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Abstract

This paper analyzes the benefits and losses associated with cooperation among ASEAN members in mitigating their CO_2 emission, particularly by implementing a uniform carbon tax across ASEAN. To achieve this goal, this paper uses a multi-country CGE model for ASEAN, known as the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) model. This study finds that the implementation of a carbon tax scenario is an effective means of reducing carbon emissions in the region. However, this environmental gain could come at a cost in terms of GDP contraction and reduction in social welfare, i.e. household income. Nevertheless, Indonesia and Malaysia can potentially gain from the implementation of a carbon tax as it counteracts price distortions due to the existence of heavy energy subsidies in these two countries.

Keywords: climate change, computable general equilibrium model, ASEAN, regional economics

JEL Code: Q54, Q56, O21, O57

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ASEAN Economic Community and Climate Change

1. Introduction

The Association of Southeast Asia Nations (ASEAN) was founded on 8 August 1967. The Declaration forming this association was signed by the Foreign Ministers of Indonesia, Malaysia, the Philippines, Singapore and Thailand. The aim and purpose were to foster cooperation in economic, social, cultural, technical, educational and other fields, as well as in the promotion of regional peace and stability through abiding respect for justice and the rule of law as well as adherence to the principles of the United Nations Charter (Khoman, 1992). Over time, due to the relative success of this association in achieving its goals, ASEAN membership has expanded to also include Brunei, Cambodia, Laos, Myanmar, and Vietnam.

To enhance the benefits of collaboration among members, in 2003, the idea of creating an ASEAN Economic Community by 2015 was proposed (Morada, 2008; Simon, 2008). The main goal is to create a single market and production base by allowing the free movement of goods, services, investments and skilled labor. Establishing deeper cooperation among members in response to global issues has been another objective.

One issue that emerged globally in the early 2000s is that of climate change, i.e. the world needs to reduce the amount of greenhouse gas (GHG) it emits (Stern, 2006). ASEAN countries' GHG emission is not insignificant (ASEAN, 2009). Leaders of ASEAN hence see the need to act together in response to this climate change issue, and they plan to do so. At the 13th ASEAN Summit in November 2007, its leaders reaffirmed the need to tackle climate change based on the principles set out by the UNFCCC through the Singapore Declaration on Climate Change, Energy, and Environment. One option under consideration is to put a price on carbon emissions. Carbon pricing takes advantage of the market mechanism in deciding where emission reductions should occur. It raises the price of goods that have associated carbon emissions in their production. Goods and services that embody high emissions will see greater increases in price than those that embody low emissions. The economic reaction to the price signal automatically implements the lower-cost abatement options (Jotzo and Mazouz, 2010).

Left unaddressed by ASEAN members so far has been a deep understanding as to how the implementation of carbon pricing policies would affect their economies. Would these policies represent a serious threat to the growth of their economies? Which household groups, rural vs urban or rich vs poor households, in their countries will have to shoulder the greatest burden of these policies, i.e. would this policy be regressive or progressive toward income distribution? The main objective of this paper, hence, is to analyze the socio-environmental-economic impact of a carbon pricing policy in ASEAN. A case study of a carbon tax, or a levy on carbon dioxide

(CO_2) emission[2], is chosen since this policy will affect all members of ASEAN[3]. Due to data availability, analysis will be focused on Indonesia, Malaysia, The Philippines, Singapore, Thailand, and Vietnam[4]. In order to look at the impact of implementing such a tax in terms of environmental improvement, economic growth, and income distribution, this paper builds a multi-country computable general equilibrium (CGE) model called the Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN). Thus far, this is the first paper to analyze the impact of a unified carbon tax policy on ASEAN economies.

The first part of this paper provides a brief literature review regarding the assessment of the impact of a carbon tax on the economy. The second part provides a brief overview of the methodology used in this study, namely the IRSA-ASEAN model. This is followed by a presentation of the results and analysis arising from the use of the IRSA-ASEAN model to simulate various policy scenarios related to the implementation of a carbon tax in the region. The last part provides a summary and conclusion.

1.1. Carbon Tax

Environmental tax policies have indeed become increasingly frequent in recent years. One reason for this is increasing concern about the quality of the natural environment; environmental taxes are generally an efficient instrument for protecting the environment. The second reason involves the revenues from environmental taxes. These revenues can be used to cut other distortionary taxes. In this way, the government may reap a "double dividend", i.e. not only a cleaner environment but also a less distortionary tax system (Pearce, 1991; Goulder, 1995; Bovenberg, 1999; Glomm *et al.*, 2007).

Nevertheless, several studies, including the one by Schob (2005), theoretically argue that an environmental tax may have a multitude of possible effects which are sensitive to the underlying institutional framework. The double dividend theory in which a revenue-neutral tax shift may yield environmental gains at virtually no cost does not always hold up. While there are significant environmental benefits associated with a tax shift, these gains are not generally costless.

Despite debate on the cost of an environmental tax to control the quality of the environment, recent studies argued that revenue-raising environmental policies are more efficient than non-revenue-raising ones because of the revenue-recycling effect (Morgenstern,

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[2] In this paper, the definition of a carbon tax is limited to a levy on the emission of carbon dioxide only; and thus, the term "carbon tax" refers to a CO_2 tax and is used interchangeably.
[3] Please also note that a policy to reduce deforestation is also an important climate change policy for ASEAN. However, this will be important mostly for Indonesia and Malaysia.
[4] Brunei Darussalam, Cambodia, Lao PDR, and Myanmar are not included due to the severe lack of data.

1995). However, the tax type, "recycling policy", and economic model significantly influence the chance that a double-dividend effect can be obtained (Lai, 2009).

The term recycling policy refers to revenue recycling, that is, using new revenues from environment-related taxes to decrease pre-existing distortionary taxes. Other forms of financial recycling are also possible, such as lump-sum transfers to households or industries, consisting of recycling the revenues to households or to industries in the form of one-off payments (Patuellia *et al*. 2005). There is increasing evidence that the way in which tax revenues are recycled is a key factor in meeting a country's economic and environmental objectives (Welsch, 1996; Corong, 2008).

A carbon tax is one type of environmental tax. Among the early works on the impact of a carbon tax on the economy are those of Poterba (1991), Pearson and Smith (1991) and Hamilton and Cameron (1994); while some of the more recent ones are those of Ojha (2009), Grainger and Kolstad (2009) and Cororaton and Corong (2009). According to these works, there are some caveats associated with the implementation of a carbon tax.

One such is the regressive nature of a carbon tax in as much as it imposes the heaviest burden on the lower income groups (Grainger and Kolstad, 2009). Most of the studies on this issue, however, concern developed countries (Baranzini *et al.*, 2000). Among others are those by Brännlund and Nordstrom (2004), Oladosu and Rose (2007), Leach (2009), and Callan *et al.* (2009), which all confirm that a carbon tax or energy tax in developed countries is regressive.

For developing countries, among the few are the works by Shah and Larsen (1992), Brenner *et al.* (2007), Corong (2008), Ojha (2009), and Coxhead et al. (2013) which show such regressivity is less pronounced with respect to household expenditure. Literature on this issue hence concludes that the regressivity of carbon taxes should be less of a concern in developing than in developed countries.

Another note of caution deals with the so-called "rebound effect"; i.e. a situation in which the implementation of carbon tax, instead of reducing, actually induces a higher level of carbon emission. The first channel of a possible rebound effect is as follows. A high energy price due to a carbon tax, besides being expected to reduce energy usage, also increases the efficiency of energy use. The rebound effect occurs when the increase in energy efficiency increases consumption of energy in such that this increased consumption offsets the energy savings that might otherwise be achieved (Sorrell and Dimitropoulos, 2008; Sorrell 2009). The second channel occurs when the recycling of revenue from a carbon tax results in increased consumption of energy, offsetting the expected energy savings due to a carbon tax. Indeed, various empirical studies and simulations have indicated that the rebound effect occurs in many countries. Among others are Brännlund *et al*. (2007) in the case of Sweden, Barker *et al.* (2007) in the case of the United Kingdom, Mizobuchi in the case of Japan (2008), as well as Holm and

Englund (2009) in the cases of United States of America and Western Europe. This paper aims to observe whether the implementation of a uniform carbon tax in ASEAN induces a situation of double dividend, is regressive and/or creates a rebound effect.

2. Methods

2.1. Inter-Regional System of Analysis for ASEAN (IRSA-ASEAN) Model

The IRSA-ASEAN model is a multi-country CGE model that emanates from the Inter-Regional System of Analysis for Indonesia Five Regions (IRSA-Indonesia5) developed by Resosudarmo *et al.* (2008), so that it bears similarities with the latter in terms of notational use. However, numerous features of the IRSA-ASEAN model also stem from other developments in CGE modeling over the last 20 years; some of these sources of inspiration are direct and easily identified, including one of the first CGE models for Indonesia by Lewis (1991), the GTAP model (Hertel, 1997), and the Globe model (McDonald et al., 2007), meaning that the IRSA-ASEAN model is a unique model in its own right, both structure-wise and purpose-wise. The IRSA-ASEAN model itself is a multi-country model that solves at the country level, meaning that optimizations are performed at this level. This approach allows for variation in price as well as in quantity for each country to be observed using this model. This approach enables observation of the impact of a shock specific to one country compared with other countries, the whole ASEAN economy, and within the country itself.

The IRSA-ASEAN model includes six ASEAN member countries, namely Indonesia, Malaysia, The Philippines, Singapore, Thailand, and Vietnam. As optimization is performed at the country level, and taking into account the "sovereignty" element of each country, the model uses neither a bottom-up nor a top-down approach[5]. Each country is instead connected through commodity flows, i.e. trade of goods and services, as well as transfer flows, i.e. remittances and savings-investments. The model also allows direct transfer of primary factors of production, e.g. fragmentation. However, due to data scarcity, this last feature is not included in the empirical study. As a consequence of the sovereignty element in the IRSA-ASEAN model, each country has its own balance of payments as well as savings and investment accounts. Each country deals directly with other countries in terms of trading and is allowed its own set of tariff barriers. For example, in the IRSA-ASEAN model, each country can export/import goods and services directly to/from the rest of the world (ROW).

Another important highlight of the IRSA-ASEAN model deals with the issue of double-dividends. The model internalizes the double-dividend hypothesis by explicitly incorporating various recycling mechanisms. In this regard, aside from the government increasing its

[5] This is in line with real world evidence in which unlike the EU, ASEAN is not a supranational organization.

expenditure, the carbon tax revenue can either be recycled directly to households, e.g. by a direct one-time lump-sum cash transfer to low-income households, or recycled back to industry, e.g. by indirect tax reduction, so that it creates a less distortionary tax system, or supposedly so.

Figure 1 shows the basic flow of commodities and production structures in each country. *XTOT(i,d)* is output, *XINT_S(c,i,d)* is the intermediate good, and *XPRIM(i,d)* is the primary input. Meanwhile, *XTRAD_R(c,d)* is the domestic[6] demand composite, *XD_S(c,d)* is the domestic and import[7] demand composite, and *XFAC(f,i,d)* is the demand for a factor of production. The following defines the subscript notations:

c	commodity;
d	destination of commodity in domestic country;
f	factors of production, labor, and capital;
h	households;
i	industry;
r	source of commodity in domestic country; and
s	source of commodity, composite between domestic country and import.

Note that *XEXP(c,r)* represents exports to the rest of the world, while the term *XIMP(c,d)* refers to imports from the rest of the world. Meanwhile, XHOU_S(c,h,d) represents household demand, XGOV_S(c,d) represents government demand, and XINV_S(c,d) represents investment demand. Also note that indirect taxes affect production output while import taxes affect composite demand.

At the first stage, with only five factors of production, a constant elasticity of substitution (CES) function can be used to determine the demand for primary factors. At the second stage, a firm's objective is to maximize profit with a Leontief production function. The Leontief production function determines the relationship between all the inputs, a composite of primary factors and intermediate goods, to outputs. Admittedly, one notable limitation to this setup is that endogenous substitution between intermediate inputs is not allowed.

[6] Note that the word "domestic" composite here refers to goods from within the country and within ASEAN.
[7] The word "import" refers to extra-ASEAN imports.

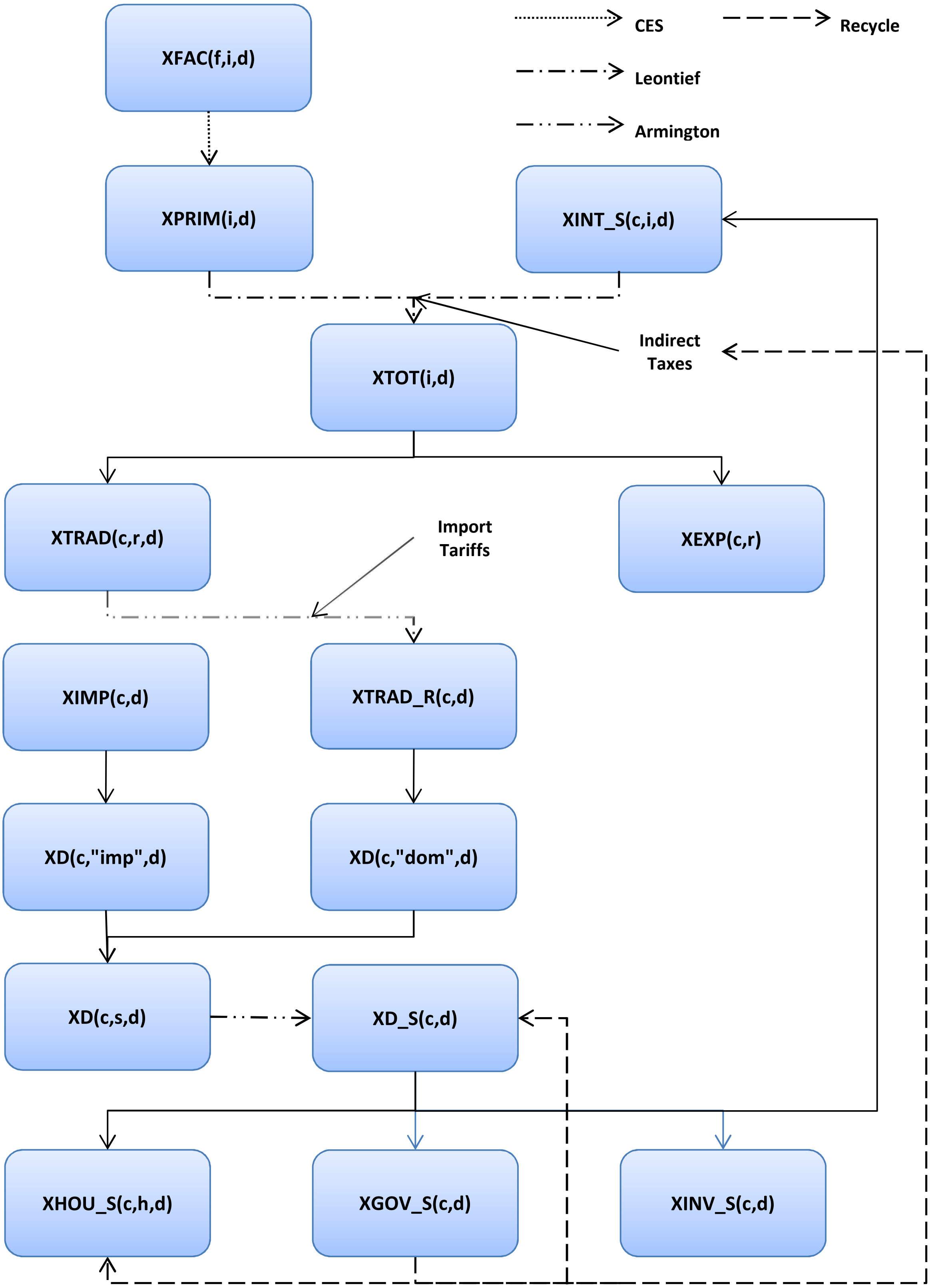

Figure 1. Production Structure of the IRSA-ASEAN Model

Furthermore, final users of commodity *c* consist of households, governments, and investments. In this model, all three share a common solution to their respective optimization problem. Each chooses its combination of commodities based on a constant budget share. Lastly, the following closures are incorporated into the IRSA-ASEAN model to guarantee that the system is solvable:

- All factor supplies are exogenous;
- Unskilled and skilled labors are mobile;
- Land, natural resources, capital are immobile;
- All household and corporate saving rates are exogenous;
- All shares of inter-institutional transfer rates are exogenous;
- World import prices are exogenous;
- Indirect tax and import tariff rates are exogenous; and
- Output price index is set as a *numeraire*.

Since land, natural resources and capital are set to be immobile across sectors and a Leontief production function is utilized in the IRSA-ASEAN model, the model produces the short-run impacts of a policy simulation.

The CO_2 emission model is held as a separate model, and yet is integrated in the CGE model. Emissions basically come from households and industrial sectors due to their fossil fuel consumption such as coal, petroleum products, and gas. The amount of carbon tax, in the IRSA-ASEAN model, is transformed into a sales tax for the consumption and use of fossil fuels borne by households and industries (Adams *et al.*, 2000; Yusuf and Resosudarmo, 2015). Revenue from these taxes is collected by the government[8].

Another distinctive feature of the IRSA-ASEAN model is that it is connected to a microsimulation model to disaggregate household groups into four groups, namely Rural-Low, Urban-Low, Rural-High, and Urban-High. Once a solution has been found for a particular simulation, through the microsimulation model, household groups are disaggregated further into one hundred groups based on population percentile groups in both rural and urban areas. The microsimulation basically disaggregates household expenditure for each commodity using an expenditure share coefficient for each percentile household group.

2.2. Data Sources

For empirical results, the IRSA-ASEAN model uses the Social Accounting Matrix for ASEAN (ASEAN-SAM) which has been calibrated from the input-output (I-O)-based Global Trade Analysis Project (GTAP) Version 7 Data Base with parameter values, e.g. value-added and

[8] Complete equations of the IRSA-ASEAN model and its GAMS syntax can be seen at http://people.anu.edu.au/budy.resosudarmo/IRSA-ASEAN1.pdf.

Armington elasticities, also obtained from this source. The database uses a common reference year of 2004 and a common currency of United States million dollars (USD million) for all six countries in the region. The database has been heavily modified using various country-specific datasets, e.g. social accounting matrices and household income/expenditure surveys, so as to provide greater insight and flexibility for policy analysis.

The additional datasets required to build the so-called ASEAN-SAM are as follows. For Indonesia, the additional data needed are the (1) 2005 Social Accounting Matrix and (2) 2005 Inter-Regional Social Accounting Matrix (Resosudarmo *et al.*, 2008); for Malaysia, the (1) 2004/2005 Household Expenditure Survey, (2) 2004 Distribution and Use of Income Accounts and Capital Accounts, (3) 2000 Population and Housing Census, and (4) 1970 Social Accounting Matrix (Pyatt *et al.*, 1984); for The Philippines, the (1) 2006 Family Income Expenditure Survey, (2) 2000 Social Accounting Matrix (Cororaton and Corong, 2009), and (3) 1997 Family Income Expenditure Survey; for Singapore, the (1) 2008 Yearbook of Statistics and (2) 2002/2003 Report on the Household Expenditure Survey; for Thailand, the (1) 2008 Key Statistics, (2) 2002 Household Socio-Economic Survey, and (3) 1998 Social Accounting Matrix (Li, 2002); for Vietnam, the (1) 2004 Living Standard Survey and (2) 1997 Social Accounting Matrix (Nielsen, 2002). Other data sets needed are the 2010 World Development Indicators, 2008 ASEAN Statistical Yearbook, 2005 ASEAN Statistical Yearbook, 2005 Bilateral Remittance Estimates (Ratha and Shaw, 2007), 2005 International Energy Prices (Metschies, 2005), and 2004 Combustion-Based CO_2 Emissions Data for GTAP Version 7 (Lee, 2008).

Procedures in constructing the ASEAN-SAM for modeling purposes are divided into three phases. The first phase involves the preparation of the GTAP Version 7 Data Base and transforming it into individual country SAMs a là McDonald et al. (2007); i.e. for Indonesia, Malaysia, The Philippines, Singapore, Thailand and Vietnam. Phase 2 is a set of steps required to transform each individual SAM a là McDonald et al. (2007) into a standard SAM form by completing international and domestic transfers. Phase 3 is when all individual SAMs are combined to form the ASEAN-SAM. Some adjustments are needed to combine these individual SAMs. Table 1 provides a detailed list of sets of the ASEAN-SAM, while Table 2 provides selected economic indicators from the ASEAN-SAM.

Table 1. List of Sets

Production Sectors		Regions
Agriculture	Trade	Indonesia
Farming	Transportation	Malaysia
Forestry	Communication	Philippines
Fishing	Financial services	Singapore
Coal	Public administration, defense, health, and education	Thailand
Oil	Dwellings and other services	Vietnam
Gas		Rest of the World
Minerals *nec*		
Food and beverages		
Textile and leather products		
Wood and paper products		
Petroleum and coal products		
Chemical, rubber, and plastic products		
Mineral products *nec*		
Metal products		
Manufacturing		
Electricity		
Gas manufacture distribution		
Water		
Construction		

Factors	Institutions
Unskilled Labor	Rural-Low Household
Skilled Labor	Rural-High Household
Land	Urban-Low Household
Natural resources	Urban-High Household
Capital	Corporate
	Government

Other Accounts
Indirect Tax
Import Tax
Saving-Investment

Table 2. Selected Economic Indicators of ASEAN-SAM, 2005

	IDN	MYS	PHL	SGP	THA	VNM
Macroeconomic Indicators						
(in USD million)						
Private Consumption	174,751	37,373	58,936	55,286	86,874	29,139
Government Consumption	20,035	11,641	8,754	13,911	16,129	2,798
Fixed Investment	49,317	17,316	14,118	31,396	40,344	15,073
Export	89,212	154,873	51,491	169,961	121,174	32,660
Import	88,496	107,987	48,969	161,818	108,691	36,666
Gross Domestic Product	244,819	113,214	84,330	108,737	155,831	43,003
Sectoral Disaggregation						
(in USD million)						
Agriculture	33,917	6,299	10,004	304	13,590	6,405
Manufacture	96,033	72,203	31,414	29,220	68,253	22,935
Service	124,752	36,397	43,059	77,289	79,855	13,687
Average Expenditure per Capita						
(in USD)						
Rural-Low	388	844	193		602	207
Rural-High	1,522	1,601	1,205		1,429	539
Urban-Low	540	939	194	7,966	1,093	165
Urban-High	1,682	3,325	2,104	21,222	4,696	1,328
Population						
(in thousand)						
Rural	114,975	8,438	32,004		44,350	60,720
Urban	101,469	16,736	51,908	4,167	20,928	21,312
Poverty Incidence (using national poverty lines)						
(in percentage)						
Rural	21.1	13.2	41.4		12.6	45.0
Urban	14.4	3.8	15.0		4.0	9.0
CO2 Emission	357,387	145,012	76,641	40,838	216,977	86,708
(in kiloton)						

2.3. Policy Simulations: Carbon Tax Implementation

With regards to policy simulations, as mentioned before, this study focuses on the economic impact of carbon tax policies. Even using only this single instrument, i.e. the carbon tax, there are many ways in which this policy can be implemented and modeled. The simulations of the model presented in this paper focus on the implementation of symmetric policies, which simply means that the chosen policy is implemented across the board in all six countries. A relatively modest carbon tax, i.e. a USD 10 per ton of CO_2 emission, is chosen in this paper.

The analyses are mainly divided into three different scenarios to simulate three possible recycling mechanisms that may be implemented. These mechanisms deal with the revenue generated from the carbon tax policy implemented by the respective government as explained previously. The first recycling mechanism (SIM1) assumes that the government retains all the revenue generated and thereby increases its consumption proportionally where the total increase equals the carbon tax revenue.

The second mechanism (SIM2) assumes that the government redistributes 50 percent of the revenue back to households in the form of a direct cash transfer to improve social welfare. In this variant, in order to conform to the real world, the government only redistributes cash to poor households in both rural and urban areas[9]. Hence, transfer shares between rural-low and urban-low income households are weighted based on the poverty incidence, i.e. the percentage of population below the national poverty line. Effectively, with greater poverty incidence in rural areas, low income households in these areas receive a greater share of the cash transfer compared to low income households in urban areas. Logically, of course, high-income households in both rural and urban areas do not receive these cash transfers.

Meanwhile, the third variant (SIM3) assumes that the government uses 50 percent of the carbon tax revenue to reduce other distortionary taxes in order to achieve a double dividend. In the IRSA-ASEAN model, the respective government proportionally redistributes the revenue obtained back to industries through a negative indirect tax. This scheme is intended to achieve a less distortionary tax system.

3. Results

Table 3 shows the short-run impacts on emission, macroeconomic indicators, and household expenditure, when implementing a carbon tax of USD 10 per ton of CO_2 emissions on all countries.[10] It is important to note that all changes are calculated at the original price level, meaning that their changes are real changes.

[9] Since the number of poor households in Singapore is trivial, in this case only the cash transfer is distributed to all low-income households.

[10] Typically between 1 to 4 years.

Table 3. Macroeconomic Results

	CO_2	Real GDP	Real Sectoral Change (%)			Real Household Expenditure Change (%)			
	%	%	Agri.	Manuf.	Serv.	Rural-Low	Urban-Low	Rural-High	Urban-High
Government (SIM1)									
Indonesia	-3.7	0.25	-0.14	-0.32	0.75	-1.1	-1.27	-1.2	-0.18
Malaysia	-4.06	0.04	0.01	-0.18	0.46	-1.36	-1.54	-1.13	-1.35
Philippines	-2.99	-0.04	-0.08	-0.43	0.25	-0.77	-0.71	-0.77	-0.73
Singapore	-0.95	-0.01	0.02	-0.35	0.12		-0.32		-0.34
Thailand	-2.38	-0.14	-0.18	-0.74	0.32	-0.91	-0.64	-1.14	-1.06
Vietnam	-6.29	-0.33	-0.06	-1.12	0.87	-1.84	-1.83	-1.77	-1.55
Household (SIM2)									
Indonesia	-3.4	0.27	0.01	0.07	0.47	2.18	0.12	-1.32	-0.9
Malaysia	-3.74	0.06	0.17	0.07	0.02	7.16	-0.76	-1.36	-1.56
Philippines	-2.82	-0.03	0.05	-0.18	0.07	5.85	0.43	-0.88	-0.9
Singapore	-0.88	-0.01	0.04	-0.26	0.09		0.45		-0.37
Thailand	-2.08	-0.08	0.01	-0.38	0.14	3.69	0.39	-1.32	-1.53
Vietnam	-5.77	-0.22	0.14	-0.65	0.32	2.44	0.26	-1.81	-1.81
Industry (SIM3)									
Indonesia	-3.34	0.26	-0.02	0.55	0.12	-1.61	-1.66	-1.35	-0.32
Malaysia	-4.03	0.04	*	0.24	-0.33	-2.76	-2.61	-0.78	-0.99
Philippines	-3.35	-0.05	-0.09	-0.28	0.12	-1	-0.63	-1.02	-0.6
Singapore	-0.94	-0.01	0.05	-0.1	0.02		-0.51		-0.22
Thailand	-2.49	-0.14	-0.12	-0.38	0.04	-2.59	-1.35	-2.25	-0.77
Vietnam	-3.67	-0.22	0.24	0.24	-1.19	-1.9	-2.62	-1.85	-2.65

* - Negligible Value

In order to understand why and how changes occur when a carbon tax is implemented, particularly when performing a welfare analysis, a more detailed examination must be conducted at the sectoral level. Table 4 shows selected sectoral prices. It is important to note that Table 4 also implicitly shows changes from the original prices. This implies, for example, that a coal price of 1.29 in Indonesia means that the price of coal has increased by 29 percent in Indonesia after a carbon tax of USD 10 per ton of CO_2 has been implemented in the form of a sales tax to industries and households.

Table 4. Selected Sectoral Price Changes

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Government (SIM1)						
Coal	1.29	1.24	1.25	1.3	1.24	1.22
Petroleum Products	1.1	1.11	1.13	1.07	1.08	1.15
Manufactured Gas	1.01	1.02	1.01	1.03	1.02	1.01
Electricity	1.03	1.03	1.03	1.02	1.02	1.01
Transportation	1.02	1.02	1.01	1	1.01	1.06
Household (SIM2)						
Coal	1.29	1.24	1.25	1.3	1.25	1.22
Petroleum Products	1.1	1.12	1.13	1.07	1.08	1.15
Manufactured Gas	1.01	1.02	1.01	1.03	1.01	1.01
Electricity	1.03	1.03	1.03	1.02	1.02	1
Transportation	1.02	1.02	1.01	1	1.01	1.06
Industry (SIM3)						
Coal	1.34	1.22	1.12	1.27	1.14	1.78
Petroleum Products	1.04	0.98	0.87	0.97	0.89	1.56
Manufactured Gas	1.06	1	0.87	0.99	0.91	1.55
Electricity	1.08	1.01	0.89	0.98	0.91	1.54
Transportation	1.06	1	0.88	0.97	0.91	1.62

Following the changes in commodity prices, production activities in turn change as well. Table 5 shows the real sectoral value-added changes in percent. Note that this table does not show real output changes because it is more important at this stage to look at the industrial changes while avoiding changes that arise from the export and import of commodities. The distinction is important, as value-added changes will affect households more than output changes. Also, the changes are in percent. Lastly, from top to bottom, the first 4 sectors are categorized as agriculture, followed by 12 sectors categorized as manufacturing, and 10 sectors as services.

Table 5. Real Sectoral Value-Added Changes in Percent

	Indonesia			Malaysia			Philippines			Singapore			Thailand			Vietnam		
	GOV (SIM1)	HOU (SIM2)	IND (SIM3)	GOV (SIM1)	HOU (SIM2)	IND (SIM3)	GOV (SIM1)	HOU (SIM2)	IND (SIM3)	GOV (SIM1)	HOU (SIM2)	IND (SIM3)	GOV (SIM1)	HOU (SIM2)	IND (SIM3)	GOV (SIM1)	HOU (SIM2)	IND (SIM3)
Agriculture	-0.12	0.04	0.00	0.05	0.15	0.03	-0.06	0.07	-0.03	0.02	0.05	0.06	-0.13	0.02	-0.06	0.08	0.21	0.32
Farming	-0.12	0.07	-0.02	-0.02	0.26	-0.07	-0.16	0.04	-0.25	0.02	0.05	0.08	-0.27	-0.03	-0.14	-0.06	0.21	0.00
Forestry	-0.38	-0.20	0.07	0.06	0.12	0.10	-0.08	-0.02	-0.08	0.01	0.01	0.02	-0.11	-0.01	-0.07	-0.28	-0.07	0.51
Fishing	-0.14	-0.04	-0.12	0.02	0.14	-0.03	-0.03	0.03	-0.02	0.02	0.03	0.03	-0.18	-0.11	-0.19	-0.29	-0.04	0.06
Coal	-0.02	-0.01	0.00	-0.04	0.01	-0.02	-0.79	-0.77	-0.91	0.00	0.00	0.00	-0.29	-0.19	-0.26	-0.16	-0.06	0.16
Oil	-0.05	-0.04	-0.03	-0.03	-0.02	-0.03	-0.17	-0.16	-0.13	-0.04	-0.04	-0.03	-0.04	-0.02	-0.02	0.01	0.06	0.14
Gas	-0.01	0.00	0.00	0.01	0.01	0.01	-0.96	-0.83	-1.04	0.00	0.00	0.00	-0.07	-0.01	-0.02	-2.96	-2.70	-1.43
Minerals *nec*	-0.42	-0.27	-0.10	-0.90	-0.78	-0.65	-0.13	-0.09	-0.14	-0.49	-0.38	-0.29	-0.13	-0.07	-0.10	-1.40	-1.20	-0.30
Food and beverages	-0.57	-0.06	-0.01	-0.25	-0.02	0.04	-0.26	0.06	-0.06	0.00	0.15	0.15	-0.43	-0.14	-0.08	-0.50	0.10	0.90
Textile and leather products	-1.53	-0.91	0.28	-0.61	-0.31	0.21	-0.43	-0.19	-0.18	-0.03	0.11	0.34	-0.54	-0.03	0.03	-0.50	0.14	2.66
Wood and paper products	-0.64	-0.35	0.34	-0.37	-0.15	0.07	-0.56	-0.43	-0.43	0.07	0.15	0.21	-0.58	-0.25	-0.14	-0.87	-0.50	0.95
Petroleum and coal products	-7.65	-7.41	-6.96	-5.35	-5.08	-5.17	-4.63	-4.43	-4.99	-3.02	-2.90	-2.62	-5.03	-4.75	-5.14	-6.00	-5.45	-2.50
Chemical, rubber, and plastic products	-2.31	-1.68	-0.58	-0.64	-0.40	-0.17	-0.61	-0.40	-0.43	-0.86	-0.79	-0.69	-1.18	-0.81	-0.49	-2.47	-1.83	0.52
Mineral products *nec*	-2.89	-2.39	-1.82	-2.00	-1.74	-1.75	-2.46	-2.22	-3.05	-0.11	-0.03	0.03	-2.14	-1.83	-2.13	-2.14	-1.69	-1.16
Metal products	-1.65	-1.14	-0.11	-0.99	-0.70	-0.28	-0.43	-0.25	-0.28	-0.26	-0.15	0.14	-1.06	-0.68	-0.40	-3.25	-2.54	0.03
Manufacturing	-1.45	-0.88	0.15	-0.04	0.28	0.57	-0.32	-0.08	-0.13	0.03	0.12	0.34	-0.46	-0.10	0.13	-1.36	-0.75	0.38
Electricity	-2.01	-1.74	-1.78	-0.50	-0.32	-0.62	-0.96	-0.83	-1.04	-0.43	-0.41	-0.49	-0.59	-0.34	-0.62	-1.93	-1.23	-0.72
Gas manufacture distribution	-0.98	-0.76	-0.43	-0.36	-0.18	-0.30	-0.95	-0.83	-1.03	-13.39	-13.37	-13.62	-0.64	-0.31	-0.49	-2.07	-1.37	-0.73
Water	-1.83	-1.26	-1.45	0.02	0.04	0.01	-0.25	0.00	-0.20	-0.07	0.02	-0.04	-0.05	0.08	-0.06	-0.72	0.03	0.15
Construction	-0.99	-0.43	0.01	-1.24	-1.06	-1.39	-0.69	-0.43	-2.98	-0.26	-0.14	-0.12	-1.40	-1.00	-2.35	-1.33	-1.09	-5.06
Trade	-0.37	0.10	-0.22	-0.38	0.09	-0.07	-0.30	0.01	-0.25	-0.06	0.08	0.06	-0.34	0.01	-0.33	-1.54	-0.91	0.54
Transportation	-2.53	-2.19	-2.00	-7.68	-7.48	-7.32	-2.69	-2.52	-2.99	-0.47	-0.40	-0.32	-3.75	-3.41	-3.76	-17.64	-17.27	-10.39
Communication	-0.52	-0.16	-0.08	-0.01	0.18	0.01	-0.49	-0.20	-0.46	0.00	0.05	0.02	-0.37	-0.05	-0.28	-0.16	0.39	1.17
Financial services	-0.66	-0.25	-0.05	1.01	0.68	0.48	-0.53	-0.17	-0.52	0.09	0.15	0.23	-0.38	-0.01	-0.17	-0.59	0.15	1.02
Public administration, defense, health, and education	10.30	5.56	3.12	8.51	4.46	2.87	3.97	2.03	4.18	1.44	0.78	0.16	8.47	4.52	6.32	9.49	5.36	-0.32
Dwellings and other services	-0.21	0.03	-0.12	0.16	0.26	0.17	-0.27	-0.10	-0.26	-0.01	0.06	0.02	-0.15	0.08	-0.17	-1.01	-0.64	-0.19

The overall impact on households can be seen from Table 3. However, it is not possible to make any claims regarding the progressive or regressive nature of a carbon tax based solely on this table, as the results are too aggregated. Therefore, it is necessary to disaggregate households further into 100 categories based on population percentile for both rural and urban areas. The percentile grouping goes from the poorest to richest based on their respective initial total expenditure. Figure 2 illustrates the percentage change in real household consumption by percentile group.

To further understand the impact of a carbon tax policy on low income households, this paper also observes the impact of simulated poverty policies (percentage of those living below each country's poverty line). The results can be seen in Table 6, which shows the poverty rate before and after each simulation.

Table 6. Poverty Rate[11]

		Initial	Government (SIM1)	Household (SIM2)	Industry (SIM3)
Indonesia	**Rural**	21.1	21.52	21.13	21.65
	Urban	14.4	14.67	14.49	14.78
Malaysia	**Rural**	13.2	13.84	9.38	16.71
	Urban	3.8	4.08	3.72	4.53
Philippines	**Rural**	41.4	42.50	40.65	41.33
	Urban	15.0	15.27	15.19	15.23
Thailand	**Rural**	12.6	13.04	12.07	14.78
	Urban	4.0	5.31	5.28	5.37
Vietnam	**Rural**	45.0	49.11	45.64	49.16
	Urban	9.0	9.32	9.15	9.58

[11] Singapore is not included in the table and subsequent analysis as it does not have an existing poverty incidence.

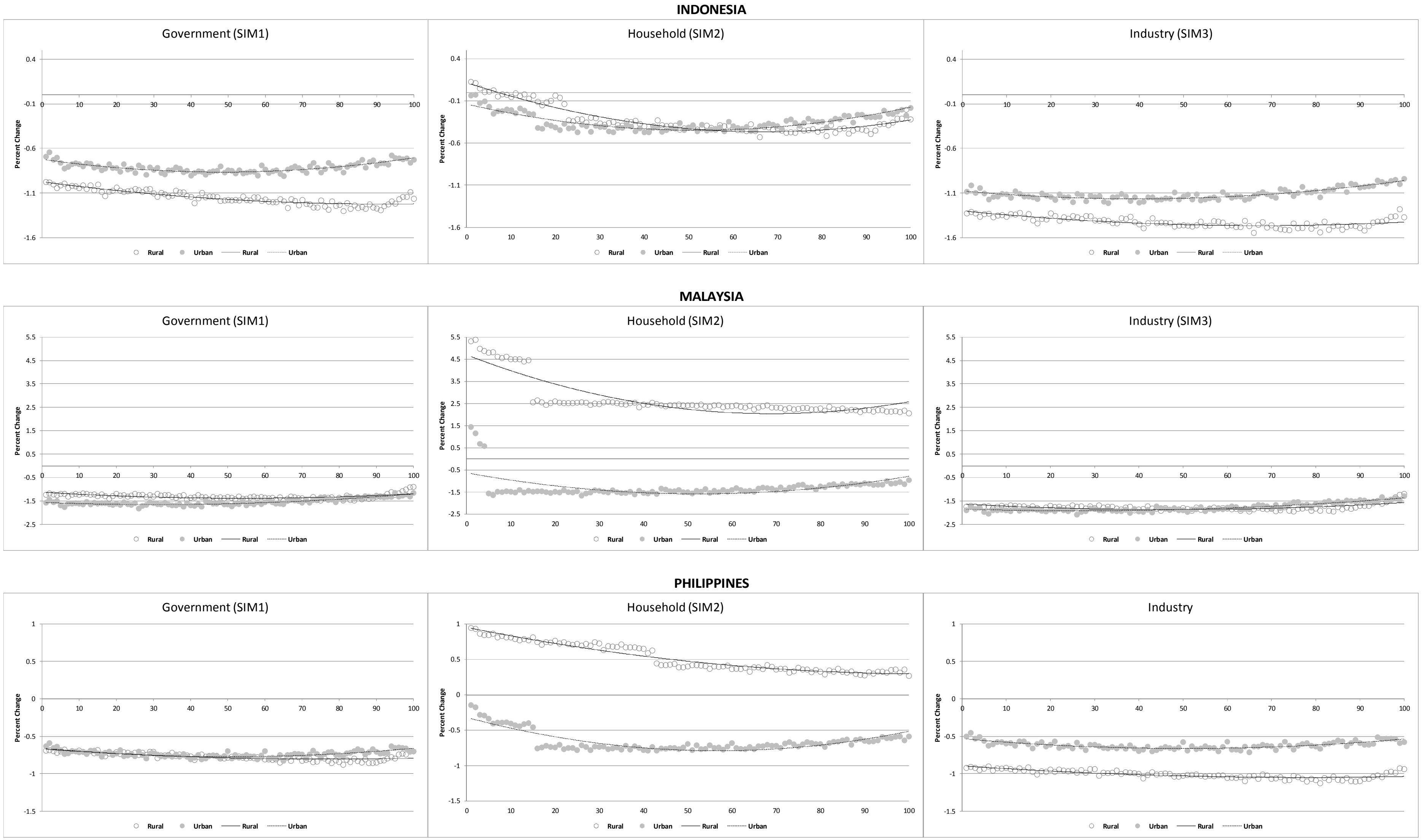

Figure 2a. Real Household Expenditure Changes in Percent

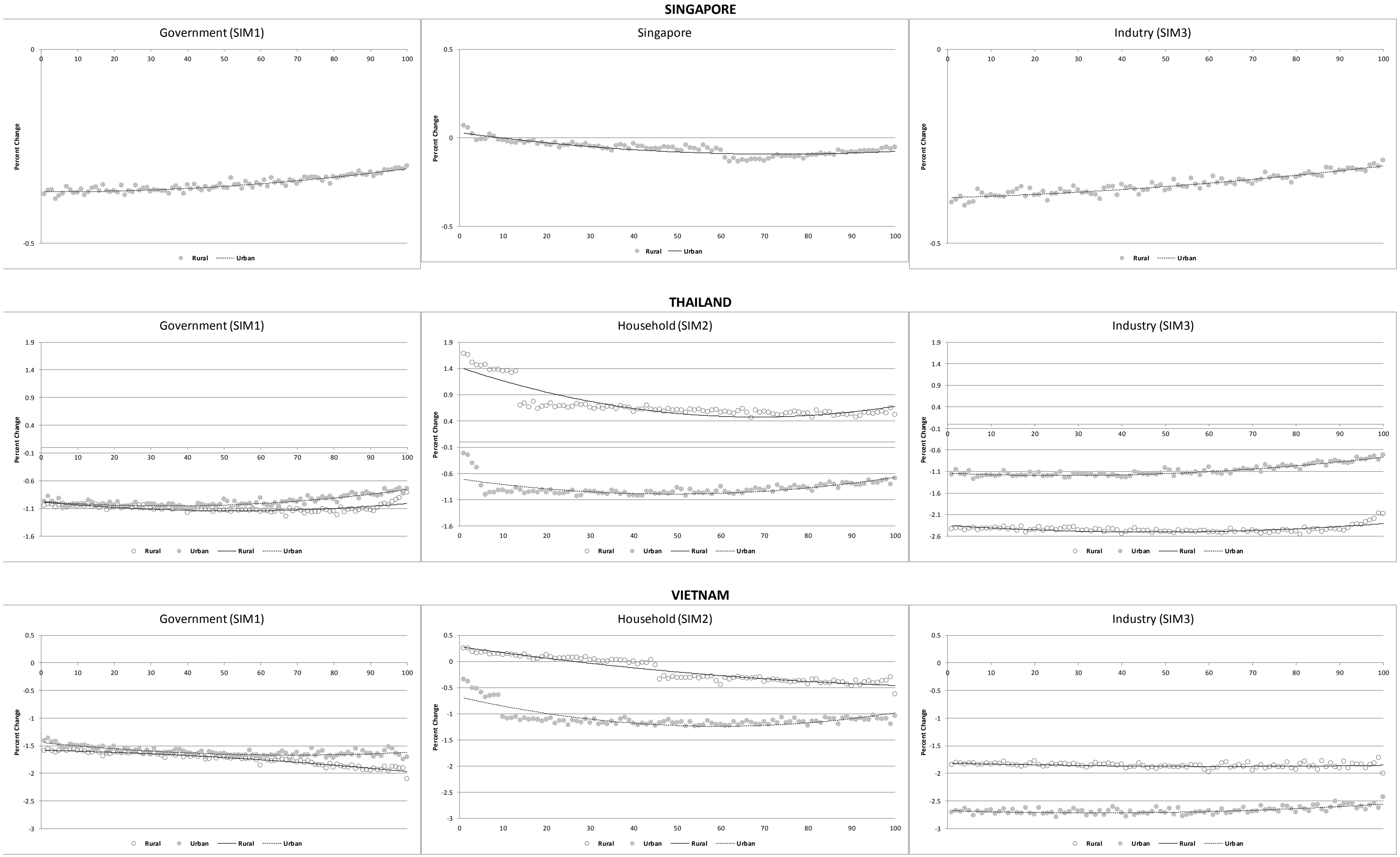

Figure 2b. Real Household Expenditure Changes in Percent

4. Discussion

4.1. Environmental and Macroeconomic Impacts

From Table 3, it can be seen that implementing a carbon tax with any recycling variants reduces carbon emissions; i.e. there is no indication of a rebound effect, at least in the short-run. However, this gain for the environment may come at a cost in terms of contraction in the GDP as well as real household expenditure. Redistributing revenue generated to low-income households appears to alleviate the cost associated with the rising price of energy; but this comes at a cost in terms of greater GDP reduction in some cases.

Of more interest is how a carbon tax affects each country differently. Determining which countries stand to gain the most from a carbon tax scheme is actually as one would expect, regardless of how the revenue generated might be redistributed. For Indonesia and Malaysia, a carbon tax has a positive effect on the overall economy. However, some sectors will more likely be adversely affected than others, namely the manufacturing sector followed by the agricultural sector; whereas the service sector will actually benefit from the implementation of a carbon tax, assuming that the government retains all the revenue generated and recycles it all back through its increase in expenditure.

All the other countries, on the other hand, exhibit a similar pattern to one another that is opposite to that of Indonesia and Malaysia. Although beneficial in terms of environmental improvement, it comes at the cost of a contraction to their respective economies. This is especially true in the case of Vietnam, as it will most likely suffer the most in terms of economic contraction with respect to all variants. Regarding sectoral changes, these countries also exhibit the same pattern as Indonesia and Malaysia, with the manufacturing sector most likely to be adversely affected, followed by the agricultural sector, which will most likely gain.

In terms of overall change, it is quite obvious why Indonesia and Malaysia are most likely to benefit as opposed to the other countries. In Indonesia and Malaysia, fuel is subsidized so that introducing a carbon tax is similar to reducing subsidies in these countries (Yusuf and Resosudarmo, 2008; Ahmad *et al.*, 2011). In other words, a carbon tax actually promotes efficiency by creating a less distortionary tax system in which the double-dividend hypothesis and the no-regret option apply. This is not true in the other countries as they do not subsidize to the extent of Indonesia and Malaysia. As such, introducing a carbon tax will most likely create a more distortionary tax system, with Vietnam suffering the most, followed by Thailand, The Philippines, and Singapore. The fact that The Philippines and Singapore do not subsidize fuel at all allows a more efficient adjustment to take place in their respective economies so that they do not suffer as much as Vietnam and Thailand.

Meanwhile, although recycling mechanisms do not affect the overall results in terms of emission reduction and economic contraction, they do significantly affect sectoral changes and household expenditure. When part of the carbon tax revenue is recycled back to low-income households in both rural and urban areas (SIM2), the first thing to note is that these two household groups are no longer as adversely affected as before. Those in the lower-income bracket are somewhat compensated by the changes as they are given a lump sum cash transfer by their respective governments. As household expenditure patterns are different from government expenditure patterns, this in turn changes the sectoral output as the household consumption share is higher for manufacturing and agricultural goods than for services, compared to the government consumption share pattern. As such, these two sectors are somewhat compensated by increased consumption as opposed to the previous recycling mechanism.

As for the third recycling mechanism (SIM3) where the government reduces indirect taxes, the first obvious thing to note is that households are no longer compensated, so that their expenditure consumption pattern changes are closer to the first recycling mechanism. However, changes in sectoral output are more erratic as a few things are happening at the same time, e.g. carbon sales tax, indirect taxes, and price changes.

One final important thing to note is that the overall results do not change according to recycling mechanisms, which is both interesting and logical. This means that not much leakage occurs between countries and the recycling mechanisms only change domestic patterns. As such, in terms of overall achievement, recycling mechanisms do not matter, although for practical policy purposes, they become very important in terms of feasibility and acceptability.

4.2. Price and Industrial Impacts

Table 4 shows that once a carbon tax is implemented, the price of coal, petroleum products, and manufactured gas immediately increases. The price of coal increases the most followed by petroleum products and manufactured gas, as coal is the "dirtiest" in terms of CO_2 content compared to the others. Changes in these commodity prices have a secondary effect, with the electricity and transportation sectors affected the most as these two sectors are the largest energy users. The logic is quite straightforward with regard to the first two recycling mechanisms but not with regard to the third (SIM3).

When the third recycling mechanism is implemented, other changes occur simultaneously that affect prices. Indirect tax reductions directly affect production activities, meaning that prices change in a different way to the other two recycling mechanisms. As indirect taxes differ greatly between countries, e.g. the existence of fuel subsidies in Indonesia and Malaysia, the third recycling mechanism affects the same sectors differently across countries.

Table 5 shows that the manufacturing sectors undergo a general contraction. Meanwhile, the agricultural sectors are not affected as much, whereas service sectors generally contract, with the exception of government-related sectors. This implies that households that rely on income from the manufacturing sector are likely to suffer the most from an income reduction, which in turn reduces their ability to consume. Meanwhile, those in the agricultural sector will most likely be unaffected income-wise, although price changes may still affect their consumption level. Those who are most likely to gain are households in the service sector, particularly government-related sectors such as defense, health, and education.

4.3. Distributional Impacts

Bear in mind, a carbon tax is generally regressive in developed countries and less so in developing countries (Yusuf and Resosudarmo, 2014). Although most ASEAN countries would fall under the developing country category, with the exception of Singapore, a quick glance at Figure 2 may not provide such a straightforward answer. Singapore, understandably the most developed country in the region in economic terms, shows clearly the regressive nature of the carbon tax. Moving to the right on the horizontal axis, the trend shows an upward sloping line that indicates how the richer the household is, the less adversely affected it is by the implementation of a carbon tax.

Vietnam, on the other hand, clearly shows the opposite, so that the richer the household is, the more adversely affected it is by the implementation of a carbon tax. This is, of course, in accordance with the fact that Vietnam is the least developed country in the region in economic terms.

For Indonesia, Malaysia, The Philippines, and Thailand, the results are not as clear, exhibiting a U-shape pattern. Although seemingly contradictory, the results are actually to be expected. These four countries fall neither under the developed country category such as Singapore nor the developing category such as Vietnam. They are actually transitional economies, right in between those two categories. The U-shape actually shows that those who are relatively poorer in their respective countries exhibit the same pattern as Vietnam does in representing a developing country in which a carbon tax is progressive. However, the few at the right end of the horizontal axis, i.e. the rich and richest, actually exhibit the same pattern as Singapore does in representing a developed country in which a carbon tax is regressive.

Furthermore, for Indonesia, The Philippines, and Thailand, those living in rural areas are more adversely affected than those living in urban areas. The reverse is true for Malaysia. This difference arises from the population composition, with Malaysia being more urbanized than the others so that the overall adverse effect is greater in urban than in rural areas. Nevertheless, the U-shape pattern holds and the turning point in Malaysia occurs sooner for those in urban areas compared to the other three countries.

Moreover, Figure 2 also shows the results when the second recycling mechanism (SIM2) is implemented. It shows that households are better off in terms of being less adversely affected by the carbon tax than in the previous scenario (SIM1). This is because in the second recycling policy, low-income households are given a one-time, lump-sum cash transfer. In Malaysia, The Philippines, Thailand, and Vietnam, rural households are much better off than urban households in Indonesia. This difference can easily be explained as low-income rural households receive a much greater share than low-income urban households as the share transfer is based on the poverty incidence ratio. In these countries, rural households receive at least twice the cash transfer in total of urban households. As for Indonesia, although more transfers are made in rural areas, the amount is less than twice that of urban households.

As for the third recycling mechanism (SIM3), Figure 2 shows that it is somewhat harder to find a similar pattern in this case because it does not directly affect households. Changes to households are the result of changes in the industrial sector. As such, it is much harder to predict the impact on households. However, the U-shape pattern holds for Indonesia, Malaysia, The Philippines, and Thailand although they are all affected in different ways; with Vietnam beginning to show the same U-shape pattern. Meanwhile, Singapore exhibits the same pattern as in the first recycling mechanism.

From Table 6 above, it is clear that without any direct compensation to households, as in SIM1 and SIM3, the poverty incidence in all countries increases, both in rural and urban areas. On the other hand, in some cases, the government can reduce the poverty rate if poor households are compensated through a direct fund transfer scheme (SIM2). Even in cases where the poverty incidence increases, the adverse effect is still less when compared to the other recycling mechanisms.

5. Conclusions and Policy Implications

The main goal of this study is to understand the impact of coordinated and non-coordinated carbon tax policies on the economy and environmental performance of each country within ASEAN. This question is a relevant one, since, first, though progress has been slow, the ASEAN community will most likely soon have to synchronize various policies; and second, some ASEAN member countries are among the top polluters in terms of CO_2 emission, so much so that they will have to react soon to control their emission.

In order to answer the above question, a multi-country CGE model for ASEAN, known as the IRSA-ASEAN, has been constructed. An ASEAN-SAM was also constructed previously as the main dataset for the CGE. This ASEAN-SAM is one of the first comprehensive data systems available for ASEAN, and hence the IRSA-ASEAN becomes one of the more comprehensive economic models for the region. Through the IRSA-ASEAN, a few conclusions can be reached with regard to the implementation of a carbon tax in ASEAN. First, in general and at least in the short-run period, a carbon tax is an effective way of reducing carbon emission. For most ASEAN countries, even if the revenue from this tax is recycled back to the economy, it does not seem to induce a rebound effect, i.e. more use of energy and so more emission.

Second, it is not obvious that ASEAN countries could always expect a double-dividend phenomenon to occur when they implement a combination of a carbon tax and a recycling policy. It is quite likely that implementing a carbon tax will contract the economies of these countries. Recycling the carbon tax revenue, though it is of utmost importance in terms of softening the impact of this policy on economic growth and household incomes, does not always induce a double dividend phenomenon. Some of the main reasons for this are as follows. Current effective tax rates for these countries have been relatively low. As a result, there is not much room to reduce other taxes to compensate for the effects of a carbon tax policy.

Third, as each country responds differently to the implementation of a carbon tax, particularly with regards to revenue re-distribution, an across the board implementation will create “winners” and “losers”. Indonesia and Malaysia are the potential winners as at the moment they are subsidizing their respective energy sectors, meaning that a carbon tax actually acts as a compensatory mechanism that will promote efficiency and a less distortionary tax system, or in this case one arising from an energy sector subsidy. Vietnam is the likely loser as the implementation of a carbon tax creates an additional distortionary tax with the only possible gain in terms of environmental improvement, which comes at a great cost in terms of a relatively large economic reduction. The Philippines, Singapore, and Thailand can still gain, depending on what their respective governments do with the revenue. Although an economic reduction is unavoidable, the cost is not that great, and also comes with great benefits in terms environmental improvement and social equity.

Fourth, in terms of distributional impact, a carbon tax is strictly progressive in Vietnam and strictly regressive in Singapore. For Indonesia, Malaysia, The Philippines, and Thailand a carbon tax is progressive for those in up to the 70 to 90 percentile income group and regressive for those at the right-end tail, or higher, income group.

Fifth, in terms of poverty, without direct compensation to households, a carbon tax will increase the poverty incidence in all countries. Although a carbon tax may still adversely affect households, even with direct compensation to poor households, the impact will be mitigated. In fact, in some cases, such a transfer would actually decrease the existing poverty incidence in a country. As such, of all the possible recycling mechanisms, direct compensation to poor households may be the most feasible and acceptable option in political, economic, and social terms.

The policy implications are as follows. First, ASEAN countries are encouraged to implement a carbon tax policy, as it is an effective mechanism to reduce CO_2 emission, at least in the short-run. However, for cases such as the Philippines, Singapore, Thailand, and Vietnam, this gain for the environment comes at a price in terms of economic contraction. While the cost may be significant for Vietnam, it is not as great as it is for The Philippines, Singapore, and Thailand. Second, ASEAN countries might want to recycle revenues from a carbon tax back to low income households and those adversely affected in their countries—complicated as this might be—as the implementation of a carbon tax does induce losses in some sectors, as well as adversely affecting certain segments of society.

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