector energy efficiency. Energy efficiency in the industrial sector mainly relates to capital, specifically equipment. Equipment maintenance and technological improvements are examples of how energy efficiency can be achieved in this sector.

Note that the industrial sector itself consists of many smaller sectors, such as food and beverage, cement, basic metal, rubber, and others. As such, energy efficiency in the industrial sector does not necessarily mean an increase in efficiency for all sectors at once. Implementation of IRSA-INDONESIA5 can simulate an increase in energy efficiency in all sectors at once or selected sectors only. Furthermore, in some cases, energy efficiency involves additional costs, e.g. through the adoption of new energy efficient technology acquired from abroad which the government can subsidise or, alternately for which the industrial sector bears the entire cost.

There is an instance in the simulation run in this paper where the stimulus occurs from equipment maintenance and technological improvements. The simulation looks at the impact of a gradual improvement in energy efficiency of up to 10 percent by 2015, beginning in 2010, in the food processing, textile, rubber, cement, basic metal and pulp and paper industries; i.e. the energy intensive industries.

The possible impact will be that these energy intensive industries increase their production since it is cheaper for them to produce their products, so enabling them to reduce product prices. However, energy sectors, such as oil and gas, mining and refineries will decline. The economies of regions that rely most heavily on their energy sectors, particularly Kalimantan, will be negatively affected. Meanwhile regions where food processing, textile, rubber, cement, basic metal and pulp and paper industries are mostly located, particularly Java, will be positively affected.

5. Electricity Sector (Sim4)

This simulation concerns how electricity has been generated. It investigates what the impact on the economy would be if the electricity sector were to be more efficient in utilising energy inputs to produce electricity. First, electricity could be cheaper and so induce higher economic growth. Second, CO_2 emissions could be lower, in particular, since most coal is utilised by the electricity power generating sector rather than by other sectors.

In this simulation, it is assumed that the electricity sector becomes gradually more efficient in using fossil fuels. It becomes 20 percent more efficient between 2010 and 2015. It is assumed in this simulation that there is no significant cost associated with the improvement. In other words, such costs are taken care of exogenously. In general this situation will improve the economic performance of all regions.

6. Energy Subsidy Policy (Sim5)

Subsidies have always been an important instrument for the Indonesian government. This issue generally relates to the question of who benefits the most from a government subsidy—certainly an important issue as it has direct bearing on the purpose of a subsidy. Of course, there are many types of subsidies, ranging from direct government transfers to low-income households to industrial subsidies to help reduce production costs in a certain sector.

This simulation, however, does not investigate the impacts of implementing a subsidy. Instead it looks at the impacts of reducing fuel subsidies. In other words, the fifth simulation looks at the gradual elimination of fuel subsidies from the year 2010 until its full abolition in 2015. The entire financial gain from subsidy reduction is distributed back into the economy through government spending. It is hard to predict what impact this will have on the economy. In general the economy might perform better compared to the baseline, but this will probably not be the case in all regions.

7. Carbon Tax (Sim6)

In this simulation, it is assumed there is a carbon tax of as much as Rp.10,000 per ton of CO_2 from 2010 onwards. This carbon tax revenue enables the government to spend more on goods and services. It is expected that industries using highly polluting energy, such as coal, will be negatively affected. On the other hand increasing the government budget will create the stimulus to boost the economy. It remains to be seen which force is stronger.

8. Deforestation (Sim7)

In this simulation, deforestation outside Java-Bali is assumed to be reduced by 10 percent from 2012 onwards mainly due to effective control of logging activities; i.e. the amount of logs produced is controlled so as to decline by as much as 10 percent from the baseline condition. Here, no compensation is offered. In a way, this simulation can also be a benchmark for comparison in other simulations related to reducing the rate of deforestation, specifically cases involving carbon emission reduction compensation.

The hypothesis is that regions with important forest and forest product industries will be negatively affected. Since these industries are in general situated Indonesia-wide, including Java where forest cover is limited, all regions will be negatively affected. This simulation provides an indication as to how funding from emission reduction compensation projects such as reducing emission from deforestation and forest degradation (REDD) should be channelled.

OBSERVATIONS REGARDING RESULTS

The following sections look at the results of simulations mentioned above. They compare four economic indicators, namely gross domestic product (GDP), household consumption per capita, poverty, and carbon emission, for all the simulations with respect to the baseline simulation (Table 4). All numbers are percentage changes; i.e. results from the policy simulations divided by the baseline minus one multiplied by a hundred, except for poverty. Poverty is the difference between poverty outcomes from the policy simulation and the baseline situation.

GDP is the most common measure of regional economic performance. A higher GDP indicates higher welfare in the region. The indicator that most specifically measures household welfare is household consumption per capita. It is assumed that the more a household consumes, the better off it is. This is the indicator typically used to differentiate rural and urban households. Even when rural and urban households are affected similarly, whether positively or negatively, in many cases, magnitudes of the impact do differ.

Concerning the poverty indicator, the most common parameter is the head-count poverty index. This index shows the percentage of poor people in a certain region; i.e. those living below a certain poverty line. The World Bank commonly use $1 a day or $2 a day as the poverty line. BPS produces a poverty line for each province in Indonesia each year. In 2008, the poverty line for urban areas was slightly above Rp. 200,000 per capita per month and slightly below Rp. 200,000 per capita per month for rural areas. This work will use the poverty lines produced by BPS and so the poverty indicators show the percentage of poor people based on their definitions.

CO_2 emission indicators represent the total emission from fuel combustion activities per year. As mentioned before, these numbers exclude the amount of emission from deforestation, land use and other factors.

In observing the results of the simulation, it is important to note that this paper assumes that the structure of the economy, except for the shocks introduced in each policy simulation, remains the same during the period of the simulation. The main benefit of having this assumption is that it can be sure that the results of this paper are mainly due to the shocks introduced. The drawback is that this might never happen in the real world. Any shock will always change the structure of the economy. Hence, in a way, this paper underestimates the "full" impact of each policy simulation.

1. Fiscal Decentralisation (Sim1)

The results of this simulation can be seen in column SIM1 of Table 4. The initial intuition is that increased central government transfers to Eastern Indonesia will benefit the region; i.e. The Eastern Indonesian economy under this policy will be better than the baseline scenario. However, this policy might negatively affect the region, in this case Java-Bali, which receives a lesser fiscal transfer from the central government. Since the initial condition is that the economy of Java-Bali performs better than that of Eastern Indonesia, the policy of increasing the fiscal transfer will lower the gap between Eastern Indonesia and Java-Bali.

In the short-run the above intuition might be true, but not in the long-run. The lower performance of Java-Bali compared to the baseline situation, in the long-run negatively affects the performance of the whole nation, including Eastern Indonesia. It can be seen from Table 4 that GDPs of all regions decline in 2020. Even more surprising is that Eastern Indonesia suffers the most in its GDP reduction compared to the baseline even though it receives an increase in funding from the central government. This shows that Eastern Indonesia does depend on other regions to the extent that an increase in revenue to the region cannot compensate for the contraction in all other regions.

Table 4. Simulation Results in 2020 as Compared to the Baseline (in %)

Region	Indicators	SIM1 Fiscal Decentra-lization	SIM2 Regional Producti-vity	SIM3 Energy Efficien-cy	SIM4 Electri-city Sector	SIM5 Energy Subsidy	SIM6 Carbon Tax	SIM7 Defo-restation
National	GDP	-0.10	0.06	0.07	0.30	2.15	0.15	-0.18
	Consumption per capita							
	- Urban household	0.02	0.04	0.21	0.90	1.23	0.05	-0.16
	- Rural household	0.06	0.05	0.29	1.11	1.62	0.07	-0.30
	Poverty							
	- Urban area	-0.04	-0.01	-0.09	-0.34	-0.46	*.**	0.09
	- Rural area	0.01	-0.01	-0.07	-0.29	-0.48	-0.03	0.17
	CO_2 Emission*	-0.06	0.05	-0.92	-3.26	2.21	-0.08	-0.22
Sumatra	GDP	-0.07	0.02	0.05	0.32	2.04	0.14	-0.26
	Consumption per capita							
	- Urban household	-0.01	0.01	0.18	0.66	1.45	0.09	-0.10
	- Rural household	-0.05	0.02	0.32	0.68	1.71	0.13	-0.53
	Poverty							
	- Urban area	*.**	*.**	*.**	*.**	*.**	*.**	*.**
	- Rural area	0.03	-0.01	-0.10	-0.24	-0.48	-0.03	*.**
	CO_2 Emission*	-0.11	0.03	-1.86	-2.48	2.17	-0.01	-0.35
Java-Bali	GDP	-0.03	0.02	0.07	0.27	2.09	0.15	-0.15
	Consumption per capita							
	- Urban household	-0.17	0.02	0.26	1.10	1.22	0.02	-0.18
	- Rural household	-0.37	0.03	0.33	1.38	1.68	0.03	-0.24
	Poverty							
	- Urban area	0.09	*.**	-0.15	-0.59	-0.67	0.01	0.09
	- Rural area	0.12	-0.01	-0.08	-0.36	-0.48	-0.03	0.20
	CO_2 Emission*	-0.06	0.04	-0.69	-3.57	2.14	-0.12	-0.19
Kalimantan	GDP	-0.09	0.03	0.09	0.42	3.06	0.20	-0.18
	Consumption per capita							
	- Urban household	0.01	*.**	0.09	0.37	-0.92	0.14	-0.12
	- Rural household	0.01	0.01	0.04	0.32	-3.84	0.19	-0.04
	Poverty							
	- Urban area	-0.01	*.**	-0.03	0.04	0.05	-0.02	0.03
	- Rural area	*.**	*.**	*.**	*.**	*.**	*.**	*.**
	CO_2 Emission*	-0.13	0.04	-0.16	-2.47	3.43	0.12	-0.18
Sulawesi	GDP	-0.07	0.02	0.04	0.29	1.81	0.13	-0.25
	Consumption per capita							
	- Urban household	-0.07	*.**	0.17	0.41	1.56	0.07	-0.15
	- Rural household	0.07	0.02	0.38	0.76	4.01	0.13	-0.40
	Poverty							
	- Urban area	-0.01	-0.01	-0.09	-0.18	-0.57	-0.03	0.39
	- Rural area	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.54
	CO_2 Emission*	-0.21	0.04	-2.57	-2.12	1.93	-0.05	-0.20
E. Indonesia	GDP	-1.38	1.03	0.01	0.18	1.27	0.09	-0.13
	Consumption per capita							
	- Urban household	4.58	0.69	-0.14	0.03	3.27	0.20	-0.20
	- Rural household	8.96	0.56	-0.26	-0.05	5.52	0.34	-0.28
	Poverty							
	- Urban area	-1.69	-0.07	0.03	0.04	-0.82	-0.05	0.04
	- Rural area	-3.31	*.**	0.11	0.21	-2.23	-0.14	0.05
	CO_2 Emission*	0.97	0.80	0.04	-2.23	2.28	0.06	-0.32

Note: * = CO_2 emission from energy combustion; *.** = a trivial number.
Source: results of model calculations with the software GAMS

Regarding household consumption per capita, it can be seen that Eastern Indonesia is the only region likely to benefit from an increased transfer of funding to the region. The household consumption per capita in the region increases by almost 9 in percent urban areas and 5 percent in rural areas, compared to the situation under baseline conditions. This higher household consumption per capita is translated into a lower level of poverty by as much as 3 and 2 percent in urban and rural areas, respectively.

Household consumption per capita does not change much in other regions. In this simulation Java-Bali faces a lower transfer of funding from the central government compared to the baseline situation, and so it is natural that household consumption per capita in this region is affected the most negatively. A lower household consumption per capita is then translated into a higher poverty level in this region. Observing what is happening in the Eastern Indonesian and Java-Bali regions, it can be concluded that shifting funding from rich to poor regions does work in reducing the poverty level of poor regions.

2. Regional Productivity (Sim2)

In this scenario, productivity in Eastern Indonesia alone improves faster and induces a higher GDP for Eastern Indonesia in 2020 than it does under baseline conditions. Better productivity also induces a higher consumption per capita in rural and urban areas in these regions, and translates into a lower level of poverty. In rural areas, however, the change in the poverty level is minimal.

The other regions also benefit from a more productive Eastern Indonesia as their GDPs in 2020 are also slightly higher in this scenario compared to the baseline. Nevertheless the impacts on other regions' GDPs are not that great and so household consumption per capita in other regions is only marginally higher than the baseline situation. Poverty levels in rural and urban Sulawesi, rural Java-Bali and rural Sumatra in 2020 are lower than their baseline levels.

It can be seen in this scenario that productivity improvement achieves both the targets of higher national economic growth and reduction in the development gap between regions. Given this result, there is certainly room for the government to incur "extra" costs to ensure the improvement of productivity such as by improving the educational system in less developed regions.

3. Energy Efficiency (Sim3)

More efficient use of energy in the energy intensive sectors—i.e. food processing, textile, rubber, cement, basic metal and pulp and paper industries—is expected to lower the operation costs of those sectors, and enable them to sell their products at a lower price. This generates higher demand for the products of those sectors and so induces higher returns to factor inputs including incomes of workers who work in those sectors. These higher returns potentially improve household consumption so households will be able to spend more, with the outcome that the economy is expected to grow. On the other hand, more efficient use of energy reduces demand for energy products meaning lower returns to factor inputs in the energy sectors including work income. Ultimately, these lower incomes could potentially reduce the economy. Hence, more efficient energy usage could have a positive or negative effect on the economy.

The result in column SIM3 in Table 4 shows that more efficient energy usage by the energy intensive sector does induce a higher GDP in 2020 compared to the baseline scenario. It is important to note that in those regions where energy sectors dominate, regional GDPs in the short run might be lower than the baseline scenarios. However, since other regions would grow faster, in the long-run the regions where energy sectors are dominant would receive spillover benefits. It turns out under this scenario such benefits in the long-run are higher than the negative impact of a lower demand for energy in the short-run.

In this scenario, household consumption per capita in general is higher than the baseline scenario in all regions. This higher income per capita is translated into a lower level of poverty in most regions, except for urban Sumatra and rural Kalimantan. In those areas, the levels of poverty remain the same as under baseline conditions.

Under this scenario CO_2 emission from energy combustion in 2020 is lower than the baseline, representing lower consumption of fuels. The ability to improve energy efficiency in the energy intensive sectors not only creates higher growth, but also reduces CO_2 emission from energy combustion, demonstrating that this is certainly one way to control CO_2 emission. Since the economy would benefit from this improvement, there is a room for the government to create programs or incentives to ensure this improvement in energy efficiency.

4. Electricity Sector (Sim4)

A more efficient electricity sector makes it cheaper to produce electricity. The lower price of electricity lowers costs in all other sectors except for the primary energy sector. Households will also be able to consume more goods and services other than electricity. The overall potential impact is the economy becoming larger than the baseline situation. On the other hand, due to a more efficient electricity sector, primary energy sectors might decline and so potentially negatively affect the economy. Ultimately it remains to be seen whether or not a more efficient electricity sector benefits the economy.

Column SIM4 in Table 4 shows that it turns out that a more efficient electricity sector does induce higher GDPs in all regions by 2020 compared to the baseline situation. The benefits of having a more efficient electricity sector are greater than the negative impact due to the decline in the primary energy sector. As GDPs increase, household consumption per capita in both rural and urban areas in all regions increases as well, except in rural Eastern Indonesia. Poverty, except in Papua and Kalimantan, declines. In Papua and Kalimantan, the increasing poverty is due to the increase in income of relatively rich households, while it declines somewhat in the case of relatively poor households.

In terms of CO_2 emissions from energy combustion, a more efficient electricity sector is an effective way to reduce these emissions. It is argued that it is even more effective than more efficient energy use in energy intensive industries. The main reason for this is that coal, the dirtiest of all energy sources in terms of CO_2 emission, is mostly consumed by the electricity sector, whereas the energy intensive industries use various types of energy. It is important to note as well that in terms of policy implementation, it is probably easier to improve the efficiency of the electricity sector, since there are fewer electric power generators than energy intensive industries.

5. Energy Subsidy Policy (Sim5)

It is important to note that currently the energy subsidy is for gasoline and kerosene. This subsidy should be eliminated for the simple reason that it encourages inefficient use of energy. A more sophisticated reason is that this inefficient use of energy leads to a state of equilibrium of goods and services in which society will not achieve the maximum possible benefits. Eliminating this subsidy should increase the GDP of the country. Column SIM5 in Table 4 illustrates this situation; compared to one baseline conditions GDP for 2020 increases in all regions. And in general, a higher GDP leads to an increase in household consumption per capita and a reduction of poverty.

It is important to observe the case of Kalimantan. Under this elimination of energy subsidy policy, the GDP of this region in 2020 is higher than its baseline condition. And compared to the change in GDP of other regions in 2020 under this scenario and at baseline, the change in Kalimantan is the highest. However, firstly, this is not true for the changes in household consumption per capita; i.e. the changes in household consumption per capita in Kalimantan are, in general, not higher than those in other regions, except in Papua. Considerable GDP gains go to an increase in return to capitals in the region compared to other regions. This means that industries in Kalimantan tend to be capital intensive ones. The second issue concerning Kalimantan is that an increase in household consumption per capita is not automatically translated into a reduction of poverty. Capital intensive industries tend to employ more highly skilled workers, and so when the size of the economy increases—i.e. the capital intensive industries expand—it is mostly the skilled workers, who are relatively not poor, who receive a higher income. The impact of this economic expansion on the poor is relatively small.

The elimination of an energy subsidy does not always lead to lower CO_2 emission for several reasons. First, elimination of gasoline and kerosene subsidies could lead to greater use of coal which emits more CO_2 than gasoline and kerosene. Second, the elimination of an energy subsidy might lead to a reduction in the use of energy and so less CO_2 would be emitted in the short run. In the long-run, since the economy grows faster without the energy subsidy, the economy will consume more energy. But energy intensity (energy use per unit of GDP) remains lower under the elimination of the subsidy compared to the situation without energy subsidy elimination. Simulation in this work demonstrates the second case. In the short run, CO_2 declines, but not in the long run, since the economy grew faster than in the baseline situation.

6. Carbon Tax (Sim6)

A carbon tax per ton of CO_2 makes a dirty type of energy relatively more expensive. Under such conditions coal would become relatively more expensive, and gas and renewable energy sources relatively cheaper. A carbon tax in general makes it more costly to produce products and so potentially negatively affects the economy. However, in this scenario, the whole revenue from carbon tax is redistributed to the economy by increasing government spending. This spending should positively affect the economy. Therefore, whichever force is bigger (the negative or the positive force) will determine the overall impact of a carbon tax on the economy.

Column SIM6 in Table 4 shows that a carbon tax, overall, positively affects the economy. GDPs in all regions in 2020 are higher than the baseline. The level of CO_2 emission in 2020 is also lower than the conditions. It is important to note that when the carbon tax is initially implemented, the level of CO_2 emission is much lower than in the baseline scenario. How low it is depends on whether or not the model allows a substitution of dirty sources for cleaner sources of energy. Nevertheless, since the economy under a carbon tax grew faster than it did without one, the gap of CO_2 emission between these two scenarios is reduced. Eventually the total CO_2 emission under a carbon tax will be higher than it is without one, since the economy is much larger. However, carbon emission intensity will still be lower under a carbon tax than under the baseline situation.

In the carbon tax simulation, in general, household consumption per capita increases in all regions in 2020, in both rural and urban areas. Poverty levels are lower, except in urban Java. The majority of sectors using coal as their energy inputs are in Java, and are negatively affected by this carbon tax. These are mostly intensive capital industries and employ skilled workers in urban areas. The negative impact on urban people in Java cannot be compensated for by the positive impact due to an increase in government budget.

7. Deforestation (Sim7)

When less timber extraction is allowed from off-Java islands, the national GDP in 2020 is lower than the baseline scenario. In terms of GDP, Sumatra and Kalimantan are affected the most. This is natural since most timber comes from these two islands and so a 10 percent reduction is significant for them. What is rather surprising is the result for Java-Bali. Although it does not have much remaining forest and moreover no restrictions on harvesting timber, the region is negatively affected. The main reason for this is that majority of wood processing industries are in Java and they are affected when less wood is available. As a consequence of this lower GDP, both urban and rural household consumption per capita in all regions in 2020 is lower than at baseline, and urban and rural poverty levels in all regions are higher.

This simulation indicates that people do need compensations for timber harvesting restrictions. The compensations should not only be distributed to rural people (i.e. forest communities) in forest production regions, but also to urban people in those regions and to also to the people in Java-Bali.

CONCLUSIONS

This paper aims to introduce IRSA-INDONESIA5 which was developed under the Analysing Path of Sustainable Indonesia (APSI) project as a policy tool for the Indonesian government. IRSA-INDONESIA5 is a dynamic inter-regional CGE. This paper also shows how this model can be implemented to help resolve several problems faced by Indonesia. Here are several general lessons from the implementation of IRSA-INDONESIA5 with regard to the issues of (1) reducing the development gap among regions in the country, (2) achieving low carbon growth and (3) reducing deforestation. Furthermore detailed research is needed to achieve more detailed policy lessons.

Reducing the development gap and enhancing national economic growth: SIM1 and SIM2 reveal that the best way to reduce the development gap among regions is by creating effective programs to accelerate the growth of human capital in the less developed regions. This way, they will grow faster and spread to other regions so that ultimately the whole country will grow faster.

There are certainly some rooms to reallocate the transfers from the central to regional governments in favour of less developed regions. However, this policy should be executed cautiously so that the negative impact on other regions is relatively small.

Achieving low carbon and high economic growth: In the short-term, the elimination of energy subsidies and/or implementation of a carbon tax works well in reducing CO_2 emission and producing higher economic growth. Such measures can be implemented gradually. For instance, the rate of a carbon tax can be initially low and then gradually be increased.

In the long-run, however, technological improvement, particularly toward a more energy efficient technology, is needed to maintain a relatively low level of emission with continued high growth. For Indonesia, the first step is to improve the efficiency of energy use in the electricity sector. The second step is to force the energy intensive industries to be more efficient in using energy, and eventually all industries as well as households. Technological improvement, if available, can be effective in achieving lower CO_2 emission while encouraging the economy to grow faster. Hence, the government should consider investing in programs that ensure the transfer of more energy efficient technology to the country.

Reducing deforestation: If reducing deforestation means reducing the amount of timber harvested, then it negatively affects the economy. To eliminate this negative impact, deforestation compensation is needed. In general there are two ways of utilising this compensation. Firstly it could be distributed to households. It is important to note that this compensation should not only be given to forest communities, but also to the poor in urban areas and regions where wood processing industries are located. The compensation funding is expected to compensate for income lost due to the reduced activity of the logging and wood processing industries. If households receive more income, it is also expected that household consumption will encourage the economy to grow faster.

Secondly, the deforestation compensation could be distributed to the government, including regional governments, with two aims in mind. First, it is expected that with this funding the government could create effective reforestation programs or improve the forest industry areas that are currently inefficient, so that reduced deforestation can be achieved without any or only a marginal reduction in logging. Second, the government would be able to spend more on various goods and services and so encourage the economy to grow, compensating for the decline due to a reduction in timber harvesting. It is important to note that combinations of the various options mentioned above are certainly possible and are to be encouraged so that the maximum benefits from deforestation compensation can be achieved.

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