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Equity and Environmental Policy in Indonesia

A thesis submitted for the degree of

Doctor of Philosophy

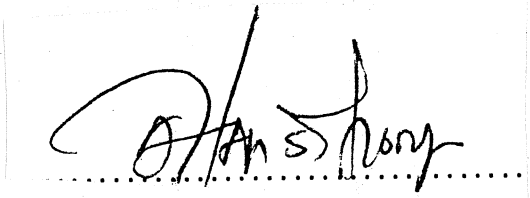
Arief Anshory Yusuf

The Australian National University

August 2007

Declaration

Unless otherwise indicated this thesis is my own work.



August 2007

Arief Anshory Yusuf

Dedicated to my mother, Sitti Mariam

and my wife, Arriya

Acknowledgement

This research thesis was carried out while I was a PhD student at the Division of Economics, Research School of Pacific and Asian Studies (RSPAS), The Australian National University (ANU) from February 2004 to August 2007. Many individuals and institutions had contributed to enable the completion of this thesis, and also transformed my time at the ANU to be the most rewarding academic experience. I would like to take this opportunity to acknowledge and thank many of them for their ongoing advice and support in the last three and half years.

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Arief Anshory Yusuf

Abstract

This thesis is an attempt to further understand the social and environmental dimension of sustainable development focusing on the impact of environmental reforms, such as pollution reduction and energy pricing policy, has on inequality and poverty for the case of Indonesia. The success of the implementation of the reforms largely depend on the desirability of their distributional effects.

A multi-sector, multi-household, Computable General Equilibrium (CGE) model is used to provide the basis for two important empirical case studies: (i) the effects of a carbon tax, and (ii) energy pricing reforms. The CGE model captures the interdependence among markets in the determination of both price of commodities and factor of productions and how it will affect distribution of income. As a departure from the previous literature, the disaggregation of household by expenditure classes allows for precise estimates of the distributional impact and poverty incidence.

The main finding from the carbon tax study suggests that in contrast to most studies from developed countries, the introduction of a carbon tax in Indonesia would not necessarily be regressive. It is shown to be strongly progressive in rural areas, and either neutral or slightly progressive in urban areas, with overall progressive distributional effect nationwide. The industries that experience the largest contraction are generally more energy intensive. The owners of factors of production in these industries are largely concentrated among higher income households and people living in the cities.

For the analysis of counter factual scenarios on energy price reforms, the result suggests that reducing subsidy on fuels used for transportation purposes (diesel, and gasoline) constitute a progressive reform. However, a reform like the October 2005 package which include a massive increase in the price of the fuel used for domestic purpose (kerosene) tends to be regressive unless accompanied by a proper and effective compensation scheme. However, the uniform transfer package implemented by the Indonesia government in October 2005 tends to over-compensate rural households at the cost of under-compensating the urban poor. An alternative package that recognizes the difference between urban and rural household's income and expenditure patterns are crucial in the attempt to minimise the adverse distributional impacts of the energy pricing reform.

In general, this study shows there is not necessarily a conflict between environmental and equity objectives, especially when the policies or reforms to achieve environmental goals are carefully designed.

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Glossary

ADO	Automotive Diesel Oil
BOE	Barrel of Oil Equivalent
BPS	Biro Pusat Statistik (Indonesian Statistics Agency)
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CO_2	Carbon Dioxide
CPI	Consumer Price Index
EKC	Environmental Kuznet Curve
EU	European Union
GDP	Gross Domestic Product
GEMPACK	General Equilibrium Modeling Package
GHG	Greenhouse Gas
GJ	Giga Joule
GOI	Government of Indonesia
GTAP	Global Trade Analysis Project
HOS	Heckscher-Ohlin-Samuelson
IDO	Industrial Diesel Oil
IEA	International Energy Agency
IFPRI	International Food Poverty Research Institute
INDOCEEM	Indonesia Comprehensive Economy Energy Model
I-O	Input Output
IPCC	International Panel on Climate Change
LES	Linear Expenditure System
LNG	Liquified Natural Gas
LPG	Liquified Petroleium Gas
OLS	Ordinary Least Square
PAKTO	Paket Oktober (October 2005 Package)
QAIDS	Quadratic Almost Ideal Demand System
SAKERNAS	Indonesian National Labour Survey
SAM	Social Accounting Matrix
SAMBAL	SAM balancing
SNA	System of National Accounts
SSA	Systematic Sensitivity Analysis
SUSENAS	Indonesian National Socio-economic Survey
tC	Ton of Carbon
UNFCC	United Nations Framework for Climate Change

Chapter 1

Introduction

1.1 Background and Motivation

The linkage between the economic, environmental and social dimension of sustainable development had been stressed since 1987 in the so-called "Brundtland report". More recently, it was mentioned as one of the three pillars of sustainable development at the 2002 Johannesburg World Summit. This three pillars concept is also known as the ESE triangle representing the Economic, Social, and Environmental dimension of sustainable development.[1]

It is widely acknowledged that the three dimensions of sustainable development are related. In many cases, the three pillars can conflict, when the goal of one of the aspects does not go hand in hand with any of the others. Azis and Salim (2005) suggest that for Indonesia, there has been greater emphasis on economic parameters and less emphasis on social and environmental parameters.

The conflict between economic and social objectives, such as between growth and inequality, has been extensively discussed in the literature. Similarly, the conflict between economic and environmental objectives has been widely debated in the theoretical and policy literature. The literature on the Environmental Kuznet Curve (EKC) provides a good example. The EKC hypothesis simply says that environmental degradation is positively associated with the level of development, but only until a certain point is reached when the relationship is reversed. To some extent, the increasing section of the curve may imply a trade-off between the level

[1] See OECD (1994) and Azis and Salim (2005).

of well-being and environmental quality[2].

The linkage – including its possible conflict – between environmental and social objectives, especially equity objectives, seems less debated in the policy arena compared to the discussion on the interaction between the economy and equity, or between the economy and the environment. However, as environmental concern is getting more widespread attention, and intervention in the form of environmental policies is becoming more widely advocated, the equity aspect of such policies is becoming increasingly important.

Because environmental issues are essentially externality problems, where the market fails to provide the optimum social benefit, to achieve environmental objectives, the role of government policy is necessary. Environmental policy then becomes the vehicle to achieve environmental goals. The equity dimension starts to become important, when it is acknowledged that the natural consequences of any government policy, including environmental policy, carries a distributional effect.

If this distributional effect is undesirable, because for example, it could increase poverty and inequality, it may be perceived as having the potential do harm to the society. If there is an expectation of such an adverse distributive effect, it may even prevent the policy from being implemented. In Indonesia, the plan to reduce fuel subsidies has always been followed by social protest. This also happens elsewhere as noted by OECD (2004, p. 79), "the social protest that followed the oil price increase of 2000 prompted reductions in environmentally-motivated taxes on oil products in countries such as France, Italy, and Australia, and the postponement of planned tax increases in others, like the United Kingdom or Germany delayed planned tax increases".

The complete picture of the distributional impact of environmental policies in general, has to consider two distinct but inseparable issues (OECD, 1994). The first is concerns related to distribution of the environmental benefit of the policy, i.e., who gains more and who gains less. The second is associated with the distribution

[2]Studies by Hettige et al. (1992), Shafik and Bandyopadhyay (1992), Grossman and Krueger (1995), and Selden and Song (1995) have been commonly referred to in the discussion and typical results of environmental Kuznet curve studies.

of financial effects of the environmental policies, i.e., who pays more and who pays less. This thesis focuses on the latter.

The trade-off between environmental and equity objectives, in the sense that lower income households pay proportionately more than higher income households following certain environmentally-motivated policies is supported by empirical evidence, especially for the case of pollution regulation or energy-related emission. For example, in developed countries, environmental policies to reduce pollution or discourage fossil fuel consumption are mostly regressive i.e., the burden of the regulations are mostly borne by lower income households, thereby making income distribution less equal.[3]

However, whether or not a similar conclusion would apply to developing countries still has to be researched. The distributional impact of environmental policies depends on the income and expenditure patterns of households[4], which may naturally be different between rich and poor countries. Therefore, whether such environmental policies are equitable or not is an empirical question.

This thesis will use Indonesia as a case study in an attempt to answer this empirical question and also to contribute to the debate of whether there is a conflict between environmental and equity goals and to what extent policy design might be able to mitigate any adverse distributive effects of environmentally-motivated reforms.

Two empirical case studies are chosen. The first is the issue of climate change policy, and the second is the issue of energy pricing reform in Indonesia. Indonesia is chosen as a case study, not only because of its importance in global climate change policy, but also because fuel subsidy is such an important issue there. The author's knowledge of Indonesia, access to data, and the potential to contribute to the debate and to policy making in Indonesia, are considered to be the main advantages.

With regard to the carbon abatement policy, the main motivation here is to contribute to the existing literature which generally concludes a carbon tax in developed

[3] As concluded, for example in literature review by OECD (1994), OECD (1995), Kristörm (2003). This will be discussed further in chapter 2.

[4] Other factors include differences in taxation, transfers and social security system.

countries is regressive (OECD, 1994). In addition, Indonesia recently ratified the Kyoto Protocol[5]. As a party to the Convention, one of the obligations is to communicate actions taken to mitigate climate change and to establish the National Committee on Climate Change. Ratifying the protocol means the issue of reducing GHG emissions will have more priority in the public discourse. The likely distributive effect of undertaking GHG reduction in developing countries will be a crucial issue thereby giving more relevance to this research.

For the second case study, i.e., energy pricing reform, the main motivation is the concern that a fuel subsidy contributes to the deterioration of environmental quality in developing countries. Government-induced market distortion has long been considered dominant cause of environmental problems. Removing this distortion, therefore, constitutes one of the important environmental policies. This includes removing environmentally-harmful fuel subsidy which is highly relevant in the Indonesian current policy context.

One of the primary motivations of this study is actually more on the lack of emphasis in the literature on the distributional aspect of environmental policies especially for developing countries. While the efficiency gain of environmental policies has been widely researched, it is difficult to find studies that assess its distributional impact outside industrialised countries. Given that the literature on developed countries generally finds energy-related environmental policies to be regressive, it would be interesting to know whether a similar conclusion could be drawn for developing countries. It has also been pointed out - for example, by Shah and Larsen (1992) - that many possible developing countries' characteristics indicate that environmental policies may not be regressive there. If so, it may have important policy implications at the local and global level. For example, a carbon trade that practically shifts the location of carbon abatement from developed to developing countries, may not only create significant efficiency gain and possible narrowing of the income gap between both, as widely suggested in the literature, but may also result in equity gain for both.

[5]on June 28, 2004

1.2 Research Scope and Objectives

To summarise, in terms of the scope of the study, this thesis will look more closely at the equity aspect of environmental policy and focus on the environmental problems related to pollution and energy related emissions, using case studies of (i) carbon tax and (ii) energy pricing reform in Indonesia. The increasingly alarming problem of climate change[6] and the importance of fossil-fuel energy subsidies[7] in developing countries are the main motivations for the chosen emphasis. As briefly discussed above, the current state of the literature is also another main motivation. Environmental policies related to pollution and energy tend to be regressive according the literature from developed countries. The lack of studies from developing countries motivates the research because the typical characteristics of a developing country's economy may lead to different conclusions.

The limiting scope of the study is that it focuses merely on the distributional cost of environmental policy that is how the financial or implementation cost of the policy is distributed. In other words, the question is about who pays for the implementation. For methodological reasons, such as the need for non-market valuation of the environmental benefit, the distribution of the benefit from better environmental quality is beyond the scope of this thesis.

The following are the specific objectives of the research.

1. To review the existing literature on the distributional impact of environmental policies related to pollution and energy-related emissions.

2. In the context of the Indonesian economy, to provide a quantitative estimate of the impact of environmental policies in the form the introduction of a carbon tax and energy pricing reform. This refers to its economy-wide impact including output and its sectoral composition, prices, and returns to factors of production.

[6] See Stern (2006) and IPCC (2007) for recent discussion.

[7] Global fuel subsidy could amount to between 250 and 300 billion dollar a year, which could "comfortably" pay off sub-Saharan Africa's entire international debt burden, leaving billions of dollars to spare (NEF, 2004)

3. To analyse how the cost of environmental policy with the two case studies above (carbon tax and energy pricing reform) is distributed to households in order to examine whether the policy is progressive or regressive and how it may affect poverty incidence.

4. To assess the feasibility of making equitable environmental policies and how policies should be best implemented to reach the dual goal of equity and the environment. This includes how to design the policies or the reforms, as well as to compare alternative various compensation mechanisms to mitigate adverse distributional impact of environmental policies.

1.3 Methodology

The main methodology to be used in this thesis is a multi-sectoral, multi-household, Computable General Equilibrium (CGE) model which provides the basis for the two important empirical case studies. CGE modeling is an attempt to use general equilibrium theory[8] as an operational tool for empirically oriented analyses of resource allocation issues in market economies (Bergman, 2005).

There are several important distinguishing features of the CGE model used in this thesis. The model has detailed energy commodities[9]; allows substitution among energy types and substitution between energy and primary factors; distinguishes detailed labor classification, and between formal and informal labour which is relevant for developing countries; introduces emission accounting and carbon taxation; and fully integrates highly disaggregated households[10] in the model which is a necessary element for distributional analysis.

The properties of the CGE model very much depend on the Social Accounting Matrix serving as its database. A Social Accounting Matrix (SAM) is a matrix

[8] General equilibrium theory is a formalisation of the observation that real-world markets are interdependent; changes in supply or demand conditions usually have repercussions on supply and demand conditions, and thus equilibrium prices, in several other markets.

[9] The model itself has 38 industries and 43 commodities, with detailed energy sectors. See Chapter 5 for detail.

[10] The model distinguishes 100 urban and 100 rural households, classified by percentile of expenditure per capita.

representation of transactions in a socioeconomic system[11]. It is a comprehensive, flexible, and disaggregated framework, which elaborates and articulates the generation of income by activities of production and the distribution and redistribution of income between social and institutional groups (Round, 2003b).

The Indonesian Social Accounting Matrix, constructed in this study constitutes the biggest and most disaggregated Indonesian SAM ever constructed at the sectoral and household level, hence contributing to the literature on SAM construction especially for developing countries.

With the SAM that takes into account detailed household disaggregation, the CGE model not only allows for simultaneously taking into account both the income and expenditure pattern as inseparable driving forces in the distributional story in an economy-wide framework, but also allows for more direct and accurate calculation of inequality indicators and poverty incidences.

In addition to the large-scale CGE model, household survey data analysis and a simple analytical model in a setup of the Heckscher-Ohlin-Copeland-Taylor model are also used to explore the possible existence of cases whereby environmental policy in developing countries is not regressive.

1.4 Expected Contribution

The expected contribution of this research is two-fold. The first relates to the understanding of the inter-related issues of equity and environmental policy. This study will emphasise and add characteristics specific to developing countries, using Indonesia as a case study, and hence will be amongst the few studies that provide quantitative estimates of the distributive effect of environmental policies outside developed countries.

[11] A Social Accounting Matrix is an essential database for computable general equilibrium (CGE) modelling. In a SAM framework every agent's expenditure has to equal its receipt (in the form of equality between column and row sum), so that a SAM explicitly represents the initial equilibrium, or market clearing conditions in the economy. Every good and service produced by industry is equal to what is demanded. Each factor of production supplied has to be absorbed by industry, and household spending has to be equal to income. An exercise using a CGE model, is basically comparing this initial equilibrium condition, with other equilibrium induced by changing exogenous shocks to the model.

To the author's knowledge, this will be the first research in Indonesia that explicitly analyses climate change policy to assess its impact on income distribution and poverty incidence. With regard to energy pricing reform, this will also be the first study using an economy-wide framework, with full integration of households disaggregated by income/expenditure classes.

The second expected contribution of this research relates to methodology. This study constructs an Indonesian Social Accounting Matrix with highly detailed household disaggregation, and using the SAM, build a Computable General Equilibrium Model with the emphasis on energy and carbon emission. The SAM constitutes the biggest and most disaggregated Indonesian SAM yet constructed at the sectoral and household level, hence contributing to the literature on SAM construction especially for developing countries. A SAM is also a basic and necessary element in CGE modelling, and its construction provides a pathway for later studies to analyze relevant policy issues. In addition, since SAM construction is rarely well-documented, hopefully the transparency in the description of this SAM construction, will provide greater replicability for future SAM construction, as well as for other researchers.

In the current literature, the methodology to assess the distributive effect of environmental policies is either micro-simulation, i.e., using household level data to examine income and expenditure patterns, or a Computable General Equilibrium (CGE) model but without detailed household level disaggregation. The methodology proposed in this research will combine these two approaches. The CGE model will capture the economy wide effect, i.e., inter-industry relationship of input-energy-emission, and the general-equilibrium mechanism of factor and commodity price determination, and disaggregation of household by income or expenditure size will provide precise estimates of the distributional impact and poverty incidence.

1.5 Outline of the thesis

Chapter 1. Introduction

This chapter discusses the background and motivation of the research and follows with an explanation of the research scope and objectives, expected contributions and organisation of the thesis.

Chapter 2. Empirical Regularities

This chapter surveys the literature on the distributional impact of environmental policy, focusing on pollution and energy-related environmental problems. In addition, this chapter also compares and contrasts the pattern of the environmentaly-sensitive spending of European households (using a dataset from Kohler et al. (1999)) with Indonesian households (using an Indonesian household survey data SUSENAS consumption module).

Chapter 3. Simple Analytical Analysis

While Chapter 2 provides cases where environmental policy in developing countries may be different from developed countries by comparing their expenditure pattern, this chapter, using a simple analytical model, illustrates the impact of environmental policy on the functional (or factorial) distribution of income. In this analytical exercise, some assumptions that may represent the typical characteristics of a developing country's economy will be introduced, i.e., the dualistic nature of the economy where it has a sector which is called "informal" where certain regulation such as labour market regulations and environmental regulations may not be able to be effectively enforced.

Chapter 4. Constructing Social Accounting Matrix

The distributional impact of policies analysed in the CGE modelling framework have been constrained in part by the absence of a Social Accounting Matrix (SAM) with disaggregated households. Since the Indonesian official SAM does not distinguish

households by income or expenditure size, it has prevented accurate assessment of distributional impacts, such as calculation of inequality or poverty incidence. This chapter describes how the Indonesian SAM developed in this study for the year 2003, with 181 industries, 181 commodities, and 200 households (100 urban and 100 rural households grouped by expenditure per capita centiles), was constructed. This SAM (with the size of 768x768 accounts) constitutes the most disaggregated SAM available for Indonesia at both the sectoral and household level. SAM construction is an essential part of CGE modeling, and this documentation provides greater transparency as well as replicability for further improvement.

Chapter 5. Computable General Equilibrium Model

This chapter is the detailed description of the CGE model to be used in the following empirical case studies. It describes the model structure such as production and consumption structure, database, parameters, method for distributional analysis, possible closures, and sensitivity analysis.

Chapter 6. Case Study: Carbon Tax

This first empirical study attempts to analyse the distributional impact of a carbon tax in Indonesia, one of the largest carbon emitter developing countries. Using the Computable General Equilibrium (CGE) model with disaggregated households as described above, this chapter will examine whether or not the introduction of a carbon tax in Indonesia is regressive. This chapter also examines what economic factors may drive the results and in what manner. Alternative revenue-recycling will also be introduced, i.e., through uniform reduction in a commodity tax rate and uniform lump-sum transfers.

Chapter 7. Case Study: Energy Pricing Reforms

The Indonesian government implemented a massive fuel price increase in 2005. While the benefit of the reform on efficiency grounds has been widely acknowledged, whether or not it was equitable is still open for debate. Various counter-factual

analyses of the recent energy pricing reform in Indonesia (October 2005 Package) are carried out. The simulations carried out in this chapter emphasise how various compensation schemes can be implemented to improve the mitigation scheme of future energy pricing reforms.

Chapter 8. Conclusion

This final chapter summarises the thesis, discusses some limitation of the research, and prospects for future research. The chapter also discusses some implications and lessons learned for other developing countries, as well as, calls for extending the research for other countries.

Chapter 2

Empirical Regularities

This chapter reviews empirical evidence of the distributional impact of environmental policies. The scope of the review is on policies that aim to reduce environmental problems related to energy consumption. These include, for example, emission of greenhouse gas and pollution from vehicle fuel use. Carbon taxes or energy taxes are the principal policy that is examined.

The chapter also undertakes a comparative analysis of household spending patterns. The spending pattern of European countries, as a representation of industrialised countries, will be compared with that of Indonesia in order to see whether there is a distinctive difference between the two.

2.1 Previous Studies

2.1.1 Empirical Findings from Industrialised Countries

Most of the studies reviewed in this chapter are from developed countries. Environmental problems could be considered new issues in development as they only started to gain widespread global attention in the 1970s, especially after the Stockholm Conference on the Human Environment in 1972. It is therefore understandable that the distributional aspect of environmental policy in developing countries has not become a focus of attention. For the case of a carbon tax, this is confirmed by Baranzini et al. (2000) who observe: "Unfortunately, there are few studies on the distributional effects of a carbon tax in developing countries or countries with

economies in transition (p. 405)". The lack of studies from developing countries widens the relevance of the research in this thesis.

A study on American households by Poterba (1991) is considered to be one of the earliest study. He analyses the distributional effect of a carbon tax by examining the expenditure pattern of households, especially the pattern of energy spending. The policy he examines is a charge of US$100 per ton of carbon implemented in 1990. Using data from the U.S. Consumer's Expenditure Survey, Poterba (1991) assumes that the US$100/ton carbon tax is fully translated into the purchaser's price[1] of various energy related products, and combines these with the data on energy expenditure pattern to estimate the distributional burden of the carbon tax. He concludes that a carbon tax is regressive which suggest that if a carbon tax were adopted without any offsetting changes in other tax or transfer programs, the burden would fall more heavily on low-income than well-off households.

The source of the regressivity is apparently that the share of income low-income households devote to heating fuel, electricity, and gasoline is significantly higher than that of better-off households. In other words, that energy-related commodity was in fact a necessity for American households. Poterba (1991, p. 8), for example reports that total energy outlays for households at the 25th percentile of the income distribution are approximately 16% of income, compared with only 7% for households at the 75th percentile of the distribution.

Another early work is by Pearson and Smith (1991) using a more or less similar method to Poterba (1991). This study examines the distributive effect of a carbon tax in European countries. For the U.K., the study uses the 1988 UK Family Expenditure Survey, and examines the impact of a tax on carbon and energy at a level equivalent to US$10 per barrel. For U.K. households, the result suggests the poorest quintile would pay 2.4% of their spending, while, the richest quintile would pay only 0.8%. Pearson and Smith (1991) conclude:

> "[In nominal terms, the carbon tax payments] are slightly lower, but show broadly similar effects: higher tax payments amongst the rich than

[1] Producer's price is not affected.

> the poor, but the burden of the tax in relation to household spending being higher for the poor than for the rich (p. 42)."

However, using a similar calculation for six other European countries, Pearson and Smith (1991) suggest that the burden of carbon tax payments is only weakly related to income or mildly regressive, except in Ireland where it tends to be strongly regressive. In their review Barker and Köhler (1998) support this finding and suggest that "carbon and energy taxes were weakly regressive for most countries, but more strongly regressive for the UK and Ireland" (p. 377).

A study for Canada was conducted by Hamilton and Cameron (1994), estimating the distributional impact of meeting the Rio target of stabilising CO_2 emissions at the 1990 level by the year 2000. The methodology used is a combination of three different methods. To get the estimated level of carbon tax to meet the stabilisation target, Hamilton and Cameron (1994), use a Computable General Equilibrium (CGE) model of the Canadian Department of Finance. The model suggests a carbon tax of US$101.56 per tonne. Using an Input-Output model, this carbon tax is then translated into increases in all prices in the economy. These price increases are then used in a micro-simulation model using Statistics Canada's micro-simulation model.

The result suggest that carbon tax in Canada is mildly regressive. In their conclusion, Hamilton and Cameron (1994) report:

> "The distributional consequences of the simulated tax are moderately regressive: decrease in consumable income for the lowest quintile of households are from 1.1 to 1.2 percent larger than for the highest quintile (p. 394)."

Cornwell and Creedy (1996) investigate the distributional implication of a reduction in emissions of 20% per cent of 1988 levels by 2005 to meet the Toronto target for Australia. The methodology used is a combination of Input-Output analysis and household demand system, which they describe as a three-stage process. In the first stage, the carbon tax is shifted forward to consumers, increasing the price of goods

in proportion to their carbon content. The second stage is calculating the demand response of consumers to the price changes. In this stage, Australian Household Survey (HES) data is used to calculate elasticities of demand for various income groups. The third stage, is to calculate the new levels of aggregated demand to determine the amount of emission reductions.

The result suggests that a carbon tax of AU$113 per tonne of CO_2 is needed to reduce emissions by 20 per cent. With regard to distributional results, the general conclusion suggests the distributive effect is regressive. For example, the simulation, increases the Gini coefficient from 0.2778 to 0.2838.[2]

Barker and Köhler (1998) examine the distributional effect of imposing additional excise duties on energy products according to their carbon content. The countries they analyse are quite comprehensive comprising all members of the European Union. The methodology used in this study is called the energy-environment-economy model for Europe (E3ME), a sectoral, regionalised, econometric model. Barker and Köhler (1998) argue that the model treats member states as distinct economic entities interacting with one another but the same time it is still one model. The model includes 11 member states, 30 industries, 27 consumer categories, 17 fuel users and 11 fuels with detail on CO_2 emissions.

The policy scenario is an increase in excise duties on energy products, such that it escalates from 1999 to 2010 and achieves levels reducing CO_2 emissions by 10 per cent below the baseline by 2010 for 11 EU member states. The results without revenue recycling suggest the excise duties are regressive, but progressive if revenue from the additional excise duties is recycled as lump-sum transfers. For example Barker and Köhler (1998) conclude that "the package of measures that is examined here is regressive across expenditure groups ...(p. 399)." It is also suggested that the results are dominated by the effects of domestic energy taxes, which are weakly regressive.

Labandeira and Labeaga (1999) study the impact of a tax levied on Spanish energy-related CO_2 emissions. A two stages approach is used in the study. The

[2]Table 3 of Cornwell and Creedy (1996, p. 31)

first step uses an Input-Output demand model to calculate the price effects of the Spanish carbon tax. The price effect is then transmitted into the second stage, using a micro-simulation model of an estimated consumer's demand system (Almost Ideal Demand System) which yields consumer reaction to the carbon tax as well as its distributional outcomes.

The policy examined is a hypothetical carbon tax rate with a rate chosen to reflect the damage associated with Spanish CO_2 emissions. Using a damage estimate from the literature, Labandeira and Labeaga (1999) focus on the impact of a carbon tax of US$20.3 per tonne of carbon. In contrast with other studies, Labandeira and Labeaga (1999) do not find that a carbon tax in Spain is regressive and concludes:

> "... the variation of equivalent losses across total expenditure deciles is inconclusive on the regressivity of the reform, although the reform has a greater effect on households with older heads (p. 318)."

Symons et al. (2000) examine the likely immediate impact of a pollution tax on the tax burden of households in a number of European countries. Although a number of pollutants are examined, they focus on CO_2. The method is basically similar to many other studies, such as Labandeira and Labeaga (1999) and Cornwell and Creedy (1996), where an input-output framework is used to assess the likely impact of pollution/energy taxes, via increases in the cost of using fossil fuels, upon the prices of consumer goods. The Input-Output approach is then combined with investigation of the expenditure patterns of households, where the price changes deriving from the taxes are linked to consumer demand.

The policy scenarios used in the study are a CO_2 tax of 0.1ECU per kg emissions of CO_2 and an energy tax that raises the same revenues as the CO_2 tax. Revenue recycling is not included in the analysis because as Symons et al. (2000, p. 7) states "we need to know the extent of the regressivity of the tax without any additional effects".

The results suggest that both a CO_2 tax and energy tax are regressive in Germany, where for CO_2, the lowest income groups pay 8% of expenditure, while the

highest income group pay just above 5%. The tax is also regressive for France and slightly regressive for Spain. The result for Spain is slightly different to the study by Labandeira and Labeaga (1999), where they found neutrality of a carbon tax. However, in Italy, the result is neutral, and in contrast to other studies, is progressive for the U.K.

Tiezzi (2001) simulate the welfare effects of the carbon-energy tax implemented in Italy in 1999. The methodology used is the True Cost of Living index number[3] for which the parameters have been obtained through demand system estimation using household level data from 1985 to 1996.

The policy examined is a new green tax, which is a carbon-energy tax based on a reduction in CO_2 emissions. As Tiezzi (2001, p. 3) suggests, the policy "is in line with the national actions defined in 1988 ... to reduce CO_2 emissions in order to comply with the obligations of the Kyoto Protocol." Tiezzi (2001) concludes:

> "Contrary to what has been found in other similar studies, the tax burden is proportionally distributed across households at different welfare levels. Thus the presumed regressivity of carbon taxation is not sustained [in Italy]. This might be due to the fact that reform has mainly hit transport fuels, whereas heating fuels price have increased relatively less (p. 12)."

Jacobsen et al. (2003) analyses the distributional implications of environmental taxation in Denmark. The taxes examined in the paper are various individual taxes, as well as the combination of all these taxes and duties related to environmental concerns. The method used by Jacobsen et al. (2003) is an examination of survey data of 3.3 per cent of the Danish population. The distributional impact is examined by looking at tax payments relative to disposable income for each income decile. Comparing the pattern of tax payments, Jacobsen et al. (2003, p. 495) concludes "the distributional effect varies a great deal between different environmental taxes,

[3] Tiezzi (2001, p. 5) describes a true cost-of-living index number (TCOL) as comparing the cost of achieving a given level of economic welfare before a price increase with the cost of achieving the same level of economic welfare after the price increase and measures how much extra income is needed to get back to the original welfare level.

with transport-related taxes reducing after-tax inequality, and green taxes [including CO_2 tax] increasing inequality".

Bork (2003) studies the impact of ecological tax reform in Germany. The ecological tax reform refers to energy taxation combined with reduced social insurance contributions. The reform was launched in 1999 with the aim of reducing energy consumption and emissions and promoting the development of environmentally sound production and technologies.

The methodology used by Bork (2003) is a combination of a macroeconomic model and a micro-simulation model. The macro model is an empirical general equilibrium model of the German economy, called the LEAN model. The model has an emphasis on energy and labour markets and is linked with a micro-simulation model that incorporates detailed household data to look at the impact on personal income distribution.

Bork (2003, p. 167) reports the reform "in itself leads to a net burden for most households ... however, as a share of household income this burden is low". With regard to distributional results, Bork (2003) concludes:

> "All in all, the ecological tax reform is not neutral in its effects on private households ... Households with lower incomes will bear a somewhat heavier burden as a share of net household income. The main reasons are the higher prices for electricity, heating oil and natural gas. By contrast, medium-income households will bear the greater burden as regard to the increased fuel taxes (p. 167)."

In other words, the study by Bork (2003, p. 167) suggests ecological tax reform in Germany is regressive. The introduction of a fuel tax, where fuel is mostly used for transportation purposes, tends to be progressive.

Brannlund and Nordstrom (2004) analyse consumer responses to changes in energy or environmental policy in Sweden. Sweden introduced a CO_2 tax in 1991, initially set at the level of US$30 per tonne. As at January 1, 1997 the tax rose to US$46 per tonne and green policy has become the Swedish policy agenda ever since.

The methodology used by Brannlund and Nordstrom (2004) is an econometric model for non-durable consumer demand that utilises micro and macro-data. They estimated a system of demand equations using micro-data from Swedish Household Expenditure Surveys with aggregate data from the Swedish National Accounts. The distinguished feature of this micro-simulation model is the incorporation of a labour-leisure choice. The specification of the demand system is the quadratic Almost Ideal Demand System or QAIDS.

The policy simulation is intended to illustrate the response and distributional impact of non-marginal changes of the CO_2 tax. The motivation is the Swedish commitment according to the Kyoto-protocol. Two scenarios are considered. The first is a 100% increase in the CO_2 tax with a tax replacement of a lower general VAT, and the second scenario is the same CO_2 tax but with a tax replacement in the form of lower VAT on public transport.

It appears the distributional impact of the first simulation is regressive. Households with the lowest income quintile pay 0.52 per cent of their disposable income, and households with the highest income quintile pay only 0.33 per cent. Brannlund and Nordstrom (2004), conclude:

> "The welfare effect, ... differs substantially between household categories. ... relative to disposable income the welfare loss will be greater for low income household indicating that the tax is regressive (p. 225)."

With regard to the second simulation, the result also suggests regressivity. Households with the lowest income quintile experience a welfare loss of 0.46 per cent of their disposable income, while households with the highest income quintile only experience 0.4 per cent. Brannlund and Nordstrom (2004, p. 227) conclude that "compared with the first scenario, the welfare loss relative to disposable income is distributed in a similar manner."

West and Williams (2004) study the incidence or distributional effect of a gasoline tax in the US. The method is the Almost Ideal Demand System estimated using 1996 and 1998 Consumer Expenditure Surveys. They compare four different measures of

the incidence of the tax: the equivalent variation, two consumer surplus measures, and a measure that implicitly assumes all demand is completely unresponsive to price.

There are three scenarios with regard to how the gas tax revenue is used: discarded, used to cut taxes on wage income, and returned as a uniform lump-sum distribution. West and Williams (2004, p. 537) report in their conclusion:

> "We find that increasing the gas tax is regressive, but this depends greatly on how the revenue is used; using the additional revenue to provide lump-sum transfers more than offsets the regressivity ..., using the revenue to cut the tax on labor income ... reduces the regressivity ..., but this effect is not sufficient to make the change progressive overall."

Wier et al. (2005), explicitly examine whether a carbon tax is regressive in Denmark. This policy is very important in Denmark because it was one of the first countries to impose explicit CO_2 taxes on both household and business energy consumption in 1992/1993. Denmark carries one of the heaviest environmental tax burdens in the world, bringing in around 10% of public revenues.

The methodology used by Wier et al. (2005) is the combination of Input-Output model and household survey data which is common in the literature[4]. The Input-Output model is used to calculate actual indirect tax payments by households for different types of commodities, whereas the consumer survey from Statistics Denmark is used for distributional analysis.

The results suggests that the carbon tax payment in Denmark is regressive. Wier et al. (2005, p. 244), for example, report that "as income rises, a falling share going to environmental taxes indicates a regressive tax". More explicitly Wier et al. (2005) suggest:

> "... low-income families paid (direct as well as indirect) CO_2 taxes constituting around 0.8% of disposable income, while high-income families paid CO_2 taxes constituting around 0.3% of disposable income (p. 245)."

[4]The same method is used, for example, by Symons et al. (2000), Labandeira and Labeaga (1999) and Cornwell and Creedy (1996).

However, Wier et al. (2005) suggest the degree of regressivity of CO_2 taxes decreases when using total expenditure instead of income.

To summarise, although not all studies reviewed conclude regressivity of environmental policy related to energy and carbon emissions, the literature generally suggests environmental policy in the form of a carbon tax or energy tax is regressive. The burden is borne proportionately more by lower income households. Similar conclusions are shared by other studies that survey more or less similar literature. The survey by Baranzini et al. (2000), OECD (1994), OECD (1996), Kristörm (2003), and Boyce et al. (2005) confirm this general tendency.

One of the earliest reviews by the OECD (1994) to provide a systematic framework that can be used to estimate the distributive effect of environmental policy indicates a general tendency toward regressivity particularly for industrialised countries. In their conclusion, OECD (1994) reports:

> ""Nevertheless, the available studies do appear to show common patterns ... pollution control cost tend to be regressive, i.e., the percentage burden is greater for lower income households than for higher income households; ... environmental taxes also tend to be regressive – at least in many OECD countries (pp.99–100)."

The same OECD report further suggests:

> "Overall, this review of the literature available on the distribution of the financial effects of environmental policies suggests the following main findings: There is evidence that economic instruments tends to be regressive with a particular concern for taxes, with a weak to mild regressivity in general (p.30)."

In its later report, specific for carbon tax, OECD (1995) concludes:

> "With regard to income distributional effects, empirical studies suggest that a national carbon tax or trading programme would be at least mildly regressive (i.e., would impose greater percentage burdens on the lower

> income groups) in many OECD countries, although there is some evidence that such programmes might actually be progressive in developing countries (p.57)."

With regard to environmental policy related to energy, a study by OECD (1996) also reaches more or less similar conclusions. They suggest "in some OECD countries, domestic energy has the character of a necessity in household budgets, and taxes on domestic energy are correspondingly regressive (p.61).".

Baranzini et al. (2000), in their evaluation of carbon taxes with regard to their competitiveness, distributional and environmental impact, suggest a tendency toward regressivity. They conclude:

> "Results from empirical studies show that carbon taxes are generally regressive, ... For instance, of the seven studies reviewed by [the 2nd Assessment Report of the IPCC] four indicate that carbon taxes are regressive, while others indicate possible proportional or progressive impacts (p.404)."

A more recent review by Kristörm (2003) which attempts to provide a framework for assessing the distribution of the financial effects of environmental policies, also concludes:

> "Our survey of the cost of environmental policy in a distributional context leads to the following conclusions. First of all, environmental policy must have distributional impacts in order to be successful. Empirical evidence tends, on balance, to suggest that environmental policy is regressive (on a gross basis) (p.44)."

Finally, Boyce et al. (2005), after reviewing studies on distributional impact of carbon tax in developed countries, conclude:

> Studies in [European] and other industrialised countries generally have concluded that carbon charges are regressive – taking a bigger slice

> in percentage term from low-income households than from high-income households – or in some case distributionally neutral or mixed (p.3).

In other words, the literature from developed countries suggests environmental policies (in the form of energy-related policies, or climate change policy) tend to be regressive.

2.1.2 Developing Countries Studies

As suggested earlier, compared to numerous studies from industrialised countries, studies from developing countries analysing the distributive effect of environmental policies hardly exist. Among the few are an early study by Shah and Larsen (1992), and recent studies by Corong (2007) and Boyce et al. (2005).

Concerning the case that most of the studies are from developed countries, Shah and Larsen (1992) argue that the conclusion from the developed country literature which confirms the regressivity of environmental policies, particularly carbon taxes, may not necessarily apply to developing countries. They argue that the source of the regressivity may have been a declining share of fossil fuel consumption with income. However, if forward shifting can be fully avoided (e.g., through price controls) the burden will fall to the capital owner. In reality, as Shah and Larsen (1992) argue, forward shifting would only be partial, and the effect of a carbon tax may be progressive, as they showed with the case of Pakistan. In developing countries, such factors as market power, price controls, import quotas, rationed foreign exchange, the presence of black markets, tax-evasion, and urban-rural migration, may cast doubt on the regressivity of environmental policies (Shah and Larsen (1992), p. 8).

Boyce et al. (2005) suggest the same thing. Explicitly Boyce et al. (2005, p. 4) mention that:

> "Whether these findings can be generalised to the developing countries of Asia, Africa, and Latin America is an open question. Patterns of household expenditure and energy use in developing countries are likely to differ from those of industrialised countries."

OECD (1995, p. 25) even conjectures that "the net effect of adding a carbon tax in developing countries may well be proportional to income, or even progressive".

The study by Shah and Larsen (1992), although no longer recent, is very comprehensive, because it includes developing countries like India, Indonesia, and Pakistan. The study attempts to quantify the efficiency and equity implication of carbon taxes for a few selected developing countries. It is unfortunate that there are almost no subsequent studies to provide enrichment of the literature on the equity impact of environmental policies in developing countries.

Shah and Larsen (1992) examine the case for carbon taxes in terms of their revenue potential, efficiency, and distributional implications. A small fossil fuel carbon tax of the order of US$10/ton is selected. However, the distributional implication is only analysed for the Pakistán case. The illustration for Pakistan uses four different cases. For the first case of 'full forward shifting' where the price increase is perfectly translated into final consumer prices, Shah and Larsen (1992, p. 8) show that "the carbon tax burden falls with income, thereby yielding a regressive pattern of incidence. Such regressivity is, nevertheless, less pronounced with respect to household expenditure". However, with only partial forward shifting the results suggest "roughly proportional incidence of carbon taxes .. and a progressive incidence pattern." Shah and Larsen (1992, p. 10) conclude that "the ... analysis suggests that the regressivity of carbon taxes should be less of a concern in developing countries than in developed countries".

Another recent study from developing countries is by Corong (2007), where he studies the economic and poverty impact of a voluntary carbon reduction for the Philippines. He uses a static Computable General Equilibrium (CGE) model calibrated to the 1994 Philippine Social Accounting Matrix (SAM) and linked to household survey data. The approach is transferring the change in household disposable income and the cost of a household specific consumer basket (per household groups) from the CGE model into the household level data.

Amongst three scenarios in the study, one is the imposition of a 385 peso carbon tax per ton of carbon emissions, with the government recycles the generated carbon

revenue by reducing income taxes imposed on households.

However, there is no discussion on the impact of the scenario on inequality because the focus is more on poverty. The result suggest national poverty incidence increases marginally as a results of the carbon tax.

Another developing countries study found in the literature is a study for China by Boyce et al. (2005). This study analyses the distributional impacts of carbon charges and revenue recycling in China, using data from a nationally representative household income and expenditure survey for the year 1995. They separate household spending into six categories, and apply a carbon loading factor to each of these categories to estimate the carbon usage embodied in these different types of household consumption.

The policy simulated is a charge of 300 yuan per metric ton of carbon. The result suggests that even without revenue recycling the effect of a carbon charge would be progressive. As Boyce et al. (2005) report:

> "The lowest decile pays 2.1% of their total expenditures ..., and the highest decile pays 3.2%. This reflects the fact that the mix of products that relatively rich people buy is, on average, more carbon intensive than what relatively poor people buy. This contrast with results from studies in other [industrialised] countries. ... Our results call into question the generality of this conclusion (pp. 9-10)."

The authors then conclude the results are primarily driven by differences between urban and rural expenditure patterns, and also conjecture that:

> "A similar pattern may exist in other developing countries – particularly where rural areas are relatively poor, consume few industrial products and obtain much of their direct energy use from firewood and other ... In contrast to the pattern often reported for industrial countries, carbon [taxes] may turn out to be progressive in many developing countries (p. 10)."

The discussion of what would primarily drive the distributional impact of environmental policy in general or a carbon tax or energy-related policy in particular, it seems that the expenditure pattern is seen as the main driver of the results. For example, some of the literature in developed countries mentions that domestic energy such as heating could drive the effect to be more regressive, while vehicle fuels or transport tends to have less regressive effects[5].

However, environmental policy may also have an effect on household income through changes in factor prices or employment caused by the restructuring of the output composition. Hardly any studies address this issue in conjunction with the expenditure pattern. Amongst the reasons is that to complete the story, it may be necessary to address it in a general equilibrium framework using a CGE model that has disaggregated households built in or integrated in the model. Most studies use household level data only, or if using a CGE model is usually linked with the household level data, but not in an integrated manner. As discussed in the previous chapter, this is the main contribution offered in this thesis, i.e., by applying a CGE model that can incorporate both expenditure and income pattern as inseparable driving forces in the distributional story. In the next chapter, the issue of how income pattern (as represented by the pattern of functional distribution of income) will be addressed in a analytical analysis. The next section will first have a closer look at the expenditure pattern.

2.2 A Closer Look at Spending Pattern: Europe and Indonesia Compared

As argued by Shah and Larsen (1992), one of the key reasons, a carbon tax may be regressive, is that the share of spending on certain commodities of which their prices are very sensitive to a carbon tax is higher in the consumption basket of poor households, and lower in that of rich households. It will, therefore, be interesting to compare the share of this spending between the industrialised and developing

[5]For example Pearson and Smith (1991) and Tiezzi (2001).

countries. Kohler et al. (1999) study the pattern of certain spending they considered environmentally sensitive, from 12 European countries. The commodities categorised as environmentally sensitive are energy, including electricity, gas, and other fuels; transportation including vehicle purchases, vehicle fuels, and public transport; and 'white goods' including the purchase of domestic appliances such as freezers and air-conditioning, etc. Kohler et al. (1999) categorized households into 6 income groups. The data from the study by Kohler et al. (1999) is borrowed, and compared with the Indonesian data.

The share of environmentally sensitive spending for Indonesian households is calculated using Indonesian household survey data, SUSENAS[6] 2002. The category of expenditure classes uses the same category as in Kohler et al. (1999) to make it comparable, i.e., according to its deviation from mean expenditure per capita.[7] The result of the calculation is shown in figure 2.1.

For European households, it can be seen that the only one of the commodities shown for which its expenditure share is declining with income is energy (the top three panels of 2.1). The poorest household, for example, spend around 9 percent while the richest household spend only 3 percent on energy. The expenditure share on energy is declining both for electricity and other energy (gas and other fuels). Therefore, it may be inferred that if the spending pattern is behind the conclusion in the literature that environmental policies are regressive in developed countries, it can be explained by the declining share of energy spending.

Interestingly, the share of spending in Indonesia on non-energy environmentally sensitive goods (vehicle purchase, vehicle fuels, public transport, and domestic appliance) in Indonesia follows a similar pattern to European households, i.e., most are increasing with income. However, the pattern of energy spending is markedly different. In total (urban and rural) the share of energy spending is increasing until the third richest group, and declining afterward. However, the richest group still

[6]SUSENAS is a national-level survey which covers all areas of Indonesia and carried out once a year using a sample of approximately 200,000 households. The more detail consumption sub-model of SUSENAS is called Module SUSENAS is carried out once every three years using a sample of 65,000 households.

[7]The category is 0.4, 0.6, 0.8, 1.2, 1.6 of mean expenditure per capita.

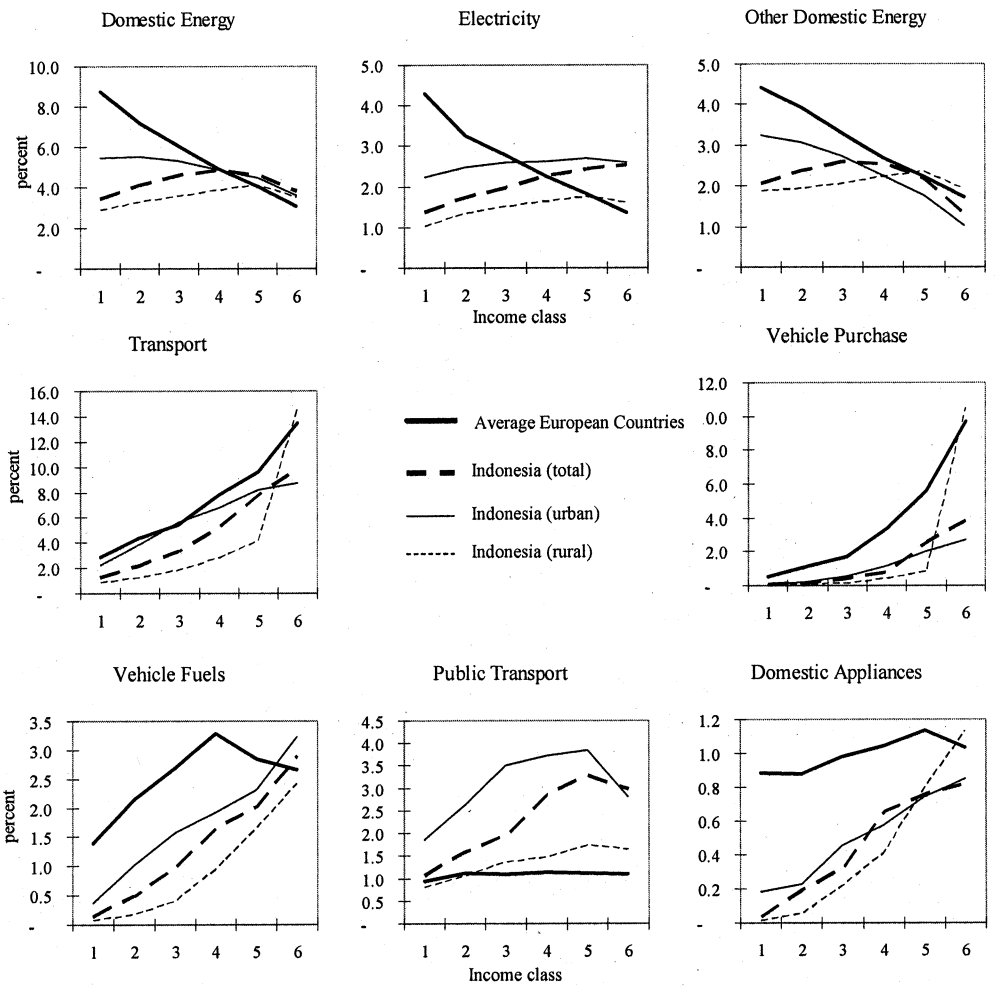


Figure 2.1: Share of environmentally sensitive spending in Indonesia and Europe

consumes proportionately more than the poorest. The share of energy spending is declining in urban area, although its slope is very much flatter than in Europe. In rural areas, the expenditure share of energy is increasing, even up to the second highest richest group.

Looking at the detailed component of energy, it can be seen that the pattern of electricity spending in Indonesia follows a totally different pattern to that of the European countries. While it is declining in European countries, it is increasing in Indonesia, both in urban and rural areas. However, the spending of urban Indonesian households on other energy follows a similar pattern to the European one, while in rural areas it is still increasing with income. It should be noted that the biggest component of other energy in European countries is gas, while in Indonesia it is kerosene, the cheapest fuel for domestic cooking.

The above comparative analysis suggests the spending pattern of the developed and developing countries may be different, and that this may have an effect on the distributional analysis of environmental policies. The expenditure share of energy in European countries is declining with income, suggesting energy is a necessity. However, energy spending in developing countries like Indonesia, is not necessarily declining with income, and certain form of energy, such as electricity, are increasing with income and thus can be considered luxuries. Therefore, while in Europe, stricter environmental regulation that is translated to higher prices of environmentally sensitive goods will be regressive, in developing countries, the burden will be more borne by the rich rather than the poor.

Chapter 3

A Simple Analytical Framework

It is suggested in the previous chapter that households in developing countries may have a different expenditure pattern to those in developed countries, and that this may drive the distributional impact of environmental policy. These policies may not necessarily be regressive. This chapter takes a closer look at the income side in attempting to study cases where environmental policy may not necessarily be regressive in developing countries. Using a simple analytical model, it analyses the impact of environmental policy on the functional (or factorial) distribution of income. In the cases of this exercise, some assumptions or cases that may represent typical characteristics of a developing country's economy will be introduced. These are the dualistic nature of such an economy, in the sense that it has a sector called "informal" where certain regulations, such as labour market and environmental regulations, may not be able to be effectively enforced.

In other words, the objective here is to see the possible distributional implication of stricter environmental policy in a developing country characterized by the presence of an informal sector which may not be subject to environmental regulation, and a formal sector which may be subject to a minimum wage policy. Throughout the analysis, the informal sector is assumed to be labour intensive, and the formal sector capital intensive.

The rest of the chapter is organised as follows: Section 3.1 briefly reviews similar models in the literature; section 3.2 discusses the setup of the model, especially the assumption of the technology representation of industries; section 3.3 analyses the factorial distributional impact of stricter environmental regulation in a comparative

static analysis; section 3.4 applies the model in a hypothetical numerical example to give a clearer illustration; and section 4.7 concludes.

3.1 Brief Literature Review

The model used as a starting point for this analysis is a simple Heckscher-Ohlin-Samuelson (HOS) 2-goods, 2-factors model, standard in the international trade literature, as extended by Copeland and Taylor (2003) and Copeland and Taylor (1997). The model is simply extended here by introducing a dualistic setting of the economy, with a possibility of labour market rigidity.

Amendment of a Heckscher-Ohlin-Samuelson model incorporating minimum wage policy, wage rigidity, or differentiated factor prices is not new. For example, Jones (1971) analyses the income distribution impact of distortion in the labour market in the form of a wage premium. Among others, studies that explicitly include minimum wage policy are Johnson (1969), and Neary (1985). Magee (1973) undertook a comprehensive review on the relationship between factor market distortions, production, and trade. Explicit reference to a dualistic setting can be found in Imam and Whalley (1985), where they explore the incidence of a sector specific minimum wage in a dualistic setting of a Harris-Todaro model. More recently, Kar and Marjit (2001) demonstrate the welfare effects of trade policy reform in a general equilibrium framework, in the presence of an informal sector.

However, only a few have analysed the impact of environmental policy in a dualistic economy setting, including Chao et al. (2000), Daitoh (2003), Dean and Gangopadhyay (1997). Chao et al. (2000) develop a general equilibrium model to examine the optimal level of environmental preservation in terms of its costs and benefits for a closed and an open economy. In an economy consisting of two main activities: farming and processing; with three different inputs (labour, land, and raw material), Chao et al. (2000) attempt to find the optimal environmental preservation and its impact on sectoral unemployment and trade in resources. An urban wage set by the government above the market clearing level is assumed in the model.

In another study, Daitoh (2003) explores sufficient conditions for welfare-improving environmental policy reform in the Harris–Todaro economy. She investigates how a stricter environmental protection policy in urban manufacturing may affect manufacturing employment and urban unemployment, and explores the sufficient conditions for welfare improvement. She concludes that a rise in the pollution tax rate in urban manufacturing has spillover effects on the two labour market distortions: less-than-optimal manufacturing employment and urban unemployment.

Dean and Gangopadhyay (1997) examine the effects of an export ban on intermediate goods in a three-sector model in which the production of intermediates gives rise to environmental damage. They primarily consider how the (second-best) optimal production and export taxes should be set in the presence of urban unemployment. They also consider policy reform, making it clear that the export ban aggravates urban unemployment in the short run, but decreases it in the long run.

Compared with the model used in the foregoing studies, the model to be used here will focus on the distributional impact of environmental policies represented here by the factorial or functional distribution of income. The model assumes full employment of both capital and labour emphasising its long-run nature, and making it consistent with the simple Heckscher-Ohlin model used as the basic starting point. The assumption of full-employment or voluntary unemployment is used by most CGE models that reflect the equilibrium of the economy.

In the context of developing countries, especially in Indonesia where open unemployment is always reported as very low, full employment may reflect the dualistic nature of the economy. When the formal sector can't absorb all of the available labour, the informal sector often becomes the place where the excess labour will be employed but at lower wages and possibly also at less than full-time hours.

3.2 The Model

As described in Copeland and Taylor (2003), the model is a simple extension of the Heckscher-Ohlin-Samuelson (HOS) 2-goods, 2-factors model, which is standard

in international trade literature. Therefore, most of the assumptions embodied in the HOS model are retained. The economy is assumed to be small, in the sense that it can not affect international prices. Goods are freely mobile across countries, but factors are not. However, factors of production can move between industries. The economy is assumed to be always in full employment emphasising the long-run nature of the model. Throughout the analysis it will be assumed that the economy is never fully specialised.

The extension introduced by Copeland and Taylor (2003) to this simple HOS model is via the introduction of pollution, as a joint product of firms' activity. The model is modified slightly to account for a setting where a developing economy faces a dualistic labour market. Industries may face different wages with minimum wages exogenously determined by government employment policy.

The discussion of the labor market structure in Indonesia before the economic crisis was extensively documented by Manning (1998). Manning (1998, pp. 138-139), for example, emphasized that wage differentials between sector was large in 1980s and segmentation remained a feature of the Indonesian labor market in 1990s, suggesting the prevalence of labor market distortion. The development of labor market in 1990s was also characterized by the growth in informal sector employment (Manning, 1998, p. 148).

In a more recent paper, Manning (2003, p. 9) again suggests that the operation of labor market in Indonesia can be best understood through a reference to a dualistic economy and employment structure. Among the recent evidence, as he suggests, is that regular wageworkers who are most directly affected by labor regulation accounted for just under 30% of all employment and half of all urban employment (Manning, 2003, p. 31).

Another study, by Sumarto and Suryahadi (2002) also stress the dualistic nature of Indonesian labor market from analyzing Indonesian data. This data highlights the fact that the Indonesian labor market is characterized by relatively limited employment opportunities in the formal sector compared with the size of the available workforce. Consequently, the labor market has become dualistic, with only about

a third of the workforce employed in the formal sector while the remainder are employed in the informal sector where employment conditions - including wage levels - are on average considerably lower than the formal sector. Alatas and Cameron (2003, p. 14) also mentioned that in contrast to developed countries, the informal sector uncovered by minimum wage policy play a large role in Indonesian labor market.

The informal sector also plays a role in the economic crisis as suggested in Fallon and Lucas (2002, p. 28). As the male wage employment rate fell from 1997 to 1998 in urban and rural areas, self-employment and unpaid family work which represent the informal labor market increased from a low base in 1997. Fallon and Lucas (2002) also stress the considerable variation between male and female, rural and urban employment during the crisis. The shifts between wage employment and self-employment, also, were more common among women than men.

3.2.1 Production and Abatement Technology

Suppose the economy consists of two sectors or industries, i.e., formal sector (F) and informal sector (I). Adapting the technological structure used in Copeland and Taylor (2003), the production structure of the industries is

$$x_i = (1-\theta_i)\, g_i(L_i, K_i), \tag{3.1}$$

$$z_i = \varphi_i(\theta_i)\, g_i(L_i, K_i), \tag{3.2}$$

where x_i is the amount of commodity produced by industry i, where $i = F, I$, F is formal sector, and I is informal sector, L_i and K_i is the amount of labour and capital, respectively, employed by industry i, z_i is the amount of emission produced by industry i, while θ_i and φ_i are parameters. Sector i, jointly produces two outputs, i.e., commodity x_i and emissions z_i.[1] The amount of emissions produced depends on the level of abatement activity of the firms. The function g_i may be interpreted as

[1] Here, there is no distinction between clean and dirty industry as both the formal and informal sector s produce pollution. Copeland and Taylor (2003) distinguish a clean and dirty sector in order to discuss the trade pattern and comparative advantage change after trade reform.

potential output, i.e., the amount of x_i to be produced if no abatement activity takes place and $g_i(\cdot)$ is increasing, concave, and linearly homogeneous, $0 \leq \theta_i \leq 1$, $\varphi(0) = 1, \varphi(1) = 0$, and $\frac{d\varphi_i}{d\theta_i} < 0$. Industry i endogenously decides how much of every unit of its potential output will be allocated to the production of x_i (or $1 - \theta_i$) and how much will be diverted to abatement activity (θ_i). $\varphi_i(\theta_i)$ captures the transformation between potential output and emissions taking into account the abatement activity. For analytical convenience, following Copeland and Taylor (2003), it is assumed that $\varphi_i(\theta_i)$ follows:

$$\varphi_i(\theta_i) = (1 - \theta_i)^{1/\gamma_i}, \tag{3.3}$$

where $0 < \gamma_i < 1$ represents the parameter of abatement technology. By imposing this special functional form, in addition to representing emission as an output of the production process, pollution can also be treated as an input to produce x_i, such that[2]:

$$x_i = z_i^{\gamma_i} \left[g_i(L_i, K_i)\right]^{1-\gamma_i}. \tag{3.4}$$

Because equation 3.4 is Cobb-Douglass, γ_i represents the cost share of pollution to produce x_i.

3.2.2 Cost Minimization and Endogenous Emission Intensity

The separability of equation 3.4 makes it possible to break the firm's problem into two stages. First, the firm minimises the cost of producing potential output $g_i(\cdot)$, and, secondly finds the most efficient way to combine $g(\cdot)$ and pollution (z_i) to produce net output or commodity x_i. In the first stage, the firm minimises the cost, given the technology to produce potential output (g_i). The unit labour and capital demand from this cost minimization can be written as

$$(l_i, k_i) = \arg\min_{L_i, K_i} \{w_i L_i + r K_i : g(L_i, K_i) = 1\}, \tag{3.5}$$

[2]by substituting equation 3.3 into equation 3.2 and 3.1.

where l_i and k_i are unit labour and capital demand, w_i is the price of labour faced by firm i, and r is the rental rate or price of capital[3]. From this first stage of cost minimization, firms can now know determine the minimum cost to produce every unit of potential output denoted by $c_i^g = w_i l_i + r k_i$.

With this knowledge, firms minimise the cost of producing good x_i (or net output in contrast to potential output) in the second stage by choosing the optimal levels of potential output and emissions. The price of emissions is the emission tax (τ_i)[4] set by the environmental regulator. The unit cost of producing net output is then:

$$c_i^x = \min_{z_i, g_i} \left\{ \tau_i z_i + c_i^g g_i : z_i^{\gamma_i} g_i^{1-\gamma_i} = 1 \right\}. \tag{3.6}$$

The First order condition of the optimization problem from equation 3.6 can be written as $\frac{z_i}{g_i}\frac{1-\gamma_i}{\gamma_i} = \frac{c_i^g}{\tau_i}$. Linear homogeneity of $x_i(\cdot)$ also implies $p_i x_i = c_i^g g_i + \tau_i z_i$. Combining these two equations can then solve for emission intensity, i.e.,

$$e_i = \frac{z_i}{x_i} = \frac{\gamma_i p_i}{\tau_i} \leq 1. \tag{3.7}$$

Following Copeland and Taylor (2003), it will be assumed $z_i \leq x_i$ to ensure the optimum emission will be an interior solution. Equation 3.7 has a very straightforward intuition. Emission intensity is endogenously determined and depends on three factors. The first is the abatement technology represented by γ_i. For example, if the firm has low abatement technology, then γ_i (the share of emission cost) will be higher, and so will the emission intensity. Secondly, the higher the commodity price, the higher the emission intensity. Commodity price, p_i, can be interpreted as the opportunity cost of abatement activity. If the cost is high, the firm will prefer to produce more net output to be sold in the market despite having to pollute more and paying tax. Thirdly, the price for emissions that has to be paid to the regulator

[3]Later in the section on comparative analysis, w_F will be assumed a minimum wage that is higher than would have been in a competitive undistorted labour market set exogenously by government. Wage in the informal sector, however, is endogenously determined in the labour market.

[4]Here, I allow for the possibility of policy variable differentiation by the regulator to each industry. This will be discussed further in the section on comparative static analysis.

by the firm (τ_i).

After the emission intensity is known, the total emissions in each sector can be calculated as $z_i = e_i x_i$. It may also be noted that, although the total emission of the industry depends on x_i, which is endogenously determined in the model, emission intensity depends only on exogenous factors. Once the market price is known, which will be equal to international commodity price in the absence of distortionary trade policy, given the firm's abatement technology and the unit emission tax set by the regulator, the amount of pollution produced by the firm for every unit of output it produces can be calculated. Despite its simplicity, this contribution by Copeland and Taylor (2003), goes beyond many applied general equilibrium analysis where pollution is only determined by technology disregarding the incentive mechanism that may drive a firm's decision on pollution.

If $z_i = e_i x_i$ is substituted into equation 3.4, and combined with equation 3.7, an expression for θ_i in terms of output price and environmental policy variable can be written as

$$\theta_i = 1 - \left(\frac{\gamma_i p_i}{\tau_i}\right)^{\gamma_i/(1-\gamma_i)}. \tag{3.8}$$

The share of resources allocated for abatement activity increases as the pollution tax increases, and falls as the commodity price (the opportunity cost of abatement) rises.

3.2.3 General Equilibrium Factor Prices and Allocation

The gross revenue the firm earns from selling commodity x_i is $p_i x_i$, while its total cost, including factor cost and total payment of emission tax, is $w_i L_i + rK_i + \tau_i z_i$. Competitive free entry condition implies $p_i x_i = w_i L_i + rK_i + \tau_i z_i$. As γ_i is the cost share of emission, then $\tau_i z_i = \gamma_i p_i x_i$ and this can be substituted to have $(1-\gamma_i)\, p_i x_i = w_i L_i + rK_i$. Recalling that $x_i = (1-\theta_i)\, g_i$, the zero profit condition

for both firms can be written as in the first two of the following equation system,

$$w_F l_F + r k_F = p_F (1 - \gamma_F)(1 - \theta_F), \tag{3.9}$$

$$w_I l_I + r k_I = p_I (1 - \gamma_I)(1 - \theta_I), \tag{3.10}$$

$$l_F g_F + l_I g_I = L, \tag{3.11}$$

$$k_F g_F + k_I g_I = K, \tag{3.12}$$

where l_F, k_F, l_I, k_I are unit factor demands as defined in equation 3.5[5]. The first two equations (equations 3.9 and 3.10) say the unit cost of producing potential output (c_i^g) or the total unit factor payment made by the firm has to be equal to the "effective" price (which will later be denoted by q_i) of the potential output received by the firm[6]. The effective or producer's price is less than the commodity price because a portion of θ_i has to be used for abatement activity, and γ_i has to be used to pay the emission tax. The last two equations are the endowment constraint which say that the total allocation of factors between sectors has to add up to the total factor endowment in the economy. The first two equations will determine the factor prices in the economy, and the last two will complete the general equilibrium of the supply side, i.e., potential output, net output, and emissions, of both industries.

3.3 Comparative Static: Who Pays for the Cleaner Air?

The setup of the model laid down in the previous section will be used to assess the factorial distributional impact of a stricter environmental policy. Before the policy change, it will be assumed a lower degree of environmental regulation has already been in place, that is at the initial condition there is $\tau_F = \tau_I = \tau > 0$. The new policy will be in the form of a higher emission tax. For the purpose of comparative static analysis, I will work on the percentage change form for convenient algebraic

[5] These factors demand can also be written as a function of factor prices.

[6] Alternative expression of the equations will be in term of unit cost of producing net output, i.e., $c_i^x = p_i (1 - \gamma_i)$, but $c_i^x = \frac{c_i^g}{1 - \theta_i}$.

manipulation. The example of analysis using the percentage change of this form can be seen in Jones (1965), or for more a recent study, Kar and Marjit (2001). The equation system 3.9 to 3.12 can be totally differentiated and presented as percentage change as follows:

$$\alpha_{LF}\hat{w}_F + \alpha_{KF}\hat{r} = \hat{q}_F - \left(\alpha_{LF}\hat{l}_F + \alpha_{KF}\hat{k}_F\right), \tag{3.13}$$

$$\alpha_{LI}\hat{w}_I + \alpha_{KI}\hat{r} = \hat{q}_I - \left(\alpha_{LI}\hat{l}_I + \alpha_{KI}\hat{k}_I\right), \tag{3.14}$$

$$\lambda_{LF}\hat{g}_F + \lambda_{LI}\hat{g}_I = \hat{L} - \left(\lambda_{LF}\hat{l}_F + \lambda_{LI}\hat{l}_I\right), \tag{3.15}$$

$$\lambda_{KF}\hat{g}_F + \lambda_{KI}\hat{g}_I = \hat{K} - \left(\lambda_{KF}\hat{k}_F + \lambda_{KI}\hat{k}_I\right), \tag{3.16}$$

where a hat over a variable indicates percentage change; $\alpha_{Li} = \frac{w_i l_i}{q_i}$ and $\alpha_{Ki} = \frac{rk_i}{q_i}$ are the labour cost share and capital cost share, respectively, in producing potential output; while $\lambda_{Li} = \frac{l_i g_i}{L}$ and $\lambda_{Ki} = \frac{k_i g_i}{K}$ are the share of factor employed in each industry. Throughout the analysis, it is assumed the informal sector is labour intensive, or more specifically, $\alpha_{LI} > \alpha_{LF}, \alpha_{KI} < \alpha_{KF}$, and $\lambda_{LI} > \lambda_{LF}, \lambda_{KI} < \lambda_{KF}$. The effective price of potential output is $q_i = p_i(1-\gamma_i)(1-\theta_i)$. Recalling θ_i is as defined in equation 3.8, the percentage change in q_i can be written as $\hat{q}_i = -\frac{\gamma_i}{1-\gamma_i}\hat{\tau}_i = -\upsilon_i\hat{\tau}_i$, because it is assumed p_i and γ_i does not change in the comparative static analysis. υ_i can be interpreted as elasticity of producer's price with respect to the emission tax. The higher γ_i is (indicating lower abatement technology or higher cost share of pollution in the cost of producing x_i), for every percentage increase in the emission tax rate and given the price of x_i, the higher the fall in the unit revenue the firm receives for every potential output produced.

As $w_i l_i + rk_i$ is the minimum cost of producing one unit of g_i,there is no alternative combination of capital and labour that will yield a lower unit cost. Firms vary l_i and k_i to set the derivative of unit costs equal to zero. Alteration in factor proportion must balance out such that the α-weighted average of the change in unit factor demand in each industry is zero. Therefore, it can be shown that $\alpha_{LF}\hat{l}_F + \alpha_{KF}\hat{k}_F = 0$, and $\alpha_{LI}\hat{l}_I + \alpha_{KI}\hat{k}_I = 0$.[7].

[7]See Jones (1965) for detail.

Therefore, the system of equations can be simplified as

$$\alpha_{LF}\hat{w}_F + \alpha_{KF}\hat{r} = -\upsilon_F\hat{\tau}_F, \tag{3.17}$$

$$\alpha_{LI}\hat{w}_I + \alpha_{KI}\hat{r} = -\upsilon_I\hat{\tau}_I, \tag{3.18}$$

$$\lambda_{LF}\hat{g}_F + \lambda_{LI}\hat{g}_I = \delta_F\left(\hat{w}_F - \hat{r}\right) + \delta_I\left(\hat{w}_I - \hat{r}\right), \tag{3.19}$$

$$\lambda_{KF}\hat{g}_F + \lambda_{KI}\hat{g}_I = -\omega_F\left(\hat{w}_F - \hat{r}\right) - \omega_I\left(\hat{w}_I - \hat{r}\right), \tag{3.20}$$

where $\delta_F = \lambda_{LF}\alpha_{KF}\sigma_F, \delta_I = \lambda_{LI}\alpha_{KI}\sigma_I, \omega_F = \lambda_{KF}\alpha_{LF}\sigma_F, \omega_I = \lambda_{KI}\alpha_{LI}\sigma_I$, and because it is assumed there is no change in factor endowment, $\hat{K} = \hat{L} = 0$.

To analyse the effect of stricter environmental regulation in the form of increase in an emission tax, the first two equations will determine the change in the factor prices. The changes in the factor prices could then be substituted into the last two equations to find out how the factors are reallocated between industries, as well as the change in output and emission.

In the comparative static analysis, the following four settings or scenarios are considered. In the first scenario, the higher emission tax is effectively enforced in both the formal and informal sectors (full compliance case). This is analysed under the assumption of an undistorted labour market where both sectors face the same factor prices. The second scenario is the case where full compliance can't be achieved because a higher emission tax can only be effectively enforced in the formal sector. This is an attempt to mimic the situation in some developing countries where government resources are too limited to enforce regulations or to assess how much pollution is being emitted by the informal sector. The third and fourth scenarios are similar to the first and second, respectively, but under the setting of a dualistic economy.

Before further analysis, the terms full and partial compliance need to be clarified. One of the purposes of the analysis is to see the distributional impact of stricter environmental regulation where in some cases this stricter regulation can only be effectively applied in the formal sector. This scenario is merely an attempt to depict the plausible representation of a situation in developing countries where the infor-

mal sector is spatially scattered, small in firm size, and hence difficult to monitor. Because it is assumed that, initially, a lower (or minimum) level of emission tax has already been applied in both sectors, a higher emission tax subsequently imposed only on the formal sector may appear in the end as tax differentiation. It could be argued that this situation is unrelated to compliance but is simply a differentiated tax rate. However, it can equally be argued that in this setting, and with certain assumptions, a different degree of compliance can be represented by a different emission tax rate, because, essentially, the sector that under-complies effectively pays a lower emission tax rate[8].

3.3.1 Case 1: Full Compliance, Undistorted labour Market

Because the labour market is undistorted; both sectors use the same abatement technology and are subject to a uniform emission tax, the system of equation determining factor prices is given as

$$\alpha_{LF}\hat{w} + \alpha_{KF}\hat{r} = -\upsilon\hat{\tau}, \tag{3.21}$$

$$\alpha_{LI}\hat{w} + \alpha_{KI}\hat{r} = -\upsilon\hat{\tau}. \tag{3.22}$$

It is easy to see that in this special case, there is no change in relative prices or relative factor prices. Therefore,

$$\hat{w} = \hat{r} = -\upsilon\hat{\tau} < 0. \tag{3.23}$$

Because pollution can be interpreted as an input to the production of x_i, together with labour and capital, bundled in one single factor, i.e., potential output, for every increase in the price of pollution (emission tax), at any given output (commodities) to be produced, firms will use less pollution, and more potential output. Because the marginal productivity of input is declining with the use of that input, marginal productivity of potential output and its price must fall. The price of capital and labour would then fall in the same proportion. The homogeneity of the x production

[8]See appendix of this chapter for detail.

function and the separability of this production function with the production function of potential output make this possible. Labour and the capital owner would lose, while "the owner of the pollution", represented by the regulator who can exogenously set the price for clean air to be polluted, would gain. As the demand side of the pollution is beyond the scope of this chapter, the welfare optimum or endogenous emission tax is not discussed here.

As $\hat{w} = \hat{r}$, w/r does not change, there is no change in factor intensity in either sector. Potential output stays the same and no factor reallocation between industries takes place. However, as emission intensity across the economy declines as a result of a higher emission tax, pollution falls together with a reduction in production of the commodity.

3.3.2 Case 2: Partial Compliance, Undistorted labour Market

A higher emission tax that can only be enforced effectively only in the formal sector can be represented with $\hat{\tau}_F = \hat{\tau} > 0$ and $\hat{\tau}_I = 0$. The zero profit conditions become:

$$\alpha_{LF}\hat{w} + \alpha_{KF}\hat{r} = -\upsilon\hat{\tau}, \tag{3.24}$$

$$\alpha_{LI}\hat{w} + \alpha_{KI}\hat{r} = 0. \tag{3.25}$$

The percentage change in factor prices is:

$$\hat{w} = \frac{1-\alpha_{LI}}{\alpha_{LI}-\alpha_{LF}}\upsilon\hat{\tau} > 0, \tag{3.26}$$

$$\hat{r} = -\frac{\alpha_{LI}}{\alpha_{LI}-\alpha_{LF}}\upsilon\hat{\tau} < 0. \tag{3.27}$$

In the case where the compliance of stricter environmental regulation is only in the formal sector, the return to labour would rise, while the return to capital would fall. Because the policy change works through the change in producer price, i.e., the net revenue per unit of sales of the commodity has been reduced owing to the higher emission tax, the price of the input used intensively in formal sector

(capital) would fall, and the price of the input used intensively in the non-complying informal sector (labour) would rise. This is actually the standard mechanics of the Stolper-Samuelson effect that works under the Heckscher-Ohlin-Samuelson small open economy setting.

Given the full-employment assumption, it can be shown that, because both sectors would use more capital for every unit of labour used (labour intensity declines in both sectors), the formal sector output would contract and informal sector output would expand. However, the factor-reallocation that takes place does not further change the factorial distribution of income, because it does not matter in this case in which industry factors are employed. However, in order to see this precisely, the factor endowment constraint in equation 3.19 and 3.20 can be used to find the change in potential output in both sectors, as follows:

$$\hat{g}_F = \frac{(\lambda_{KF} - 1) A_1 + (1 - \lambda_{LF}) A_2}{\lambda_{KF} - \lambda_{LF}} < 0, \tag{3.28}$$

$$\hat{g}_I = \frac{\lambda_{KF} A_1 - \lambda_{LF} A_2}{\lambda_{KF} - \lambda_{LF}} > 0, \tag{3.29}$$

where $A_1 = \frac{(\delta_F + \delta_I)\upsilon\hat{\tau}}{\alpha_{LI} - \alpha_{LF}} > 0$, $A_2 = -\frac{(\omega_F + \omega_I)\upsilon\hat{\tau}}{\alpha_{LI} - \alpha_{LF}} < 0$, with the assumption that because the informal sector is labour intensive, $\lambda_{KF} - \lambda_{LF} > 0$. Hence, it is confirmed that activity in the formal sector would contract while activity in the informal sector would expand. As $\hat{l}_F = -\alpha_{KF}\sigma_F(\hat{w} - \hat{r}) < 0$, then $\hat{L}_F = \hat{l}_F + \hat{g}_F < 0$ and $\hat{L}_I > 0$. There would be some labour moving from the formal to to the informal sector. In this case, as there is no difference in wages between the sectors. This result does not change the income distributional story as regards labour. However, as the next section will show, this is not the case when the labour market is distorted.

3.3.3 Case 3: Full Compliance, Dualistic Economy

The zero profit condition in the case where the stricter regulation can be enforced effectively in both sectors in a dualistic setting can be written as:

$$\alpha_{KF}\hat{r} = -\upsilon\hat{\tau}, \tag{3.30}$$

$$\alpha_{LI}\hat{w}_I + \alpha_{KI}\hat{r} = -\upsilon\hat{\tau}. \tag{3.31}$$

To recall, it is assumed that w_F is exogenous, and now does not change, and w_I is determined to clear the labour market in the formal sector. The change in the factor prices can then be given as:

$$\hat{w}_F = 0, \tag{3.32}$$

$$\hat{w}_I = \frac{1}{\alpha_{LI}}\frac{\alpha_{LF}-\alpha_{LI}}{1-\alpha_{LF}}\upsilon\hat{\tau} < 0, \tag{3.33}$$

$$\hat{r} = -\frac{1}{1-\alpha_{LF}}\upsilon\hat{\tau} < 0. \tag{3.34}$$

While the price of employed labour in the formal sector does not change owing to minimum wage policy, the wage in the informal sector and the return to capital both fall. However, the complete distributional impact for a dualistic setting, has to consider the effect of factor reallocation. As in the formal sector, the wage is fixed and the rental rate falls, the formal sector becomes more capital intensive. As $\hat{w}_I \neq \hat{r}$, factor intensity in the informal sector also changes. The percentage change in the capital labour ratio is given by $\sigma_I\frac{\alpha_{LF}+(1-\alpha_{LI})}{1-\alpha_{LF}}\upsilon\hat{\tau} > 0$, where σ_I is the elasticity of substitution in the informal sector. Therefore, the informal sector also become more capital intensive. When both sectors become more capital intensive, but the informal sector is still more labour intensive, activity in the formal sector would contract and activity in the informal sector expands. More precisely, the change in the activity in both sectors can be found using the factor endowment constraints as

follows

$$\hat{g}_F = \frac{(\lambda_{KF}-1)B_1 + (1-\lambda_{LF})B_2}{\lambda_{KF}-\lambda_{LF}} < 0, \tag{3.35}$$

$$\hat{g}_I = \frac{\lambda_{KF}B_1 - \lambda_{LF}B_2}{\lambda_{KF}-\lambda_{LF}} > 0, \tag{3.36}$$

where $B_1 = \frac{\delta_I\alpha_{LF}+\alpha_{LI}\delta_F}{\alpha_{LI}}\frac{\upsilon\hat{\tau}}{1-\alpha_{LF}} > 0$, and $B_2 = -\frac{\omega_I\alpha_{LF}+\alpha_{LI}\omega_F}{\alpha_{LI}}\frac{\upsilon\hat{\tau}}{1-\alpha_{LF}} < 0$. This result suggests that, compared to case 1, although stricter environmental regulation is effectively and uniformly enforced in both sectors, there is one industry, i.e., the informal sector is expanding activity while the formal sector is contracting. Intuitively, it reflects the wage rigidity faced by the formal sector. As the price of capital falls but the wage is fixed, the capital requirement in the formal sector intensifies. This also happens in the informal sector, but, because the wage is flexible, capital intensification is not as severe as in the formal sector. The informal sector can absorb the excess supply of labour, but the formal sector can't, so that activity in the informal sector will expand.

The term 'activity' is important here, because it does not necessarily reflect output in terms of commodity and only reflects potential commodity and emission to be produced. Activity may increase in one sector but only to reduce pollution (or for abatement activity). However, as far as distribution is concerned, there would be a transfer of inputs from the formal to the informal sector.

From a distributional point of view, there would be new groups of labour initially in the formal sector that would transfer to the informal sector and be worse-off, as they would earn lower wages than would have been received previously. Whether or not the effect of this stricter environmental regulation is progressive (income-equalising) or regressive, remains to be analyzed further and depends on the initial distribution of income. This will be discussed in an illustrative numerical example in section 3.4.

3.3.4 Case 4: Partial Compliance, Dualistic Economy

When compliance is only partial, i.e., $\hat{\tau}_F = \tau > 0$, $\hat{\tau}_I = 0$, the change in zero profit conditions in the formal and informal sector, respectively, will be:

$$\alpha_{KF}\hat{r} = -\upsilon\hat{\tau}, \tag{3.37}$$

$$\alpha_{LI}\hat{w}_I + \alpha_{KI}\hat{r} = 0. \tag{3.38}$$

The percentage change in factor prices will be

$$\hat{w}_F = 0, \tag{3.39}$$

$$\hat{w}_I = \frac{1-\alpha_{LI}}{\alpha_{LI}(1-\alpha_{LF})}\upsilon\hat{\tau} > 0, \tag{3.40}$$

$$\hat{r} = -\frac{1}{1-\alpha_{LF}}\upsilon\hat{\tau} < 0. \tag{3.41}$$

Although there is the same effect as in case 2, where the wage rises and the rental rate falls, here the sign in the change in factor returns does not necessarily depend on factor intensity. Therefore, even if the informal sector is not labour intensive, labour in the informal sector will always be better off, and those who managed to stay in the formal sector will be protected from income change. Here, even though the factor market is distorted, the Stolper-Samuelson effect still takes place, where the owner of a factor that is used intensively in the informal sector will be better off.

As equation 3.37 shows, the wage rigidity faced by industries in the formal sector, in the sense that they cannot reduce the wage, forces them to take the only option, which is to change the rental rate in order to maintain zero profit condition. This falling rental rate is shared by the informal sector because both sectors face the same price for capital. However, the producer's price of commodity produced by informal sector does not change, in order to maintain zero profit condition, so the wage in the informal sector has to rise, if the rental rate falls. Workers in the informal sector are better off.

To find out precisely how the factor will be redistributed following this envi-

ronmental policy shock, the change in the potential output in both sectors can be written as:

$$\hat{g}_F = \frac{(\lambda_{KF} - 1) C_1 + (1 - \lambda_{LF}) C_2}{\lambda_{KF} - \lambda_{LF}} < 0, \tag{3.42}$$

$$\hat{g}_I = \frac{\lambda_{KF} C_1 - \lambda_{LF} C_2}{\lambda_{KF} - \lambda_{LF}} > 0, \tag{3.43}$$

where $C_1 = \frac{\delta_1 + \alpha_{LI}\delta_E}{\alpha_{LI}} \frac{v\hat{\tau}}{1-\alpha_{LF}} > 0$, and $C_2 = -\frac{\omega_I + \alpha_{LI}\omega_E}{\alpha_{LI}} \frac{v\hat{\tau}}{1-\alpha_{LF}} < 0$. As both sectors become more capital intensive, activity in the formal sector will contract, and activity in the informal sector will expand. There would be also labour reallocation from the formal to the informal sector that may further change the distributional story.

3.4 Illustrative Numerical Example

The comparative static analysis discussed previously concludes that when stricter environmental regulation can be enforced uniformly across industries in an undistorted labour market, both labour and capital owners will be hurt. Similarly, when the labour market is dualistic, returns to labour and capital both fall. The remaining labour in the formal sector will be protected but labour unable to stay in the formal sector will be paid a lower wage in the informal sector. This may have effects on the overall distribution of income.

When stricter environmental regulation can only be enforced in the capital-intensive formal sector, disregarding whether the economy is dualistic, the capital owner will always be worse-off. However, because informal sector activity expands, the distributional impact may also depend on the factor reallocation from the formal and the informal sector. Therefore, whether environmental policy is regressive or progressive depends on the initial income distribution, and also on the change in the income gap between the capital owner and labour, and between formal and informal labour. To make the story more intuitive in terms of the impact on income distribution, the following discussion illustrates a hypothetical developing economy to see

what may happen after a stricter environmental policy is implemented, especially regarding income distribution.

First, it is assumed the production function of potential output is Cobb-Douglass, that is $g_F = L_F^{\alpha} K_F^{1-\alpha}$, and $g_I = L_I^{1-\alpha} K_I^{\alpha}$, and $\alpha = 0.25$ reflecting the informal sector is far more labour intensive than the formal sector. This may represent a typical situation in developing economies. The economy is assumed to be relatively labour abundant such that $L = 30$ and $K = 20$. The parameter of abatement technology is assumed to be the same, i.e., $\gamma = 0.01$ and the initial emission tax that is applied in both sectors is $\tau_F = \tau_I = 0.01$. The price of commodities produced by the formal sector is assumed to be higher than those produced by the informal sector. This is a plausible assumption for most developing countries. The price of commodities produced by the formal sector is assumed to be 50% higher. This makes the initial distribution of income favour capital, as the wage will be roughly half the rental rate.

For a clearer distributional illustration it is assumed the economy consists of 50 households, each owning either one unit of labour or one unit of capital. This simplification makes it possible to construct an index of income distribution such as a Gini Index which will be equal to zero if the share of income earned by a certain group of households (formal labour, informal labour, or capital owner) is equal to their share in the population.

The four cases discussed in the previous section are considered to see the effect of increasing an emission tax by from 0.01 to 0.015 (50%). The result of this simulation can be seen from Table 3.1.

Table 3.1: Numerical Illustration of the impact of a 50 percent increase in emission tax

	Undistorted					Dualistic					
		Compliance						Compliance			
	Initial	Full	Change	Partial	Change	Initial	Change	Full	Change	Partial	Change
Formal Sector (F)											
Wage (w_F)	0.44	0.43	-0.01	0.44	0.00	0.66	0.22	0.66	0.00	0.66	0.00
Rental (r_F)	1.01	0.99	-0.01	0.98	-0.02	0.88	-0.13	0.86	-0.02	0.86	-0.02
w_F/r_F	0.44	0.44	0.00	0.45	0.01	0.75	0.31	0.76	0.01	0.76	0.01
Labor (L_F)	13.41	13.41	0.00	12.93	-0.48	7.12	-6.29	6.96	-0.16	6.93	-0.19
Capital (K_F)	17.58	17.58	0.00	17.44	-0.14	16.01	-1.57	15.96	-0.05	15.87	-0.14
L_F/K_F	0.76	0.76	0.00	0.74	-0.02	0.45	-0.32	0.44	-0.01	0.44	-0.01
Potential Output (g_F)	16.43	16.43	0.00	16.18	-0.25	13.07	-3.36	12.97	-0.10	12.90	-0.17
Net output (x_F)	16.03	15.81	-0.23	15.57	-0.46	12.76	-3.28	12.48	-0.28	12.41	-0.35
Pollution (z_F)	4.81	2.37	-2.44	2.34	-2.47	3.83	-0.98	1.87	-1.96	1.86	-1.97
Emission intensity (e_F)	0.30	0.15	-0.15	0.15	-0.15	0.30	0.00	0.15	-0.15	0.15	-0.15
Informal Sector (I)											
Wage (w_I)	0.44	0.43	-0.01	0.44	0.00	0.46	0.02	0.45	-0.01	0.46	0.00
Rental (r_I)	1.01	0.99	-0.01	0.98	-0.02	0.88	-0.13	0.86	-0.02	0.86	-0.02
w_I/r_I	0.44	0.44	0.00	0.45	0.01	0.52	0.09	0.53	0.00	0.54	0.01
Labor (L_I)	16.59	16.59	0.00	17.07	0.48	22.88	6.29	23.04	0.16	23.07	0.19
Capital (K_I)	2.42	2.42	0.00	2.56	0.14	3.99	1.57	4.04	0.05	4.13	0.14
L_I/K_I	6.86	6.86	0.00	6.67	-0.19	5.73	-1.13	5.70	-0.04	5.59	-0.14
Potential Output (g_I)	10.25	10.25	0.00	10.62	0.37	14.79	4.54	14.91	0.12	15.01	0.22
Net output (x_I)	9.92	9.78	-0.14	10.28	0.36	14.31	4.39	14.23	-0.08	14.52	0.21
Pollution (z_I)	1.98	0.98	-1.01	2.06	0.07	2.86	0.88	1.42	-1.44	2.90	0.04
Emission intensity (e_I)	0.20	0.10	-0.10	0.20	0.00	0.20	0.00	0.10	-0.10	0.20	0.00
Aggregates											
GDP	33.97	33.49	-0.48	33.63	-0.34	33.44	-0.53	32.94	-0.50	33.14	-0.31
Income	33.27	32.81	-0.46	32.97	-0.30	31.36	-1.91	30.86	0.50	31.13	-0.23
Tax revenue	0.70	0.68	-0.02	0.66	-0.04	2.08	1.39	2.08	0.00	2.01	-0.08
Inequality											
Gini Index	0.10	0.10	0.00	0.10	0.00	0.06	-0.04	0.06	0.00	0.06	0.00

As can be seen from Table 3.1, stricter environmental regulation has reduced pollution at the cost of overall output (GDP) and income in all cases. The reduction in pollution is greater when the stricter regulation can be enforced in both sectors. With regard to the distributional cost of this cleaner environment, it can be seen that in the case where the regulation can be enforced on the whole economy, both factor rewards fall proportionally at the same rate, and it does not change the overall distribution of income. The inequality index stays the same. When stricter regulation can only be enforced in the formal sector, pollution only falls there. As output of the informal sector expands, pollution from the informal sector continues to rise, despite falling aggregate pollution. Because, initially, the rental rate is higher than the wage, and the wage rises while the rental rate falls, the income distribution improves.

To account for a dualistic labour-market setting, it is supposed that before stricter environmental regulation take place, the government sets a minimum wage policy to protect labour in the formal sector to be 50% higher than the otherwise competitive wage rate. Although not related to environmental policy, it may be worth discussing the impact of this policy on the initial economy. The minimum wage policy reduces overall output because of inefficiency in production. As both sectors no longer face the same marginal rate of substitution, the economy experiences inefficiency in production and this can be represented by an equilibrium level of production below the production possibility frontier. The capital owner is worse-off as, at any given output, higher capital requirement must be accompanied by falling marginal productivity of capital and rental rate. As the capital market is always in equilibrium and the capital account is closed (capital outflow is not possible in this model), the minimum wage policy is bad for the capital owner.

However, the wage in the informal sector rises slightly. As the labour economics literature generally suggests, in the partial equilibrium analysis, a higher minimum wage in the formal sector would reduce the wage in the labour-intensive informal sector due to an increasing supply of labour released by the formal sector. However, in partial equilibrium analysis, the labour demand curve in the informal sector by

assumption does not shift because capital and output in the industry stays constant. In the general equilibrium setting, the drop in the rental rate in the informal sector would increase demand for capital and this will reduce demand for labour and the marginal productivity of labour and wage would rise. This result is not new and has been confirmed in the trade literature. For example, Johnson (1969) suggests that in certain cases, a minimum wage that applies to only part of the productive economy may benefit workers in all sectors. Jones (1971) also concludes that minimum wage applied in an industry in which labour receives the smaller distributive share (capital intensive sector) must raise the wage rate in both industries. Therefore, this can explain that minimum wage policy will work if it is intended to improve income distribution. The Gini coefficient is lower compared to a situation without a minimum wage policy. However, it is worth stressing that this improved distribution of income is at the cost of a lower level of overall output.

In contrast to the case when the labour market is undistorted, stricter environmental regulation, if it can be enforced in all sectors, changes the income distribution despite the fall in both the wage and rental rate. The Gini index falls slightly. This occurs because there is some labour movement from the formal to the informal sector and that labour receives a lower wage rate than before.

Those who pay the most for the better environmental quality are workers who are unable to remain employed in the formal sector. However, although activity in the informal sector expands, the output and pollution still falls. In the case when stricter regulation can only be enforced in the formal sector, the income distribution improves even more, not only from the fall in return to capital, but also from the fall in the return to labour forced to move from the formal to the informal sector.

3.5 Concluding Remarks

The comparative static analysis using this simple model illustrates that stricter environmental regulation, if enforced uniformly across industries in an undistorted labour market, hurts both labour and capital owners, leaving income distribution

unchanged. However, when an economy is dualistic, the environmental policy has a slightly different distributional effect. Although the return to capital and labour in the informal sector falls, workers who manage to remain in the formal sector are protected from being worse-off. However, some workers who cannot stay in the formal sector and must move to the informal sector, earn a lower wage. In this illustrative simulation, it is confirmed that, contrary to the case where an economy is not dualistic, across-sectors (or uniform) stricter environmental regulation changes the distribution of income.

When stricter environmental regulation can only be enforced in the formal sector, then assuming (plausibly) that the formal sector is capital intensive, whether or not the economy is dualistic, the capital owner will always be worse-off. However, since informal sector activity expands, the distributional impact may also depend on labour reallocation from the formal to the informal sector. This hypothetical example illustrates that the change in income distribution in this case, which is in favor of labour, is greater when the economy is dualistic.

Overall, this simple exercise using a simplified model illustrates some cases where stricter environmental regulation may not necessarily create an adverse distributional impact. The model is intended to illustrate some of the anticipated distributional effects of an emission tax being introduced in developing countries. It should be noted that in the context of developing countries, the resource reallocation taking place following a policy shock, in this case a pollution tax, involves some adjustment cost. The immediate distributional effect an environmental tax could be temporary loss of jobs, earning, and to some extent a decrease of welfare of those who are vulnerable. It is important in the real policy context, that such adjustment cost is taken into account and mitigated by compensation policy if pursuing the long-run target of restructuring is the ultimate agenda. In addition to the adjustment cost, some other restrictive assumptions used, such as being strictly long-run, assuming a closed capital account and disregarding that the informal sector commodity may not be fully tradable, indicate that the results from this simple model are not meant to be taken as general predictions.

3.A Appendix: Compliance and Emission Tax

The term compliance usually refers to a situation where a firm decides not to comply with regulation, for example by evading the tax (emission tax evasion) or under-reporting true emissions.

However, it needs to be emphasised that the main and most sensible reason why stricter environmental regulation can't be applied in the informal sector is related to compliance. The question is whether this compliance problem can be represented with a lower emission tax rate. From the regulator's perspective, given a certain emission tax in the informal sector, if the emission reported is less than the actual emission, the tax revenue received is as if the tax rate for the actual emission was lower. However, this is not sufficient, as firms also need to see that their 'effective' emission tax rate is lower, because the concern is more about the behaviour of firms, not the regulator. The following argument is an attempt to show that in certain cases, firms that do not comply fully with the regulation may be seen as those who perceive an effective tax rate lower than the formal emission tax rate set by the regulator.

Suppose that in the informal sector, ν_I is the amount of emission reported (subject to emission tax rate τ_I) which is less than true emission z_I. It is possible however, that the regulator may discover the dishonesty of the firm and a penalty of ϕ may be imposed. Suppose the penalty is increasing by the amount of under-reporting or $\phi(z_I - v_I)$, where $\phi' > 0, \phi'' > 0$. The probability of being discovered under-reporting is $\beta(\nu_I)$ which is assumed to be a function of reported emission. The regulatory agent may have some expectation of the true emission given, for example, the characteristic of the firm, so the greater the amount of emission reported the less the probability of being discovered or $\beta' < 0$. In this uncertainty, the firm profit will be either $\pi^1 = p_I x_I(z_I, g_I) - c_I^g g_I - \tau_I \nu_I$, with probability $(1-\beta)$ or $\pi^0 = p_I x_I(z_I, g_I) - c_I^g g_I - \tau_I z_I - \phi(z_I - \nu_I)$, with probability β. The firm maximizes

expected profit that will yield the following first order condition

$$p_I \frac{\partial x_I}{\partial g_I} = c_I^g, \tag{3.44}$$

$$p_I \frac{\partial x_I}{\partial z_I} = \beta\left(\tau_I + \phi'\right), \tag{3.45}$$

$$\tau_I + \beta'\left(\tau_I\left(z_I - v_I\right) + \phi\right) = \beta\left(\tau_I + \phi'\right). \tag{3.46}$$

Combining the last two equations can give

$$p_I \frac{\partial x_I}{\partial z_I} = \tau_I + \beta'\left(\pi^1 - \pi^0\right) < \tau_I. \tag{3.47}$$

This equation says the marginal value product of emission has to be equal to the cost or price of the emission. In other words,the "effective" emission tax is less than the tax rate set by the regulator. Because the marginal product of emission or $\frac{\partial x_I}{\partial z_I}$ is decreasing with the level of emission, the optimal emission under this uncertainty case will be higher than under full compliance. The net effect of the tax rate is similar to the case of a lower tax but with full compliance. Therefore, in the analysis in this chapter, it may be argued that the partial compliance scenario may be represented by $\hat{\tau}_I = 0$ and $\hat{\tau}_F > 0$.

Chapter 4

Constructing The Social Accounting Matrix

A Social Accounting Matrix (SAM) is a matrix representation of transactions in a socioeconomic system. It is a comprehensive, flexible, and disaggregated framework, which elaborates and articulates the generation of income by activities of production and the distribution and redistribution of income between social and institutional groups (Round, 2003b). The need for a Social Accounting Matrix for assessing a more elaborate distributional impact of development, and the inadequacy of the standard System of National Accounts (SNA) has been long acknowledged (Stone, 1985).[1]

A Social Accounting Matrix is an essential database for computable general equilibrium (CGE) modelling. In a SAM framework every agent's expenditure has to be equal to its receipts (in the form of equality between column and row sum), so that the SAM explicitly represents the initial equilibrium, or market clearing conditions in the economy. Every good and service produced by an industry is equal to what is demanded. Each factor of production supplied has to be absorbed by industry, and household spending has to be equal to income. An exercise using a CGE model is basically comparing this initial equilibrium condition, with other equilibria induced by changing exogenous shocks to the model.

This chapter will discuss the construction of an Indonesian Social Accounting Matrix. Constructing a specifically-designed SAM not only requires large-scale household survey data, but also involves reconciliation of various different data

[1] Richard Stone himself was granted nobel prize for the development of the SNA.

sources. This chapter is organized as follows. Section 4.1 starts with the description of the SAM structure to be constructed, followed by section 4.2 which describes the data used to construct the SAM. The discussion then continues with the steps carried out in the process of construction. Section 4.3 starts with how national level data are used as a basis for the SAM; section 4.4 discuss the disaggregation of factor payments; section 4.5 describes the disaggregation of households; and step 4.6 describes the final reconciliation. Finally section 4.7 ends with the discussion on some limitations of the Indonesian SAM constructed, and the potential for further improvement.

4.1 SAM structure

The Indonesian statistics office (BPS) publishes a SAM[2] every five years. However, this official SAM is limited in terms of its sectoral disaggregation (it only has 23 sectors), and most importantly in terms of household classifications. Since many policy shocks typically analyzed in a CGE model are at a specific sectoral level, it is often necessary to have a lot more detailed sectoral disaggregation. Consequently, building a specifically-designed SAM to cover detailed sectoral disaggregation is unavoidable for most CGE modelers.

Moreover, the official Indonesian SAM distinguishes only 10 households groups, which classifies households, mainly according to their occupational status[3]. This classification is sufficient as long as the analysis is intended just to compare and contrast the policy impact among these socioeconomic classes. However, when one starts to ask more precise questions, such as: how different are the impacts of policies between the poor and the rich, how much will inequality change, whether the policies are regressive or progressive; and how much is poverty incidence changed by the policies, then this classification has prevented those questions from being adequately answered.

[2]or In bahasa Indonesia, "Sistem Neraca Sosial Ekonomi (SNSE)", or System of Social and Economic Accounts.

[3]Occupational status refers to the type of occupation of the household head, such as whether professional, farmers, casual workers, and so on.

The SAM to be constructed is aimed at detailing 181 sectoral classifications, 16 labour classifications[4], and distinguishing 200 households classified by expenditure per capita size (100 urban, and 100 rural household, grouped by centiles of expenditure per capita). This will constitute the most detailed and disaggregated Indonesian SAM at sectoral and household level yet constructed[5].

[4]See Appendix for the list of sector and labour classification.
[5]The size of the SAM will be of 768×768 accounts, in contrast to official BPS SAM of 102×102.

Table 4.1: Structure of 768×768 Indonesian SAM

		Activities 1···181	Commodity Domestic 1···181	Commodity Imported 1···181	Factor labour 1···16	Factor Capital	Ind. Tax	S-I	Households 1···200	Transfers	Enterprises	Gov't	ROW	TOTAL
Activities	1 ... 181		MAKE Matrix											Industry Sales
Domestic Commodities	1 ... 181	Domestic Intermediate Input						Domestic Investment	Domestic Hou. Consumption			Domestic Gov't Consumption	Export	Total Dom. Demand
Imported Commodities	1 ... 181	Imported Intermediate Input						Imported Investment	Imported Hou. Consumption			Imported Gov't Consumption		Total Import
labour	1 ... 16	Salary and Wages											labour used abroad	Total labour Demand
Capital		Non-labour											Cap. used abroad	Capital Demand
Ind. Tax		Tax/ Subsidy		Tariff										Ind. Tax Reven.
Urban HH	1 ... 100				labour Income: Urban	Capital Income: Urban				Inter-Hous. Transfer			ROW transfer to HH	Total Hous. Income
Rural HH	1 ... 100				labour Income: Rural	Capital Income: Rural				Inter-House. Transfer			ROW transfer to HH	Total Hous. Income
Transfer									Transfer to HH					Int. Hou. Transfer
S-I									Household Saving		Enterprise Saving	Gov't Saving		Total Saving
Government							Ind.Tax Revenue		Direct Tax		Ent. Trans. to Gov't	Inter G Transfer	ROW Tans. to Gov't	Govt Revenue
Enterprises						Enter-Capital					Inter Ent. Trans.		ROW Trans. to Enter.	Ente. Income
ROW				Import	Foreign labour	Foreign Capital			HH Transfer to abroad		Ent Trans. to abroad	G. Transfer to abroad		Forex Outflow
TOTAL		Industry Costs	Dom. Supply	Import Supply	labour Supply	Capital Supply	Ind. Tax Revenue	Total Invest.	Household Spending	Int. Hou. Transfer	Enter. Spending	Govern. Spending	Forex Inflow	

A CGE model uses a Social Accounting Matrix as a representation of an initial equilibrium. One of the most important features of a SAM, the equality between row and column totals in the matrix, explicitly portrays some of the most important market clearing conditions in the economy. Market clearing in the commodity market will be reflected in commodity accounts. The value of commodities supplied by each industry has to be equal to what is demanded by various demanders (intermediate demand by industries, various institutions, and various households). At the same time, the equality of column totals and row totals of factor accounts in SAM also records market clearing in the markets of various factors of production. In addition, some theoretical features of a standard CGE model are also explicitly represented in a SAM. Among others, these are the equality between industry costs and sales (zero-profit competitive condition), and the conditions that household budget constraint are satisfied. In short, a SAM is the basic and necessary ingredients for a CGE model. Technically, before any simulation is conducted, a balanced and consistent SAM ensures all agents' income or receipts are spent, which in turn guarantees equilibrium, database balance, and nominal homogeneity[6] of the CGE model.

Table 4.1 is the structure of the Social Accounting Matrix to be constructed. It has 768 rows and 768 columns in all. It distinguishes industries from commodities to allow for industries producing multiple commodities, or the same commodity produced by several industries. In all, 181 sectoral classifications are distinguished, and 200 households (100 urban and 100 rural classified by centile of expenditure per capita) are classified by centile of expenditure per capita. This section describes the process of constructing the SAM, starting with describing the data used, and other steps carried out to produce it.

The principle is to extend the 181 sector Input-Output table into a Social Accounting Matrix structure, using the official SAM 2003 as initial information. In the first step, the goal is to construct 181 sectors SAM with similar structure as the

[6]Real/quantity variables will not change if all prices increase, a standard and basic theoretical implication of neo-classical CGE model.

official SAM 2003 but with only one single household and one single labour. The labour classification will be extended in step 2, while the household will be disaggregated in step 3. This approach follows the practice called Macro to Micro SAM, and as Round (2003a) suggests, this has been the approach used by most SAMs compiled under the IFPRI modelling projects.

4.2 Data Sources and Description

The data sources used in this SAM construction are (1) Official BPS SAM 2003 (102×102 accounts); (2) 181 sectors Input-Output table 2003; (3) SUSENAS Core Module 2003, with 894,427 individual observations; (4) SUSENAS Core Module 2002, with 862,210 individual observations; (5) SUSENAS Consumption Module 2002, with 64,441 household observations; and (6) SUSENAS Income Module 2002, with 64,441 households observations.

4.2.1 BPS SAM, and Input-Output Table

The BPS SAM is regularly published every 5 years. It has less detailed sectors than the I-O table and distinguishes only 8 to 10 households. In its recent SAM for the year 2003, BPS recognises 23 industries and 8 household categories. The household categories in this SAM are (1) agricultural employee; (2) agricultural employer; (3) casual employer low-income, clerical, sales, casual employee in transportation sectors, personal services, office employee; (4) non-labour force and unaccounted occupation (rural); (5) high-income casual employer, non agricultural employer, manager, military, professional, technical, teacher, clerical, and high-income sales; (6) casual employer low-income, clerical, sales, casual employee in transportation sectors, personal services, office employee; (7) non-labour force and unaccounted occupation (urban) and; (8) high-income casual employer, non agricultural employer, manager, military, professional, technical, teacher, clerical, and high-income sales.

This classification is mainly based on the occupational status of the household head. In distributional analysis, difficult questions are posed such as: whether

the cost of certain policies are biased toward the poor or the rich; whether they are regressive or progressive; and how large their impact is on poverty incidence. In addition, certain policies directed specifically toward the poor, such as cash transfers, are also difficult to analyse.

Although the BPS SAM is limited in sectoral and household detail, it is still very informative, in the sense that it records a lot of information with regard to transactions among institutions such as government, enterprises, and the rest of the world.

The Input-Output table records industry's costs and sales. Industry costs (or inputs) comprise purchases of raw materials (intermediate inputs), both from domestic, and imported sources, as well as primary factor costs (salary, operating surplus, and indirect taxes/subsidies). On the other hand, Industry output consists of their sales to other industries as both intermediate and final demand. The latter consists of household, investment, government, and export demand. The Input-Output table serves as a core basis for constructing the Social Accounting Matrix.[7]

The I-O table is also regularly published every 5 years, the latest of which is for the year 2000. However, BPS occasionally publishes an interim I-O/SAM . This 'interim' SAM/I-O table is an update of the regular 5 year interval publication using information of the most recent aggregates, such as value-added or final demand[8]. Once, this updated I-O is published, the SAM division of the BPS follows by publishing the updated SAM.

The most recent 'updated' I-O table and SAM published by the BPS are for the year 2003. Usually, the I-O table has up to 175 sectors. Because the research questions addressed in this thesis requires detailed sectoral disaggregation, especially, on energy related sectors (electricity, and detail of fuels e.g. gasoline, kerosene, etc.), the 181 sector Input-Output table was obtained from the I-O division of the BPS.

[7]SAM and I-O table are closely related, not only because the I-O table is part of the SAM, but also in constructing the SAM, I-O is usually used as the basis or the anchor. Whenever there is inconsistency, information from the I-O table dictates the SAM (Source: interview with SAM divison of the BPS).

[8]For the I-O table, for example, the Leontief technical coefficient is usually assumed to be constant, and the transaction using information from more recent aggregates are estimated.

The 181 sectors Input-Output table, and the 102 accounts BPS SAM will be used as a starting point to construct the 768 accounts SAM. This will be described in detail in the Step 1 section.

4.2.2 Household Survey Data

The National Socioeconomic Survey (SUSENAS) is a series of large-scale multi-purpose socioeconomic surveys initiated in 1963-1964 and fielded every year or two. Since 1993, SUSENAS surveys cover a nationally representative sample typically composed of 200,000 households. Each survey contains a core questionnaire which consists of a household roster listing gender, age, marital status, and educational attainment of household members, supplemented by modules covering about 60,000 households that are rotated over time to collect additional information such as health care and nutrition, household income and expenditure, and labour force experience

Household disaggregation of the Social Accounting Matrix requires detailed expenditure, and income sources. This disaggregated information contained in the SUSENAS Module is not collected annually, but every 3 years. The latest SUSENAS data with an expenditure and income module is for the year 2002. The sample size of this module is 64,442 households compared to the core SUSENAS with sample size of about 200,000 households. This smaller sampling frame attempts to represent the population of provinces, while the core can be disaggregated to represent every district.

As will be explained in detail in section 3.3, the information from the expenditure module of the SUSENAS will be used to disaggregate household consumption expenditures. The expenditure for each commodity in the SAM will be distributed to 200 households aggregated by expenditure per capita centile. The same will be applied to sources of income such as labour income by skills, as well as non-labour income and transfers. In constructing the SAM, SUSENAS as well as SAKERNAS (labour force surveys) play a crucial role. These are used as information to disaggregate industry use of primary inputs (labour and capital). The industry use of primary inputs that comes from the I-O table has two limitations. First, it has only two

factors (labour and capital[9]). Secondly it does not capture the informality (duality) in the economy. It only records formal labour payments (salary and wages) incurred by industry. The I-O table has the categories for factor payments: salary/wages and operating surplus. The problem is there are some significant amounts of unpaid labour lumped together in the operating surplus category, which is calculated as a residual after formal wage payments.

4.3 Step 1: Disaggregated Sectors but One labour, and One Household

The official Indonesian Social Accounting Matrix 2003 has 102 accounts, and consists of 16 labour categories, one non-labour factors, 8 households, 23 industries, 23 commodities (domestic and imported), and other institution accounts (Saving-Investment, Government, Enterprises, and Rest of the World). On the other hand, the Indonesian Input-Output table 2003 has 175 sectors, which in this thesis is then expanded to 181 sectors including energy sectors in detail. The expansion disaggregates the petroleum products sector into 6 components (Gasoline, Automotive Diesel Oil/ADO, Industrial Diesel Oil/IDO, Kerosene, Liquefied Petroleum Gas/LPG, and other fuels), and separate electricity from the electricity and gas sectors[10].

As illustrated in Table 4.1, information from the Input-Output table was used to fill the following sub-matrix in the SAM.

1. Domestic intermediate input matrix (181×181).
2. Imported intermediate input matrix (181×181).
3. labour payment by industries (1×181).
4. Gross operating surplus or non-labour payment by industries (1×181).

[9] Or in the I-O table definition capital is referred to gross operating surplus.

[10] This expansion of the I-O table was conducted by staffs from the BPS Input-Output Table Division.

5. Indirect tax and subsidies, paid or received by industries (2×181). The sum of tax and subsidy over industries are received by the government, in the government account.

6. Domestic final demand, i.e. domestic commodity purchased as capital formation, household consumption, government consumption, and exports (181×4).

7. Imported final demand, i.e., imported commodities purchased as capital formation, household consumption, and government consumption (181×3).

8. Tariff on imported commodities (1×181)

9. Rest of the world receipts from domestic sales of imported commodities. This is total imported commodities, sum over all demanders (industry as intermediate and final demand).

10. The MAKE matrix, a diagonal matrix that show how industries supply commodity to the market. Currently it is assumed the MAKE matrix is diagonal or a single industry producing only a single commodity. Other modifications, such as single industry producing multiple commodities can be conveniently setup in sectoral aggregation.

The sum of rows 1 to 5 are total industry cost or input, while 1 to 6, if sum over column will be total industry sales. The former is equal to the latter.

As also illustrated in Table 4.1, information from the SAM 2003 was used to fill in the following sub matrix.

1. labour and non-labour payments received by Rest of the World.

2. Non-labour payments (capital) received by Enterprises.

3. The rest of factor payment (salary and non-labour) received by households.

4. Household other expenditures, which consist of savings, transfers to other households, direct tax, and transfers to the Rest of the World.

5. Household non-factor income, which consists of, transfers from other households, from enterprises, from government, and from the rest of the world.

6. Enterprises' receipts and outlays.

7. Government revenue and expenditures.

The next step is to disaggregate labour into more detail categories.

4.4 Step 2: Disaggregating Factor Payments

SAM 2003 has 16 classifications of labour. It recognises 4 skills types (agricultural, non-agricultural unskilled, clerical and services, and professional workers), urban-rural distinction, and formal and informal (unpaid) workers. Together, it distinguishes 16 labor categories. However, the Input-Output table only distinguishes a single type of labour recorded in the wage bills of industrial costs. Gross operating surplus is then calculated as residuals. In developing countries, where a significant portion of industry does not officially record all payments to labour, this practice may lead to misleading information.

First, the economy will appear to be highly endowed with capital, which is unlikely to be the case for developing countries like Indonesia. For example, from the Input-Output table, compensation of employees in Indonesia only accounts for around 35% of value added, whereas in the European Union, for example, the number is around 65%[11].

A second implication, is that certain industries which are supposed to be relatively labour intensive (e.g. agriculture compared with manufacturing) will instead appear to be capital intensive. Factor intensity is a very important driver of behaviour in the CGE model. For example, the parameters of most production functions used in the CGE model are function of factor shares. The reliability of some CGE models which rely purely on the Input-Output table with the resulting understate-

[11]Source: GTAP Database.

ment of labour, will be in question[12]. Understatement of labour compensation is quite common in a developing country Input-Output table. Cororaton (2003), for example shows the case for the Philippines.

In the Social Accounting Matrix, BPS has attempted to correct this issue by making a distinction between paid and unpaid labour. BPS defines unpaid labour as workers who run a household business, or are employed by a family member. These are subtracted from the gross operating surplus recorded in the Input-Output table. For example, data from the Labour Force Survey (SAKERNAS) records the number of hours of 'informal' labours, but without recording the amount of the wage payment[13]. The number of hours is imputed as labour compensation by multiplying it with the average wage in the formal sector for a similar type of labour (distinguished by skill type, and industry of employment). From the same data, BPS can disaggregate labour by 16 skills-type in the construction of the SAM.

In constructing the 181 sectors SAM, a similar kind of approach is used. Instead of SAKERNAS, however, the SUSENAS Core Module 2003 is used. The necessary information is available in both survey data. However, the SUSENAS sample size is a lot larger (894,427 compared to 297,642 individuals in SAKERNAS). From SUSENAS, the employment status for employed workers (shown in table 4.2) can be obtained. It is clear that in terms of the number of labour employed, the degree of informality in the Indonesian labour market is very high.

The Rupiah salary earned is only recorded for employees in category 4 of Table 4.2. Wage imputation will be carried out for all other than category 4. This approach is also used by Ivanic (2004) in the reconciliation of the GTAP database[14] with household survey data.

SUSENAS 2003 distinguishes 341 skills type or job classifications. To match the SAM, this classification is first aggregated into 4 classifications (agricultural, production/manual, clerical, and professional). Average[15] wages per hour in the

[12]Standard WAYANG model, for example, is based mainly on Indonesian Input-Output table which records around 34.36% of the aggregate labor share (source: Wayang 2002 database).

[13]Which in many cases, such as family workers, do not even involve cash (unpaid).

[14]including Indonesian GTAP database.

[15]Median is used instead of mean.

Table 4.2: Employment Status

	Employment Status	Un-weighted Freq.	%	Weighted/Pop. Freq.	%.
1.	Self Employed: without workers	85,415	22.7	19,635,423	21.67
2.	Self Employed: with unpaid workers	76,225	20.26	17,480,674	19.3
3.	Self Employed: with paid workers	11,966	3.18	3,037,090	3.35
4.	Employee (formal)	103,961	27.63	26,986,276	29.79
5.	Agricultural casual workers	14,135	3.76	4,698,661	5.19
6.	Non-agricultural casual workers	8,480	2.25	2,524,201	2.79
7.	Unpaid workers	76,059	20.22	16,233,250	17.92
	Total	376,241	100	90,595,575	100

Source: SUSENAS 2003 (Core Module)

formal sector is then calculated for specific skill-types, urban-rural location, and sectoral classification[16]. Finally, the monthly return to labour (earning) for self-employed individuals is imputed by multiplying number of hours per month with the average wage in the formal sector. The result is the distribution of wage earning over sectors, skills type, urban-rural, and distinguishes return to labour by self-employed individuals, which is disregarded in Input-Output table. This information is then used to disaggregate labour payments in the SAM constructed in step 1.

However, sectoral classification in the Input-Output table is not exactly the same as that used in SUSENAS. The sectors in SUSENAS which has detailed 182 classification, is fairly disaggregated in manufacturing and services, but is very broad in agriculture. Both the IO and SUSENAS sectors have to be first aggregated into 88 sectors to have a consistent comparison[17]. Therefore, to maintain the 181 sectoral detail, it has to be assumed that some industries within the same broader categories[18] have similar pattern of compensation of employees.

The share or composition of skill-type estimated in SUSENAS is then used to disaggregate formal compensation of employees in the SAM. The ratio of informal labour to formal labour from SUSENAS is used to take out some imputed labour from gross operating surplus ("residual" non-labour payment). This informal labour is then disaggregated using informal skill-type composition by industry as estimated from SUSENAS. The new non-labour payment is what remains.

[16] Classification is aggregated into 14 broad sectors.
[17] Based on mapping from BPS (ISIC to I-O classification).
[18] 88 sectoral classification.

4.5 Step 3: Disaggregating Household Expenditures and Incomes

Households accounts in the SAM will distinguish urban and rural households each of which comprises 100 households grouped by centile of expenditure per capita. As mentioned in the previous section, unlike the household classification in the BPS SAM, which classifies households by occupation of the household head, an income or expenditure size classification may allow more detail and precise distributional impact of policy analysis. Poverty incidence and Gini coefficient in urban and rural areas, as well as nation wide, can also be conveniently assessed. For example, Warr (2006), using a Social Accounting Matrix of the Lao economy with the same classification of households as a database in the CGE model, calculates the impact of large-scale investment on poverty and inequality.

4.5.1 Expenditure

The first task of the disaggregation of household expenditure is to reclassify commodity classification in SUSENAS into the classification of the I-O table. In SUSENAS, consumption expenditure is classified into 339 commodities, while the I-O table only has 181 commodities. They do not coincide. As emphasized by Keuning and de Ruijter (1988), a household survey classification uses categories corresponding to household's wants, while the I-O table (or SAM) classification is more closely linked to the production system. Fortunately, an official mapping between those classifications is available from BPS.

However[19], the mapping of this classification is not a simple '*some to one*[20]' mapping. There are a few cases, where one commodity type purchased as final goods by households are considered sales from various industries in the in I-O classification. The mapping is made slightly more complex. Furniture purchased by households, for example, may come from sale of the leather industry, the wood product industry,

[19] As confirmed during the the author's visit to BPS in June 2006..
[20] A single I-O commodity mapped to some SUSENAS commodities.

or even the metal industry.

Suppose that x_j^{IO} is the target classification of expenditure which is 181 commodities of the I-O table, where $j = 1, \ldots, m$, $m = 181$. From SUSENAS, household expenditure can be defined as x_i^{SUS}, where $i = 1, \ldots, n$, $n = 339$, $m < n$. The mapping, then can be represented by the following equation, by which for each of 64,442 households[21], the consumption spending classified by I-O classification can be calculated as

$$x_j^{IO} = \sum_{i=1}^{n} \omega_{ij} \cdot x_i^{SUS}, \tag{4.1}$$

such that,

$$\sum_{j=1}^{m} \omega_{ij} = 1, \tag{4.2}$$

where ω_{ij} is the contribution of consumption of good i to the consumption of good j which is the element of a weight matrix $\mathbf{W}_{m \times n}$. This matrix is constructed based on information from the official I-O to the SUSENAS commodity mapping. This mapping has been used by BPS in the construction of the I-O table and the SAM.

4.5.2 Income

In the SAM, the household's income sources distinguish labour income (16 classification, i.e., 4 skill-type, 2 urban-rural, 2 formal-informal), non-labour income, transfers from other household, and transfers from other institutions[22]. Disaggregated labour income classification allows flexibility in the CGE model structure in terms of labour market segmentation. For example, urban unskilled labour may have a different wage with rural unskilled labour, because the wages are cleared in a different labour market. This structure is not possible when there is only one aggregated unskilled labour category.

Table 4.3 shows the source of household income, calculated from the SUSENAS Income Module 2002. Again it shows that, if all net revenue from household business is considered to be return to capital (or non-labour), it will under-estimate labour

[21] Number of observations in SUSENAS 2002 Consumption Module.

[22] Transfer from other institutions include from government, enterprises, and the Rest of the World.

Table 4.3: Household Sources of Income (pct)

	Urban	Rural	Total
Salary/Wages	49.1	31.2	42.2
Household Business	32.1	53.0	40.2
Agriculture	3.7	31.9	14.6
Non-agriculture	28.4	21.1	25.6
Capital	9.6	7.9	8.9
Transfer	9.2	7.9	8.7
Total	100.0	100.0	100.0

Source: SUSENAS 2002 (Income Module)

endowment in the economy. The task now, is

1. To disaggregate formal salary/wage into return to 8 classifications of labour. This could be identified, since the data records the occupation or skill-type of every working family member.[23]

2. To separate the return to labour and the return to capital from what is recorded as net revenue (production revenue minus cost) of household production/business. The approach is similar to step 2 as previously discussed when splitting the industries payment to labour from operating surplus. Since, individuals whose status is self-employed also record their working-time, the imputed salary, is then calculated as their working time multiplied by the average formal wage for their specific skill type, and their specific sector of employment. The imputed wage is then subtracted from household business net-revenue and the residual is defined as part of the return to capital.

3. The imputed labour can also be classified by 8 skill-types.

The result is then estimates of income sources for each household in the survey data, as detailing 16 classifications of labour, non-labour, and transfers. Table 4.4 shows the sources of income category after the imputation of wage from self-employment.

The results closely resemble the structure of labour income calculated from the official BPS SAM. However, it should be noted that the official SAM definition

[23] Even to a lot more detailed classification than the broader 4 skills classes.

Table 4.4: Household Income Source with Imputed Labor

Income Source	Urban	Rural	Total	BPS SAM
labour	69.12	59.68	65.44	68.47
Formal	56.43	34.44	47.85	42.19
Agricultural	2.02	9.36	4.88	4.98
Production/Manual	19.48	12.68	16.83	15.48
Clerical/Services	22.20	6.43	16.05	14.47
Professional	12.73	5.97	10.09	7.26
Imputed	12.69	25.24	17.59	26.27
Agricultural	1.31	15.48	6.84	10.29
Production/Manual	3.81	4.35	4.02	5.49
Clerical/Services	7.19	5.28	6.45	9.71
Professional	0.39	0.14	0.29	0.79
Non-labour	21.39	32.22	25.62	19.94
Transfers	9.49	8.11	8.95	11.59
Other Household	5.07	5.39	5.19	5.52
Other transfers	4.42	2.72	3.75	6.07
Total	100.00	100.00	100.00	100.00

Source: Author's calculation

of informal labour is broader than defined here. This thesis only recognizes self-employed labour as informal labour, not other unpaid labour. Therefore, the higher share of imputed labour, and lower share of non-labour in the BPS SAM, is expected.

4.5.3 Aggregation and Reconciliation

The next step is to combine or merge household expenditure data, calculated from the SUSENAS Consumption Module, which is already classified by the Input-Output commodity group, with income data, as calculated from the SUSENAS Income Module. Apart from consumption expenditure, transfers to other households, as well as other transfers are also recorded. Saving is calculated as a residual. Since all accounts in the SAM constructed in step 1 are already balanced (receipts and layouts of every account are equal), it is also important to maintain the balance (expenditure equal income) of households at the micro or household level data.

Ideally, when total consumption from the household survey is aggregated, taking into account sampling weight, the aggregate has to be close to the national aggregates. In fact, even in total (not by component of expenditure), this is rarely the case. Aggregate from SUSENAS will fall short of the national account by significant factors. For example, Akita et al. (1999) mentions a wide discrepancy between total

household expenditure estimated based on the SUSENAS data and total private consumption expenditure from the national accounts. This problem is typical. It is necessary to reconcile both data sources. This is also confirmed by Ravallion (2003), after comparing datasets for 90 countries.

After aggregating by taking into account household sampling weight, the total consumption expenditure calculated from SUSENAS falls short of that from the I-O table by a factor of 2.8. It also shows, that the factor is higher for non-food expenditure, especially luxury goods. A few reasons could account for this discrepancy.

1. The SUSENAS and the I-O are recorded for different years, i.e., SUSENAS is for 2002 and the I-O table is for 2003.

2. Under-reporting, especially for certain expenditure such as non-necessities.

3. Some expenditures in the I-O table are imputed, such that, expenditure items in the I-O do not exist in SUSENAS. In this case, these are expenditure on banking, finance, and trade.

4. Sample bias, i.e., the possibility that the sampling does not perfectly represent the population. The under-representation of high income groups is very likely, and could be due to the non-response rate or even the sampling frame itself.[24] Consequently, the household sampling weight used in the aggregation is not accurate.

5. Mapping error, namely the inaccuracy in the mapping between the household survey commodity classification and the I-O commodity classification.

The discrepancy between data calculated from the household survey with its aggregated counterpart is common and expected in the practice of constructing a Social Accounting Matrix using data from household surveys (Robilliard and Robinson, 2003). The same problem also arises in any studies which require reconciliation between data from national accounts and household surveys. As Ravallion (2003)

[24] A few interviews with BPS staffs suggest that this may be the case.

suggests, the relationship between these two datasets is becoming of more considerable interest in the area of applied work to assess the effect of economic growth, or growth promoting policies on the extent of absolute poverty.

Two different routes are common in the reconciliation process. The first is to adjust the household survey data to fit the aggregate or macro SAM. The second is the other way around. In the first method, it is likely the process may change the pattern of expenditure or income at the household level part. In the second method, the process may have implication on the structure of the economy. The decision to follow one, over the other, depends on a judgement as to which data is more reliable and the implication and complication that may arise in the process. Considering that fitting an already established and official national account data to match the household survey will likely change the economic structure such as standard macroeconomic aggregates like value added (GDP), an approach with the flavour of the first one will be used. The scale factor is calculated by comparing the aggregate expenditure from the Input-Output table, and from the survey data, for each of the 181 items of consumption.[25] After that, working again with the household survey data, consumption spending by item is re-scaled using the scale factor, but total consumption for every household is controlled to maintain the balance of income and spending.

Aggregation is conducted by first dividing the households into urban and rural categories, and then assigning an expenditure per capita class to each household. Each household must belong to one of the 100 centiles of expenditure per capita. The data are then aggregated, or added-up, taking into account each household sampling weight, producing 100 household groups for each of the urban and rural areas. The income and expenditure of the resulting 200 households is then fitted

[25] Before this, three commodities have to be imputed to the household survey data since they are not recognized in the survey. They are trade, banking, and finance. For trade, it is imputed using the aggregate share of the I-O table. For Banking and finance it is imputed using the aggregate share but only applied to households that record having any transaction with financial sectors (i.e. saving accounts for banking, and buying and selling financial assets for the finance sector). This will reduce the error of forcing poor households, for example, to have similar patterns of financial dealing to the rich ones. Working at the level of the household survey data makes this kind of adjustment possible.

into the SAM, as explained in the next section (step 4).

4.6 Step 4: Final Reconciliation and Balancing

The final process involves some other reconciliation and final adjustment in response to minor imbalances in the SAM. The final process of disaggregating the households account in the SAM is as follows.

1. Total income, which is equal to total expenditure, of the single representative household in the Macro SAM is distributed to the 200 households using the share calculated in step 3. This total will be the control in the later step of splitting this total income/expenditure into its detailed components for each household group.

2. The total income/expenditure of each household group is split into its detailed component using the pattern (share) calculated in step 3. The components of expenditure include consumption expenditure on 181 commodities, transfers, and saving, whereas the components of income include labour income (16 classifications), non-labour income, and transfers.

3. Total aggregate consumption expenditure (sum over commodities) in the Macro SAM is used as a control to maintain the value of aggregate consumption expenditure in the component of GDP by expenditure. To do this, every household's components of consumption spending is re-scaled by a single aggregate scaling factor.

4. Each of the 181 items of consumption spending for every household is split into domestic and imported components using the share from the Macro SAM[26].

5. Household saving is re-calculated as residuals by subtracting from total expenditure (as a control), consumption expenditure and other non-consumption

[26] Here, it is assumed spending on every commodity carries the same import content disregarding who consumes it.

spending (non-household transfer, transfer to ROW and direct tax is calculated using the share from the Macro SAM taking into account tax-spending calculated in step 3).

6. Components of household income are calculated using the pattern (share) calculated in step 3. Non-household transfers (transfer from government, enterprises, and ROW are calculated using the shares from the Macro SAM.

The method of disaggregating households in step 1 to 6, ensures household accounts for each of the 200 households are balanced, that is total income is always equal to total spending. However, since other accounts, such as commodity account (which shows the amount of each commodity demanded and supplied) and factor account (which shows how much of each factor of production is supplied and used by industries) may not be balanced as a consequences of controlling household accounts.

The imbalance in the commodity account, however, is not significant, after the reconciliation in step 3 at the micro level. The standard deviation of the scale factor (ratio of spending in Macro SAM to spending calculated from household survey data) has been reduced by the reconciliation in step 3 from 12.04 (with the mean of 3.81) to 0.32 (with the mean of 1.04). These minor imbalances will be taken care later at the final stage using balancing program explained subsequently in the appendix of this chapter.

Final reconciliation is carried out for factor accounts. The following pattern is found. Labour, especially imputed labour, has supply exceeding demand, while non-labour has demand exceeding supply. It is assumed that for imputed (informal) labour, the imbalance is due to under-recording of informal labour (and equivalently over-recording of non-labour/capital, since operating surplus is the residuals) by industries. Therefore the compensation of informal labour costs is scaled-up (with different scale for every skill-type) to match the supply. This takes some value out from operating surplus or non-labour input, hence non-labour compensation (operating surplus) is equivalently reduced.

In contrast, for formal labour-compensation, the adjustment is made in the household accounts. Since (formal) salary and wages are original data from the I-O table, and its record of salary/wage is usually considered more reliable, it is kept intact. It is assumed that households underestimate non-labour income, and the adjustment at the household account is the switch between (formal) labour and non-labour income. At the same time, the imbalance in formal labour and non-labour account is reduced.

To produce the exactly balanced SAM, the SAM is balanced using a mathematical-programming method commonly used to estimate or balance the Input-Output table or Social Accounting Matrix. In this case, a GEMPACK program, developed by Horridge (2003), is used in this final refinement.

4.7 Concluding Remarks

This chapter describes the construction of an Indonesian Social Accounting Matrix, with emphasis on the distribution across households. It extends the official BPS SAM by having 181 detailed sectoral classifications, 16 labour classifications, and distinguishing 200 households classified by centile of expenditure per capita. This SAM constitutes the biggest and most disaggregated Indonesian SAM at the sectoral and household level yet constructed, hence contributing to the literature on SAM construction especially in developing countries. A SAM is also a basic and necessary element in CGE modelling, and its construction has provided a pathway for later studies to analyze relevant policy issues. In addition, since SAM construction is rarely well-documented, the transparency in the description of this SAM construction, hopefully provides replicability for SAM construction in the future[27], as well as for other researchers.

Shortcomings in this SAM construction could include possible weak assumptions and/or lack of availability and quality of the data used. The variety of different data sources, although collected by the same agency, may have been produced for differ-

[27]For example, when data source is updated to more recent years.

ent purposes and with different methods. Inconsistency among those data sources are unavoidable. In these situations, definitions, with the assumptions contained, as well as judgments are an inevitable but common practice in the SAM construction. In many parts of the process, art is more dominant than science. This concern is actually one of the motivations for this thesis, with the expectation that improvement will be made in the future.

4.A Appendix

4.A.1 List of Industries/Commodities

Table 4.5: List of 181 Industries/Commodities

1 Paddy	62 Sugar	123 Non-iron metal products
2 Maize	63 Peeled grain	124 Kitchen wares, and tools
3 Cassava	64 Chocolate	125 Metal furniture
4 Sweet potatoes	65 Milled and peeled coffee	126 Structural metal product
5 Other root crops	66 Processed tea	127 Other metal products
6 Groundnut	67 Soya bean products	128 Prime movers engine
7 Soybean	68 Other foods	129 Machinery and apparatus
8 Other beans	69 Animal feed	130 Electrical generator, motor
9 Vegetables	70 Alcoholic beverages	131 Electrical machinery etc.
10 Fruits	71 Non alcoholic beverage	132 Communication apparatus
11 Cereals and other food crops	72 Tobacco products	133 Household appliances
12 Rubber	73 Cigarettes	134 Other electrical appliances
13 Sugarcane	74 Cleaning kapok	135 Battery
14 Coconut	75 Yarn	136 Ship and its repair
15 Oil palm	76 Textile	137 Train and its repair
16 Fibre crops	77 Textile products	138 Motor vehicles (cars)
17 Tobacco	78 Knitting mills	139 Motor cycle
18 Coffee	79 Carpet, rope and textile	140 Other transport equipment
19 Tea	80 Wearing apparel	141 Aircraft and its repair
20 Clove	81 Leather	142 Photographic and optical eq.
21 Cacao	82 Leather products	143 Jewelry
22 Cashew fruit	83 Footwear	144 Musical instruments
23 Other estate crops	84 Sawmill and preserved wood	145 Sporting and athletics goods
24 Other agriculture	85 Plywood and the like	146 Other manufacturing
25 Livestock and product	86 Wooden building component	147 Electricity
26 Fresh milk	87 Wooden furniture	148 Gas
27 Poultry and its product	88 Other wood products	149 Water supply
28 Other livestock raising	89 Non-plastic plait	150 Residential building
29 Wood	90 Pulp	151 Construction on agriculture
30 Other forest product	91 Paper and cardboard	152 Public work
31 Sea fish and product	92 Paper and cardboard product	153 Utility construction
32 Inland water fish and product	93 Printing and publishing	154 Other construction
33 Shrimp	94 Basic chemical	155 Trade
34 Agriculture services	95 Fertilizer	156 Vehicle repairs
35 Coal	96 Pesticides	157 Restaurant
36 Crude oil	97 Synthetics resin, plastic etc.	158 Hotel
37 Natural gas and geothermal	98 Paints, vernishes etc.	159 Railway transport
38 Tin ore	99 Drug and medicine	160 Road transport
39 Nickel ore	100 Native medicine	161 Sea transport
40 Bauxite ore	101 Soap and cleaning product	162 River and lake transport
41 Copper ore	102 Cosmetics	163 Air transport
42 Gold ore	103 Other chemicals product	164 Services allied to transport
43 Silver ore	104 Gasoline	165 Communication services
44 Ore and sand iron	105 Automotive Diesel Oil	166 Banking
45 Other mining	106 IDO	167 Other financial intermediaries
46 Non-metal mining	107 Kerosene	168 Insurance and pension funds
47 Crude salt	108 LPG	169 Real estate and dormitory
48 Quarrying all kinds	109 Other fuels	170 Business services
49 Meats	110 Liquefied of natural gas	171 General government
50 Processed meat	111 Smoked and crumb rubber	172 Government education
51 Dairy products	112 Tire	173 Government health services
52 Canned fruits and vegetables	113 Other rubber products	174 Other government services
53 Salty fish and dry fish	114 Plastics product	175 Private education services
54 Processed and preserve fish	115 Ceramic and earthenware	176 Private health services
55 Copra	116 Glass product	177 Other private services
56 Animal and vegetable oil	117 Clayand ceramic products	178 Private motion picture
57 Rice	118 Cement	179 Recreations
58 Wheat flour	119 Other non-ferrous products	180 Personal and household ser.
59 Other flour	120 Basic iron and steel	181 Other goods and services
60 Bakery products and the like	121 Basic iron and steel products	
61 Noodle, macaroni, etc.	122 Non-ferrous basic metal	

4.A.2 List of labour Classification

Table 4.6: List of 181 Industries/Commodities

	Urban/ Rural	Formal/ Imputed	Skill type
1.	Urban	Formal	Agricultural Workers
2.	Rural	Formal	Agricultural Workers
3.	Urban	Imputed	Agricultural Workers
4.	Rural	Imputed	Agricultural Workers
5.	Urban	Formal	Production, Transport Operator, Manual, and Unskilled Workers
6.	Rural	Formal	Production, Transport Operator, Manual, and Unskilled Workers
7.	Urban	Imputed	Production, Transport Operator, Manual, and Unskilled Workers
8.	Rural	Imputed	Production, Transport Operator, Manual, and Unskilled Workers
9.	Urban	Formal	Clerical, Services workers
10.	Rural	Formal	Clerical, Services workers
11.	Urban	Imputed	Clerical, Services workers
12.	Rural	Imputed	Clerical, Services workers
13.	Urban	Formal	Administrative, Managerial, Professional, and Technician Workers
14.	Rural	Formal	Administrative, Managerial, Professional, and Technician Workers
15.	Urban	Imputed	Administrative, Managerial, Professional, and Technician Workers
16.	Rural	Imputed	Administrative, Managerial, Professional, and Technician Workers

4.A.3 SAM Balancing Program

As described in more detail in Horridge (2003), in the final stage of constructing a SAM, the balance in a SAM A_{ij}, is often not satisfied, i.e.,

$$\sum_i A_{iq} \neq \sum_j A_{qj} \tag{A1}$$

or column total q is not equal to row total q. Therefore, the problem is to seek to construct a revised SAM B_{ij}, which is close to A_{ij}, and is balanced,

$$\sum_i B_{iq} = \sum_j B_{qj}. \tag{A2}$$

However, before doing any balancing using this method, a significant imbalance due to a more structural problem has to be resolved first.

The solution to the above problem is to find a scale vector K such that

$$B_{ij} = A_{ij}\frac{K_i}{K_j} \tag{A3}$$

where K satisfies equation A2 above. This is what is implemented by the SAMBAL GEMPACK program, where K can be discovered by direct or iterative methods. This program uses the same principle as in the RAS or Entropy method, and as McDougall (1999) suggests, many of those matrix balancing methods are in fact producing more or less the same results. The reason to choose one program is simply the familiarity of the software used. In this case, this program is chosen because of the convenience of having the program in the GEMPACK environment.

This program also allows flexibility in fixing certain cells in the SAM in the balancing process. This will be useful when it is certain that some cells are produced by reliable information so that there is no need to change them. In the case of this SAM construction, these are (1) value added or primary factors for every industry, since this will guarantee that GDP will not change at all, (2) cells that involve trade data (export and import by commodity), and finally (3) indirect taxes, subsidies, and tariffs.

Chapter 5

A Computable General Equilibrium Model

General equilibrium theory is a formalisation of the observation that real-world markets are interdependent. The changes in supply or demand conditions usually have repercussions on the equilibrium prices on several other markets. Computable general equilibrium (CGE) modeling is an attempt to use general equilibrium theory as an operational tool for empirically oriented analyses of resource allocation issues in market economies (Bergman, 2005).

The CGE model has been used as a tool for many aspects of economic policies and is popular among policy-oriented economists to analyse the impact of economic policy that may have large inter-sectoral effects. For example, Arrow (2005, p. 13) mentions that "in all cases where the repercussions of proposed policies are widespread, there is no real alternative to CGE".

The CGE model to be used for the case study on carbon tax and energy pricing reform[1] is built based on the ORANI-G model, an applied general equilibrium model of the Australian economy. Its theoretical structure is a typical static general equilibrium model which consists of equations describing: (1) the demands for produced inputs and primary factors by the industries; (2) the supplies of commodities; (3) the demands for inputs for capital formation; (4) the household demand system; (5) the demand for export; (6) the government demands; (7) the relationship of basic values to production costs and to purchaser prices; (8) market-clearing conditions for commodities and primary factors; and (9) numerous macroeconomic variables

[1] As discussed in Chapters 6 and 7.

and price indices (Horridge, 2000).

The demand and supply equations for private-sector agents are derived from the solutions to the optimisation problems (cost minimisation and utility maximisation) and are assumed to underlie the behaviour of the agents in conventional neoclassical microeconomics. The agents are assumed to be price-takers, with producers operating in competitive markets with zero profit conditions.

As an overview, the following modifications to the standard ORANI-G model structure[2] are implemented.

1. The standard ORANI-G model treats energy commodities as intermediate inputs under the Leontief production function. Therefore, it does not allow price-induced energy substitution. The first modification is to allow substitution among energy commodities, and also between primary factors (capital, labour, and land) and energy[3].

2. The model incorporates carbon (CO_2) emission accounting, and carbon taxation mechanism.[4]

3. The standard ORANI-G has only one single household. Adding a multi-households feature is thus another important modification to the model. The multi-household feature is not only added to the expenditure or demand side of the model[5], but also to the income side[6].

4. The standard ORANI-G model is almost purely based on an Input-Output table, whereas this research needs many types of information which is only available from a Social Accounting Matrix. For example, in the Indonesian Social Accounting Matrix (SAM), the corporate or enterprise sector owns a

[2]To be distinguished from modification to the model's database.

[3]This modification is more or less similar to the modification in the INDOCEEM (Indonesian Comprehensive Economy and Energy Model) model, another ORANI-G based model built by Monash University and Indonesian Ministry of Energy.

[4]This modification, follow closely the treatment in MMRF-Green model, a dynamic, multi-sectoral, multi-regional CGE model of Australian Economy, as described in Adams et al. (2000).

[5]Such as done for some of other ORANI-G version.

[6]More or less similar modification to ORANI-G model has been made to the very popular WAYANG model, an ORANI-G based Indonesian CGE model.

great deal of undistributed earning, and the value of transfers among institutions such as from government to households, are recorded. These important features cannot be captured from an I-O based model alone. The model is then modified to incorporate inter-institution transfers, most importantly from the government to households.

This chapter is divided into five sections. The first section describes the model structure which is again sub-divided into the description of the production structure; the structure of household demand; the treatment of carbon emission and tax; the market clearing conditions and other equations. The second section describes the database and parameters of the model. The third section discusses the approach for analysing distributional effects. The choice of closures is discussed in the fourth section, and the final section discusses the approach for sensitivity analysis.

5.1 Model structure

The CGE model contains numerous sets of equations. Due to limited space, only the important sets of equation will be described here.

In the description of the model structure, some definitions and conventions need to be clarified. Firstly, a level variable is represented by an upper-case letter, while a percentage change variable is represented by a lower-case letter. For example, the number of persons employed in sector i can be represented by L_i, while l_i represents the percentage change of L_i, or $l_i = 100\frac{\Delta L_i}{L_i}$.

Secondly, unless otherwise stated, the definition of the sets as represented by a subscript in a variable is listed in Table 5.1. For a more detailed list of the set definitions, see Table 5.2 which shows the list of commodities, industries, labour classes, and households. As shown in Table 5.2, the model distinguishes 38 industries and 43 commodities. Among the 43 commodities, there is a subset of 6 fuel commodities. These are coals, natural gas, gasoline, diesel for automotive, diesel for industry, kerosene, LPG, and other fuels. The model also distinguishes 16 labour classifications and 200 household classes. The households are grouped into urban

Table 5.1: Subscript, superscripts and set definition

Set	*Definition*
$i \in$ IND	Set of 38 industries
$c \in$ COM	Set of 43 commodities
$f \in$ FUEL $\subset$ COM	Set of 8 fuel/energy commodities, a subset of COM
$s \in$ SRC	Set of 2 sources, i.e., domestic and import
$h \in$ HH	Set of 200 households, 100 urban, 100 rural households
$o \in$ OCC	Set of 16 labour classes
Supersripts	*Indicates users of the commodities or factors*
0, example p^0	Basic values, e.g., basic prices.
1, example x^1	Industries, e.g., demand for intermediate inputs
2, example x^2	Investors, e.g., demand for investment goods
3, example x^3	Households, e.g., as demand for commodities
4, example x^4	Exports, e.g., demand for exports
5, example x^5	Governments, e.g., demand for commo. by government
6, example x^6	Stocks, e.g., demand for commodities as inventories

and rural households. In urban and rural households, there are 100 households classified according to the level of real expenditure per capita, which is ranked into centiles, where the first centile is the poorest and the 100^{th} centile is the richest.

Thirdly, the naming of the variables in this chapter follows closely the ORANI-G model. These are among others:

1. Real percentage change variables are usually represented by a variable starting with a letter x or q.

2. Percentage change of prices of commodities and factors are usually represented by a variable starting with a letter p.

3. Percentage change of nominal variables are usually represented by a variable starting with a letter w.

4. Initial nominal value of transactions are usually represented by a coefficient starting with a letter V.

5. In many of the variables there are usually superscripts of numbers that are either $0, 1, 2, 3, 4$, 5, or 6. Table 5.1 explain the use of these supersripts.

Table 5.2: Detailed list of sets

	Industries (IND)		Commodities (COM)		Labour (OCC)
1	Paddy	1	Paddy	1	Urban, formal, agriculture
2	Other food crops	2	Other food crops	2	Rural, formal, agriculture
3	Estate crops	3	Estate crops	3	Urban, informal, agriculture
4	Livestock	4	Livestock	4	Rural, informal, agriculture
5	Wood and forests	5	Wood and forests	5	Urban, formal, production
6	Fish	6	Fish	6	Rural, formal, production
7	Coal	7	Coal	7	Urban, informal, production
8	Crude oil	8	Crude oil	8	Rural, informal, production
9	Natural gas	9	Natural gas	9	Urban, formal, clerical
10	Other mining	10	Other mining	10	Rural, formal, clerical
11	Rice	11	Rice	11	Urban, informal, clerical
12	Other food (manuf.)	12	Other food (manuf.)	12	Rural, informal, clerical
13	Clothing	13	Clothing	13	Urban, formal, professional
14	Wood products	14	Wood products	14	Rural, formal, professional
15	Pulp and paper	15	Pulp and paper	15	Urban, informal, professional
16	Chemical product	16	Chemical product	16	Rural, informal, professional
17	Petroleum refinery	17	Gasoline		
		18	Diesel (automotive)		Household (HH)
		19	Diesel (industrial)	1	Urban, centile 1
		20	Kerosene	2	Urban, centile 2
		21	LPG	3	Urban, centile 3
		22	Others	⋮	
18	LNG	23	LNG		
19	Rubber and products	24	Rubber and products		
20	Plastic and products	25	Plastic and products		
21	Nonferrous metal	26	Nonferrous metal		
22	Other metal	27	Other metal	⋮	
23	Machineries	28	Machineries	97	Urban, centile 97
24	Automotive industries	29	Automotive industries	98	Urban, centile 98
25	Other manufacturing	30	Other manufacturing	99	Urban, centile 99
26	Electricity	31	Electricity	100	Urban, centile 100
27	Water and gas	32	Water and gas		
28	Construction	33	Construction	101	Rural, centile 1
29	Trade	34	Trade	102	Rural, centile 2
30	Hotel and restaurants	35	Hotel and restaurants	103	Rural, centile 3
31	Road transportation	36	Road transportation	⋮	
32	Other transportation	37	Other transportation		
33	Banking and finance	38	Banking and finance		
34	General government	39	General government	⋮	
35	Education	40	Education	197	Rural, centile 97
36	Health	41	Health	198	Rural, centile 98
37	Entertainment	42	Entertainment	199	Rural, centile 99
38	Other services	43	Other services	200	Rural, centile 100

5.1.1 Production

The activity of the production sectors can be represented by a production function. A production function transforms various inputs into output. The production function is assumed to be separable, that is it can be written as a function of a composite of some subsets of inputs. For example, the output Y is a function of capital K, labour L, and energy E. The separability means Y can also be written as a function of a primary factor composite V (a function of K and L), and E, or $Y = f(K, L, E) = f(V(K, L), E)$. This is called a nested production function. The structure of the nested production function for each industry is illustrated in Figure 5.1. Firms carry out an optimisation problem at each stage (or nest). They minimise the total cost of purchasing the inputs at that stage. The optimisation at each stage gives a solution in the form of the demand for inputs.[7]

Demands for primary factors

For a given labour composite, each firm minimises the total cost of hiring various or skills or occupation types of labour. Labour composite is a Constant Elasticity of Substitution aggregation of various labour types. The solution determines the optimum composition of various types of labour and produces the demand for labour by each industry (i) and each skill group or occupation (o), and the price of labour composite for each industry. The demand for labour by industry (i) and skill group (o) (in percentage change) is given by:

$$x_{io}^{1lab} = x_i^{1lab\_o} - \sigma_i^{1lab}\left(p_{io}^{1lab} - p_i^{1lab\_o}\right), \tag{5.1}$$

where x_{io}^{1lab} is the demand for labour of skill o by industry i, $x_i^{1lab\_o}$ is the labour composite, σ_i^{1lab} is the elasticity of substitution among skills, p_{io}^{1lab} is the price of labour of skill o, by industry i, and $p_i^{1lab\_o}$ is the effective price of labour composite for each industry, which is defined as:

[7] The derivation of these optimisation problems and their solution in terms of the demand for inputs are not discussed here in detail. Derivation for these equations are discussed, for example, in Horridge (2000), Dixon et al. (1992), and Dixon et al. (1997).

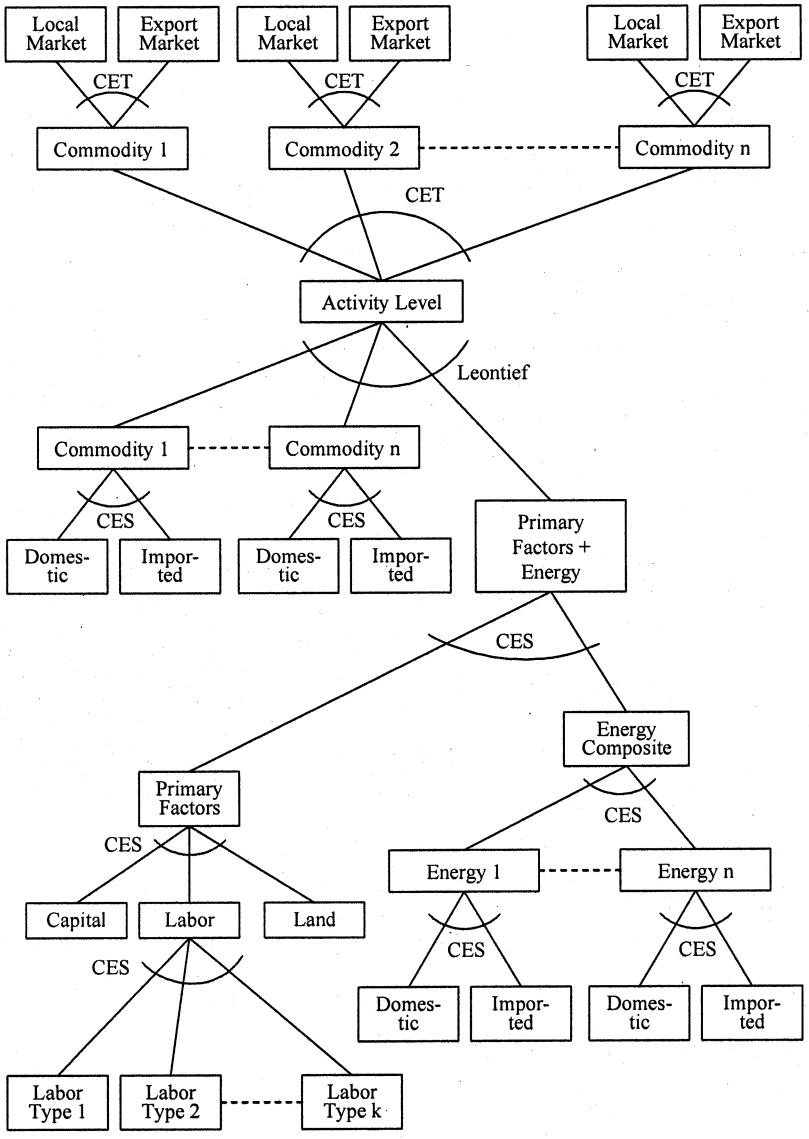


Figure 5.1: Structure of production

$$V_i^{\text{1lab\_o}} \cdot p_i^{\text{1lab\_o}} = \sum_{o \in \text{OCC}} V_{io}^{\text{1lab}} p_{io}^{\text{1lab}}, \tag{5.2}$$

where V_{io}^{1lab} is the total labour payment by industry i for each labour class o, and $V_i^{\text{1lab\_o}} = \sum_o V_{io}^{\text{1lab}}$. Equation 5.2 simply says that the effective price of labour is the weighted average of the price of labour for various skills. Equation 5.1 states that the demand for labour with certain specific skill is directly proportional to the labour composite, and will fall if its relative wage rises due to the substitution effect. The magnitude of the substitution effect depends on the elasticity of labour among different skills.

In the next stage of the optimisation, each firm minimises the total cost of primary factor given the primary factor composite. The primary factors include effective labour or labour composite ($x_i^{\text{1lab\_o}}$), capital (x_i^{1cap}), and land (x_i^{1lnd}). The solution to the optimisation problem yields the demand for each primary factor. The industry demand for effective labour is given by:

$$x_i^{\text{1lab\_o}} = x_i^{\text{1prim}} - \sigma_i^{\text{1prim}} \left(p_i^{\text{1lab\_o}} - p_i^{\text{1prim}} \right), \tag{5.3}$$

where x_i^{1prim} is demand for the primary factor composite, σ_i^{1prim} is the elasticity of substitution between primary factors, and p_i^{1prim} is the effective price of primary factors.

The industry demand for capital is given as:

$$x_i^{\text{1cap}} = x_i^{\text{1prim}} - \sigma_i^{\text{1prim}} \left(p_i^{\text{1cap}} - p_i^{\text{1prim}} \right). \tag{5.4}$$

The Industry demand for land is given as:

$$x_i^{\text{1lnd}} = x_i^{\text{1prim}} - \sigma_i^{\text{1prim}} \left(p_i^{\text{1lnd}} - p_i^{\text{1prim}} \right). \tag{5.5}$$

The effective price of primary factors is given by:

$$V_i^{1\text{prim}} \cdot p_i^{1\text{prim}} = V_i^{1\text{lab\_o}} p_i^{1\text{lab\_o}} + V_i^{1\text{cap}} p_i^{1\text{cap}} + V_i^{1\text{lnd}} p_i^{1\text{lnd}},$$

where $V_i^{1\text{lab\_o}}$ is the (initial) value of labour cost, $V_i^{1\text{cap}}$ is the value of capital cost, $V_i^{1\,\text{lnd}}$ is the value of land cost, and $V_i^{1\text{prim}}$ is the sum of all primary factor costs.

The following equation defines the change in the total cost of primary factors.

$$\begin{aligned} 100 \cdot \Delta V_i^{1\text{prim}} &= V_i^{1\text{cap}} \left(p_i^{1\text{cap}} + x_i^{1\text{cap}}\right) + V_i^{1\text{lnd}} \left(p_i^{1\text{lnd}} + x_i^{1\text{lnd}}\right) \\ &\quad + \sum_{o \in \text{OCC}} V_i^{1\text{lab}} \left(p_{io}^{1\text{lab}} + x_{io}^{1\text{lab}}\right) \end{aligned} \tag{5.6}$$

Sourcing of intermediate inputs

As also illustrated in Figure 5.1, firms use both domestic and imported commodity to be used as intermediate inputs. For each commodity, firms optimise the composition between the domestic and imported commodity by minimising the total cost of obtaining the commodity from both sources for any given amount composite commodity. The solution to the optimisation problem produces source specific commodity demands:[8]

$$x_{csi}^1 = x_{ci}^{1\_\text{s}} - \sigma_c \left(p_{csi}^1 - p_{ci}^{1\_\text{s}}\right), \tag{5.7}$$

where x_{csi}^1 is the demand for commodity c from source s (either domestic or imported) by industry i, $x_{ci}^{1\_\text{s}}$ is the domestic-import composite of commodity c, p_{csi}^1 is the price of commodity c from source s faced by industry i, $p_{ci}^{1\_\text{s}}$ is the effective price of domestic-imported composite, and σ_c is the Armington elasticity between domestic and imported commodity. The effective price of commodity composite is defined as:

$$p_{ci}^{1\_\text{s}} = \sum_{s \in \text{SRC}} S_{csi}^1 p_{csi}^1 \tag{5.8}$$

[8] Derivation for these equations are discussed, for example, in Horridge (2000), Dixon et al. (1992), and Dixon et al. (1997).

where S^{1}_{csi} is the share of industry i's purchase on domestic or imported commodity c.

Substitution among energy commodities

The model allows for price-induced substitution among energy commodities. Firms determine the optimum composition of energy inputs by minimising the total cost of purchasing various energy commodities, for a given amount of energy composite. The optimisation produces the demand for energy or fuel types, or for $f \in FUEL \subset COM$:

$$x^{1\_s}_{fi} = x^{1\text{ener}}_{i} - \sigma^{1\text{ener}}_{i}\left(p^{1\_s}_{fi} - p^{1\text{ener}}_{i}\right), \tag{5.9}$$

where $x^{1\_s}_{fi}$ is the demand for energy or fuel type f by industry i, $x^{1\text{ener}}_{i}$ is the energy composite, $p^{1\_s}_{fi}$ is the price of energy f faced by industry i, $p^{1\text{ener}}_{i}$ is the effective or average price of energy, and $\sigma^{1\text{ener}}_{i}$ is the elasticity of substitution among energy commodities. The average or effective price of energy to each industry is given as:

$$V^{1\text{ener}}_{i} \cdot p^{1\text{ener}}_{i} = \sum_{f \in \text{FUEL}} V^{1\text{pur\_s}}_{fi} p^{1\_s}_{fi}, \tag{5.10}$$

where $V^{1\text{pur\_s}}_{fi}$ is the value of industry i's purchase of energy f, and $V^{1\text{ener}}_{i} = \sum_{f} V^{1\text{pur\_s}}_{fi}$ is the total purchase of energy inputs.

Substitution between energy and primary factors

In the model, firms can also substitute between energy composite and primary factor composite. The demand for energy composite is a function of relative price between energy and primary factor composite, and is given as:

$$x^{1\text{ener}}_{i} = x^{1\text{eprim}}_{i} - \sigma^{1\text{eprim}}_{i}\left(p^{1\text{ener}}_{i} - p^{1\text{eprim}}_{i}\right), \tag{5.11}$$

where $x^{1\text{ener}}_{i}$ is the demand for energy composite, $x^{1\text{eprim}}_{i}$ is the primary factor and energy bundle (composite), $p^{1\text{eprim}}_{i}$ is the effective price of primary factor and energy composite, and $\sigma^{1\text{prim}}_{i}$ is the elasticity of substitution between energy composite and

primary factor composite. The demand for primary factor composite ($x_i^{1\text{prim}}$) is given as:

$$x_i^{1\text{prim}} = x_i^{1\text{eprim}} - \sigma_i^{1\text{eprim}} \left(p_i^{1\text{prim}} - p_i^{1\text{eprim}} \right), \tag{5.12}$$

where $p_i^{1\text{prim}}$ is the effective price of primary factor composite. The average or effective price of primary factors-energy composite is given as:

$$\left(V_i^{1\text{ener}} + V_i^{1\text{prim}} \right) \cdot p_i^{1\text{eprim}} = V_i^{1\text{ener}} p_i^{1\text{ener}} + V_i^{1\text{prim}} p_i^{1\text{prim}}, \tag{5.13}$$

where $V_i^{1\text{ener}}$ is the total purchase of energy commodities, and $V_i^{1\text{prim}}$ is the value of total primary factor costs.

Top production nest

At the top stage (see Figure 5.1), firms determine the demand for various (non-energy) intermediate inputs, and value added-energy composite by minimising the total cost subject to a Leontief production function. The optimisation determines the demand for non-energy commodity:

$$x_{ci}^{1\_s} = x_i^{1\text{tot}}, \tag{5.14}$$

where $x_{ci}^{1\_s}$ is the demand for intermediate input of commodity c by industry i, and $x_i^{1\text{tot}}$ is the total output produced by industry i. Equation 5.14 is the implication of a Leontief production function where the demand for intermediate input is directly proportional to the total output without any substitution effect among the intermediate inputs.

The demand for value-added-energy composite is given as:

$$x_i^{1\text{eprim}} = x_i^{1\text{tot}}, \tag{5.15}$$

The cost of primary factors and cost of purchasing intermediate inputs add up

to the total cost of production as follows:

$$\Delta V_i^{1\text{tot}} = \Delta V_i^{1\text{prim}} + \sum_{c\in\text{COM}} \sum_{s\in\text{SRC}} \frac{1}{100} V_{csi}^{1\text{pur}} \left(p_{csi}^1 + x_{csi}^1\right), \tag{5.16}$$

where $\Delta V_i^{1\text{tot}}$ is the change in the total cost of production, $\Delta V_i^{1\text{prim}}$ is the change in the total cost of primary factors as defined in equation 5.6, and $V_{csi}^{1\text{pur}}$ is the value of industry i's purchase of commodity c, from both imported and domestic sources.

The model allows for a single producer (or industry) to produce more than one commodity. In this case, the producer maximises the revenue from selling various commodities given a constant elasticity of transformation (CET) function. The supply of commodity c by industry i (q_{ci}^1) is given as:

$$q_{ci}^1 = x_i^{1\text{tot}} + \sigma_i^{1\text{out}} \left(p_c^{0\text{com}} - p_i^{1\text{tot}}\right), \tag{5.17}$$

where $\sigma_i^{1\text{out}}$ is the elasticity of transformation, and $p_i^{1\text{tot}}$ is the average price received by industry given as follows:

$$p_i^{1\text{tot}} = \sum_{c\in\text{COM}} \frac{V_{ci}^{\text{make}}}{V_i^{\text{make\_c}}} p_{ci}^{\text{q1}}, \tag{5.18}$$

where V_{ci}^{make} is a matrix that records the value of commodity c produced by industry i, and $V_i^{\text{make\_c}} = \sum_c V_{ci}^{\text{make}}$. p_{ci}^{q1} is the price received by industry i for commodity c it produces. Each industry gets the same price for a given commodity, that is:

$$p_{ci}^{\text{q1}} = p_c^{0\text{com}} \tag{5.19}$$

The zero pure profit condition is written as:

$$V_i^{1\text{tot}} \left(p_i^{1\text{tot}} + x_i^{1\text{tot}}\right) = 100 \Delta V_i^{1\text{tot}}. \tag{5.20}$$

Equation 5.20 equalises the industry revenue from selling commodities with the total cost of production eliminating excess profit.

The total output of commodity c produced by various industries ($x_c^{0\text{com}}$) is a simple summation over industries, or:

$$x_c^{0\text{com}} = \sum_{i \in \text{IND}} \frac{V_{ci}^{\text{make}}}{V_c^{\text{make\_i}}} q_{ci}^1, \tag{5.21}$$

where $V_c^{\text{make\_i}} = \sum_c V_{ci}^{\text{make}}$.

Industry supply commodities to either the local or export market. The supply to the export market (x_c^4) is given as:

$$\tau_c \left(x_c^{0\text{dom}} - x_c^4 \right) = p_c^{0\text{dom}} - p_c^{\text{e}} \tag{5.22}$$

where $x^{0\text{dom}}$ and $p_c^{0\text{dom}}$ is the output and price of commodities for local market, respectively; p_c^{e} is the price of export of commodity c, and τ_c is the inverse of the elasticity of transformation between exportable and locally used commodities. The supply of commodities to domestic market ($x_c^{0\text{com}}$) is given as:

$$x_c^{0\text{com}} = (1 - S_c^{\text{exp}}) x_c^{0\text{dom}} + S_c^{\text{exp}} x_c^4, \tag{5.23}$$

where S_c^{exp} is the share of the sales of commodity c sold to the export market. The transformation maintains the zero pure profit condition, that is:

$$p^{0\text{com}} = (1 - S_c^{\text{exp}}) p_c^{0\text{dom}} + S_c^{\text{exp}} p_c^{\text{e}}. \tag{5.24}$$

5.1.2 Households

Household demand

The household demand system follows a linear expenditure system (LES). However, the LES demand system only applies for composite (bundle of imported and domestic) commodities. Therefore, the combination of imported and domestic commodity to form a composite is modeled using Armington aggregation as also used in forming the commodity composite for intermediate inputs. To account for this, the

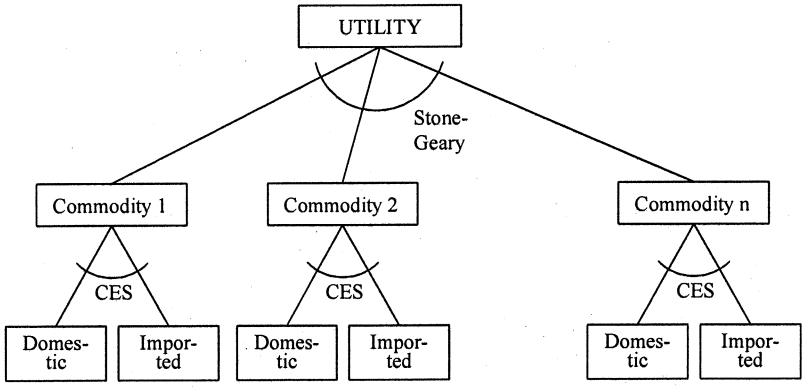


Figure 5.2: Structure of household demand

structure of demand is modelled as a nested demand function. Figure 5.2 illustrates the nested structure of household demand. At the first stage, for each commodity c, each household determines the optimum combination of imported and domestic commodity to be consumed by minimising the total cost of purchase of a given level of composite commodity. The optimisation produces the Import-domestic composition of household demand, as follows:

$$x^3_{csh} = x^{3\_s}_{c\bar{h}} - \sigma_c \left(p^3_{csh} - p^{3\_s}_{c\bar{h}} \right), \tag{5.25}$$

where x^3_{csh} and p^3_{csh} are the demand and price, respectively, for commodity c from source s (imported or domestic) by household h, $x^{3\_s}_{c\bar{h}}$ is the import-domestic composite commodity, σ_c is the Armington elasticity, and $p^{3\_s}_{c\bar{h}}$ is the effective price of commodity composite, given as:

$$p^{3\_s}_{c\bar{h}} = \sum_{s \in \mathrm{SRC}} S^3_{csh} p^3_{csh}, \tag{5.26}$$

where S^3_{csh} is the share of household h's expenditure on commodity c from source s.

At the final stage, each household maximises the Klein-Rubin utility function, by choosing the optimum quantity of composite commodity c, satisfying the budget constraint. More specifically, the optimisation problem for household h is:

$$\max_{X_{ch}^{3\_S}} U = \prod_c \left(X_{ch}^{3\_S} - X_{ch}^{3SUB}\right)^{S_{ch}^{3LUX}} \text{ s.t. } \sum_c X_{ch}^{3\_S} P_{ch}^{3\_S} = V_h^{3\_TOT}, \tag{5.27}$$

where $X_{ch}^{3\_S}$ is the quantity of (composite) commodity c; X_{ch}^{3SUB} is the subsistence quantity of the commodity (a parameter); S_{ch}^{3LUX} is the marginal budget share of commodity c; and $V_h^{3\_TOT}$ is the household total disposable income. The solution to the optimisation problem will produce the Linear Expenditure System (LES) as follows:

$$P_{ch}^{3\_S} X_{ch}^{3\_S} = P_{ch}^{3\_S} X_{ch}^{3SUB} + S_{ch}^{3LUX} \left(V_h^{3\_TOT} - \sum_k P_{kh}^{3SUB} X_{kh}^{3SUB}\right). \tag{5.28}$$

The total quantity of composite commodity $\left(X_{ch}^{3\_S}\right)$ consist of its subsistence component and its luxury component, or $X_{ch}^{3\_S} = X_{ch}^{3SUB} + X_{ch}^{3LUX}$. The Luxury demand for composite commodities is the second part of equation 5.28, that is:

$$\begin{aligned} P_{ch}^{3\_S} X_{ch}^{3LUX} &= S_{ch}^{3LUX} \left(V_h^{3\_TOT} - \sum_k P_{kh}^{3SUB} X_{kh}^{3SUB}\right) \\ &= S_{ch}^{3LUX} V_h^{3LUX}, \end{aligned} \tag{5.29}$$

where $V_h^{3LUX} = V_h^{3\_TOT} - \sum_k P_{kh}^{3SUB} X_{kh}^{3SUB}$. Therefore, in percentage change, the demand for luxury commodity can be written as:

$$x_{ch}^{3lux} + p_{ch}^{3\_s} = w_h^{3lux}, \tag{5.30}$$

where w_h^{3lux} is the percentage change of V_h^{3LUX}. The total household demand for composite commodities can be written as:

$$x_{ch}^{3\_s} = B_{ch}^{3lux} x_{ch}^{3lux} + \left(1 - B_{ch}^{3lux}\right) x_{ch}^{3sub}, \tag{5.31}$$

where B_{ch}^{3lux} is the ratio of supernumerary (or luxury) expenditure to total expenditure.

The total real consumption of household h ($x_h^{3\text{tot}}$) can be defined as:

$$V_h^{3\text{tot}} \cdot x_h^{3\text{tot}} = \sum_{c \in \text{COM}} \sum_{s \in \text{SRC}} V_{csh}^{3\text{pur}} x_{csh}^{3}. \tag{5.32}$$

The household specific consumer price index ($p_h^{3\text{toth}}$) is given as:

$$V_h^{3\text{tot}} \cdot p_h^{3\text{tot}} = \sum_{c \in \text{COM}} \sum_{s \in \text{SRC}} V_{csh}^{3\text{pur}} p_{csh}^{3}. \tag{5.33}$$

The household budget constraint (determine $w_h^{3\text{lux}}$) is written as:

$$w_h^{3\text{tot}} = p_h^{3\text{tot}} + x_h^{3\text{tot}}. \tag{5.34}$$

Household income

Households receive income from various sources. The source of income is labour income (with various skill types), income from land ownership, from capital ownership, transfers from the government, enterprises, and the rest of the world (foreign transfers). The following equation determines the total household income:

$$\begin{aligned} Y_h y_h \;=\; & \sum_{o \in \text{OCC}} Y_{ho}^{\text{lab}} \left(p_o^{\text{1lab\_i}} + x_{oh}^{\text{1labh}}\right) + \sum_{i \in \text{IND}} Y_{hi}^{\text{lnd}} \left(p_i^{\text{1lnd}} + x_{ih}^{\text{1lndh}}\right) \\ & + \sum_{i \in \text{IND}} Y_{hi}^{\text{cap}} \left(p_i^{\text{1cap}} + x_{ih}^{\text{1caph}}\right) + Y_h^{\text{trg}} w_h^{\text{trg}} + Y_h^{\text{trhy}} w_h^{\text{trhy}} + Y_h^{\text{trwy}} w_h^{\text{trwy}} \\ & + Y_h^{\text{trhe}} w_g^{\text{trhe}} - Y_h^{\text{trhx}} w_h^{\text{trhx}} - Y_h^{\text{trwx}} w_h^{\text{trwx}} - Y_h^{\text{tax}} w_h^{\text{tax}} \end{aligned} \tag{5.35}$$

where y_h is the percentage change of household nominal income, Y_h is the (initial) value of total household nominal income, Y_{ho}^{lab} is the value of labour income for skill o; $p_o^{\text{1lab\_i}}$ is the price of labour of skill o, x_{oh}^{1labh} is the quantity of labour of skill o supplied by household h; Y_{hi}^{lnd} is the value of income from land of industry i, p_i^{1lnd} is the returns to land, x_{ih}^{1lndh} is the household supply of land; Y_{hi}^{cap} is the value of income from capital, p_i^{1cap} is the returns to capital, x_{ih}^{1caph} is the quantity of capital supplied by household h, Y_h^{trg} and w_h^{trg} are the value and percentage change, respectively, of transfers from government, Y_h^{trhy} and w_h^{trhy} are the value and percentage change,

respectively, of transfers from other households, Y_h^{trhe} and w_h^{trhe} are the value and percentage change, respectively, of transfers from the enterprise or corporate sectors, Y_h^{trwy} and w_h^{trwy} are the value and percentage change, respectively, of transfers from abroad (rest of the world), Y_h^{trhx} and w_h^{trhx} are the value and percentage change, respectively, of transfers to other households, Y_h^{trwx} and w_h^{trwx} are the value and percentage change, respectively, of transfers to the rest of the world; and Y_h^{tax} and w_h^{tax} are the value and percentage change, respectively of household income tax.

The household disposable income is determined by the following consumption function.

$$w_h^{\text{3tot}} = f_h^{\text{3tot}} + y_h, \tag{5.36}$$

where f_h^{3tot} is the shifter of the average propensity to consume.

5.1.3 Market clearing and other equations

Market clearing equations ensure that the supply of a commodity is equal to what is demanded. The domestic and imported commodities are demanded by various users, that is producers or industry users of intermediate inputs, households, government, and investors. The market clearing equation for each commodity c simply adds up its demand by various users to be equal to what is supplied. Market clearing equations ensure the market is in equilibrium and will determine the prices for commodities.

There are also market clearing equations for primary factors of production that will determine the price or returns to these factors. For example, for each type of labour class, there is one market clearing condition that equalises its demand by industries with the total available labour supplied by households.

In addition to market clearing equations, there are numerous other equations that determine macro or aggregate variables, as well as some definition or identities.

5.1.4 Accounting for carbon emissions

The model incorporates carbon (CO_2) emission accounting, and a carbon taxation mechanism.[9] In this study, only CO_2 emissions from fossil-fuel burning is included, meaning that it excludes other source of CO_2 emission such as from land-use change or deforestation. Data on detailed emissions by sector and by type of fuel for Indonesia are not available. However, Statistics of Indonesian Energy Balance, reports the detailed consumption of fossil-fuel by type of energy (natural gas, coal, gasoline, diesel, kerosene, LPG, others) in energy unit[10]. From the data on energy consumption measured in unit of energy, the amount of CO_2 emissions can be calculated. Later on, by assuming that all users of energy face the same prices[11], using the Social Accounting Matrix data with detailed consumption of energy by various industries and households and by type of energy, a matrix of CO_2 emissions by fuel type, and by users (industry and households) or $E_{f,u}$ can be calculated. More specifically, the matrix can be calculated as:

$$E_{f,u} = \delta \cdot \varpi_f \cdot CC_f \cdot \phi \cdot Q^E_{f,u}, \tag{5.37}$$

where $E_{f,u}$ is the CO_2 emission by energy type f, consumed by user u, in tons, $Q^E_{f,u}$ is the quantity of energy consumption by energy type f, consumed by user u, in energy unit (Barrel of Oil Equivalent/BOE), ϕ is a factor to convert BOE to Giga-Joules, CC_f is the carbon content of energy type f in ton of carbon per Giga-Joules (tC/GJ), ϖ_f is the oxidation factor by energy type, i.e., fraction of carbon oxidised, and δ is a constant (44/12) that transform carbon (C) into CO_2 emissions. Data on the quantity of energy consumption by energy type ($Q^E_{f,u}$) is obtained from Statistics of Indonesian energy balance 2003, whereas ϖ_f, CC_f, ϕ are obtained from

[9] This modification, follow closely the treatment in MMRF-Green model, as described in Adams et al. (2000).

[10] In this case, Barrel of Oil Equivalent (BOE).

[11] One of the causes of the variation of the prices is regional variation. However, most of the price of energy products are adminstered, and the regional variation is due to transportation margin. Because the transaction in the SAM used in disaggregating the quantity of energy use is in basic prices (or producer prices), the common prices assumption could be plausible. Another adjustment is also made for taking into account different prices paid by households and industries due to fuel subsidy.

the database of International Panel on Climate Change (IPCC).

Following Adams et al. (2000), the government revenue from CO_2 tax (R) can be calculated as:

$$R = \tau \cdot \sum_f \sum_u E_{f,u}, \tag{5.38}$$

where τ is a specific tax on CO_2 (in rupiah per ton of CO_2), and $E_{f,u}$ is the quantity (tones) of emission of CO_2 by energy type f and by user u. Because the emission tax will be imposed as ad-valorem energy/fuel tax, R will be equivalent to:

$$R = \sum_f \sum_u \frac{t_{f,u}}{100} P_f Q_{f,u}, \tag{5.39}$$

where t_f is an *ad valorem* tax rate, P_f is the (basic) price of fuel f, and $Q_{f,u}$ is the quantity of energy consumed by user u. For every energy type f and user u, the specific CO_2 tax can be translated into an ad-valorem fuel/energy tax as follow:

$$t_{f,u} = \tau \frac{100 \cdot E_{f,u}}{P_f \cdot Q_{f,u}}. \tag{5.40}$$

Part of the equation 5.40 can also be defined as emission intensity per Rupiah use of energy (EI_{fu}), that is:

$$EI_{fu} = \frac{E_{f,u}}{P_f Q_{f,u}}. \tag{5.41}$$

For any specific price of carbon (or carbon tax) the impact of a specific carbon tax on the *ad valorem* tax rate for each energy type depends not only on technical or chemical matter such as its carbon content, but also on economic variables or market conditions such as prices.

Given the above definitions, the following equations are added to the structure of the model. The first is an equation that determines the quantity of CO_2 emission from various sources, that is:

$$x^{co2}_{fsi} = x^1_{fsi}, \tag{5.42}$$

$$x^{co2}_{fsh} = x^3_{fsh}, \tag{5.43}$$

where f is an element of the set of fuel commodities (FUEL). Equation 5.42 suggests the quantity of CO_2 emission from industry i produced from the consumption of fuel f is directly proportional to the quantity of fuel the industry consumes. Equation 5.43 suggests the same thing for the case of households. The total CO_2 emission (x^{co2tot}) is then calculated as:

$$X^{\text{co2tot}} \cdot x^{\text{co2tot}} = \sum_{u\in \text{ USER}} \sum_{s\in \text{SRC}} \sum_{f\in \text{ FUEL}} X^{\text{co2}}_{fsu} x^{\text{co2}}_{fsu}, \tag{5.44}$$

where USER is a set of industry (IND) and household (HH) combined, X^{co2}_{fsu} is the initial quantity of emission, and $X^{\text{co2tot}} = \sum_u \sum_s \sum_f X^{\text{co2}}_{fsu}$ is the sum of initial CO_2 emissions from various sources and various fuel types.

Following Adams et al. (2000), a specific (rupiah/ton) carbon tax (Δt^{CO2}) can be expressed as an *ad valorem* fuel/energy tax. The expression is more or less[12] the percentage change form of equation 5.40.

$$\Delta t^{\text{1fuel}}_{fsi} = EI_{fsi}\left(T^{\text{co2}} \cdot \left(x^{\text{co2}}_{fsi} + f^{\text{co2i}} - x^{1}_{fsi} - p^{0}_{fs}\right) + 100\Delta t^{\text{co2}}\right), \tag{5.45}$$

$$\Delta t^{\text{3fuel}}_{fsh} = EI_{fsh}\left(T^{\text{co2}} \cdot \left(x^{\text{co2}}_{fsh} + f^{\text{co2i}} - x^{3}_{fsh} - p^{0}_{fs}\right) + 100\Delta t^{\text{co2}}\right), \tag{5.46}$$

where $\Delta t^{\text{1fuel}}_{fsi}$ is the change in the *ad valorem* tax rates faced by industry due to the change in the specific carbon tax; EI_{fsi} is the initial emission intensity per rupiah worth of energy used (as also defined in equation 5.41); T^{co2} is the initial rate of carbon tax; x^{co2}_{fsi} is the percentage change of CO_2 emission by industry i; f^{co2i} is a price index to preserve nominal homogeneity; x^{1}_{fsi} is the quantity of fuels consumed as intermediate inputs; p^{0}_{fs} is the basic price of fuel; $\Delta t^{\text{3fuel}}_{fsh}$ is the change in *ad valorem* tax rate faced by households due to the change in the specific carbon tax; x^{co2}_{fsh} is the percentage change of CO_2 emission by household h; and x^{3}_{fsh} is the quantity of fuel consumed by household h.

The change in *ad valorem* fuel tax rate is specified in equations 5.45 and 5.46 translated into the general *ad valorem* commodity taxes. For fuel commodities $f \in$

[12] Except in this case, a subscript s which distinguishes domestic and imported sources is added.

FUEL $\subset$ COM:

$$\Delta t^1_{fsi} = \Delta t^0_{fsi} + \Delta t^{0-s}_f + \Delta t^{\text{all}} + \Delta t^{\text{1fuel}}_{fsi}, \tag{5.47}$$

$$\Delta t^3_{fsh} = \Delta t^3_{fsh} + \Delta t^{0-s}_f + \Delta t^{\text{all}} + \Delta t^{\text{3fuel}}_{fsh}, \tag{5.48}$$

where Δt^1_{fsi} and Δt^3_{fsh} are the changes in *ad valorem* commodity tax rates for industry and household, respectively. Δt^0_{fsi}, Δt^3_{fsh}, Δt^{0-s}_f, Δt^{all} are exogenous shifter variables. The change in the *ad valorem* taxes which are a function of the fuel taxes, are then translated into the purchaser prices of commodities. For industries which purchase commodities for intermediate inputs, the purchaser price equation is the following:

$$V^{\text{1pur}}_{csi} p^1_c = \left(V^{\text{1bas}}_{csi} + V^{\text{1tax}}_{csi}\right) p^0_{cs} + V^{\text{1bas}}_{csi} \Delta t^1_{csi}, \tag{5.49}$$

where p^0_{cs} is the basic price of commodity c from source s; V^{1bas}_{csi} is the basic value of industry purchase of commodities, and V^{1tax}_{csi} is the tax revenue collected from the basic purchase; and $V^{\text{1pur}}_{csi} = V^{\text{1bas}}_{csi} + V^{\text{1tax}}_{csi}$ is the industry consumption of intermediate goods valued at purchaser price. The industries which purchase investment goods face the following price equation:

$$V^{\text{2pur}}_{csi} p^2_{csi} = \left(V^{\text{2bas}}_{csi} + V^{\text{2tax}}_{csi}\right) p^0_{cs} + V^{\text{2bas}}_{csi} \Delta t^2_{csi}, \tag{5.50}$$

where V^{2bas}_{csi} is the basic value of industry purchase of investment goods, and V^{2tax}_{csi} is the tax revenue collected from the purchase; and $V^{\text{2pur}}_{csi} = V^{\text{2bas}}_{csi} + V^{\text{2tax}}_{csi}$ is the industry consumption of investment goods valued at the purchaser price. The purchaser price for households is defined as:

$$V^{\text{3pur}}_{csh} p^3_{csh} = \left(V^{\text{3bas}}_{csh} + V^{\text{3tax}}_{csh}\right) p^0_{cs} + V^{\text{3bas}}_{csh} \Delta t^3_{csh}, \tag{5.51}$$

where V^{3bas}_{csh} is the basic value of the household purchases of commodities, and V^{3tax}_{csh} is the tax revenue collected from the basic purchase; and $V^{\text{3pur}}_{csh} = V^{\text{3bas}}_{csh} + V^{\text{3tax}}_{csh}$ is the household consumption of commodities valued at the purchaser price. For exported

commodities, the purchaser price equation is[13]:

$$V_c^{4\text{pur}} p_c^4 = \left(V_c^{4\text{bas}} + V_c^{4\text{tax}}\right) p_c^e + V_c^{4\text{bas}} \Delta t_c^4, \tag{5.52}$$

where $V_c^{4\text{bas}}$ is the basic value of the exported commodities, and $V_c^{4\text{tax}}$ is the tax revenue collected from the (basic) purchase; and $V_c^{4\text{pur}} = V_c^{4\text{bas}} + V_c^{4\text{tax}}$ is the export of commodities valued at purchaser price. For commodities purchased by the government, the purchaser price equation is given as[14]:

$$V_{cs}^{5\text{pur}} p_{cs}^5 = \left(V_{cs}^{5\text{bas}} + V_{cs}^{5\text{tax}}\right) p_{cs}^0 + V_{cs}^{5\text{bas}} \Delta t_{cs}^5, \tag{5.53}$$

where $V_{cs}^{5\text{bas}}$ is the basic value of the government purchase of commodities, and $V_{cs}^{5\text{tax}}$ is the tax revenue collected from the (basic) purchase; and $V_{cs}^{5\text{pur}} = V_{cs}^{5\text{bas}} + V_{cs}^{5\text{tax}}$ is the government consumption of commodities valued at purchaser prices.

5.2 Database and Parameters

The database for the model is based on the Social Accounting Matrix 2003 specifically constructed for this research as described in detail in Chapter 4. For the purpose of the case studies, the 181 industries in the SAM are aggregated into 38 industries and the 181 commodities are aggregated into 43 commodities.

There are some sets of parameters the values of which have to be estimated or borrowed from the literature or other models. These sets of parameters are: (1) Armington elasticities between domestic and imported commodities, σ_c, (2) export elasticities, ε_c, (3) elasticities of substitution among labour types (or skills), $\sigma_i^{1\text{lab}}$, (4) elasticities of substitution among primary factors, $\sigma_i^{1\text{prim}}$ (5) CET transformation elasticities for industries with multiple commodities, Ω_i (6) elasticities of substitution among energy types, σ_i^{ener}, (7) elasticities of substitution between energy composite and primary factor, $\sigma_i^{\text{enerprim}}$, (8) expenditure elasticities for LES household demand system, η_{ih}, and, (8) the Frisch parameter or elasticity of marginal utility

[13] Which is also a zero pure profits condition in exporting.

[14] Which is also a zero pure profits condition in distribution to government.

of income for each household, ϕ_h.

Parameters 1 to 5, i.e., σ_c, ε_c, $\sigma_i^{1\text{lab}}$, $\sigma_i^{1\text{prim}}$, Ω_i, are borrowed from the GTAP database. Parameters 6 and 7, i.e., σ_i^{ener} and $\sigma_i^{\text{enerprim}}$, respectively, are borrowed from thr INDOCEEM model. Parameters η_{ih} are estimated econometrically, and the Frisch parameter ϕ_h is calculated based on the study by Lluch et al. (1977).

It can be shown that all parameters of the LES household demand can be written as a function of only expenditure elasticity and the Frisch parameter (the elasticity of marginal utility of income). Therefore, the parameters of the demand system that are supplied to the model are these two sets of parameters only, expenditure elasticities for specific commodities and specific household, ε_{ih}, and the Frisch parameter for each household, ϕ_h.

The best approach to estimate the parameters of the LES is using a demand system estimation model. However, the household survey (SUSENAS) does not have price data and obtaining the unit value or prices from the value and volume of consumption data is not possible. The alternative is to estimate the expenditure elasticities by the regression of the Engel curves. Following Deaton and Case (1988), in the estimation, the Engel curve is specified for 44 broad commodity classification i for urban and rural sample, specified as:

$$w_i = \alpha_i + \beta_i \ln(y) + \gamma_i \ln(s) + \sum_j \theta_{ij} R_j + e_i, \tag{5.54}$$

where w_i is the expenditure share of commodity i, y is total expenditure, s is household size, R_j is regional (in this case, provincial) dummy variables, and e_i is the error term. The engel curves are estimated using the OLS method with robust (Huber-White) standard error. the expenditure elasticities for commodity i, ε_i, is calculated as:

$$\eta_i = 1 + \frac{\beta_i}{w_i}. \tag{5.55}$$

Table 5.3 shows the regression result and the calculated expenditure elasticities using the mean of expenditure share over the samples.

The Frisch parameter is calculated based on the widely-known study by Lluch

et al. (1977) who estimated the relationship between the Frisch parameter and income per capita. The conjecture from the study is used to calculate the Frisch parameter for each household, that is:

$$\phi_h = -36 \cdot Y_h^{-0.36}, \tag{5.56}$$

where Y_h is income per capita in 1970 US Dollar.

Table 5.3: Estimation Result of the Engel Curve and Expenditure Elasticity

	Urban				Rural			
Commodity	β_i	s.e		ε_i	β_i	s.e.		ε_i
Automotive diesel oil	0.00061	0.00007	**	3.397	0.00074	0.00029	*	5.604
Food (agriculture)	-0.00794	0.00021	**	0.614	-0.01880	0.00060	**	0.551
Appliances	0.00234	0.00013	**	1.561	0.00540	0.00020	**	2.082
Beverages	0.00512	0.00020	**	1.559	0.00466	0.00024	**	1.776
Chemical products	-0.00849	0.00022	**	0.799	-0.00517	0.00026	**	0.874
Clothes	0.00118	0.00010	**	1.123	0.00282	0.00013	**	1.291
Coffee and tea	-0.00460	0.00008	**	0.497	-0.00469	0.00013	**	0.647
Communication equipment	0.00424	0.00026	**	1.989	0.00725	0.00040	**	3.426
Communication services	0.02341	0.00037	**	2.866	0.00330	0.00019	**	4.771
Dairy products	0.00875	0.00035	**	1.565	0.00933	0.00029	**	2.427
Drugs/medicines	0.00002	0.00012		1.004	-0.00015	0.00014		0.964
Edible oil	-0.00930	0.00012	**	0.475	-0.01108	0.00017	**	0.556
Education	0.01258	0.00055	**	1.575	0.00346	0.00031	**	1.453
Electricity	0.00083	0.00021	**	1.033	0.00126	0.00020	**	1.079
Fish	-0.01234	0.00038	**	0.754	-0.00277	0.00058	**	0.958
Flours/bread	0.00235	0.00015	**	1.242	0.00155	0.00022	**	1.166
Fruits	0.00612	0.00029	**	1.220	0.01019	0.00039	**	1.374
Furniture	0.00186	0.00011	**	1.810	0.00414	0.00019	**	2.787
Gasoline	0.01456	0.00031	**	2.270	0.01130	0.00028	**	3.063
Water and gas	0.00166	0.00012	**	1.275	0.00063	0.00006	**	1.674
Health	0.00731	0.00074	**	1.488	0.00985	0.00077	**	1.758
Hotel and restaurant	0.00753	0.00054	**	1.188	0.01268	0.00065	**	1.607
Jewelry	0.00218	0.00016	**	1.767	0.00563	0.00029	**	2.953
Kerosene	-0.01530	0.00020	**	0.228	-0.00302	0.00021	**	0.840
Livestock	-0.00331	0.00023	**	0.888	0.01122	0.00037	**	1.418
LPG	0.00424	0.00009	**	2.166	0.00182	0.00008	**	3.432
Meat	0.00894	0.00028	**	1.475	0.01483	0.00035	**	2.228
Noodles	-0.00112	0.00014	**	0.890	0.00329	0.00017	**	1.382
Other durable	-0.00397	0.00029	**	0.607	-0.01973	0.00052	**	0.358
Other fuels	0.00348	0.00009	**	2.177	0.00424	0.00020	**	3.175
Other transportation	0.00488	0.00058	**	1.238	0.00893	0.00075	**	2.072
Food (manufacturing)	-0.01072	0.00062	**	0.890	0.00368	0.00066	**	1.050
Other services	0.04807	0.00153	**	1.352	0.00459	0.00086	**	1.061
Paper/print products	0.00541	0.00017	**	1.623	0.00281	0.00024	**	1.500
Plastic, ceramics, etc	0.00092	0.00008	**	1.311	0.00232	0.00012	**	1.645
Recreation	0.00107	0.00008	**	2.162	0.00094	0.00007	**	2.643
Rice	-0.08405	0.00074	**	0.191	-0.12345	0.00101	**	0.358
Road transportation	0.00116	0.00016	**	1.134	0.00269	0.00014	**	1.774
Sugar	-0.00913	0.00012	**	0.423	-0.01000	0.00020	**	0.611
Textiles	-0.00001	0.00024		1.000	0.00450	0.00032	**	1.137
Tobacco products	-0.00813	0.00068	**	0.867	0.02490	0.00101	**	1.315
Vegetables	-0.02382	0.00029	**	0.498	-0.02076	0.00040	**	0.678
Vehicles	0.02141	0.00103	**	3.576	0.03471	0.00158	**	6.171

Note: **) significant at 1%, *) significant at 5%. Source: SUSENAS 2002 Consumption Module

5.3 Distributional Analysis

In a general equilibrium framework, the distributional impact of any exogenous shocks to the model (for example policy or external shocks) works through the market mechanism. In response to the shocks, optimising firms will change their demand for factor inputs, intermediate inputs, and supply of commodities. The change in a firm's demand for factors of production will affect factor prices or employment and at the end affects household incomes and its distribution across households. The change in the income of each household depends on the composition of factor ownership (e.g., unskilled labour, skilled labour, capital, and land) of the household.

The change in household incomes together with the changes in all commodity prices, will simultaneously change the household expenditures on various commodities. This will affect the distribution of income and expenditure. In a general equilibrium framework, this series of mechanisms works simultaneously in inter-related markets. Therefore, any attempt to assess the distributional impact of policies by identifying either their impact on either household expenditure *or* household income will be considered incomplete because it is a one-sided story. Both sides are endogenous, and a CGE model elegantly takes these two different forces into account.

Figure 5.3 illustrates how a subsidy cut on fuels affects income distribution across households. The government may affect fuel prices by changing indirect taxes or subsidies. A subsidy cut on fuels will increase the price of fuels sold in the commodity markets. Household demand for fuels will fall. Household demand for other commodities may change as well because in a demand system commodities are inter-related. The household total expenditure will change and this will affect household welfare. How much each household expenditure change depends on their consumption pattern which varies across households. However, this is not the end of the story.

Because fuels are also used by industries as intermediate inputs, the rise in their prices will affect the industry optimal decision in the production process. Transportation sectors, for example, will be heavily affected, and most probably will

contract, as well as some other industries. The industry decision on the level of production will affect the demand for various factors of production such as skilled labour, unskilled labour, and capital. This will in turn change their prices such as wages. When wages fall, because factors of production are supplied by households, their factor income will decline.

How much each of the households experience income falls/rises depends on their composition of factor ownership and thus on how much their income will fall/rise from the change in employment or wages. When household income falls, this will again affect household demand for commodities and expenditures. When the new equilibrium is reached, there will be a new distribution of household welfare which could be measured by the new distribution of their (real) expenditure.

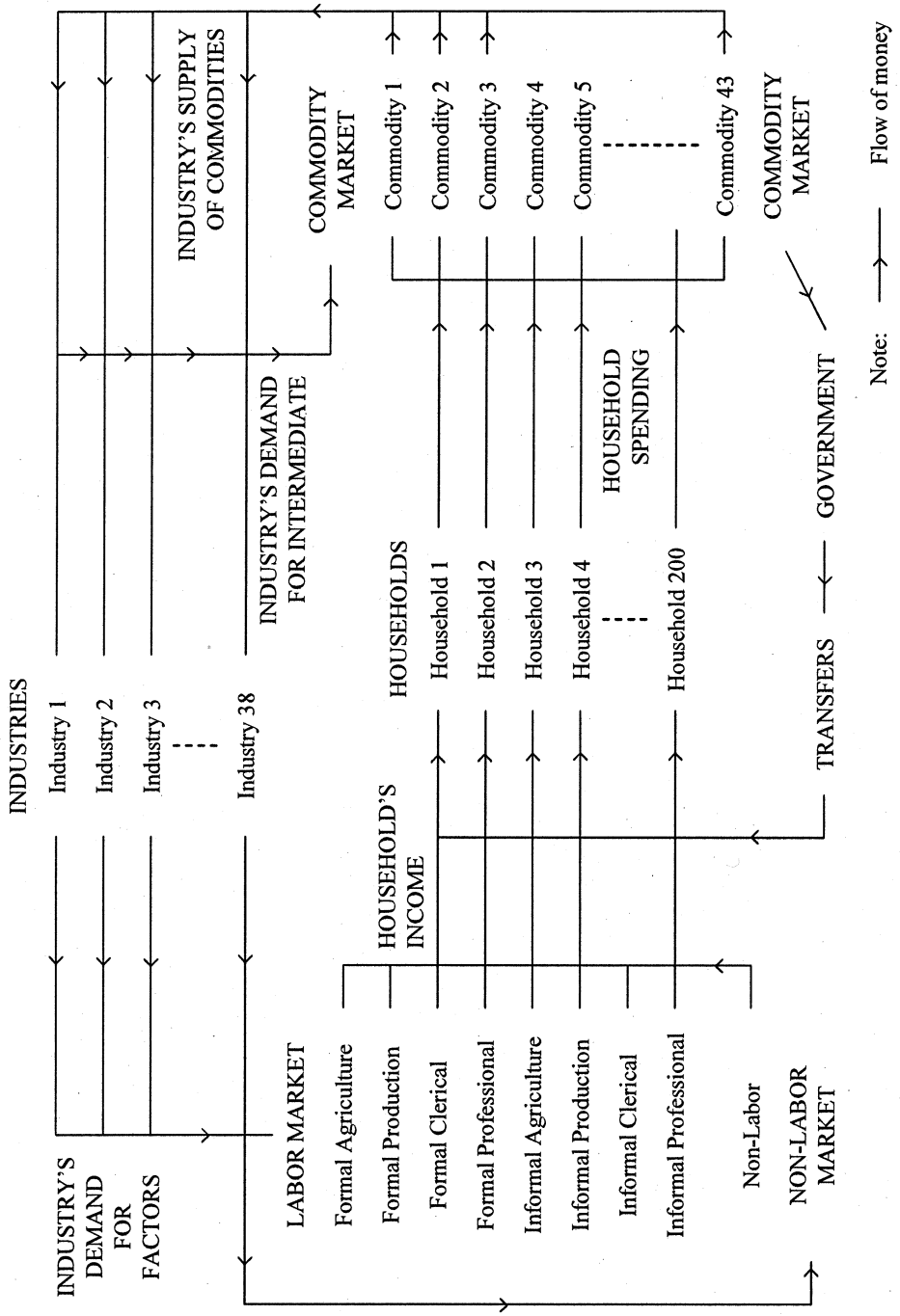


Figure 5.3: The Mechanism by which a subsidy cut on commodities affects the distribution of income

In the literature, there are various approaches for dealing with the income distribution analysis in a CGE model. The traditional one is the representative household method where it is assumed that the distribution of income or expenditure follows a certain functional form[15]. The distribution is assumed to remain constant before and after the shock. One of the weaknesses is that the behaviour of a group of households is usually dominated by the richest. There has been growing evidences to suggest that the variation within one single household-category is important and can significantly affect the results of the analysis (Decaluwé et al., 1999). Household-specific shocks, such as transfers to targeted household groups, are also impossible to carry out using this approach. Studies for Indonesia by Sugema et al. (2005) and Oktaviani et al. (2005), among others, belong to this type of approach.

The most common studies for Indonesia are CGE studies that use the official household classification of the SAM, i.e., 10 socioeconomic classes. The distributional impact is only analysed by comparing the impact of policies among these socioeconomic classes. Studies by Clements et al. (2003) Resosudarmo (2003), Azis (2000), and Azis (2006), among others, follow this approach.

Another approach is a top-down method where price changes produced by the CGE model are transferred to a separate micro-simulation model such as a demand system and income-generation model. Price changes are exogenous in this micro-model, hence the endogeneity of prices is ignored. Studies for Indonesia by Bourguignon et al. (2003) and Ikhsan et al. (2005) are in the class of this type of approach. Some attempts has been made to improve this approach by providing a feedback from the micro-model to the CGE model. Belonging to this category among others are studies by Filho and Horridge (2004) for Brazil, and Savard (2003) for the Philippines.

The most recent approach is multiplying the number of households into as many as households available in the household level data. Increasing computation capacity allows a large number of households to be included in the model. It allows the model to take into account the information from the household data in greater detail

[15]For example, log-normal distribution.

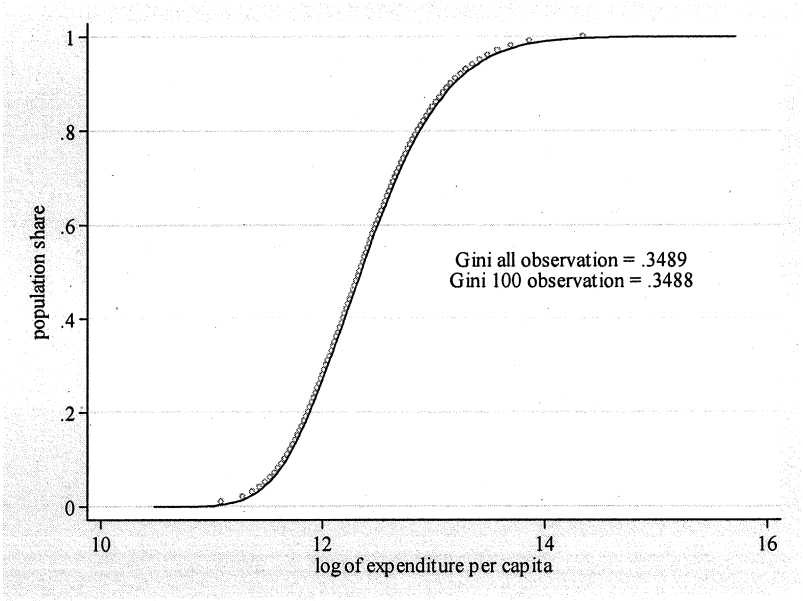


Figure 5.4: The accuracy of distributional analysis using 100 centiles

avoiding pre-judgment about aggregating households into categories. All prices are endogenously determined by the model and no prior assumption of any distribution parameter is necessary. Drawbacks of this approach are the difficulties of data reconciliation and the fact that the size of the model can become a computational constraint. This integrated-microsimulation-CGE model has been used in various studies including Annabi et al. (2005) for Senegal, Plumb (2001) for U.K., Cororaton and Cockburn (2005) and, Cororaton and Cockburn (2006) for the Philippines.

The last approach, to be used in this paper, is disaggregating or increasing the number of household categories by the size of expenditure or income per capita. If the categories is detailed enough, such as 100 centiles, the distributional indicators such as poverty incidences or standard inequality indicators can be estimated more precisely. For example, Warr (2006) used this approach for Laos in assessing the poverty impact of a large scale irrigation investment.

The ideal approach in a distributional analysis where disaggregated households are integrated in the CGE model is when all observations in the household survey are integrated in the model like in the Micro-simulation CGE models. If only 100 representative households are used classified by centile of expenditure per capita,

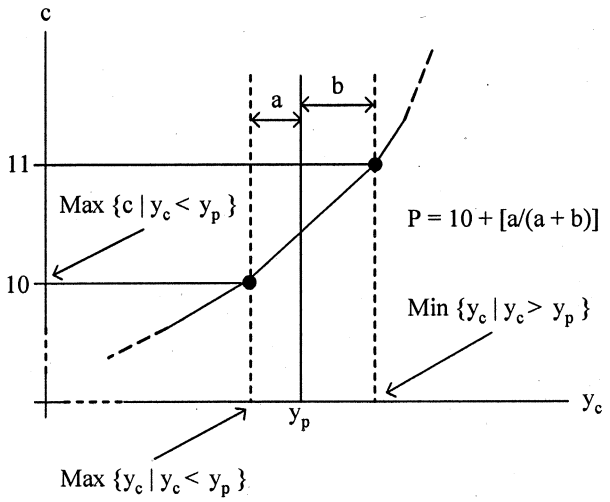


Figure 5.5: Calculating Poverty Incidence

how accurate is the distributional story? As Figure 5.4 illustrates, poverty incidence and inequality calculation could be fairly accurate. The solid line represents the continuous data point of urban households of 29,278 observations using SUSENAS 2003 consumption module. This line can be used to calculate poverty incidence using the relevant poverty line. The gray circle points represent the data points where observations are collapsed or aggregated into 100 households by centiles of expenditure per capita. Calculating poverty incidences using only these 100 data points seems to be fairly accurate. Moreover, the calculation of the Gini coefficient using all 29,278 observations and using only 100 observations produce almost identical results.

The poverty incidence is simply calculated by finding a point in the vertical axis in Figure 5.4 where the cumulative distribution function of expenditure per capita crosses the vertical line representing the poverty line. Because it only represents 100 centiles or 100 data points, only the discrete number of poverty incidence can be found. The exact poverty incidence is then linearly approximated to find the residual decimal point.

Let $c = 1, \ldots, n$ be the centile of expenditure per capita where $n = 100$, and y_c be the real expenditure per capita of the household belonging to the c-th centile.

Poverty incidence is then calculated using:

$$P\left(\{y_c\}, y_P\right) = \max\left\{c | y_c < y_P\right\} + \frac{y_P - \max\left\{y_c | y_c < y_P\right\}}{\min\left\{y_c | y_c > y_P\right\} - \max\left\{y_c | y_c < y_P\right\}} \tag{5.57}$$

where $\{y_c\}$ is a set containing all y_c, and y_P is the poverty line. The first term is simply the centile of which expenditure per capita is the closest from the origin (the left) to the poverty line. The second term is the linear approximation at the decimal point of the poverty incidence. This formula is illustrated in Figure 5.5.

The change in the poverty incidence after a policy shock (simulation) is calculated as:

$$\Delta P = P\left(\{y_c'\}, y_P\right) - P\left(\{y_c\}, y_P\right) \tag{5.58}$$

where

$$y_c' = \left(1 + \frac{\hat{y}_c}{100}\right) \cdot y_c \tag{5.59}$$

where $\hat{y}_c$ is the percentage change in *real* per capita expenditure of the centile c produced from the simulation of the CGE model.

The Gini coefficient is calculated as:

$$G\left(y_c\right) = \frac{1}{n}\left(n + 1 - 2\frac{\sum_{c=1}^{n}\left(n + 1 - c\right) y_c}{\sum_{c=1}^{n} y_c}\right) \tag{5.60}$$

5.4 Closures

There are at least three considerations in specifying the closures for the simulations. First, the closures have to be able to accommodate the research questions specified. For example, when the research objective is to find out the aggregate welfare impacts of particular shocks, then aggregate real consumption, as indicator of welfare, has to be one of the endogenous variables. For example, as Horridge (2000) stated, the choice of closure is affected by the needs of a particular simulation. Second, the closure should also be able to minimise the weakness due to the feature of the real world that cannot be explained by the model. For example, because the model is static, to avoid the inter-temporal allocation of welfare impact, at the expenditure

side, the real investment and the trade balance should be treated as exogenous (Warr, 2001). Finally, the closure is associated with the idea of the simulation timescale, meaning the period of time which would be needed to adjust to a new equilibrium (Horridge, 2000). The objective is to specify the closure as realistic as possible, representing the particular economy, and accommodating the research questions to be investigated.

In specifying a macroeconomic closure, on the aggregate demand side, aggregate real investment, aggregate real government consumption, and trade balance (in real terms) are treated as exogenous, whereas the aggregate real consumption is endogenous hence can be interpreted as the aggregate index of welfare. This prevents, for example, inter-temporal allocation of welfare impact, due to capital accumulation that may increase welfare in the future (Warr, 2001).

For the case study on carbon tax, at the fiscal side, for some scenarios of 'revenue-neutral' carbon tax, the government budget surplus/deficit is exogenised. The variable that is used to balance the government budget is general sales tax rate, or the amount of cash compensation to households, depending on the simulation objectives. This will be discussed in detail in Chapter 6.

For the case study on energy pricing reform, at the fiscal side, the government budget surplus/deficit is endogenous, while aggregate real government consumption is fixed. Any excess revenue from subsidy reduction left over after compensation may lead to the government running a budget surplus. Related to the fuel price increase in October 2005, Manning and Roesad (2006), for example, suggest that delays in spending early in the fiscal year 2006, both at the centre and in the regions, have meant that the fuel price increases have had an unnecessary and avoidable contractionary impact on aggregate demand.

The reason for this closure specification is to isolate the impact of policy scenarios to be investigated. The simulations try to mimic the policy scenarios as implemented in October 2005 and try to examine their income distributional impact. Exogenising the budget surplus requires fiscal adjustment that will have other distributional implications. In both carbon tax and energy price reform case studies, nominal

exchange rate is the numeraire.

Another important closure is the factor market closures. In an ORANI type of model, there are at least three factor market closures, each representing the timescale of the simulation (Horridge, 2000).

1. A standard short-run closure where capital is specific and cannot move across sectors, the industry-specific price of capital is the equilibrating variable. In this standard short-run closure, labour is mobile across industries but real the wage is exogenous, that is all wages are indexed to the CPI, and labour is demand-determined. Employment is allowed to change, therefore it also allows for unemployment where the neoclassical full employment assumption is relaxed. Many other CGE models share similar closure specifications. Another assumption underlying this specification is that labour may be in surplus and thus hired at exogenous real wages (de Janvry and Sadoulet, 2002).

2. A variant of the standard short-run closure is exogenising the nominal wage, a more Keynesian flavour.

3. The other type of closure is a long-run closure where aggregate employment is exogenous which is a typical neoclassical closure with full employment. On the capital side, industries capital is endogenous.

For the carbon tax case study, the analysis will use a closure with the neoclassical full-employment assumption in the labour market. The real wages are endogenous serving as the equilibrating variable to satisfy the full employment conditions. The limitation of this closure is that the carbon tax will have a low impact on GDP because factors of productions are constrained from the supply side. Impact on GDP from a carbon tax is usually channeled through its impact on employment or capital stocks. However, because the focus of the case study is on its distributional implication channeled through the changing factor prices from resource reallocation, fixity of factors on the aggregate level is less of a concern.

In the analysis the case study on energy pricing reform, a short-run analysis is the focus. The ORANI short-run factor market closure is chosen with some slight

modification to suit the condition in Indonesian economy. Because the objective of the exercise is to compare and contrast various scenarios of energy pricing reform with different type of compensation scheme, the amount of shock in the price of fuels and the amount of transfers to households should mimic what was implemented by the Indonesian government. Because the idea of compensation is to mitigate the distributional and poverty impact following the increase in fuel prices, short-run time scale will be more realistic. Compensation is essentially not a long-run story.

Moreover, in the long-run closure, GDP on the supply side is constrained by the exogeneity of aggregate factor supply and full employment assumption (long-run closure). Because real aggregate investment, real government consumption and trade balance are exogenous, the real consumption expenditure will follow exactly the change in the real GDP. The impact on welfare, then, will be so small that compensation (with the size implemented in October 2005) would not have been necessary.

In addition, by fixing the real wages and allowing for employment to change, it is possible to see the impact of such reform on employment[16]. Wage rigidities are also considered the main factors that cause unemployment in Indonesia (Basri and Patunru, 2006). To accommodate the characteristics of Indonesian labour market, in the labour market closure, only real wage for the formal labour is set to be exogenous. It means the nominal wage follows the movement of consumer price index. However, for the informal labour market, it is assumed that the labour market is not as rigid as in the formal labour market. Here, the adjustment in nominal wage is assumed to be slower[17].

[16] As suggested by Manning and Roesad (2006), for example, many anecdotal evidence suggests that the price rises also affected employment adversely.

[17] Half of the change in the consumer's price index. This follows a closure of INDOCEEM model in some studies analysing fuel subsidy cut in Indonesia as done for example by Ikhsan et al. (2005). See Appendix 7.A in Chapter 7, for the sensitivity analysis to this parameter.

5.5 Sensitivity Analysis

In a CGE exercise, because some of the parameters are taken from other sources such as others studies, models, or the literature, it is necessary to examine the reliability of the results with respect to uncertainty in the parameters. In a standard or 'ad-hoc' sensitivity analysis, the model is solved for one or two different sets of parameters, and then the sensitivity of the change in the endogenous variables are examined. However, because there are many parameters which are imputed into the model, this approach is difficult or less practical to implement in examining the sensitivity of the results on the independent uncertainty about the values of several parameters. In this model, for example, for Armington elasticity alone, because the model has 38 different commodities, the sensitivity analysis to each of the parameters would be computationally burdensome.

Recent advances in the literature on sensitivity analysis offer a rather convenient approach which is called a systematic sensitivity analysis[18]. The question to be asked in this sensitivity analysis is how reliable the results is if we vary 'all' the parameters in the model, for example, by 50%. Therefore, if for example, the Armington elasticity of commodity A is 5, then it is allowed to vary between 2.5 and 7.5. This will be done for all the parameters. The popular approach is a typical Monte Carlo simulation, where independently enough number from each of the range value of the parameters is drawn in a sufficiently large draw such that the result is statistically accurate. However, with this kind of approach, a time and computational constraint will prevent the accuracy of the estimates.

The new approach is the so-called Systematic Sensitivity Analysis (SSA) via Gaussian Quadrature. This is a type of programming or optimisation method. Given the distribution of M parameters, what is the best possible choice of parameters in N simulations to find the estimate of the means and standard deviations for all endogenous variables? A procedure for choosing the N parameters made in this way is often referred to a Gaussian quadrature. However, this assumes (1) the simulation

[18]See Arndt (1996), Pearson and Arndt (2000), and its implementation among others in Hertel et al. (2003), and Plumb (2001).

results are well approximated by a third-order polynomial in the varying parameters; (2) that all the parameters which vary have a symmetric distribution[19]; (3) the parameters vary quite independently (zero correlation). For example, Arndt (1996) demonstrates that the results are often surprisingly accurate, given the relatively modest number of times the model is solved.

The confidence interval for each endogenous variables is calculated by employing Chebyshev's inequality. Suppose that an endogenous variable y has a mean μ and standard deviation σ. Chebyshev's inequality says that, whatever the distribution of the variable in question, for each positive real number k, the probability that the value of y does not lie within k standard deviations of the mean μ is no more than $\frac{1}{k^2}$. The confidence interval is calculated as $\mu \pm k \cdot \sigma$, where $k = 3.16$ for 90% confidence interval, and $k = 4.47$ for the 95%. In this SSA, all parameters are assumed to vary by 50%, and the SSA is implemented in Gempack (Pearson and Arndt, 2000).

[19]The SSA carried out in this paper, the parameters are assumed to have triangular distribution.

Chapter 6

Case Study I: A Carbon Tax

6.1 Background

The problem of global warming has increasingly become more alarming, and scientific studies are now more conclusive that humans are responsible[1]. In a famous report, Stern (2006) suggests scientists are now able to attach probabilities to temperature outcomes and impacts on the natural environment associated with different levels of greenhouse gas stabilisation. For example, his report suggests that without appropriate action, there is at least a 50% chance of exceeding a 5^0C global average temperature change during the following decades. Such a change would transform the physical geography of the world. His report concludes:

> "Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20^{th} century. And it will be difficult or impossible to reverse these changes (Stern, 2006, p. ii)."

Despite these concerns, multilateral action for greenhouse gas stabilisation, such as proposed under the Kyoto Protocol, have been less than promising. One of the main reasons for this is the associated high cost of such action in terms of economic growth. This argument has been used by both the U.S. and Australian governments

[1] As reported by the recent fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), published in February, 2007 (source: The Economist, February 8^{th} 2007, 'Climate change: Heating Up'.)

against ratifying the Kyoto Protocol and is a clear example of the perception or belief that economic and environmental objectives cannot go hand in hand.

The linkage between the economic, environmental and social dimensions of sustainable development was first introduced in the 1987 Bruntland report. It was again emphasised in the 2002 Johannesburg World Summit as being the three pillars of sustainable development and by this time the environmental link included climate change. With the issue of climate change, the inter-related elements of sustainable development could be in conflict.

Equity is an integrated part of global climate change policy. This includes how the responsibility of actions should be distributed 'fairly' across nations. This was the reason why the 1992 United Nations Framework Convention on Climate Change (UNFCC) declared that the responsibility of actions across nations should follow the principle of 'common but differentiated responsibilities'. Sharing the burden equally is regarded as unfair owing to developing countries' historically low greenhouse gas emissions. However, the lack of a formal commitment for developing countries under the Kyoto Protocol has been used as by the U.S. as an argument against ratification.

Participation by developing countries in stabilising global greenhouse gas emissions is crucial and would be the important driver needed to resume the halting progress of multilateral efforts. Per capita carbon emissions in developing countries are still much lower than that of developed countries. Nevertheless, developing countries are increasingly contributing to the accumulation of greenhouse gases. Developing countries already account for half of annual global greenhouse gas emissions, and future emission growth will mainly come from developing countries (Jotzo, 2004).

For the developing countries themselves, there are many reasons to justify more active participation in global carbon stabilisation. The impact of climate change tends to hurt the poorest countries most, and this includes Indonesia. Developing regions are already warmer, suffer from high rainfall variability, are heavily dependent on agriculture, and suffer from a lack of adequate health provision and low-quality public services. Being low income countries with low budget constraint,

adaptation to harmful effects of climate change will be more difficult (Stern, 2006).

As the fourth largest country in terms of population, Indonesia is important in global climate change policy. Even though it ranks 7^{th} in total CO_2 emission from fossil fuels among developing countries, Indonesia ranked 2^{nd}, after China in 2000 if CO_2 emissions from land use change (mainly deforestation) are included[2]. In fact, even including industrialised countries, Indonesia is one of the 20 biggest carbon emitting nations overall in 2002, with emissions continues to grow rapidly at around 6.6% annually.

The changing composition of Indonesia's energy mix has also caused some concern about the Indonesian contribution to the global climate problem. Although emissions from consumption of liquid petroleum products is still dominant (amounting to 49% of Indonesia's 2002 fossil-fuel CO_2 emissions), emissions from natural gas consumption and coal usage, although quite variable, have risen steadily since the early 1970s and accounted for 15% and 24% of Indonesia's total 2002 emissions. As Indonesia is running out of oil, the future priority of coal as an alternative fuel for electric power generation has become an important item on Indonesia's future agenda. Indonesia recently became a net oil importer, and its coal reserves with current production capacity will last for the next 50 years (Tanujaya, 2005). In addition, with a population exceeding 210 million people, although Indonesia's per capita emission rate of 0.39 metric tons of carbon in 2002 is well below the global average, it has grown ten-fold since the early 1950s (Marland et al., 2005).[3]

Although discussion on the formal commitment of carbon emission stabilisation in developing countries, as well as in Indonesia, is perhaps still in its infancy, it has recently gained a lot more attention, even in Indonesia itself. Indonesia recently ratified the Kyoto Protocol[4]. One of the obligations as a party to the convention is to communicate actions taken to mitigate climate change and also to establish a National Committee on Climate Change. By ratifying the protocol, the issue of reducing greenhouse gas emissions will have more prominence in public discourse.

[2]Source: World Resource Institute Online Database.
[3]See figure 6.1.
[4]In July 2004 (Jotzo, 2004).

Carbon abatement policy, like many other environmentally-motivated policies, carries a distributional effect within a country that implements it. A complete picture of this distributional impact has to consider two distinct but inseparable issues (OECD, 1994). The first is the concerns related to the distribution of the environmental benefit of the policy, who gains more and who gains less. The second concern is associated with distribution of the financial effects of the policies, who pays more and who pays less.

In relation to potential distributional benefits from a global reduction in greenhouse gas emissions, in the case of Indonesia, the questions to be asked are, among others, which parts and/or sectors of the country and its population are likely to be affected. On the other hand, the distribution of financial effects relates more to how the costs of compliance or implementation of policy will be distributed across different groups. The implementation costs of environmental policies can be socially regressive. Lower-income groups may be subject to a disproportionately higher share of environmental compliance costs. The case study in this chapter is intended to address this part of the distributional story.

The conflict between environment and equity objectives in the case of carbon abatement policies has been prevalent, as the literature from developed countries has suggested. As discussed previously in Chapter 2, a carbon tax has been mostly found to be regressive, that is, lower income households pay disproportionately more than higher income households.

As discussed previously, the increasing relevance of developing countries' role in global climate change policy is one of the motivations for this case study. However, this chapter is also motivated by the empirical regularities from developed country studies that carbon abatement policies are regressive. In short, this research is mainly motivated by the lack of emphasis in the literature on the distributional aspect of carbon abatement policy in developing countries.

As argued in the previous chapters, there are many possible developing-countries' characteristics that may point to a conclusion that environmental policies such as a carbon abatement policy may not necessarily be regressive in developing countries.

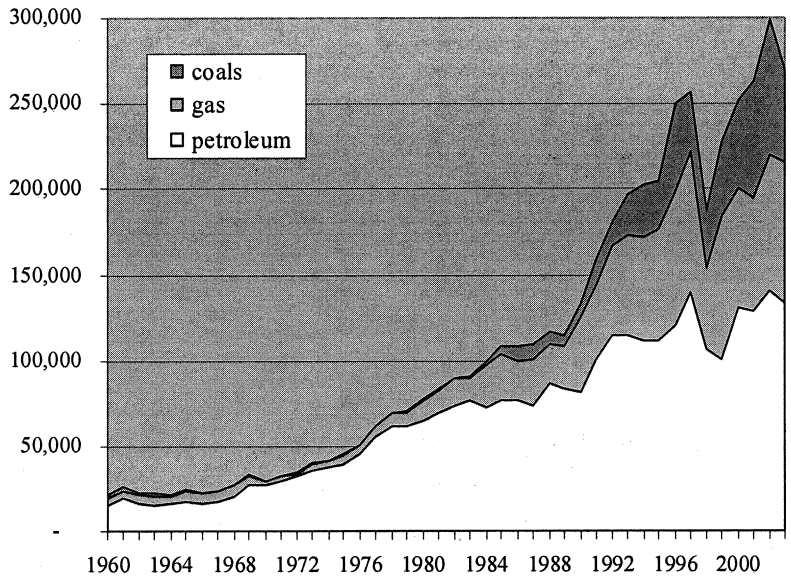


Figure 6.1: Trend of Indonesian CO_2 emission by sources 1960 – 2003 (thousand tonnes)

In Indonesia, as in some other developing countries, although the manufacturing sectors, is relatively more energy-intensive, its share has increasingly been more dominant in the economy's output, yet the largest share of the labour forces is still employed in the agricultural sector and to some extent the services sector. A carbon abatement policy will most likely hit energy-intensive sectors which are typically also capital intensive. The returns to factors that are more intensively employed in these sectors, such as capital, skilled-labour, and formal urban workers, will be under more pressure than factors more intensively employed in less energy intensive sectors,such as agriculture and some of the services sector. These are, among others, land, informal urban, and rural agricultural workers. As the owners of factors in the less energy intensive sectors are most likely to be lower income households, this may drive the distributional impact of a carbon abatement policy to be more progressive than regressive.

Moreover, in contrast to developed countries, the expenditure pattern of lower income households in developing countries is likely to be less energy-intensive. For example, in countries like Indonesia, domestic heating is not part of everyday con-

sumption, vehicle ownership is still a luxury for the majority of the population, and electricity consumption, including its use for energy-intensive household appliances, is still not regarded as a necessity, especially in rural areas, where most Indonesians live.

Encouraging developing countries to participate more actively in the global multilateral effort for greenhouse gas stabilisation has increasingly become necessary. If these typical characteristics of developing countries do drive the distributive effect of a carbon abatement policy to be more progressive, it may have important policy implications at both the local and global level. At the local level, if its known to be non-regressive, the effort to curb greenhouse gas emission will generate less political and social resistance. At the global level, understanding that carbon abatement policies may not necessarily carry adverse distributional effects in developing countries, may add more social benefit, in terms of distributional implication, when the location of carbon abatement is partially shifted from developed to developing countries.

6.2 Scenarios and simulation strategy

In contrast to developed countries who have a legal commitment under the Kyoto Protocol to cut CO_2 emissions, Indonesia does not yet have to follow a certain scenario of emission reduction. In this case study, a carbon tax of Rp. 280,000 per ton of CO_2 emission[5] is introduced with three different scenarios of revenue-recycling[6].

In the first scenario (SIM 1), a carbon tax will be implemented without revenue recycling. That is, the revenue from the carbon tax is assumed to be used for fiscal adjustment, allowing the government to run a budget surplus. This is intended to see the direction of the distributional cost, if the tax revenue is not returned to the

[5] Around US$ 32.6.

[6] A carbon tax of this amount is chosen to reduce emissions by 6.6%, i.e., the Indonesian historical growth rate of emission. So, essentially, this is a scenario of emission stabilisation. An arbitrary carbon tax can always be set, such as being equal to the social cost of carbon from the literature, or any level, but the direction of the distributional result, which is the focus of this chapter, will not significantly change.

economy or used for compensation.

Two options will be considered for revenue-recycling in order for the carbon tax policy to be 'revenue-neutral'. In the second scenario (SIM 2), implementation of a carbon tax will be accompanied by a reduction in the uniform general *ad valorem* sales tax rate for all commodities, such that government revenue is in balance. To do this, a uniform sales tax shifter would be endogenised while government saving is exogenised. The other relevant scenario for the revenue-recycling mechanism is to give a uniform lump-sum transfer to all households. This will be the third scenario (SIM 3).

Another option is a reduction in the income tax rate, as widely discussed in the 'double-dividend-hypothesis' literature. This alternative is not implemented in this exercise for at least two reasons. First, for the double dividend hypothesis to work, it is necessary to have an endogenous labour supply, which is not specified in the CGE model. Second, income (especially labour income) tax collection in Indonesia is low in terms of population coverage, making the likelihood of reducing the income tax rate less feasible.

6.3 Results and discussion

6.3.1 Macroeconomic and industry results

The summary of the macroeconomic, emission, and factor market result is shown in Table 6.1, whereas Table 6.2 shows the results on industry output and the prices of several relevant commodities.

GDP, as well as consumption expenditure (which can be treated as an indicator of aggregate welfare) fall slightly in all three scenarios. However, the simulation suggests that SIM 2, where revenue from the carbon tax is returned to the economy as the uniform reduction in commodity tax rate, produces the lowest decline in welfare effect, where real aggregate consumption falls by only 0.03 percent. A reduction in the commodity tax rate, following the carbon tax implementation, minimises the impact on commodities prices, as can be seen in Table 6.2, from the lowest CPI

percentage increase of 0.58%. This creates an expansionary effect on the economy because of the increase in the demand for commodities and the resulting output expansion. The uniform cash transfers (SIM 3) to all households do not generate as much expansionary pressure on the domestic economy as the reduction in commodity tax, although it may have a better distributional outcome.

The immediate effect of introducing carbon tax is an increase in the price of energy products because the carbon tax is implemented through an increase in the *ad valorem* tax rate on energy commodities, the magnitude of which depends mainly on their carbon content. The price of coal rises most (by more than 100%), followed by other energy and closely-associated products such as electricity and transportation.

Energy related sectors are hurt the most. For example, in SIM 1, output of petroleum refinery and coal mining fall by 3.9% and 2.9%, respectively. Other related sectors to experience significant contraction are natural gas, LNG, electricity, water and gas, road, and other transportation sectors.

In terms of factor reallocation, the simulations suggests that, in general, following implementation of the carbon tax, the energy and capital intensive manufacturing sectors tend to contract while agriculture and service sectors tend to experience a slight expansion. Resources have been reallocated from the energy sectors, most non-food manufacturing industries and utility sectors, to agriculturally-based sectors (such as paddy, other crops, and wood sectors), and to some food-manufacturing sectors and services sectors (such as hotel and restaurants).

As indicated in Table 6.3, industries which experience a significant decline in output are relatively energy intensive. Other than energy sectors (petroleum refinery, coals, crude oil, and natural gas), these industries are, among others, LNG, chemical products, pulp and paper, nonferrous metal, electricity, water and gas, construction, and transportation. As Table 6.3 also reveals, most of these industries are also capital intensive. This structural change would affect the functional distributional of income, by the tendency to reduce the return to capital more than to other factors. In turn, this would tend to hurt households proportionately more

Table 6.1: Simulated Macroeconomic, Emission, and Factor Market Effects of a Carbon Tax

	SIM 1 No-revenue recycling	SIM 2 Uniform cut on com. tax rate	SIM 3 Uniform transfers
Macroeconomics			
GDP	-0.04	-0.02	-0.03
Consumption expenditure	-0.06	-0.03	-0.04
CPI	1.32	0.58	1.75
Export	-0.11	0.67	-0.12
Import	-0.16	0.93	-0.16
CO_2 emission	-6.55	-6.39	-6.52
Real wage			
Agriculture, rural, formal	-0.58	1.62	1.28
Agriculture, urban, formal	-0.54	1.78	1.48
Agriculture, rural, informal	-0.48	1.63	1.61
Agriculture, urban, informal	-0.49	1.70	1.63
Production, rural, formal	-2.68	2.03	-2.73
Production, urban, formal	-4.65	0.56	-5.21
Production, rural, informal	-2.23	2.25	-2.55
Production, urban, informal	-2.24	2.22	-2.98
Clerical, rural, formal	-2.17	1.49	-2.92
Clerical, urban, formal	-3.12	0.66	-4.10
Clerical, rural, informal	-1.76	2.11	-1.64
Clerical, urban, informal	-1.78	2.05	-1.93
Professional, rural, formal	-3.19	0.50	-4.32
Professional, urban, formal	-3.55	0.54	-4.63
Professional, rural, informal	-2.19	1.49	-2.72
Professional, urban, informal	-2.06	2.46	-3.45
Average return to capital	-5.77	-1.86	-6.23
Average return to land	-0.41	1.81	1.78

Table 6.2: Simulated Industry and Prices Impacts of Carbon Tax

	SIM 1 No-revenue recycling	SIM 2 Uniform cut on com. tax rate	SIM 3 Uniform transfers
Output of industries			
Paddy	0.09	0.09	0.29
Other food crops	0.05	-0.09	0.09
Estate crops	-0.13	-0.08	-0.38
Livestock	0.13	0.14	0.35
Wood and forests	0.09	0.15	0.05
Fish	-0.08	-0.03	-0.02
Coal	-2.94	-2.88	-2.95
Crude oil	-0.29	-0.30	-0.28
Natural gas	-0.69	-0.69	-0.69
Other mining	-0.10	-0.23	-0.08
Rice	0.10	0.10	0.31
Other food (manufactured)	0.15	0.18	0.58
Clothing	0.41	0.96	0.64
Wood products	0.23	0.33	0.04
Pulp and paper	-0.07	0.17	-0.14
Chemical product	-0.66	-0.27	-0.41
Petroleum refinery	-3.87	-4.01	-3.83
LNG	-2.89	-2.83	-2.89
Rubber and products	-0.20	0.54	-0.51
Plastic and products	-0.05	0.46	0.07
Nonferrous metal	-1.61	-1.93	-1.49
Other metal	-0.37	-0.12	-0.28
Machineries	-0.50	2.45	-0.22
Automotive industries	0.35	-0.08	-0.47
Other manufacturing	0.20	0.38	0.76
Electricity	-1.44	-1.32	-1.29
Water and gas	-2.24	-2.13	-2.68
Construction	-0.01	-0.01	-0.02
Trade	0.05	0.09	0.29
Hotel and restaurants	0.30	0.10	0.24
Road transportation	-0.66	-0.67	-0.58
Other transportation	-1.44	-1.29	-1.43
Banking and finance	0.23	0.02	0.10
General government	0.00	0.00	0.00
Education	0.11	0.06	0.04
Health	0.31	0.17	0.49
Entertainment	0.60	0.49	0.23
Other services	0.29	0.04	-0.25
Prices of commodities			
Coal	131.80	131.95	132.47
Natural gas	26.35	27.27	26.50
Gasoline	24.61	24.72	24.59
Diesel (Automotive)	45.31	45.56	45.44
Diesel (Industries)	43.48	43.83	43.67
Kerosene	29.30	29.54	29.93
LPG	25.62	26.28	24.71
Other fuels	21.37	21.90	21.46
Electricity	16.93	16.97	17.38
Water and gas	12.38	12.13	12.16
Road transportation	1.77	1.30	1.58
Other transportation	2.36	1.00	2.31
CPI	1.32	0.58	1.75

Table 6.3: Cost Share of Industries and Changes in Output

	Share of total input					Change in
	labour	Capital	Land	Energy	Oth. Int	Output
Paddy	51.40	16.56	14.50	0.00	17.54	0.09
Other food crops	57.36	17.35	15.20	0.01	10.09	0.05
Estate crops	52.73	11.21	8.88	0.29	26.89	-0.13
Livestock	42.39	8.08	3.41	0.03	46.08	0.13
Wood and forests	36.37	21.78	21.34	0.42	20.09	0.09
Fish	38.96	8.77	27.19	1.98	23.09	-0.08
Coal	8.09	72.01		13.17	6.73	-2.94
Crude oil	5.80	80.74		6.41	7.06	-0.29
Natural gas	5.81	80.97		6.44	6.77	-0.69
Other mining	26.38	47.48		2.16	23.98	-0.10
Rice	6.17	8.32		0.02	85.49	0.10
Other food (manufactured)	15.23	18.59		0.84	65.34	0.15
Clothing	14.58	19.10		0.83	65.48	0.41
Wood products	18.24	25.36		1.05	55.35	0.23
Pulp and paper	13.92	22.79		1.51	61.79	-0.07
Chemical product	11.88	14.70		3.56	69.86	-0.66
Petroleum refinery	7.54	57.83		8.04	26.60	-3.87
LNG	1.66	51.77		40.05	6.51	-2.89
Rubber and products	15.80	14.82		1.82	67.56	-0.20
Plastic and products	7.81	20.26		0.82	71.11	-0.05
Non-ferous metal	20.40	34.71		6.82	38.07	-1.61
Other metal	9.90	14.06		1.79	74.26	-0.37
Machineries	9.35	13.31		0.63	76.71	-0.50
Automotive industries	15.67	29.73		0.80	53.80	0.35
Other manufacturing	14.06	26.56		1.40	57.98	0.20
Electricity	5.92	50.14		19.33	24.62	-1.44
Water and gas	17.27	26.37		13.42	42.93	-2.24
Construction	23.09	9.55		4.76	62.60	-0.01
Trade	35.27	26.83		1.48	36.42	0.05
Hotel and restaurants	36.93	10.99		0.04	52.04	0.30
Road transportation	21.40	22.11		8.31	48.17	-0.66
Other transportation	12.48	18.17		10.33	59.01	-1.44
Banking and finance	18.90	53.47		0.25	27.38	0.23
General government	53.98	5.62		2.14	38.26	0.00
Education	43.72	8.54		1.10	46.65	0.11
Health	54.50	9.02		0.19	36.29	0.31
Entertainment	17.24	18.11		0.10	64.55	0.60
Other services	25.06	34.83		0.31	39.79	0.29

endowed with capital.

The changes in the return to factors as shown in Table 6.1, clarify these points. The adjustment in the production sectors affects the prices of factors. In general, the capital owner is hurt more compared with other factors. The return to capital declines the most, followed by real wages, and return to land. In all scenarios, the return to capital falls. In the labour market, for SIM 1, real average return to capital falls most by -5.77%, while the return to land falls by only 0.41%, and the fall in real wages varies depending on skills, but it is always much less than the fall in the return to capital. Real wages fall more for urban and formal skilled labour, reflecting the contraction in the industries employing this labour more intensively. The real

wage of urban formal production workers (mostly employed in the manufacturing sectors), urban formal clerical workers, and urban formal professional workers falls the most, by 4.6%, 3.1%, and 3.5%, respectively. On the other hand, agricultural labour only experiences a slight fall in real wages. This adjustment in the factor market will have an important impact because it can drive the distributional effect of a carbon tax to be more progressive from the income side.

As far as the macroeconomic impact or aggregate welfare is concerned, the revenue recycling mechanism in the form of lump-sum transfers is inferior to a commodity tax cut, given the same neutrality of the government budget. One possible explanation for this is that even though a lump-sum transfer for a rural household is a windfall, the economy is driven more by the spending of richer households. Therefore, a uniform tax rate cut for all commodities is more expansionary through the resulting increase in the demand for commodities.

6.3.2 Distributional results

Table 6.4 shows the summary of the distributional effect of a carbon tax for all three scenarios. In the table, both the poverty effect, indicated by the change in the head count poverty incidence, and inequality effect, indicated by the change in the Gini coefficients, are shown for urban, rural, and urban + rural households. Figure 6.2 illustrates in greater detail how each simulation affects household incomes, the household specific CPI, and household real expenditures across urban, rural, and expenditure classes.

In general, the simulations suggest that the introduction of a carbon tax in Indonesia would hurt urban households more than rural households. Its impact in rural areas would be progressive, suggesting the poor would gain relatively more than the rich, whereas in urban areas its distributional direction depends on how the revenue from a carbon tax is recycled. It is relatively neutral for the case of no-recycling and tax rate reduction, but progressive for the case of uniform lump-sum transfers. The overall net-impact nationwide is progressive for all scenarios, as can be seen from the reduction in the Gini coefficient.

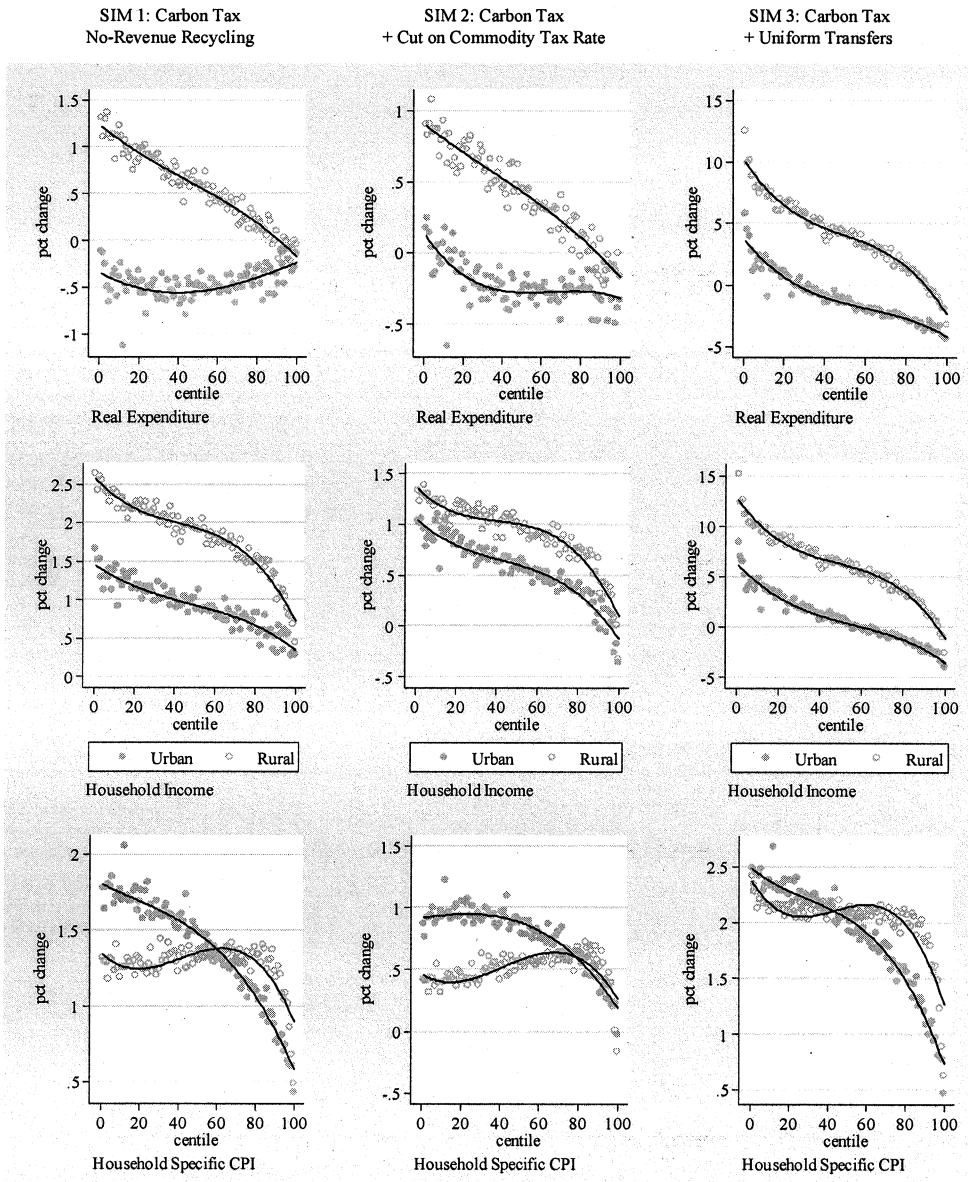


Figure 6.2: Simulated impact on households' real expenditure, income, and households' specific CPI

Table 6.4: Simulated Distributional Effect of a Carbon Tax

	SIM 1 No-revenue recycling	SIM 2 Uniform cut on com. tax rate	SIM 3 Uniform transfers
Urban			
Ex-ante Poverty Incidence	13.600	13.600	13.600
Ex-post Poverty Incidence	13.768	13.613	12.915
Change in Poverty Incidence	0.168	0.013	-0.685
Rural			
Ex-ante Poverty Incidence	20.200	20.200	20.200
Ex-post Poverty Incidence	19.430	19.743	16.198
Change in Poverty Incidence	-0.770	-0.457	-4.002
Urban + Rural			
Ex-ante Poverty Incidence	17.194	17.194	17.194
Ex-post Poverty Incidence	16.852	16.951	14.703
Change in Poverty Incidence	-0.343	-0.243	-2.492
Urban			
Ex-ante Gini Coefficient	0.347	0.347	0.347
Ex-post Gini Coefficient	0.347	0.347	0.337
Change in Gini Coefficient	0.000	0.000	-0.010
Rural			
Ex-ante Gini Coefficient	0.277	0.277	0.277
Ex-post Gini Coefficient	0.274	0.275	0.260
Change in Gini Coefficient	-0.003	-0.002	-0.017
Urban + Rural			
Ex-ante Gini Coefficient	0.350	0.350	0.350
Ex-post Gini Coefficient	0.347	0.348	0.333
Change in Gini Coefficient	-0.003	-0.002	-0.017

General results from the simulations suggest that almost all rural households experience a welfare gain as their real expenditure per capita rises. As can be seen from figure 6.2, these gains are distributed progressively, as the percentage changes in the welfare of poorer households are higher than for richer households. However, in simulations 1 and 2, almost all urban households are worse-off, and the effect is more or less neutrally distributed, while in simulation 3, the lowest 20% are better-off, and the distributive effect is progressive.

The driving forces behind these results are closely related to the impact of a carbon tax on both commodity prices and factor prices, combined with a distinct pattern of consumption and factor endowments for each household. From the simulations, it may be suggested that within the same expenditure class, households in rural areas tend to gain more (or to lose less) than households in urban areas. Both in urban and rural areas, poor households tend to gain more (or to lose less) than rich households, and the rural poor tend to gain greater benefit (or a smaller loss)

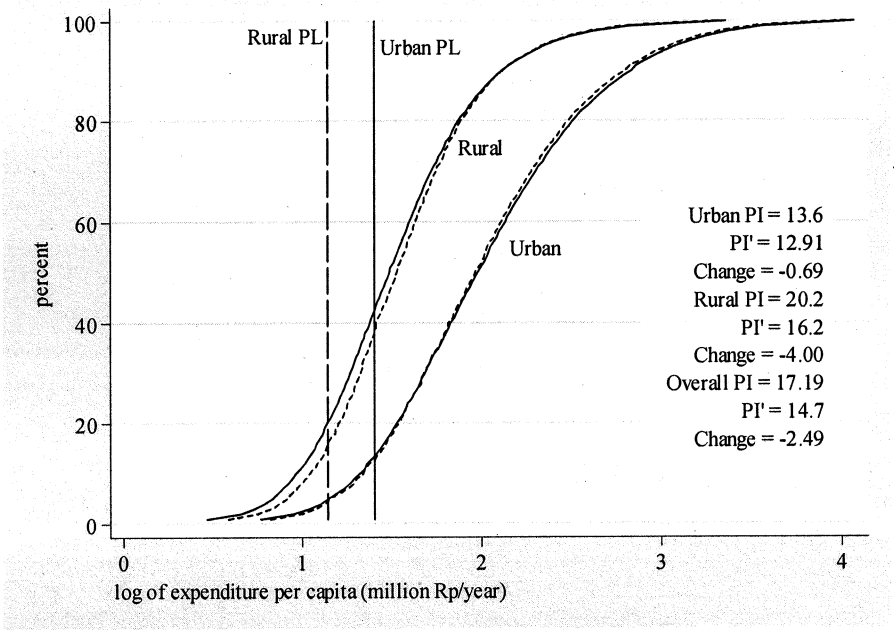


Figure 6.3: Simulated Poverty Impact of a Carbon Tax (SIM 3)

than the urban poor.

One of the contributing features of the CGE model with full-integration of disaggregated households is that it can reveal what causes the distributive effect from both the expenditure and the income pattern. Unlike a partial equilibrium analysis, which only looks at the demand side and is associated only with the expenditure pattern of the households, or even a CGE model with a separate top-down microsimulation model, the CGE model used in this study is able to offer deeper analysis on its distributive effect from the income side. From the story of the industry results, the factor reallocation in the economy tends to be biased against capital and skilled labour, and in favor of the agriculture and the services sectors, and hence agricultural, unskilled, and informal workers. This may explain why its distributive effect is progressive from the income side of households. As can be seen from Figure 6.2, in all scenarios, the percentage change in household incomes is clearly declining (suggesting progressivity) as expenditure centiles rise, both in rural and urban areas. Meanwhile, rural households' incomes, in general, increases more than urban household incomes.

This result is more or less explained by the typical characteristic of a develop-

ing country economy, where abundant unskilled and prevalently rural labour are employed in less energy-intensive and less capital-intensive sectors. In general equilibrium 'mechanics', there would be factor reallocation from energy-intensive sectors (which are mostly also capital intensive) into less energy-intensive (and less capital-intensive) sectors such as agriculture. Expansion in these sectors would have favourable distributional consequences in a developing country like Indonesia. For example, as shown before, the return to land, and the return to informal, unskilled, rural, agricultural workers rise relative to the return to capital or to formal skilled workers. This would drive the favourable distributional impact from the income side, as also illustrated by the declining percentage change in (nominal) income over expenditure centile both in urban and rural areas.

It may be expected that the characteristics of the economy are different in more developed countries, where most of the sectors are energy-intensive, capital-intensive and less agricultural. This may explain why the distributive effect of a carbon tax in developed countries has been reported in various studies as generally regressive. This study shows that the distributive effect of a carbon tax in developing countries may not necessarily be the same. This is still the case even if only looking at the income side pattern of households, which is related to typical factor market features in developing countries.

Moreover, the other side of the story is that the consumption basket of poorer households in Indonesia tends to be less energy intensive. For example, electricity usage, not to mention vehicle ownership, is not as common as in richer countries. So, there is an expectation that progressivity may also originated from the expenditure side.

As illustrated in the bottom panel of Figure 6.2, progressivity from the expenditure side could be determined if household specific CPI is increasing over the centiles, suggesting that the price paid for the total consumption bundle increases more for richer households than it does for poorer households. As shown in those figures, in rural areas this may be true from the poorest to around the 80^{th} centile, as from the 80^{th} centile, its pattern is declining. Hence, from the expenditure side,

it is progressive for the lower and middle income classes.

The story is rather different in urban areas. Poorer urban households are under pressure from the expenditure side. The household specific CPI is declining over the expenditure centile in urban areas, suggesting that the price paid by poorer households for their consumption basket increases more than that paid by richer households. This means urban household consumption is more sensitive to the price of energy-related products than rural households' consumption. Among others, these products are fuels, electricity, and transportation. What drives the regressivity from the expenditure side in urban areas is actually the lower-income households dependence on domestic fuel, especially kerosene. The dependence on kerosene is explained, among others, by the high kerosene subsidy, making its price much lower than the competitive market price. In turn, the regressivity from the expenditure side, and the progressivity from the income side, drive the neutrality of the distributive effect of a carbon tax in urban areas. However, overall the nationwide distributional impact is still progressive, despite the regressivity from the expenditure side in urban areas.

With regard to the impact on poverty, because rural households (especially lower income ones) experience an increase in real-expenditure, poverty in rural areas falls in all scenarios. As expected, rural poverty falls most (by 4%) when the revenue from a carbon tax is returned in the form of uniform lump-sum transfers (see Figure 6.3). Because the rural population is a lot larger than the urban population, the declining poverty incidence in rural areas helps nation-wide poverty incidence fall in all simulations, despite increasing poverty incidence in urban areas (for SIM 1 and SIM 2).

Comparing alternative revenue-recycling schemes suggests a uniform reduction in the general commodity tax rate has a favourable aggregate welfare impact (in terms of aggregate real consumption and GDP). GDP falls the least in SIM 2, with a magnitude of half of SIM 1. However, the uniform lump-sum transfer has more favourable distributional impact and inequality falls the most nation-wide. The Gini coefficient falls significantly by 0.017 compared with only 0.002 with a uniform sales

tax cut. The poverty impact of uniform lump-sum transfer is also most favourable. Poverty falls nationwide by 2.5%, which is due to the fall in rural poverty incidence of 4%, as shown in Figure 6.3.

However, a uniform reduction in the rate of commodity tax has a more favorable macroeconomic impact because of its potential for boosting consumption spending, as shown in the discussion of the macroeconomic impact in the earlier section. Moreover, a uniform cash transfer is not a common instrument of redistribution, and may be difficult to implement both administratively and politically.

It should also be noted that introducing a uniform reduction in commodity tax, may affect the direction of the initial distributive effect of a carbon tax when the carbon tax revenue is not recycled. First, the reduction in inequality (in terms of the reduction in Gini coefficient) is lower in SIM 2 (with tax-cut) compared to SIM 1 (no-recycling). Because the pattern of the change in the household specific CPI over the centiles from both simulations seems similar (except in its overall magnitude), it is less likely that commodity price rises contribute to the different result. This is understandable because the reduction in commodity taxes is uniform across commodities, hence will have a more or less similar impact on commodity prices. However, the pattern of the change in household income is relatively different between the two simulations. Comparing the change in income of urban and rural households, the figures show the gap between the change in income of urban and rural households is narrower in SIM 2 (tax-cut) compared to SIM 1 (no-recycling). This result may therefore suggest that what is happening in the factor market has driven the different distributional result between the two simulations.

Table 6.1 may help explain this result. The outputs of industries tend to fall with less magnitude in SIM 2, simply because of the increasing demand due to reduced prices brought about by a uniform sales tax-cut. The increase in demand for commodities offsets the decline in demand for labour by industries that would have happened without the tax-cut. Real wages of all types of labour rise instead of fall, and the return to capital falls much less in SIM 2 than in SIM 1. Some industries (such as pulp and paper, rubber, plastics, and machineries) manage to

avoid contraction and some others contract a lot less. Most of these industries are capital intensive, and employ more intensively urban-formal production workers and so may contribute in minimising the urban bias of the distributive effect of a carbon tax. However, despite these factors, a carbon tax with revenue recycled through a uniform reduction in the general sales tax is still progressive, inequality-reducing, adding to its preferability because of its more favourable macroeconomic effects.

6.4 Systematic sensitivity analysis

Table 6.5 shows the result of systematic sensitivity analysis for a carbon tax simulation (SIM 1, no-recycled revenue), assuming a triangular distribution in the parameters, with 50% variation from the mean, and applied using the Gaussian Quadrature approach. In general, the result suggests the result is robust to variation in the extraneous parameters, as shown by the low standard deviation of most endogenous variables.

However, some macroeconomic variables tend to be more sensitive to parameters. For example, statistically speaking, because the upper confidence interval of GDP or aggregate consumption is non-negative, it cannot be concluded that the GDP or aggregate consumption will fall following a carbon tax implementation with 90% confidence level. The CPI is relatively insensitive and CO_2 emission seems to have a very wide confidence interval.

For factor price variables, the real wages of some types of labour, such as agricultural labour, are relatively more sensitive, but the real wages of other types of labour are relatively less sensitive to variation in parameters. However, the qualitative direction is robust with even a 95% confidence level. Moreover, the pattern on the change in relative real wage for various type of labour[7], which has an implication in the distributional story, is robust to sensitivity analysis.

Looking at the confidence interval in real household expenditure by centile suggests the distributional impact of a carbon tax is less likely to be sensitive to pa-

[7]For example, the percentage change on the real wage of formal urban production workers, compared to the real wage of informal, rural, agricultural workers.

Table 6.5: SSA of SIM 1: Carbon Tax (50 percent Variation in All Parameters)

	mean	s.d.	Con. Interval (90%) lower	upper	Con Interval (95%) lower	upper
Macroeconomics						
GDP	-0.040	0.013	-0.081	0.001	-0.098	0.018
Aggregate consumption	-0.061	0.020	-0.122	0.001	-0.148	0.027
CPI	1.324	0.033	1.218	1.430	1.174	1.473
CO2 emission	-6.535	0.656	-8.609	-4.461	-9.468	-3.602
Real wage						
Agriculture, rural, formal	-0.587	0.127	-0.988	-0.187	-1.154	-0.021
Agriculture, urban, formal	-0.548	0.118	-0.922	-0.175	-1.077	-0.020
Agriculture, rural, informal	-0.478	0.120	-0.858	-0.099	-1.015	0.059
Agriculture, urban, informal	-0.497	0.111	-0.849	-0.144	-0.995	0.002
Production, rural, formal	-2.691	0.178	-3.254	-2.128	-3.487	-1.894
Production, urban, formal	-4.647	0.190	-5.248	-4.047	-5.497	-3.798
Production, rural, informal	-2.236	0.195	-2.851	-1.620	-3.106	-1.365
Production, urban, informal	-2.245	0.202	-2.883	-1.606	-3.148	-1.342
Clerical, rural, formal	-2.178	0.069	-2.397	-1.959	-2.487	-1.869
Clerical, urban, formal	-3.126	0.111	-3.479	-2.774	-3.625	-2.628
Clerical, rural, informal	-1.763	0.114	-2.124	-1.402	-2.274	-1.253
Clerical, urban, informal	-1.786	0.112	-2.139	-1.433	-2.285	-1.287
Professional, rural, formal	-3.183	0.134	-3.606	-2.761	-3.781	-2.586
Professional, urban, formal	-3.551	0.115	-3.915	-3.188	-4.065	-3.037
Professional, rural, informal	-2.198	0.184	-2.780	-1.616	-3.021	-1.375
Professional, urban, informal	-2.070	0.114	-2.431	-1.708	-2.581	-1.558
Average price of capital	-4.447	0.082	-4.705	-4.189	-4.813	-4.082
Average price of land	0.919	0.116	0.553	1.284	0.401	1.436
Output						
Coal	-2.933	0.454	-4.370	-1.496	-4.965	-0.901
Natural gas	-0.687	0.139	-1.128	-0.247	-1.310	-0.064
Refinery	-3.837	0.447	-5.252	-2.423	-5.838	-1.837
Electricity	-1.436	0.090	-1.722	-1.151	-1.841	-1.032
Water and gas	-2.238	0.066	-2.448	-2.028	-2.535	-1.941
Road transportation	-0.663	0.077	-0.906	-0.419	-1.007	-0.318
Other transportation	-1.430	0.172	-1.974	-0.885	-2.200	-0.659
Prices						
Coal	131.877	1.574	126.901	136.853	124.840	138.914
Natural gas	26.561	1.542	21.684	31.439	19.663	33.459
Gasoline	24.626	0.294	23.696	25.555	23.311	25.940
Diesel (Automotive)	45.251	0.828	42.634	47.868	41.550	48.952
Diesel (Industries)	43.442	0.786	40.957	45.927	39.928	46.956
Kerosene	29.305	0.534	27.615	30.995	26.915	31.695
LPG	25.714	1.293	21.626	29.802	19.932	31.495
Other fuels	21.389	0.696	19.187	23.591	18.275	24.503
Electricity	16.953	0.852	14.260	19.646	13.144	20.761
Water and gas	12.379	0.295	11.445	13.312	11.058	13.699
Road transportation	1.763	0.060	1.572	1.953	1.493	2.032
Other transportation	2.349	0.072	2.121	2.578	2.027	2.672
Real consumption						
Urban						
Centile 1	0.135	0.031	0.036	0.234	-0.005	0.275
Centile 2	0.083	0.031	-0.014	0.180	-0.054	0.220
Centile 3	0.060	0.030	-0.034	0.154	-0.072	0.193
Centile 4	-0.306	0.031	-0.403	-0.209	-0.443	-0.168
Centile 5	-0.514	0.039	-0.636	-0.393	-0.687	-0.342
Centile 13	-0.296	0.029	-0.386	-0.205	-0.423	-0.168
Centile 95	-0.247	0.028	-0.335	-0.159	-0.372	-0.123
Centile 96	-0.407	0.024	-0.482	-0.333	-0.513	-0.302
Centile 97	-0.223	0.026	-0.305	-0.141	-0.339	-0.107
Centile 98	-0.569	0.022	-0.640	-0.499	-0.669	-0.470
Centile 99	-0.509	0.020	-0.571	-0.447	-0.597	-0.421
Centile 100	-0.343	0.026	-0.424	-0.262	-0.458	-0.229
Rural						
Centile 1	1.657	0.070	1.434	1.880	1.342	1.972
Centile 2	1.546	0.068	1.331	1.760	1.242	1.849
Centile 3	1.625	0.077	1.381	1.869	1.280	1.970
Centile 4	1.711	0.063	1.511	1.911	1.428	1.994
Centile 5	1.453	0.063	1.254	1.652	1.171	1.735
Centile 20	1.157	0.058	0.974	1.339	0.899	1.415
Centile 95	0.002	0.040	-0.124	0.127	-0.176	0.179
Centile 96	-0.228	0.038	-0.347	-0.108	-0.396	-0.059
Centile 97	-0.251	0.035	-0.362	-0.139	-0.408	-0.093
Centile 98	-0.123	0.040	-0.250	0.004	-0.302	0.056
Centile 99	-0.049	0.049	-0.203	0.105	-0.267	0.169
Centile 100	-0.224	0.050	-0.383	-0.066	-0.448	0.000

rameter variation. For example, it can be concluded with 95% confidence that the real expenditure of the poorest 1% household in rural areas would rise at least by 1.342%, and that of the richest 1% of households will not be better-off (0% rise in expenditure per capita). Therefore, a carbon tax tends to reduce inequality in rural areas.

The direction of the impact on poverty can also be looked at from the point of view of what happens to the percentage change in real expenditure for households closest to the poverty line. Because a 95% confidence interval for the real expenditure of the 13th centile household is between -0.386% to -0.205%, it can be concluded that poverty would fall in urban areas following introduction of a carbon tax with 95% confidence.

6.5 Concluding Remarks

The simulations suggest that in contrast to most studies for developed countries, implementation of a carbon abatement policy via the introduction of a carbon tax in Indonesia would not necessarily be regressive. Instead, it would be strongly progressive and robust to various alternative recycling-schemes in rural areas. It would be either neutral or slightly progressive in urban areas. Its overall distributive effect nation-wide would be progressive, as shown by the decline in inequality indicators.

A closer look at what may contribute to the favourable distributive effect of a carbon tax reveals the progressivity is driven from both household income and expenditure pattern. The resource reallocation in the economy following the introduction of a carbon tax would be in favour of factors endowed more proportionally by rural, and lower income households, as shown, for example, by contraction of the energy intensive manufacturing sectors and expansion of the agriculture and service sectors. The typical expenditure pattern in developing countries, which is less-energy-sensitive, also helps drive progressivity of the result especially in rural areas.

The results may have important global policy implications. Encouraging de-

veloping countries to reduce carbon emissions not only increases the efficiency of carbon abatement globally, but may also have a favorable distributional implication for the developing countries themselves, in contrast to a less preferable distributional impact in developed countries. Whereas a global 'efficiency gain' from shifting the location of carbon abatement from industrialised to developing countries has been widely acknowledged, this study introduces the addition notion of a 'global equity gain'.

Chapter 7

Case Study II: Energy Pricing Reform

7.1 Background

In NEF (2004), it was suggested that the global fuel subsidy could amount to between 250 and 300 billion dollars a year, which could comfortably pay off sub-Saharan Africa's entire debt burden and still leaves billions of dollars to spare. The fuel subsidy creates a distortion by disregarding the economic value of fuel, creating excess consumption and discouraging energy substitution. The fuel subsidy has been a constraint on the agenda to switch the future direction of the country's energy mix following Indonesia being a net oil importer since 2004.

The fossil fuel subsidy is also regarded as a major cause of environmental problems, not only from the pollution created by excessive fossil fuel combustion by industry and vehicles, but also due to excessive traffic and the inconvenience it causes. The fuel subsidy also discourages the development of a more traffic-free public transport infrastructure. In most big Indonesia cities, this is already a major public concern.

In addition to the above efficiency-related problem, the fuel subsidy is often regarded as inequitable. Vehicle owners benefit greatly from the subsidy, and fuel price reform has been widely advocated as a means of promoting efficiency as well as equity.

However, in the Indonesian context, the biggest concern is the fiscal burden

Table 7.1: Fuel Subsidy, Government Budget, and Oil Price, 1999 - 2006

	1999	2000	2001	2002	2003	2004	2005	2006
Fuel Subsidy (Rp Trillion)	40.9	53.8	68.4	31.2	30.0	59.2	89.2	62.7
Government Spending (Rp Trillion)	201.9	188.4	260.5	322.2	376.5	430.0	411.6	470.2
Percent	20.26	28.56	26.25	9.68	7.97	13.77	21.67	13.34
World crude oil price ($/barrel)	17.12	27.07	22.72	23.47	27.1	34.62	49.86	60.32

Source: Ministry of Finance, and U.S. IEA

of the subsidy. For example, in the year 2000 the fuel subsidy amounted to 53.8 trillion rupiah, or almost a third of total central government spending (see Table 7.1). Since the government always has a political constraint with regard to reducing this subsidy, spending has been heavily constrained by the fluctuation in the world oil price.

When the world oil price started to rise rapidly from 2004 onward, the government saw no option but to reform its fuel pricing policy radically. In October 2005, the government made a big adjustment in fuel prices following a rapid rise in the world crude oil price. So, in the end, it was international market and not the efficiency argument campaigns from energy-pricing reformists that urged the government to implement the reform.

Over the fast few years, reduction of the fuel subsidy has been one of the Indonesian government's main agendas. It has made a gradual reform in fuel pricing policy through adjustments in fuel prices since the year 1999 (see Box 1 and Figure 7.1).

However, strong opposition from the people and parliament has slowed the reform. Most arguments against the reform were based on the concern that an increase in fuel prices would translate into an increase in other prices, and that would reduce purchasing power, and exacerbate poverty. The fear was that the rise in fuel prices would create a chain reaction, affecting other costs like transportation and other important commodities, thereby hurting the economy, and the most vulnerable.

Box 1. Timeline of Indonesian Fuel Pricing Policy

1 January 1999

Before 1999, all fuel prices were heavily subsidised. Since January 1999, the government of Indonesia (GOI) has allowed the aviation fuel price to follow the market mechanism. At that time the price of Avtur was Rp. 1,700 and the price of Avgas was Rp. 1,080.

1 April 2001

Fuel prices were set according to three categories: (a) fuels consumed by the general public were subsidised; (b) fuels for industry were set at 50% of the market price (mean of Platts Singapore of the previous month plus 5 percent), and would be increased gradually; (3) fuels for international business activities were 100% of the market price.

16 June 2001

Another adjustment with a statement that fuel prices for industry could be increased or decreased depending on international prices.

6 January 2002

The gasoline price was adjusted to accord fully (100%) with the international price; the kerosene price for the general public was increased to Rp. 600. Other fuel (for industry) prices were set at 75% of the market price. the GOI also sets a price ceiling system (maximum and minimum retail price) depending on international crude oil prices

1 March 2002

The GOI delegated monthly retail prices to PERTAMINA (state-owned oil company). At PERTAMINA's discretion, fuel prices may fluctuate according to average market prices. Fuel prices (except kerosene) started to fluctuate relatively more often during 2002 (see figure 7.1). Adjustment to fuel prices was made in April, May, June, July, August, September, October, November, and December 2002.

1 January 2003

The price of kerosene was increased from Rp. 600 to Rp. 700. The usual adjustment in other fuel prices was made. Adjustment in the price of fuels (except kerosene) was made almost every month after that. The GOI increased the diesel price by 21.9% but then reduced it again by 6.5% due to public protest. Figure 7.1 shows a rare case where the diesel price fell in February 2003.

1 October 2005

The GOI released Presidential Decree (Perpres) no. 55/2005 declaring a massive increase in the price of gasoline from Rp. 2400 to 4500 (87.5%), in diesel from Rp. 2100 to Rp. 4300 (104.7%) and in kerosene from Rp. 700 to Rp 2000 (185.7%).

The reform package was announced on 1 October, 2005, increasing retail fuel prices for gasoline, kerosene, and diesel. The price of gasoline was increased by 87.5%, diesel by 104.7% and surprisingly kerosene by 185.7%. The huge increase in the kerosene price stirred doubt among many economists - who initially regarded subsidy reduction was equitable - over the distributional direction of this reform[1] because kerosene is the primary energy source for urban poor.

7.2 Previous Studies

The World Bank (2006) is the only available study that assesses the distributional impact of the October 2005 Package. Other studies do exist that analyse the impact

[1] Among others are Azis (2006), Oktaviani et al. (2005), and many other commentators in the media.

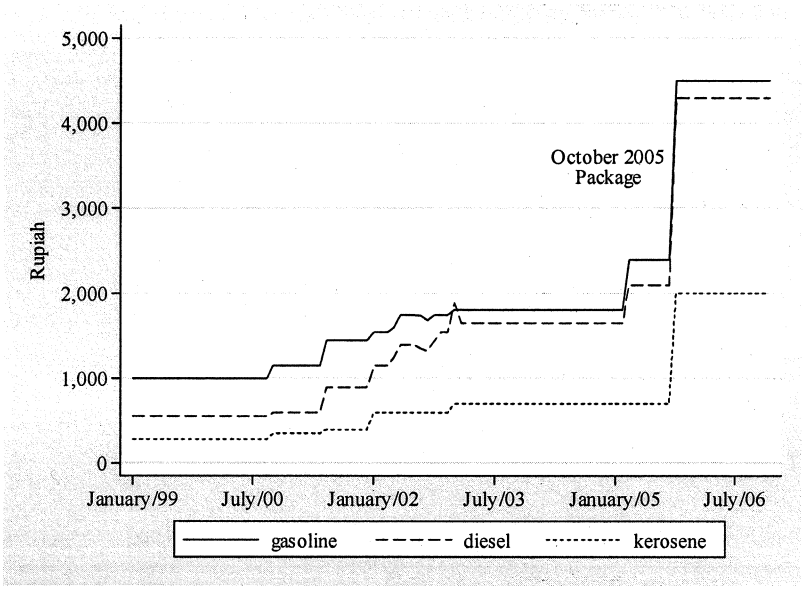


Figure 7.1: Price of gasoline, diesel, and kerosene, 1999 - 2006

of fuel subsidy reduction or fuel price rise for Indonesia although they do not explicitly analyse the October 2005 reform. These are Clements et al. (2003), Sugema et al. (2005), and Ikhsan et al. (2005) published before the October 2005 package was implemented.

The method used by the World Bank (2006) is a simulation using SUSENAS 2004 household survey data. It looks at the impact of the increase in various fuel prices on household expenditure, assuming no mitigating substitution effects. The total impact is disaggregated into the impact of the fuel price increase on the price of public transport (assuming 25 percent pass-through of the diesel price); and the general impact of residual inflation on the rest of the consumption bundle. The overall incremental inflation (due to the fuel price increase) assumption is based on a time-series analysis of the overall elasticity of inflation to the fuel price increase (0.06 percent for 10 percent increase in fuel prices). The residual (non-fuel and non-transport) incremental inflation rate is computed at about 1.9 percent for the October fuel price increases.

The result suggests that, in the absence of any compensatory measures, the October 2005 package would have led to a 5.6 percentage point increase in poverty

incidence. Compensation in the form of an unconditional cash transfer to poor and near-poor households would, on average, more than offset the negative impact of the fuel price increase. Hence, the impact of the combined effects of the fuel price increase and the compensation point to an overall net positive income gain for the poorest 20 percent of the population. With even greater mistargeting of this random cash benefit to the bottom 60%, the World Bank (2006) concludes that the reform still leads to a positive net impact on the bottom 40%.

However, it is not clear from this study, how household behaviour [2] is modelled. Although the transmission mechanism from the increase in fuel prices on inflation seems to be based on historical data, other price transmissions, such as the increase in transport price from the increase in the diesel price seems to be ad-hoc. The simulation does not take into account the economy-wide effect of the fuel price rises on the supply side, and its likely impact on households' factor income. It seems that household income is assumed to be fixed, only changed by cash compensation.

Another study by Ikhsan et al. (2005) analyses the distributional impact of the March 2005 fuel price adjustment that increased the price of kerosene to industry by 22.22%; gasoline by 32.60%; diesel for transportation by 27.27%; diesel for industry by 33.33; and diesel oil and fuel oil by 39.39%. Because the price of kerosene for domestic household use was not increased, the urban poor's consumption of kerosene was not directly affected by this reform. Therefore, the impact on poverty or inequality would be minimal.

The method used by Ikhsan et al. (2005) is a combination of a Computable General Equilibrium (CGE) model (INDOCEEM[3]) and a simulation using household survey data making it more or less similar to the method used by the World Bank (2006). However, the price changes are taken from the CGE model simulation. In the literature, this approach is in a class of top-down micro-simulation approach. In this class of approach, a CGE model and a micro-simulation model are not integrated. The CGE model is first solved, and its price results are transferred to the

[2]The description of the methodology is not explained in detail but only briefly in the footnote.
[3]The INDOCEEM model is an Indonesian CGE model based on ORANI-G developed initially by Monash University and the Indonesian Ministry of Energy.

micro-simulation model. The household survey data used was the SUSENAS 2002 consumption module.

The policy examined by Ikhsan et al. (2005) is the March 2005 fuel price adjustment with various compensation schemes in the form of subsidies to rice and education spending by the poor with various assumptions about effectiveness. The fuel price increase was simulated in the INDOCEEM model, and that produced increases in the price of all other commodities. For example, the simulation suggests an increase in the Consumer Price Index (CPI) of 0.97%. The price increases were then transferred to the SUSENAS micro-simulation model. The result suggests and by 0.24% without compensation, whereas poverty falls by 2.6% with compensation that is 100% effective, and by 1.89% with compensation that is 75% effective (Ikhsan et al., 2005, table9). The policies simulated reduce inequality slightly.

The advantage of the method used by Ikhsan et al. (2005) is the use of a CGE model where different various fuel commodities are distinguished allowing for different shocks to different type of fuels[4]. However, the methodological caveat of this approach is that there is only one single representative household in the CGE model. Therefore, in order to see the distributional impact, it has to rely on other methods.

When the price changes are transferred from the macro (CGE) model to the SUSENAS-based micro-simulation model, they become exogenous. In reality, the structure of demand of various households determines new equilibrium prices. Conversely, using a top-down approach, the price changes used in the micro-simulation are only determined in a single household CGE model. In addition, there is no connection with the factor market in the micro-simulation, hence households factor income will not affected by the policy shock because there is no direct link between the supply side and household income.

In another study, Clements et al. (2003) use a CGE model based on data from a Social Accounting Matrix with multi households, hence household heterogeneity

[4]Not many CGE models can do this because even with 175 sectors I-O table, the petroleum product sector is not disaggregated. INDOCEEM used a specially designed I-O table built with the help of the Indonesian Statistics office (BPS).

is integrated[5] directly into the CGE model. Clements et al. (2003) examine the scenario of increasing the price of petroleum products by 25%. However, the model has only one type of aggregated fuel commodity. This limits the distributional analysis because to be relevant, at least kerosene (an important fuel for poor households) should be distinguished. Another disadvantage of the model is it only has 10 categories of household grouped by socioeconomic classes and not by income size. Therefore, direct progressivity or regressivity as well as poverty incidence cannot be assessed easily.

The Clements et al. (2003) study suggests aggregate real household consumption falls from 2.1% to 2.7% following a 25% increase in the price of petroleum products. Urban and high income households suffer the most, indicating the progressivity of the reform. However, it should be noted the high income category indicated in the SAM is not necessarily the highest income size, but is based on the socioeconomic characteristics of mainly household type of occupation. Clements et al. (2003) argue that high income household groups suffer more because they are endowed with relatively more capital and the sectors where production declines most are capital intensive. Higher-income groups also consume more petroleum products and utilities. The study also reports an increase in poverty incidence. However, the poverty incidence is calculated by assuming a certain value of elasticity of poverty to mean consumption.

Another study is conducted by Sugema et al. (2005) which analyse the impact of the March 2005 fuel prices rise. In this study, the poverty impact analysis is carried out using a SUSENAS-based micro-simulation, and the macro-impact is analysed using an ORANI-based CGE model. The analyses are conducted separately, and neither are integrated nor top-down.

The CGE model used in Sugema et al. (2005) has 10 household groups, as classified in the Indonesian Social Accounting Matrix (SAM). The model is used to simulate a 29% average increase in the petroleum price. Because there is only one aggregated petroleum product in this model, the price increase does not re-

[5] As opposed to a top-down approach as in Ikhsan et al. (2005)

ally represent the March 2005 price adjustment as kerosene price did not rise in this package, so that the impact on households will be over-estimated. The result suggests household petroleum product consumption falls from 17.51% to 22.86%. Aggregate household real consumption falls by 0.99% (without compensation), and by 0.91% (with compensation).

The more detailed distributional story in Sugema et al. (2005) is analysed using SUSENAS 2004 data. The increase in the fuel prices in March 2005 is *assumed* to lead to inflation of 12.5%. Various assumptions on the effectiveness of compensation are based on the examination of similar compensation schemes conducted previously. The result suggests poverty would rise by 1.95%. This poverty impact seems relatively high considering the petroleum price only rises by 29%. The reason could be due to the assumed high elasticity of inflation with respect to the fuel price rise, which is 0.43, as well as high elasticity of the poverty line with respect to inflation (of 1.3). By comparison, the World Bank (2006) only assumes 0.06 percent inflation for every 10 percent increase in fuel prices based on historical data.

7.3 Scenario and simulation strategy

In this case study, the CGE model described in Chapter 5, will be used to simulate the economy-wide and distributional impact of the October 2005 package. It attempts to answer in greater detail whether the reform is progressive or regressive, as well as its likely impact on poverty incidence. It also evaluates various scenarios of reform each with a different types of compensation schemes with the aim of providing better alternative scenarios for further future reform. This is relevant because, even after the last 'shocking' fuel price increase in October 2005, the price of gasoline and kerosene were still only 70% and 31% respectively of the market price. The government plans to remove this subsidy totally in the next one to two years. Therefore, this is still an important policy that will remain in the near future, especially because kerosene is consumed proportionally more by the urban poor.

Table 7.2 summarises the scenarios to be simulated. All of these scenarios are

Table 7.2: Simulation Scenarios: Energy Price Reform

	Scenario	Note
SIM 1.	NO-KER	October 2005 Package without increasing kerosene price (Gasoline 87.5%, Diesel 104.7%)
SIM 2.	ALL FUELS	October 2005 Package (Gasoline 87.5%, Diesel 104.7%, Kerosene 185.7%)
SIM 3.	100% UT	October 2005 Package with unconditional cash transfers to targeted household of Rp. 1.2 million with 100% effectiveness.
SIM 4.	75% UT	October 2005 Package with unconditional cash transfers to targeted household of Rp. 1.2 million with 75% effectiveness.
SIM 5.	100% UTUR	October 2005 Package with unconditional cash transfers to targeted household with higher amount to urban household and lower amount to rural household (100% effectiveness)
SIM 6.	SUB ONLY	Transfers as subsidy on education and health
SIM 7.	SUB	October 2005 Package with subsidy on education and health

related to the October 2005 package of fuel pricing reform, i.e., increasing the price of gasoline by 87.5%, diesel by 104.7%, and kerosene by 185.7%. The initial database is modified to mimic the fuel price system of the year 2005 before implementation of the reform, in the sense that the rate of fuel subsidy represents the situation in 2005 where the market (or international) price of fuel products was relatively high due to the rapid increase in the crude oil price.

There are two ways to conduct the simulations. The first is by reducing the rate of subsidy on fuels and let their price be determined endogenously by the model. However, this would not exactly mimic implementation of the reform in reality because fuel prices are administered or determined in Indonesia. Once new fuel prices are announced they stay the same until another adjustment and can be regarded as exogenous in this sense. In addition, it is difficult to determine how much the subsidy rate should be reduced to mimic the October 2005 package. The second approach is then used, in which the price of fuels is set exogenously and the subsidy rate is set to be determined endogenously in the model. In this way, the simulation can exactly represent the rate of the price increase as announced by the government on the 1st of October 2005.

The objective of Simulation 1 (SIM 1 NO-KEROSENE) is to see the economy wide impact of the October 2005 package and more importantly, its distributional direction had the kerosene price increase not been part of the reform. Many Indonesian economists believe a fuel price subsidy benefits the rich more, hence its removal or reduction will hurt them more than the poor, and would therefore be considered progressive. This expectation is usually based on anecdotal evidence of vehicle ownership where vehicle fuels are an important part of the expenditure of the rich. However, because kerosene is an important part of the consumption of the poor in urban areas, it may be incorrect too generalise that a subsidy on all types of fuels is regressive. In this scenario, the price of gasoline and diesel will be increased, but kerosene will be excluded. Compensation is also excluded to examine the initial distributional direction of the impact of the subsidy reduction policy.

In Simulation 2 (SIM 2 ALL FUELS), the October 2005 reform package, i.e., increasing the price of gasoline, diesel, and kerosene, is implemented without compensation to see the likely distributional impact if a major reform were to be implemented without compensation.

Simulation 3 (SIM 3 100% UT) is exactly what was implemented by the government. It is an increase in the price of gasoline, diesel, and kerosene, plus unconditional cash transfers to targeted households. Being unconditional means the transfers are lump-sum and recipient households have discretion over its use.

In all the simulations, initial or ex-ante poverty incidence is based on the official SUSENAS-based poverty incidence in 2005[6]. However, it transpired that the target of the compensation was not only those below the official poverty line, but also those known as near poor. The number of targeted households was greater than the number of the 'officially' poor.

Initially, the program targeted 15.5 million poor and near-poor households (around 28 percent of the national population and in excess of the poverty rate of 16 per-

[6]Poverty line is calculated based on this official poverty incidence. This poverty line then will be used to calculate ex-post poverty incidence from ex-post distribution of real expenditure per capita. The calculation of poverty incidence is all in real term based on the change in real expenditure per capita. Real poverty line, then is a constant.

cent) (ESMAP, 2006). However, the recipients list was later inflated to 19.2 million households (BPS, 2006) and far outnumber the poor as defined by the SUSENAS poverty line. The calculation suggests the number of recipient households is almost twice the poverty incidence in urban and rural areas. Based on this calculation, cash transfers in the simulation will be given to the lowest 24% of the population in urban areas, and the lowest 42% in rural areas (twice the percentage of the poor in the respected population). With this assumption, the total amount transferred is Rp. 18.3 trillion rupiah[7]. The World Bank (2006) considered this scheme to be the world's largest ever cash transfer program. Rp 300,000 per household and was disbursed every three months, totalling Rp 1.2 million in one year.

In Simulation 3, it is assumed that the compensation scheme is 100% effective, although this is clearly too idealistic. There are many possible sources for the ineffectiveness of the compensation. The ex-ante targeting may be imperfect, in the sense that some entitled households were not included while some households not entitled were targeted. This source of ineffectiveness was mainly due to statistical recording errors. Another source of ineffectiveness is the possibility that compensation did not fully reach the targeted households (although the cash has already been disbursed). This may happen due to ineffective administration or bureaucracy in the disbursement process, as well as to corruption.

However, there is not yet any consensus on the degree of effectiveness of the compensation scheme. An estimate of the degree of effectiveness of the scheme may be indicated by a study conducted by SMERU (2006). The study compares the number of recipient households with the number of poor households across regions and examines their correlation. This was possible because the study uses a type of poverty mapping that enables observation in geographical detail. The exercise suggests a coefficient of correlation of 0.65 to 0.72. Based on this, another simulation, Simulation 4 (SIM 4. 75% UT), is conducted, assuming the effectiveness of compensation is 75 percent. In this simulation, the amount of cash given to every

[7] At the 2003 price level, since the model database is using SAM 2003. For comparison with the actual amount of transfers, it is calculated that with 19.2 million households as beneficiaries, the actual amount at the 2005 price level will be around Rp 23 trillion rupiah.

centile group of targeted households is reduced by 25%[8].

Another issue that seems to be missing in the public discussion with regard to the effectiveness of the compensation scheme is the rather simplistic approach of giving the same amount of money to all households across Indonesia. Indonesia is a large country, and its geographic nature comprising an archipelago of thousands of islands is one of the reasons why price level, for example, vary greatly across regions. Even though setting and planning different amounts of transfers to different regions may seems to not be a simple task, some distinction between urban and rural households could have made more sense. Simply by using information from the most recent household survey, it is easy to see that urban households will be hurt more than rural households by any jump in the kerosene price simply because poor rural households consume much less kerosene. Therefore, giving more money to urban poor and less to rural poor be regarded as a sensible option. Simulation 5 (SIM 5 100% UTUR) attempts to simulate a slight modification in the scheme by giving different amounts of transfers to urban and rural households recognising the possibility that urban households would be affected more by the reform.

In this simulation (SIM 5), the same amounts of total budget is allocated but urban households receive a higher amounts of transfer than rural households. The amount of money transferred to urban households is increased by 70 percent and the transfers to rural households are reduced by 30 percent. This figure is ad-hoc, with the constraint that the total aggregate amount of the compensation is the same, and the results would not increase poverty in rural areas. As this simulation assumes 100 percent effectiveness, it is comparable to SIM 3.

The compensation scheme being an unconditional lump-sum cash transfer invites much criticism. Giving a cash lump-sum to poor households with total discretion as to its spending left up to them can be seen to be a less wise way of helping the poor compared to giving them education, for example. However, critics may be missing the point that this transfer is by nature a compensation. The idea is to mitigate

[8]This can be interpreted as mistargeting households within each centile group or it may also be interpreted as the amount of cash being received by the targeted households diminishes by 25%. In practice, both cases could happen.

the adverse distributional effect of fiscal and efficiency-motivated reform.

SIM 6 (SUB ONLY) and SIM 7 (SUB) are implemented to account for the idea of subsidising human capital investment as a compensation for fuel pricing reform. Had the compensation scheme built in this kind of subsidy, what would its distributional impact have been? To explore this issue, Simulation 6 (SIM 6 SUB ONLY) first introduces a subsidy to targeted households for spending on health and education unrelated to fuel pricing reform. The purpose is to discover the distributional direction of this sort of compensation scheme. In Simulation 7 (SIM 7 SUB), the subsidy is combined and built into the fuel pricing reform of the October 2005 package. For comparison purposes, the subsidy rate for targeted households is increased (in similar proportions between education and health) so that the budget allocated is equivalent to the unconditional cash transfers.

7.4 Results and discussion

7.4.1 Macroeconomic and industry results

Table 7.3 shows the impact of various different scenarios on selected macroeconomic variables and industry output. The increase in the price of gasoline by 87.5%, diesel by 104.7%, and kerosene by 185.7% reduces real GDP by around 2.7% for Simulations 2, 3, 4, and 5[9]. Employment falls by around 5.5 percent and aggregate real household consumption, which can be interpreted as an index of aggregate welfare, falls by around 4 percent under the same scenarios. The decline in real GDP and aggregate consumption for Simulation 1 is much smaller because it does not include an increase in the price of kerosene. In Simulation 7, the smaller decline in real GDP and aggregate consumption can be explained by the increasing demand for factors employed in the health and education sectors due to the subsidisation of these sectors.

In all simulations, except for Simulation 6, industry output falls as a result of the increase in the price of petroleum products. The increase in fuel prices lowers

[9]Compared to base line, without the reform.

fuel demand resulting in an immediate reduction in the output of the refinery industry. The final (new equilibrium) reduction in the output of petroleum refineries is around 8 percent in Simulations 2,3,4, and 5. Other industries which experience big contractions are those closely related to the petroleum refinery sector. For example, in Simulation 2, these are road transportation (−4.87%), other transportation (−6.62%), utility sectors (electricity by −3%, and water and gas by −4.15%), and some manufacturing industry (automotive by −4.4% and rubber and products by −4.91%). After simulating an increase in the price of petroleum products, Clements et al. (2003) report that industries which experience a large contractions are similar type of industries to those just mentioned.

7.4.2 Distributional results

One of the advantages of the CGE model with households disaggregated by centile of expenditure per capita, is direct calculation of the inequality indicator such as (but not limited to) the Gini coefficient[10]. Therefore, an objective answer to the question of whether a policy shock is progressive or regressive is readily available. When the policy simulation increases the Gini coefficient, the policy can be judged regressive. If it reduces the Gini coefficient, it can be regarded as progressive. In addition, as shown in Chapter 5, the model also allows direct calculation of poverty incidence, in urban areas, rural areas, and all of Indonesia.

The following discussion focuses on the distributional results, i.e., with concentration on inequality and poverty incidence, for all the simulated scenarios. Table 7.4 summarises the distributional results of the simulations.

Figures 7.2 to 7.8 illustrate the impact of each scenario on household real expenditure, income, and household specific consumer price index (CPI) for urban and rural households as well as across centiles. In the same figures, Gini coefficients including the Lorenz curve for urban, rural, and nation-wide are reported. How each scenario affects real expenditure of each household group can be indicated from these figures. The percentage change in real expenditure is used to calculate inequality

[10]See detailed discussion in Chapter 5.

Table 7.3: Simulated Macroeconomic and Industry Results: Energy Price Reform

	Scenario						
	1	2	3	4	5	6	7
Macroeconomic							
Gross Domestic Product (real)	-1.72	-2.67	-2.68	-2.68	-2.67	0.24	-2.42
Household expenditure	-2.61	-4.03	-4.03	-4.03	-4.02	0.36	-3.65
Export	-1.72	-2.40	-2.46	-2.44	-2.45	0.37	-2.07
Import	-2.38	-3.32	-3.40	-3.38	-3.39	0.51	-2.86
Employment	-3.32	-5.52	-5.53	-5.53	-5.52	1.57	-4.19
Industry output							
Paddy	-0.57	-1.22	-0.88	-0.96	-0.97	0.24	-0.97
Other food crops	-1.04	-2.06	-1.81	-1.87	-1.85	0.22	-1.81
Estate crops	-1.57	-2.81	-2.71	-2.74	-2.72	0.43	-2.39
Livestock	-1.67	-3.13	-2.91	-2.97	-2.94	0.30	-2.81
Wood and forests	-0.96	-1.71	-1.69	-1.69	-1.70	0.31	-1.40
Fish	-1.08	-1.91	-1.76	-1.80	-1.80	0.11	-1.76
Coal	-0.06	-0.12	-0.12	-0.12	-0.12	0.02	-0.10
Crude oil	-0.14	-0.16	-0.17	-0.16	-0.17	0.01	-0.15
Natural gas	-0.19	-0.21	-0.21	-0.21	-0.21	0.01	-0.19
Other mining	-0.52	-0.75	-0.76	-0.76	-0.76	0.11	-0.64
Rice	-0.52	-1.14	-0.79	-0.87	-0.89	0.23	-0.91
Other food (manufactured)	-1.91	-3.37	-3.13	-3.19	-3.16	0.27	-3.07
Clothing	-2.14	-3.71	-3.67	-3.68	-3.68	0.51	-3.23
Wood products	-1.10	-1.98	-2.10	-2.07	-2.11	0.23	-1.74
Pulp and paper	-2.32	-3.57	-3.63	-3.61	-3.59	1.87	-2.02
Chemical product	-2.79	-4.08	-4.02	-4.04	-4.03	0.61	-3.53
Petroleum refinery	-4.57	-7.93	-7.95	-7.94	-7.95	0.10	-7.85
LNG	-0.83	-0.79	-0.79	-0.79	-0.79	0.02	-0.77
Rubber and products	-3.34	-4.91	-5.09	-5.05	-5.08	0.63	-4.35
Plastic and products	-1.97	-3.16	-3.18	-3.18	-3.21	0.38	-2.80
Nonferrous metal	-1.09	-1.63	-1.61	-1.61	-1.62	0.33	-1.34
Other metal	-1.53	-2.19	-2.22	-2.21	-2.23	0.39	-1.85
Machineries	-3.16	-4.79	-4.95	-4.91	-4.97	0.60	-4.27
Automotive industries	-3.10	-4.42	-5.02	-4.87	-5.01	0.44	-4.03
Other manufacturing	-2.36	-3.87	-3.70	-3.74	-3.73	0.64	-3.28
Electricity	-1.98	-2.99	-2.91	-2.93	-2.86	0.41	-2.60
Water and gas	-2.98	-4.15	-4.49	-4.40	-4.35	0.39	-3.78
Construction	-0.15	-0.22	-0.22	-0.22	-0.22	0.26	-0.01
Trade	-1.95	-3.29	-3.17	-3.20	-3.14	0.52	-2.81
Hotel and restaurants	-2.13	-3.78	-3.81	-3.80	-3.73	0.50	-3.30
Road transportation	-3.53	-4.87	-4.91	-4.90	-4.86	0.62	-4.32
Other transportation	-5.18	-6.62	-6.70	-6.68	-6.66	0.74	-5.97
Banking and finance	-1.63	-2.72	-2.90	-2.85	-2.85	0.37	-2.38
General government	-0.08	-0.12	-0.13	-0.13	-0.13	0.01	-0.11
Education	-1.58	-2.52	-2.52	-2.52	-2.40	12.31	7.29
Health	-1.50	-2.56	-2.51	-2.52	-2.52	13.63	8.69
Entertainment	-2.26	-3.86	-4.22	-4.13	-4.19	0.64	-3.29
Other services	-2.36	-3.65	-4.05	-3.95	-4.00	0.29	-3.36

and poverty incidence after each shock (ex-post). In addition, the household income and household specific CPI changes indicate how the expenditure and factor income patterns of each household contribute to the distributional results.

In an economy-wide framework, both expenditure and income patterns contribute to the distributional story. They are integrated and taken into account simultaneously in the model. Household specific CPI is a consumption-weighted average of the price increase of every commodity consumed by the respective household. It reflects the contribution of its household expenditure pattern and behaviour. On the other hand, the change in household income reflects the changes in all sources of household income, comprising income from labour by skill types, capital, land, and transfers (such as from compensation).

Table 7.4: Summary of distributional results: Energy Price Reform

	SIM 1 PAKTO'05 NO-KER	SIM 2 PAKTO'05	SIM 3 PAKTO'05 100 UT	SIM 4 PAKTO'05 75 UT	SIM 5 PAKTO'05 100 UTUR	SIM 6 CT	SIM 7 PAKTO'05 CT
Urban							
Ex-ante Poverty Incidence	11.370	11.370	11.370	11.370	11.370	11.370	11.370
Ex-post Poverty Incidence	12.525	14.002	12.485	12.780	11.400	9.444	12.311
Change in Poverty Incidence	1.155	2.632	1.115	1.410	0.030	-1.926	0.941
Rural							
Ex-ante Poverty Incidence	19.510	19.510	19.510	19.510	19.510	19.510	19.510
Ex-post Poverty Incidence	20.067	21.341	17.415	17.900	19.158	17.363	19.864
Change in Poverty Incidence	0.557	1.831	-2.095	-1.610	-0.352	-2.147	0.354
Urban + Rural							
Ex-ante Poverty Incidence	15.803	15.803	15.803	15.803	15.803	15.803	15.803
Ex-post Poverty Incidence	16.632	17.999	15.170	15.568	15.625	13.757	16.424
Change in Poverty Incidence	0.829	2.196	-0.633	-0.235	-0.178	-2.046	0.621
Urban							
Ex-ante Gini Coefficient	0.347	0.347	0.347	0.347	0.347	0.347	0.347
Ex-post Gini Coefficient	0.344	0.352	0.345	0.347	0.341	0.341	0.346
Change in Gini Coefficient	-0.003	0.005	-0.001	0.000	-0.006	-0.006	-0.001
Rural							
Ex-ante Gini Coefficient	0.277	0.277	0.277	0.277	0.277	0.277	0.277
Ex-post Gini Coefficient	0.272	0.274	0.258	0.262	0.262	0.271	0.268
Change in Gini Coefficient	-0.005	-0.003	-0.019	-0.015	-0.014	-0.006	-0.009
Urban + Rural							
Ex-ante Gini Coefficient	0.350	0.350	0.350	0.350	0.350	0.350	0.350
Ex-post Gini Coefficient	0.345	0.350	0.339	0.342	0.340	0.344	0.344
Change in Gini Coefficient	-0.005	0.000	-0.011	-0.008	-0.010	-0.006	-0.006

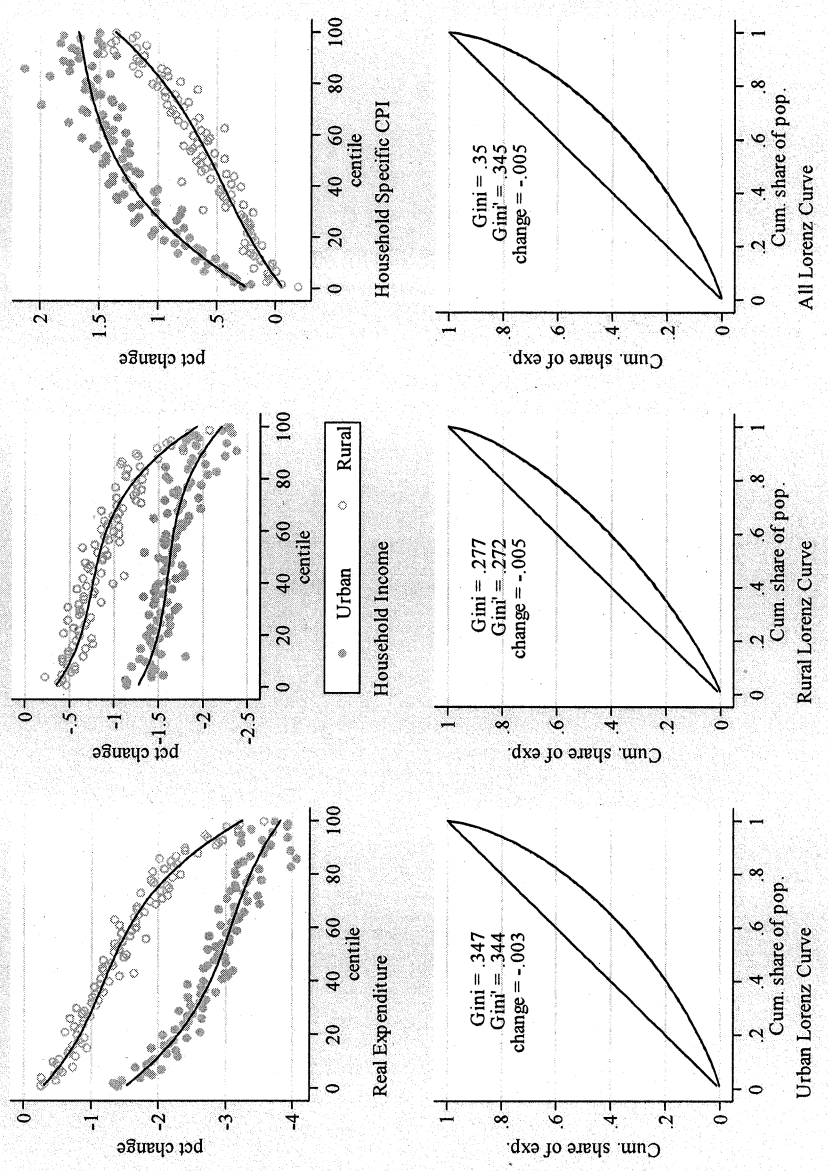


Figure 7.2: Simulated Distributional Impact of Energy Price Reform (SIM 1)

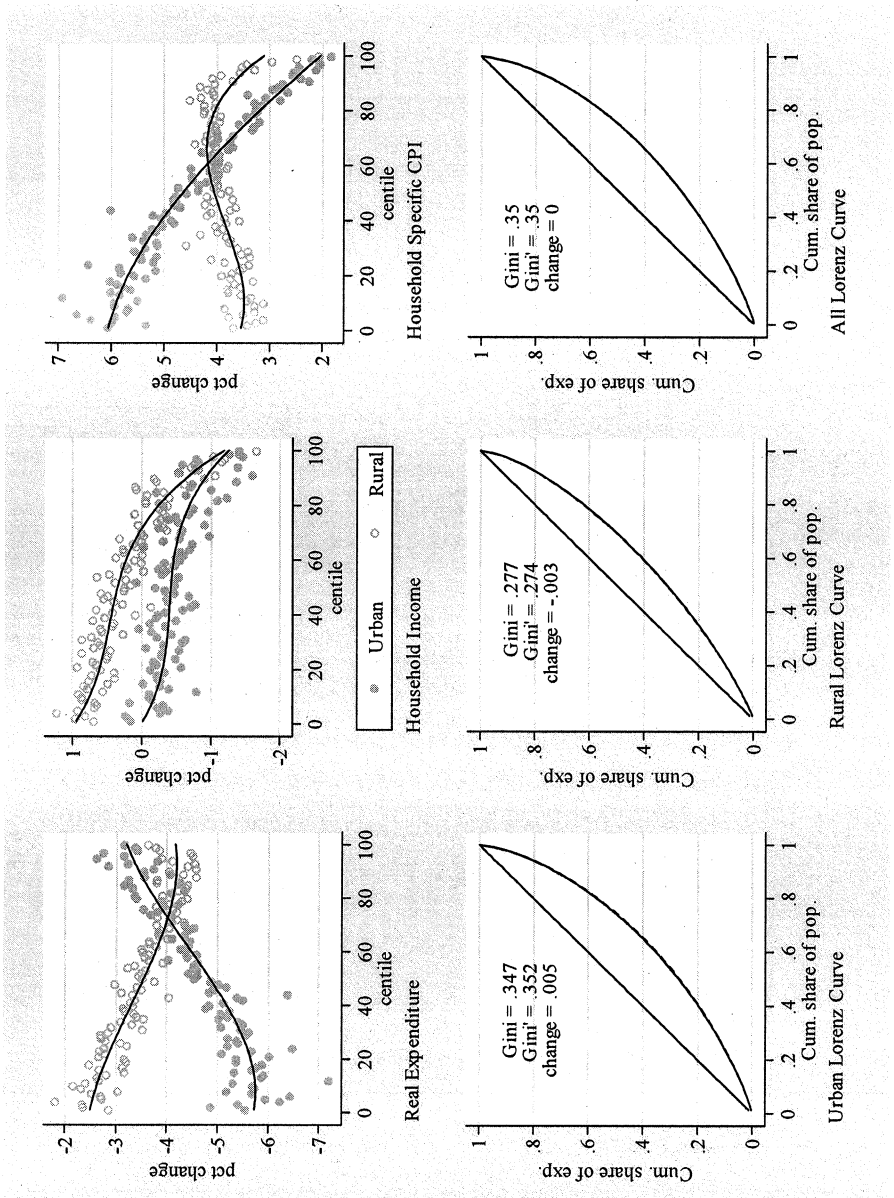


Figure 7.3: Simulated Distributional Impact of Energy Price Reform (SIM 2)

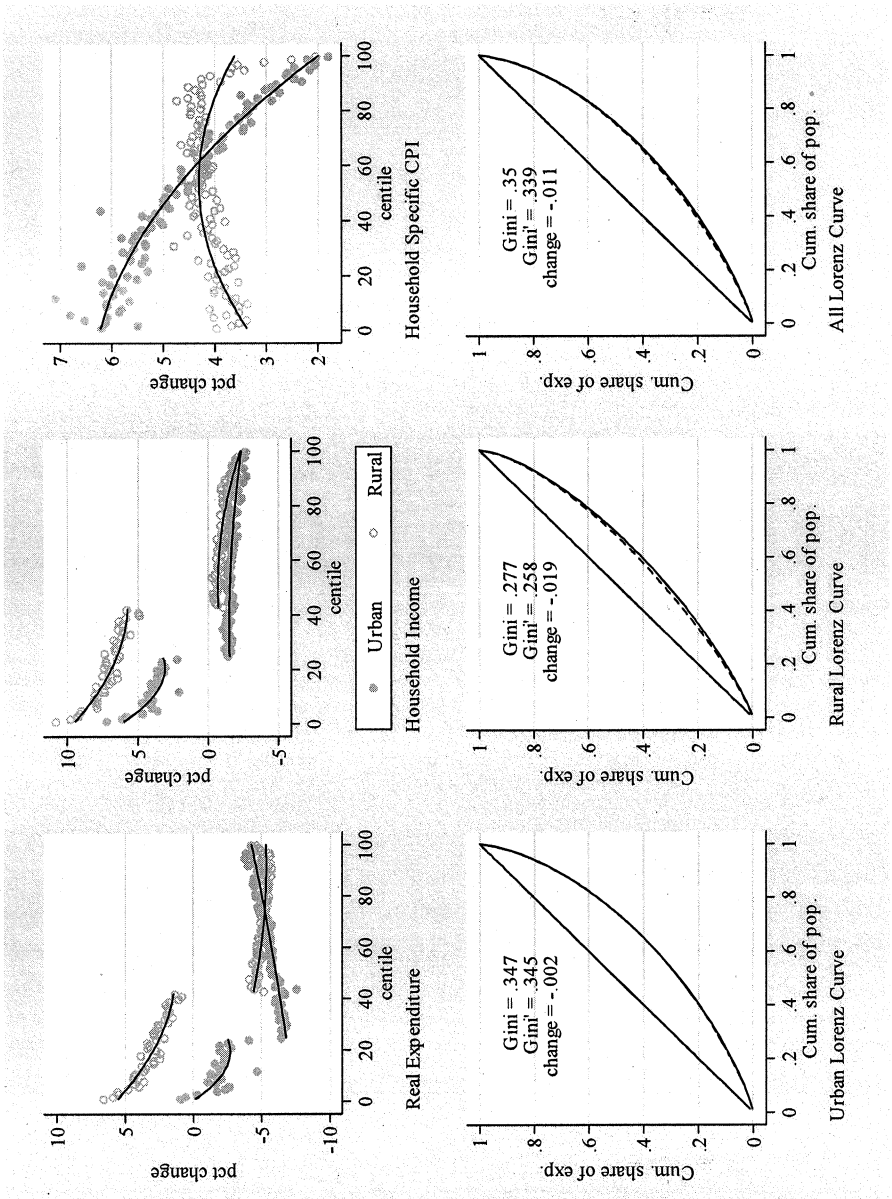


Figure 7.4: Simulated Distributional Impact of Energy Price Reform (SIM 3)

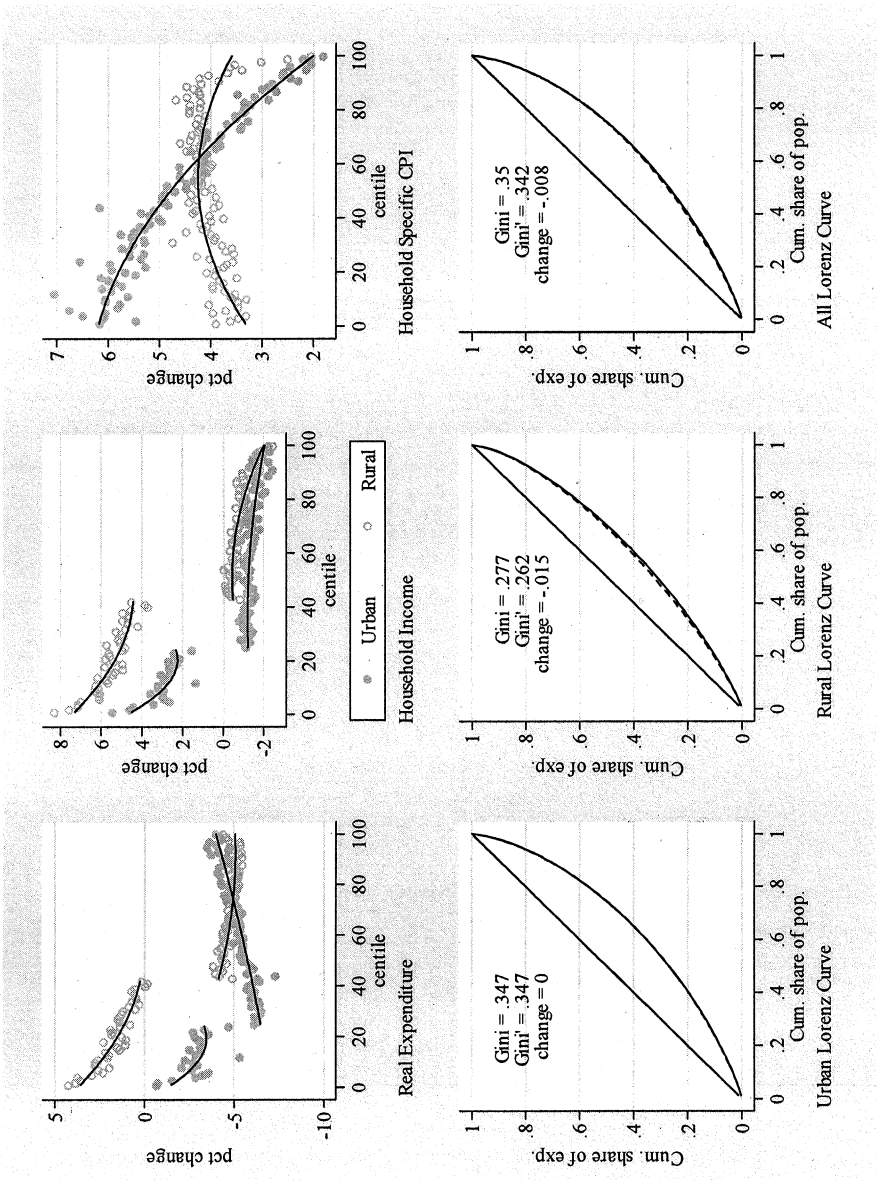


Figure 7.5: Simulated Distributional Impact of Energy Price Reform (SIM 4)

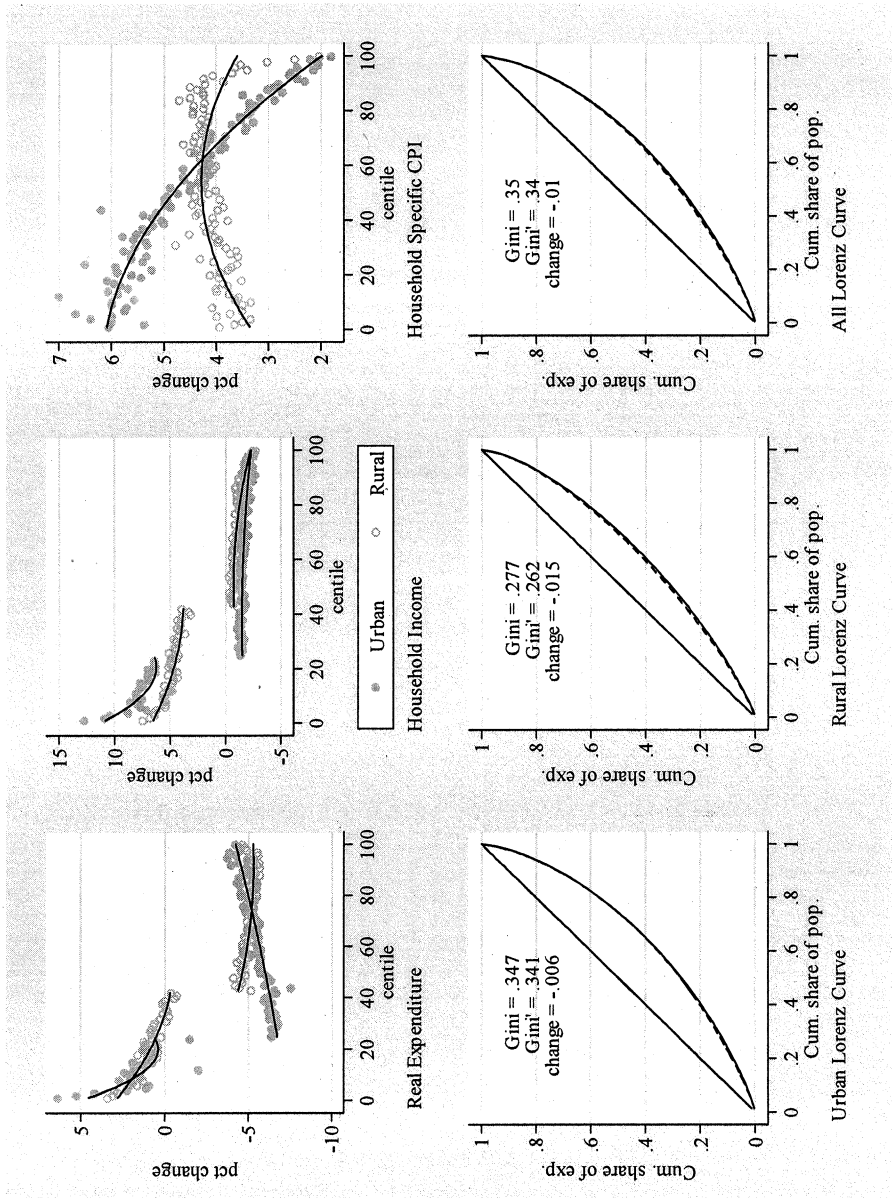


Figure 7.6: Simulated Distributional Impact of Energy Price Reform (SIM 5)

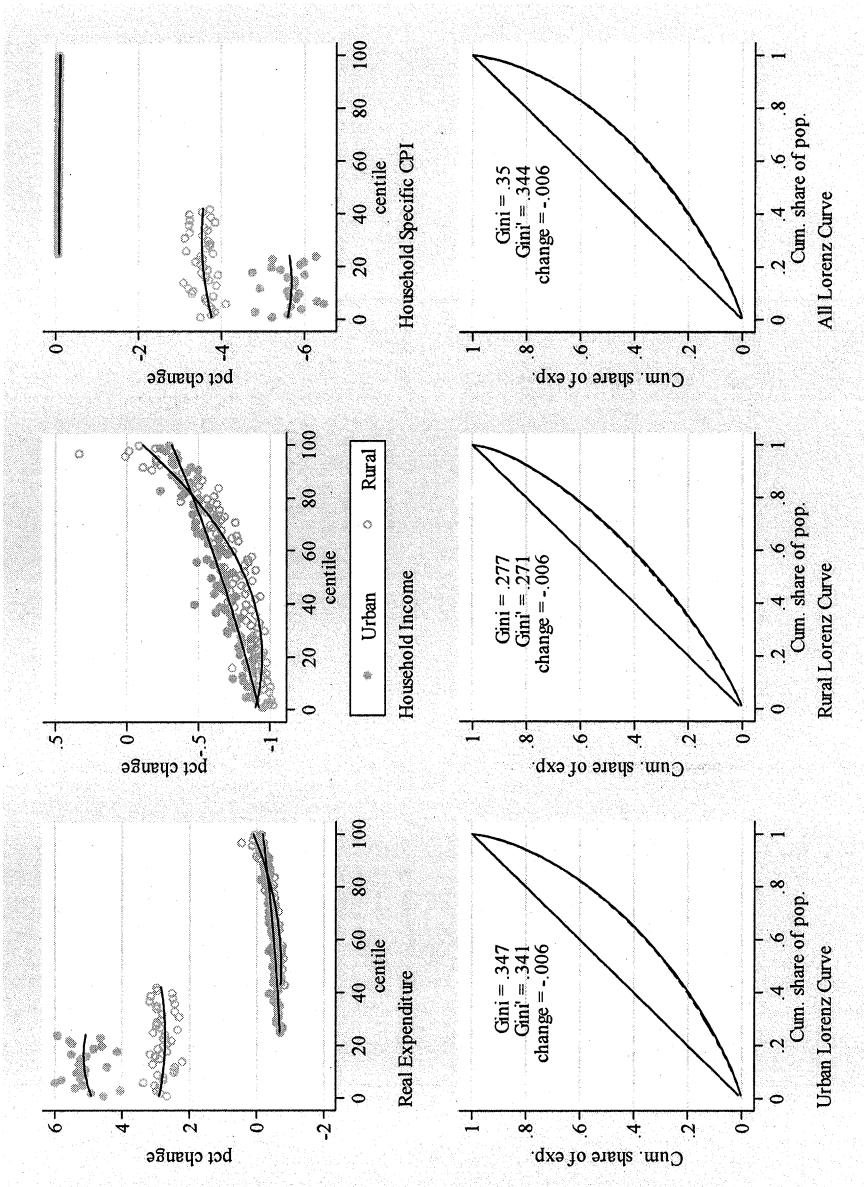


Figure 7.7: Simulated Distributional Impact of Energy Price Reform (SIM 6)

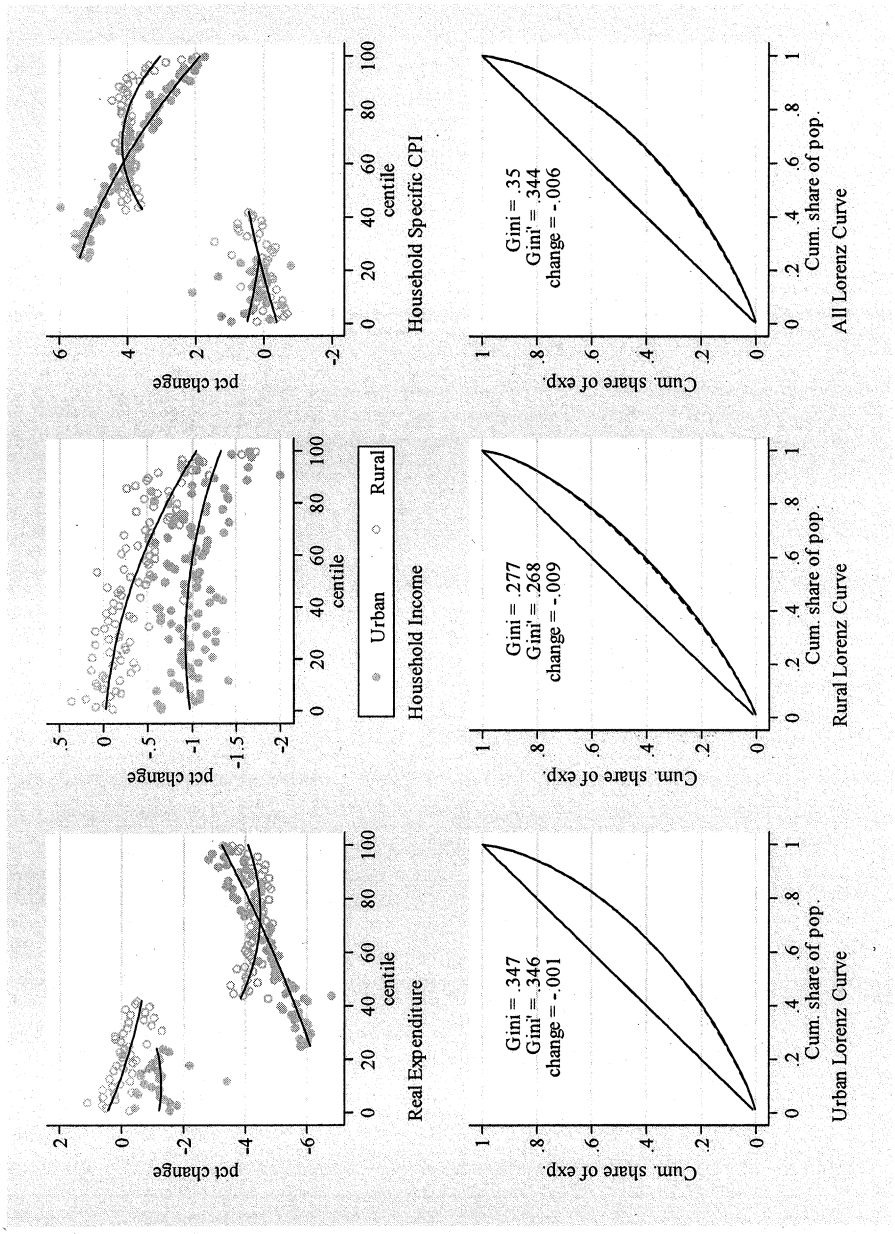


Figure 7.8: Simulated Distributional Impact of Energy Price Reform (SIM 7)

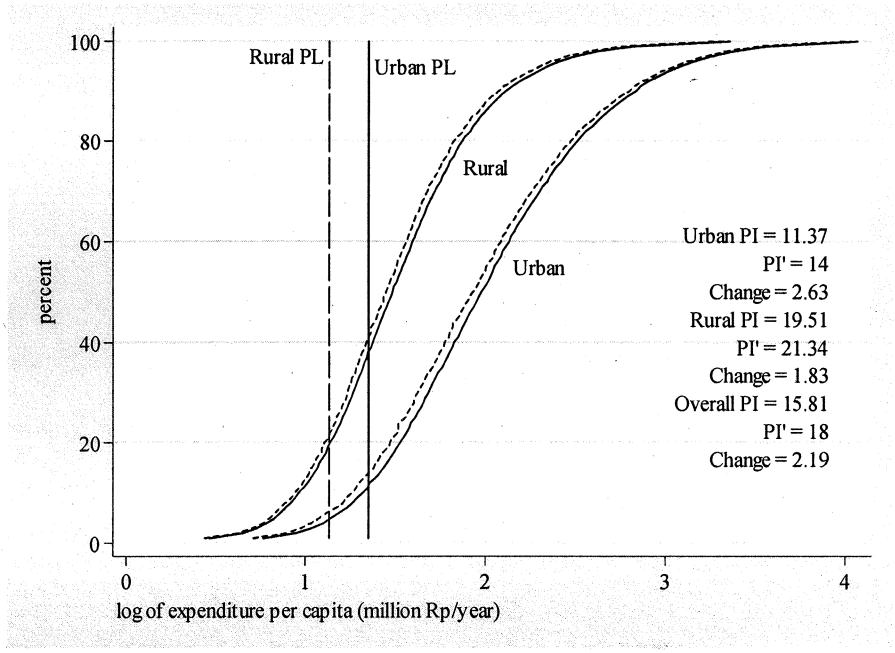


Figure 7.9: Simulated Poverty Impact of Energy Price Reform (SIM 2)

SIM 1: Increasing the price of fuels (except kerosene) without compensation

Before the implementation of the fuel price reform in October 2005, the fuel subsidy was regarded as both inefficient and inequitable. Because the rich are regarded as the biggest consumers of fuel, especially vehicle fuels, it has been a long-held view that reducing the fuel subsidy would hurt them more, and would therefore be progressive. To some extent Simulation 1 (SIM 1 NO-KEROSENE) supports this view. The fuel subsidy on gasoline and diesel has been inequitable, so that cutting the subsidy on these vehicle fuels would be a progressive reform. In this simulation, the October 2005 package without compensation is simulated but only for non-kerosene commodities.

Looking at the result from SIM 1, where the increase in the fuel prices excludes kerosene, as suggested from Figure 7.2, the declining pattern of the fall in real expenditure over centiles suggests the progressivity of the scenario. This happens in both urban and rural areas. As a result, inequality drops in both areas, as well as

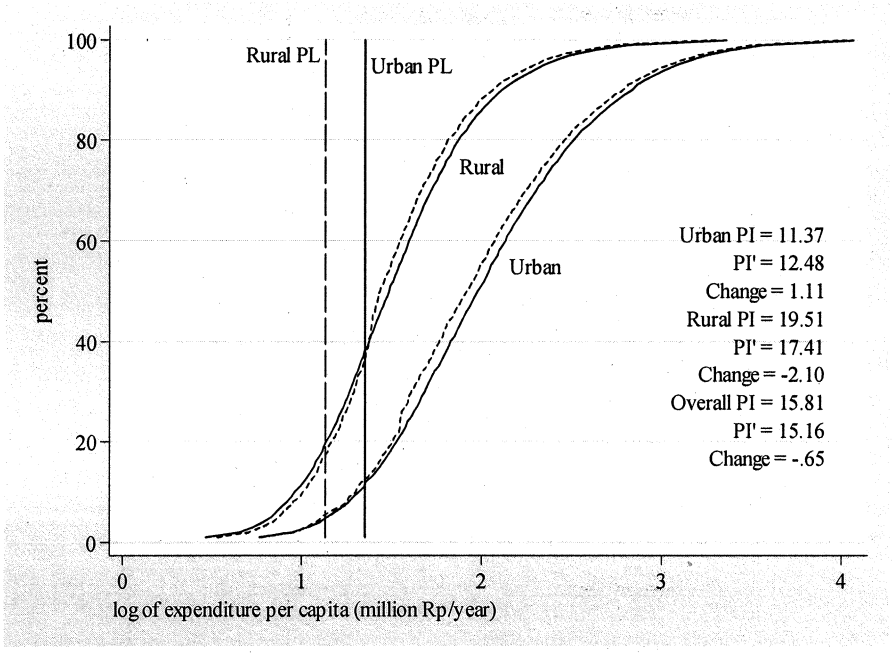


Figure 7.10: Simulated Poverty Impact of Energy Price Reform (SIM 3)

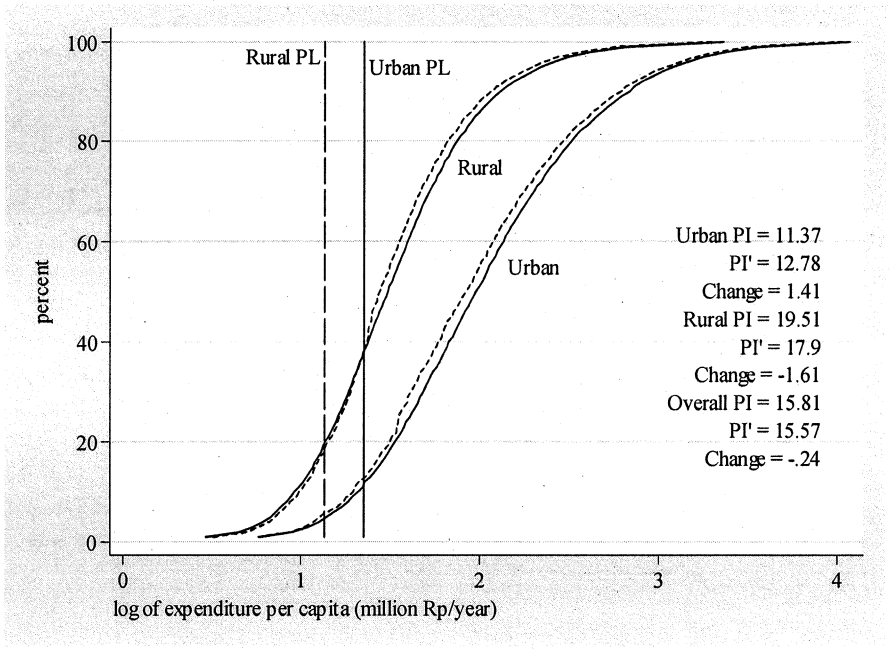


Figure 7.11: Simulated Poverty Impact of Energy Price Reform (SIM 4)

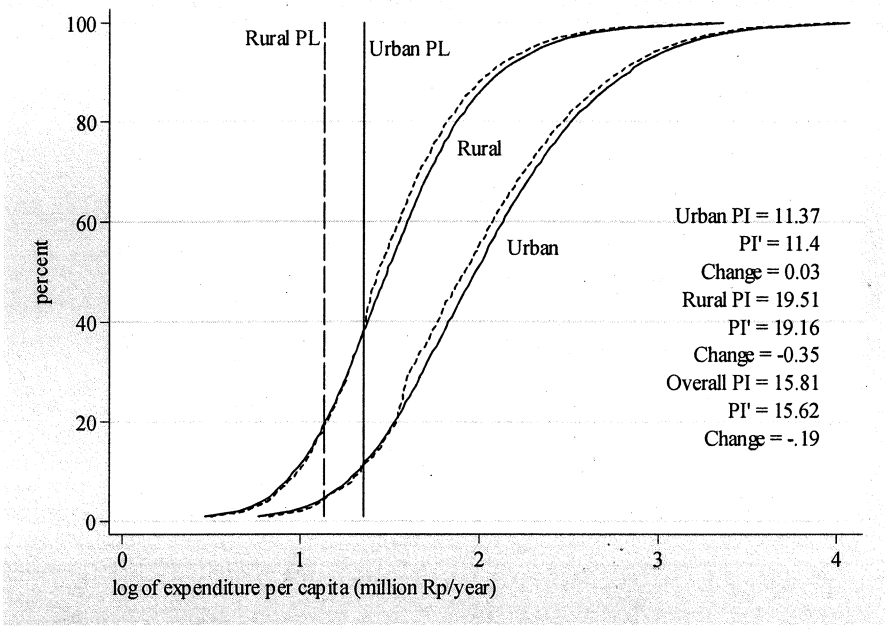


Figure 7.12: Simulated Poverty Impact of Energy Price Reform (SIM 5)

nation-wide, as indicated by the falling Gini coefficients. This progressivity is driven both by household consumption (by the pattern of the change in household CPI) and income pattern (by the pattern of the change in household income). Richer households tend to experience a greater increase in consumer price, reflecting their higher dependence on non-kerosene vehicle fuel consumption. The fall in their income is also higher compared to poorer households, reflecting the adjustment in the factor market which does not favour the factor endowment of high income households.

However, the urban poor is the bigger consumer of kerosene and the actual reform package implemented in October 2005 increased its price much more than other fuels. The kerosene administered price was drastically increased (185.7 percent), much more than the increase in other fuel prices (87.5 percent for gasoline, and 104.7 percent for diesel). Simulation 2 attempts to examine whether the reform being implemented this way can still be regarded as progressive.

SIM 2: Increasing the price of all fuels (without compensation)

To find out the distributional impact of this package, the increase in the administered price of fuels without compensation is simulated in SIM 2 (ALL FUELS). The simulation produces a markedly different distributional story. In urban areas, real expenditure of the 20 percent poorest households declines within the magnitude of about 5 to 7 percent, whereas the richest 20 percent households experience a decline of only about 2 to 4 percent. The pattern of the fall in the real expenditure of urban households clearly increases over centiles. As a result, inequality increases in urban areas, as the Gini coefficient increases from 0.347 to 0.352 (see Figure 7.3).

In contrast, the distributional impact is slightly progressive in rural areas. Real expenditure of the poorest 20% falls by around 3%, while the richest 20% falls by around 4%. Overall, the impact reduces inequality. Nationwide (urban and rural areas combined) the October 2005 package without compensation is neutral with a negligible impact on the Gini coefficient. As Figure 7.3 suggests, the main driver of the regressive result in urban areas is the dependence of urban lower income households on kerosene consumption, as well as on other commodities related to fuels such as spending on transportation. This is reflected by the increase in their household specific CPI which is far higher than that of higher income households.

Figure 7.3, which illustrates the result of SIM 2, also shows the impact of the fuel price increases through factor income. It suggests urban households, in general, experience a lower fall in income compared to rural households. In addition, in both urban and rural areas, richer households experience more adverse income shocks. This clearly shows the impact of fuel price rises through industry employment of capital and labour are biased against urban and richer households. In rural areas, this helps in shaping the progressivity of the reform. However, in urban areas, because the impact through the consumption pattern is far more severe, the reform cannot avoid being regressive.

The October 2005 package without compensation may have a significant impact on poverty as well. As shown in Figure 7.9, poverty incidence increases by 2.63% in urban areas and by 1.83 percent in rural areas. In all, poverty incidence, nation-wide,

rises by 2.19 percent. Using the population data for 2005, Simulation 2 suggests that without compensation the reform package could have driven around 5 million people into poverty.

The analysis of the 'what-if' scenarios exercised in SIM 2 suggests that while the reduction in fuel subsidy as part of the energy pricing reform has a strong basis in term of economic efficiency, how it is implemented is important in relation to the concern about distributional effects. Reducing the fuel subsidy per se, without careful prior examination as to how the reform will affect the poor, may generate an adverse distributional impact. This should be avoided because the reform should be carried out with the least cost and that includes the distributional cost in terms of its inequality and poverty implications.

SIM 3 and 4: Increasing the price of fuels with compensation

It could be that the distributional concern was the main reason why the actual fuel pricing reform in the October 2005 package was combined with a compensation scheme. The scheme chosen by the Indonesian government was a lump-sum cash transfer to targeted households (households considered poor and near poor). Targeted households were given an annual cash transfer of 1.2 million rupiah in four installments. The government claimed the amount of the transfer was more than adequate to compensate for the potential fall in welfare of the poor. Some studies, such as Ikhsan et al. (2005) and the World Bank (2006) backed this claim. Simulation 3 (100% UT) is carried out to see the distributional impact of this reform package. The simulation assumes 100 percent effectiveness of the cash transfers in reaching the targeted households.

As shown in Figure 7.4, the claim that the cash transfer more than compensated for the adverse welfare impact on the poor is only true in the case of the rural poor. Although some of the poorest centiles of the urban poor gain positive (nominal) income because of the transfer, when it is deflated with the increase in their specific CPI, the net real expenditure effect is still negative. In urban areas, none of the targeted households experience a positive welfare gain. The scheme over-compensates

the rural poor and under-compensates the urban poor. However, the October 2005 package reduces inequality, especially in rural areas, by 0.019 point, and reduces the overall Gini coefficient from 0.35 to 0.339. This decline in inequality is driven mainly by the significant increase in the real expenditure of the rural poor; the less severe fall in the real expenditure of the urban poor (due to the compensation) than the urban non-poor, and the sharp decline in the real expenditure of the non-targeted (non-poor or richer) households.

Figure 7.10 illustrates the poverty impact of Simulation 3 (100% UT). Due mainly to under-compensation of the urban poor, the October 2005 package (with compensation) still can not prevent urban poverty incidence from rising by 1.11 percentage points, despite the fall in the rural poverty incidence by almost 2.1 percentage points. However, the overall net nationwide impact is a slight decline of 0.65 percent. As the population is higher in rural areas, the decline in rural poverty incidence helps prevent an overall increase in the nation-wide poverty incidence.

The poverty impact is even higher when the compensation scheme is 75% effective. Urban poverty incidence increases by 1.41% instead of 1.11% (with 100% effectiveness) and the fall in rural poverty incidence is only 1.61% instead of 2.01%. The fall in inequality is also lower compared to the case of 100% effectiveness (See Table 7.4).

SIM 5: Increasing the price of fuels and giving more transfers to the urban poor

Given the tendency for uniform cash transfers to over-compensate rural and under-compensate urban households, the scheme is slightly modified in Simulation 5 (100% UTUR) by giving more cash to urban and less to rural targeted households. The result suggests this modification may prevent quite a significant number of urban households from falling into poverty, by still leaving the poverty incidence in rural areas intact. In this simulation, the poverty incidence in urban area increases by a negligible amount, in contrast to 1.11 percent if the amount of money is uniform across urban and rural households. In rural areas, poverty incidence still falls by

0.35 percent. The number of people in urban areas falling into poverty due to the reform might have been reduced significantly had the compensation been modified in this way. Uniform cash transfers could produce a much larger number of additional poor, compared to this slightly modified compensation.

The purpose of the compensation scheme is to mitigate the poverty or distributional impact of a reform. Naturally, it is not a structural poverty eradication program. The objective of the scheme is 'to compensate' households for any adverse impact from the reform. Therefore, even if the uniform compensation scheme could potentially reduce poverty nation-wide due to the over-compensation in rural areas, if this was at the cost of a huge increase in poverty in urban area, a slightly modified compensation scheme may still be preferable. In terms of policy effectiveness, it might even have another advantage by minimising resistance to the reform due to the fact that the urban poor are generally stronger politically than the rural poor.

SIM 6 and 7: Increasing the price of fuels and subsidising education and health expenditure as compensation

Simulation 6 tries to reveal the likely distributional impact of a price subsidy given to targeted households in the form of an education and health subsidy (more or less using the same budget as the cash transfers). Simulation 6 is not related to energy pricing reform or the increase in fuel prices, but only seeks the economy wide impact of the price subsidy, including distributional consequences, with other policies remaining unchanged. On the other hand, Simulation 7 combines SIM 6 with the increase in the price of fuels as implemented in October 2005. The result of SIM 6 suggests a price subsidy for the spending of the poor on education and health increases the output of education sectors by 12.31%, and the health sector by 13.63% (see Table 7.3). Because the subsidy is given only to the lower income classes, the simulation tends to be progressive, reducing the Gini coefficient in urban and rural areas, as well as nationwide. However, from the point of view of the factor market, the subsidy expands the output of certain sectors that favour the higher income class. This happens because the education and health sectors employ factors such as

skilled-labour which are owned by higher income households more intensively. The percentage change in household income is greater for higher income groups both in urban and rural areas. However, because the subsidy is given to the poorer part of the population, the decline in their household specific CPI drives the distributional impact to be more progressive.

When conditional transfers like these are used as a compensation scheme together with the October 2005 package, the story turns out to be rather different. The results from Simulation 7 (SUB) suggest the inequality impact is neutral in urban areas, progressive in rural areas and slightly progressive nationwide. Because the expansion in the education and health sectors increases demand for more skilled-labour and capital, for which higher income households have proportionally greater endowments, it drives the regressive results through the income pattern. The pattern on the fall in household income shows increasing trends toward higher income groups (see Figure 7.8). In urban areas, the progressivity is weakened by the high dependence of the urban poor on kerosene and other fuel-related consumption, such as transportation.

More importantly, the fall in household purchasing power (as indicated by the increase in household specific CPI) does not help compensate the poor. Both in urban and rural areas, almost all households (including the poor) experience a fall in real expenditure. As a result, poverty rises in urban areas by 0.9%. In contrast to the cash transfers, a subsidy on education and health as compensation increases poverty in rural areas by 0.35% and because most of the poor population is rural, poverty incidence rises nationwide by 0.62%. A subsidy on health and education may be good as an incentive for human capital investment, but may not necessarily be effective as a means of short-run compensation to mitigate the adverse poverty impact of a fuel pricing reform. It may be better suited for longer-term objectives, especially if combined with policies to promote education spending by modifying the expenditure pattern or demand behaviour toward education, especially for rural households. However, this is a longer-term approach of a structural poverty alleviation program, not an ad-hoc occasional compensation scheme to minimise the short

term distributional cost of a particular reforms such as energy pricing.

7.5 Systematic Sensitivity Analysis

The systematic sensitivity analysis (SSA) is carried out for a representative simulation, in this case SIM 3 (October 2005 package + uniform cash transfers). The result is shown in Table 7.5, where the means, standard deviation, and confidence interval for selected variables are reported.

Looking at the standard deviation and the confidence interval, the result of the systematic sensitivity analysis reveals the percentage change in endogenous variables is fairly robust or insensitive to variations in the extraneous parameters. For example, the confidence interval reveals the shock will reduce GDP by -3.15% to -2.08% with a 95% confidence level, or there is at least a 95% probability that the shock will reduce aggregate real consumption between -4.75% to -3.14%. In addition, the sensitivity analysis suggests employment is more sensitive to variations in parameters compared to GDP. The range of the change in employment is almost twice the range in the change in GDP.

The distributional results also seem robust to the sensitivity analysis. Looking at the sensitivity analysis for the change in real expenditure per capita of households below the poverty line, it suggests at least 95% chance that Simulation 3 (October 2005 package + uniform compensation) will increase poverty in urban areas and will reduce poverty in rural areas.

7.6 Concluding Remarks

The Indonesian government implemented a massive fuel price increase in 2005. While the benefit of the reform on efficiency grounds has been widely acknowledged, whether the reform was equitable is still debated.

This question is answered in this case study using a Computable General Equilibrium (CGE) model with disaggregated households that allows for a rich and

Table 7.5: SSA of SIM 4: Energy Price Reform (50 percent Variation in All Parameters)

	mean	s.d.	Con. Interval (90%) lower	Con. Interval (90%) upper	Con Interval (95%) lower	Con Interval (95%) upper
Macroeconomics						
GDP	-2.617	0.119	-2.995	-2.239	-3.151	-2.083
Aggregate consumption	-3.944	0.180	-4.515	-3.374	-4.751	-3.138
CPI	3.929	0.113	3.572	4.287	3.423	4.436
Employment	-5.405	0.240	-6.164	-4.646	-6.478	-4.332
CO2 emission	-7.096	0.427	-8.445	-5.747	-9.004	-5.189
Employment						
Agriculture, rural, formal	-2.878	0.182	-3.454	-2.302	-3.693	-2.063
Agriculture, urban, formal	-3.603	0.191	-4.208	-2.997	-4.459	-2.747
Agriculture, rural, informal	-2.614	0.174	-3.165	-2.062	-3.393	-1.834
Agriculture, urban, informal	-2.690	0.181	-3.262	-2.118	-3.499	-1.881
Production, rural, formal	-4.421	0.235	-5.164	-3.677	-5.472	-3.369
Production, urban, formal	-8.184	0.338	-9.252	-7.117	-9.695	-6.674
Production, rural, informal	-4.214	0.247	-4.995	-3.434	-5.318	-3.110
Production, urban, informal	-5.008	0.293	-5.935	-4.081	-6.319	-3.697
Clerical, rural, formal	-4.232	0.232	-4.965	-3.499	-5.269	-3.196
Clerical, urban, formal	-6.926	0.310	-7.907	-5.945	-8.313	-5.539
Clerical, rural, informal	-5.094	0.255	-5.901	-4.288	-6.235	-3.954
Clerical, urban, informal	-5.325	0.263	-6.157	-4.493	-6.501	-4.148
Professional, rural, formal	-3.097	0.172	-3.643	-2.552	-3.868	-2.326
Professional, urban, formal	-5.597	0.242	-6.361	-4.832	-6.677	-4.516
Professional, rural, informal	-4.898	0.270	-5.752	-4.045	-6.105	-3.692
Professional, urban, informal	-5.674	0.310	-6.653	-4.694	-7.059	-4.289
Average price of capital	-9.638	0.202	-10.276	-9.001	-10.540	-8.737
Average price of land	-9.892	0.688	-12.067	-7.717	-12.968	-6.816
Output						
Coal	-0.122	0.023	-0.194	-0.050	-0.224	-0.021
Natural gas	-0.208	0.039	-0.332	-0.084	-0.383	-0.033
Refinery	-7.867	0.618	-9.822	-5.912	-10.631	-5.102
Electricity	-2.840	0.155	-3.331	-2.349	-3.535	-2.146
Water and gas	-4.391	0.181	-4.963	-3.819	-5.200	-3.582
Road transportation	-4.823	0.222	-5.525	-4.122	-5.816	-3.831
Other transportation	-6.597	0.414	-7.908	-5.287	-8.451	-4.744
Real consumption						
Urban						
Centile 1	1.025	0.212	0.353	1.697	0.075	1.976
Centile 2	0.667	0.214	-0.008	1.343	-0.288	1.623
Centile 3	-0.197	0.217	-0.884	0.489	-1.168	0.773
Centile 4	-1.668	0.219	-2.362	-0.975	-2.649	-0.687
Centile 5	-2.247	0.219	-2.940	-1.555	-3.227	-1.268
Centile 13	-1.802	0.221	-2.500	-1.104	-2.789	-0.815
Centile 95	-3.711	0.227	-4.429	-2.994	-4.726	-2.697
Centile 96	-4.242	0.220	-4.938	-3.546	-5.226	-3.258
Centile 97	-3.825	0.231	-4.555	-3.095	-4.857	-2.792
Centile 98	-4.515	0.198	-5.140	-3.890	-5.399	-3.631
Centile 99	-4.444	0.204	-5.090	-3.798	-5.357	-3.530
Centile 100	-4.225	0.189	-4.822	-3.628	-5.070	-3.381
Rural						
Centile 1	6.618	0.187	6.028	7.209	5.783	7.453
Centile 2	5.918	0.171	5.378	6.458	5.155	6.681
Centile 3	5.545	0.170	5.007	6.084	4.784	6.307
Centile 4	5.600	0.170	5.063	6.137	4.841	6.360
Centile 5	4.830	0.161	4.319	5.341	4.108	5.552
Centile 20	2.763	0.159	2.261	3.265	2.053	3.473
Centile 95	-5.018	0.134	-5.441	-4.596	-5.616	-4.421
Centile 96	-5.604	0.141	-6.050	-5.157	-6.235	-4.972
Centile 97	-5.569	0.141	-6.016	-5.122	-6.201	-4.937
Centile 98	-4.950	0.128	-5.355	-4.544	-5.523	-4.377
Centile 99	-4.834	0.137	-5.268	-4.400	-5.447	-4.221
Centile 100	-4.650	0.140	-5.092	-4.207	-5.275	-4.024

accurate distributional story. With this method, the analysis is carried out on the recent energy pricing reform in Indonesia (October 2005 Package) using various counter-factual scenarios.

The simulations suggest the reform could be progressive if only 'vehicle fuel' prices are increased. However, if the price of domestic fuel (kerosene) is also increased at the magnitude implemented in October 2005, this would tend to increase inequality, especially in urban areas. From the comparison of various different scenarios it may be concluded that proper and effective compensation is important to mitigate the distributional cost or poverty impact of the reform.

Uniform cash transfers to poor households without regard to their heterogeneity tend to over-compensate the rural poor but under-compensate the urban poor. Other results suggest non-cash compensation in the form of subsidising the education and health spending of the poor, may not be effective in mitigating the reform despite its possible desirability as a longer-term poverty alleviation program.

7.A Appendix: Sensitivity Analysis to Labor Market Closure

Rigidity in the labor market is represented by fixing real wage such that nominal wage follow consumer's price index, such that:

$$w_r = w_n - \delta \cdot p$$

where w_r is the percentage change in real wage, w_n is the percentage change in nominal wage, and p is the percentage change in consumer's price index (CPI), whereas δ is the speed of adjustment parameter. In the labor market closure used in this chapter, real wage is fixed, hence nominal wage follow CPI. For formal labor market, nominal wage follows CPI fully ($\delta = 1$), but for informal labor market the adjustment is assumed to be slower i.e.$\delta = 0.5$. In this appendix the the sensitivity analysis to the δ used is carried out.

The sensitivity analysis is conducted for $\delta = 0.25$, 0.5, 0.75, and 1. The focus is on distributional impact. Figure 7.A1 and Figure 7.A2 shows the impact on the real expenditure across percentiles of households for urban and rural areas, respectively.

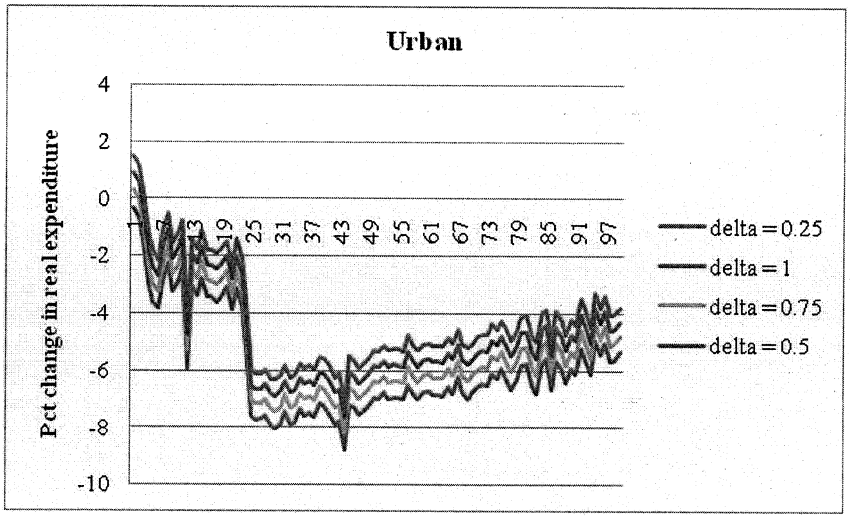


Figure 7.A1. Incidence on expenditure across households with varying δ (urban)

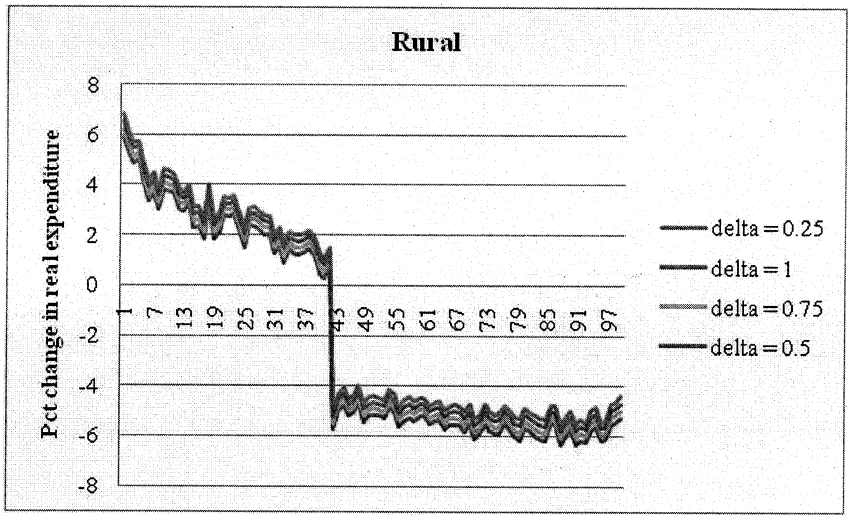


Figure 7.A2. Incidence on expenditure across households with varying δ (rural)

As both figures suggest, the pattern of distributional effect is almost identical. Only its magnitude varies. This suggests that the progressivity or the regressivity

Table 7.6: Distributional Effect (Gini and Poverty Incidence) with varying delta

			$\delta = 0.25$	$\delta = 0.5$	$\delta = 0.75$	$\delta = 1$
Ex-ante	Gini	Urban	0.3477	0.3477	0.3477	0.3477
		Rural	0.2776	0.2776	0.2776	0.2776
		All	0.3505	0.3505	0.3505	0.3505
	Poverty	Urban	11.37	11.37	11.37	11.37
		Rural	19.51	19.51	19.51	19.51
		All	15.80	15.80	15.80	15.80
Ex-post	Gini	Urban	0.3462	0.3462	0.3462	0.3462
		Rural	0.2583	0.2582	0.2582	0.2581
		All	0.3397	0.3393	0.3388	0.3383
	Poverty	Urban	12.33	12.49	12.65	12.82
		Rural	17.33	17.42	17.51	17.60
		All	15.05	15.17	15.29	15.42
Change	Gini	Urban	-0.001	-0.001	-0.001	-0.001
		Rural	-0.019	-0.019	-0.019	-0.020
		All	-0.011	-0.011	-0.012	-0.012
	Poverty	Urban	0.96	1.12	1.28	1.45
		Rural	-2.18	-2.10	-2.00	-1.91
		All	-0.75	-0.63	-0.51	-0.38

of the impact will be almost identical. The distributional effect is insensitive to changing parameter δ. The change in Gini coefficient, then, will be insensitive to the assumption of the value of δ (in fact they are almost identical), as Table 7.6 below suggests.

The magnitude of the change in the real expenditure per capita, however, varies especially for urban households. For rural households, the variation across households percentiles is insignificant, and as a result its poverty impact is almost insensitive to the changing parameter. Compared to rural households, the percentage change in expenditure per capita for urban households is more sensitive to δ, but not to a worrying extent. In short, the distributive effect is not sensitive to the assumed value of parameter δ.

Chapter 8

Conclusion

8.1 Key Findings and Contributions

It is widely acknowledged that the three dimensions of sustainable development – economic, social, and environmental – are crucial, inseparable and interrelated. In many cases, the three dimensions can conflict when the goal of one aspect does correspond with any of the others. This thesis attempts to look more closely at the social and environmental dimensions of sustainable development. The analysis focuses on the equity aspect of environmental policy in the case of environmental problems related to pollution and energy-related emissions.

This thesis first looks at what the literature generally finds on the distributional impact of environmental policies related to pollution and energy-related emissions. This literature is mostly from industrialised countries, but this thesis demonstrate cases where these findings cannot be generalised to developing countries. Using the case study of Indonesia, this thesis also aims to provide a quantitative estimate of the impact of the introduction of a carbon tax and energy pricing reform – chosen to be the case studies – on the economy, and to analyse how the cost of the policy is distributed to households in order to examine whether it is progressive or regressive and how it may affect poverty incidence. This thesis also attempts to assess the feasibility of designing equitable environmental policies and how they should best be implemented to reach the dual goals of equity and the environmental improvement.

The literature review confirms that environmental policies aimed to reduce energy-related emissions or pollution, such as carbon or energy taxes, are generally regres-

sive. The burden is borne more proportionately by lower income households. However, it is argued that due to the difference in characteristics, such policies may not necessarily be regressive if implemented in less developed countries.

The examination of the expenditure patterns of Indonesian and European households reveals that their spending patterns are different and this may play an important role in the distributional analysis of environmental policies. In Europe, the share of energy spending in total expenditure declines with income, suggesting energy is a necessity. However, the share of energy spending in Indonesia does not necessarily decline with income, and certain types of energy, such as electricity, can be regarded as a luxury in that their share of expenditure increase with income.

The distributional effect of environmental policies is not only driven by households' spending patterns. Household income may also be affected by how the policies affect the markets for factor of production. In this regard, the type of factors households are endowed with, and the institutional setting that may play a role in the factor market adjustment, may also drive the direction of the distributional impact. In this respect, certain characteristics of developing countries, may make a difference. This thesis conducts an analytical exercise using a simple model that emphasises a dualistic labour market to illustrate this issue, and provides certain cases where environmental policies in developing countries may not necessarily be regressive from the perspective of the factorial distribution of income. The main result suggests that when an economy has a capital-intensive formal sector, a labour-intensive informal sector, and a distortion in the labour market due to the existence of minimum wage policy in the formal sector, an environmental policy implemented through a pollution tax may improve factorial income distribution.

This thesis also offers some methodological contributions. In Indonesia, this will be the first[1] research that explicitly analyses climate change policy to assess its impact on income distribution and poverty incidence. With regard to energy pricing reform, this research will also be the first study using an economy-wide framework with full integration of households disaggregated by income/expenditure classes.

[1]To the author's knowledge.

The analysis of the distributional impact of policies in the CGE modelling framework has been constrained in part by the absence of a Social Accounting Matrix (SAM) with disaggregated households. The Indonesian Social Accounting Matrix constructed in this study constitutes the biggest and most disaggregated Indonesian SAM yet constructed at the sectoral and household level, hence contributing to the literature on SAM construction especially in developing countries. A SAM is also a basic and necessary element in CGE modelling and its construction has provided a pathway for later studies to analyse relevant policy issues. In addition, since SAM construction is rarely well-documented, the transparency of description in this case will hopefully provide greater replicability for future SAM construction as well as for other researchers.

Using the case study on carbon abatement policy (an increasingly more widely-discussed and topical global issue) and energy pricing reform in Indonesia (a recently implemented relevant local issue in Indonesia), this thesis attempts to answer questions such as whether a conflict between the environment and equity exists and to what extent policy design can mitigate the adverse distributional effect, if any, of environmentally-motivated policies.

In the case study on a carbon abatement policy via the introduction of a carbon tax, the results from various simulations suggest that, in contrast to most studies from developed countries, its introduction in Indonesia would not necessarily be regressive. It is shown to be strongly progressive in rural areas, and either neutral or slightly progressive in urban areas. Its overall distributive effect nationwide is shown to be progressive.

The industries which experience a larger contraction generally are more energy intensive, and happen to be those which employ proportionally more capital, skilled-labour, and urban formal labour relative to unskilled, rural, and informal labour. These industries will tend to reduce employment of these factors or reduce their wages. The ownership of these factors of production tend to be concentrated among higher income households, and those who live in the cities. In contrast, the income sources of the largely rural poorer part of the population are mostly wages from

employment as informal agricultural or unskilled labour. Sectors which happen to employ these factors intensively experience less contraction or even expansion.

For example, the demand for the products of the food crops sector, other agriculture, or even food-manufacturing, may increase due to the increase in income of lower income households, because these products constitute the largest share of their consumption. As these sectors are also relatively less energy intensive, they do not face constraint in expanding supply. Because these sectors largely employ informal, agricultural, and unskilled labour, the poor may also benefit from the rise in their income and therefore a carbon tax may work to the benefit of these vulnerable households.

The typical expenditure pattern in developing countries, which is less energy sensitive, also helps drive the progressivity of the result especially in rural areas. For lower income households, the increase in the cost of acquiring their consumption bundle is lower than for the wealthy in the cities. Together with the increase in their factor income, this implies that rural households, especially poorer ones, may experience a welfare gain.

In the analysis of counter factual scenarios on the energy pricing reform of the October 2005 package in Indonesia, the simulations suggest reducing vehicle fuels subsidy hurts higher income classes more and hence constitutes a progressive reform. It supports the claim that a subsidy on vehicle fuels is regressive. However, in the case of Indonesia, where urban lower income households constitute the biggest consumers of domestic fuel like kerosene, a reform like the October 2005 package, with a massive increase in the kerosene price (almost tripled), tends to be regressive unless accompanied by a proper and effective compensation scheme.

The comparison of various types of compensation in the simulations suggests designing an effective form of compensation does matter in mitigating the distributional impact of energy pricing reforms. A well-targeted scheme will recognise the fact that the poor differ in terms of their income and consumption patterns. The uniform transfers implemented in the October 2005 reform tends to over-compensate rural households at the cost of under-compensating the urban poor. The example of

a slight modification to the scheme that gives more to urban and less to rural households may significantly help minimise the rise in urban poverty incidence. With regard to the recent widely-discussed subsidy targeting education and health spending as an alternative compensation scheme, the simulation suggests it may not be effective in minimising the poverty impact of an energy pricing reform. It might be better suited for the longer-term objectives of poverty alleviation programs.

To conclude, this study shows there is not necessarily a conflict between environmental and equity objectives, especially when the policies or reforms to achieve environmental goals are carefully designed. Moreover, the result from the case study of the carbon abatement policy may have an important global policy implication. Encouraging developing countries to reduce carbon emissions not only increases the efficiency of carbon abatement globally but may have a favourable distributional implication for the developing countries themselves, in contrast to a less favourable distributional impact in developed countries. Whereas a global 'efficiency gain' from shifting the location of carbon abatement from industrialised to developing countries has been widely acknowledged, this study introduces the additional notion of a 'global equity gain'.

8.2 Future Research

This thesis may still have many weaknesses both in terms of the generalisation of the results and the caveats of the methodology. The issue of the conflict between environment and equity may also be relevant for other types of environmental problems. For Indonesia, they are, among others, deforestation and the depletion of other natural resources such as marine resources.

The exclusion of carbon emissions from land use change in the model used in this thesis is a weakness in itself. In Indonesia, carbon emissions from deforestation constitute the biggest source of emissions. It is important for further research to model explicitly the emissions from land use change to obtain a better picture of the distributional impact of climate change policies.

The generalisation of the results to conjecture that the distributional impact of energy-related environmental policies may not be regressive or could even be progressive in developing countries, calls for wider coverage of other developing countries, apart from Indonesia, including the other biggest carbon emitters such as China and India. To the author's knowledge, a study for these countries using the CGE framework does not yet exist. The results of this future research may strengthen the result and provide a stronger argument to accelerate the active participation of developing countries in future action to reduce global warming.

Action to reduce greenhouse gases should be a global multilateral effort in order to be effective. That is why analysis in a multi-country setting such as examining global carbon trading is highly relevant. However, among numerous multi-country studies on this issue using a global CGE model hardly any touch on the distributive effect within countries. Incorporating a detail distributive effect within a country in a global CGE model in the setting of a global climate change policy would be a worthwhile effort and difficult task.

The model used in this thesis is comparative static. Extending the model to make it dynamic would provide a time path of how an environmental policy and its impact on the economy and income distribution would evolve over time. In the dynamic setting, it is also possible to model the government decision to invest and purchase of capital goods, and hence its contribution to the capital accumulation and the future growth of the economy. In the context of energy pricing reform or carbon taxation, the government then has options to invest the proceeds from the tax revenue to invest in productive resources. This could also be motivated by redistributive agenda.

Another possible useful extension to the model would be extending the detail at the household level. This could be done, for example, by building an integrated-microsimulation CGE model, where the household level details in the survey data are integrated in a CGE model. With this extension, more flexible analysis would be possible such as the ability to look at the distributional impact across other categories of households, not only by income size but by other socioeconomic char-

acteristics. Endogenising labor supply decision will also be a contribution to the public finance literature, especially in regards to the empirical evaluation of double-dividends hypothesis of environmental taxation in Indonesia. Extending the model to become a multi-regional model would also make possible the analysis of the distributional impact of an environmental policy across regions. All of these issues are open for further research.

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