The Economic Value of Indonesia's Natural Gas

A quantitative assessment of three gas policies

Aldi Martino Hutagalung

UNIVERSITY OF TWENTE.

**THE ECONOMIC VALUE OF INDONESIA'S NATURAL GAS:
A QUANTITATIVE ASSESSMENT OF THREE GAS POLICIES**

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Aldi Martino Hutagalung
Born on 10th of March 1980,
in Jakarta, Indonesia

This Thesis has been approved by

Promotor: Prof.dr. Jon C. Lovett

Co-Promotor: Dr. Maarten J. Arentsen

Members of the graduation committee:

Chair and Secretary:	Prof.dr.ir. A.J. Mouthaan	UT/BMS
Promotor :	Prof.dr J.C. Lovett	UT/ BMS-CSTM
Co-Promotor:	Dr. M.J Arentsen	UT/ BMS-CSTM
Member:	Prof.dr.ir. M. Wolters	UT/CTW-THW
Member:	Prof.dr. N.S. Groenendijk	UT/BMS-PA
Member:	Prof.dr. A.E. Steenge	Rijksuniversiteit /Faculteit Economie en Bedrijfskunde
Member:	Dr. Djoni Hartono	University of Indonesia, faculty of Economics
Member:	Dr. A.F. Correljé	Delft University of Technology/ Faculty Technology, Policy and Management

The work described in this thesis was performed at the Twente Centre for Studies in Technology and Sustainable Development, School of Management and Governance, University of Twente, Postbus 217, 7500 AE, Enschede, The Netherlands

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List of Abbreviations and Acronyms

ADB	Asian Development Bank
BAKOREN	Badan Koordinasi Energi Nasional
BPH	Badan Pengawas Hilir Migas
BTU	British Thermal Unit
CAPEX	Capital Expenditure
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
DITJEN MIGAS	Direktorat Jenderal Minyak dan Gas Bumi
DPR	Dewan Perwakilan Rakyat
DMO	Domestic Market Obligation
EOR	Enhanced Oil Recovery
GDP	Gross Domestic Product
GNP	Gross National Product
GTAP	Global Trade Analysis Project
HSD	High Speed Diesel
IEA	International Energy Agency
IGP	Indonesian Gas Price
INEP	Integrated Energy Planning
IO	Input Output
KEN	Kebijakan Energi Nasional
KESDM	Kementerian Energi dan Sumber Daya Mineral
KUBE	Kebijakan Umum Bidang Energi
LES	Linear Expenditure System
LNG	Liquefied Natural Gas

LPG	Liquefied Petroleum Gas
LR	Long Run
MCM	Million Cubic Meters
MMBTU	Million British Thermal Unit
MMSCFD	Million Standard Cubic Feet per Day
MP3EI	Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia
OECD	Organisation for Economic Co-operation and Development
OPEX	Operation Expenditure
PGN	Perusahaan Gas Negara
PLN	Perusahaan Listrik Negara
PSC	Production Sharing Contract
PWC	Price Waterhouse Coopers
RUKN	Rencana Umum Kelistrikan Nasional
RUPTL	Rencana Umum Penyediaan Tenaga Listrik
SAM	Social Accounting Matrix
SR	Short Run
TAGP	Trans Asean Gas Pipeline
TCF	Trillion Cubic Feet
UNEP	United Nations Environment Programme
WiP	With Policy Intervention
WoP	Without Policy Intervention

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Chapter 1 Introduction

1.1 Background and motivation

With a population of more than 200 million, Indonesia is the fourth most populous country in the world, after China, India, and the United States. Economic activity and population growth, especially in the last two or three decades, have brought rapid growth in energy demand for domestic use. The country still depends heavily on fossil energy, namely oil and natural gas, which contributed almost 70% of primary energy consumption (41.8% and 18.3%, respectively) in 2011 (Kementerian Energi dan Sumber Daya Mineral, 2012b). Energy has a double role, as a source of state revenue and as a stimulant to domestic economic growth. As oil production started to decline, Indonesia changed its energy focus to natural gas, which is cheaper and cleaner. Natural gas is seen as the future energy of Indonesia. Since 2001, domestic gas demand grew slowly at 2.8% per annum (IEA, 2008). Recent increase in the demand for gas has been highly affected by replacement of higher priced oil with gas; it was estimated that, in 2006, natural gas replaced 1.9 billion barrels of oil usage (IEA, 2008). However, this drastic change was not accompanied by sufficient preparation (for example, there was insufficient infrastructure connectivity), because natural gas had not been part of long-term planning as a significant part of the energy mix.

To cope with the problems in natural gas policy, we have to look back at their roots; energy policy was not based on solid analysis. Many energy policy decisions not only addressed the problems insufficiently, but they also resulted in additional economic and social costs for the government (Muliadiereja, 2005). The main difficulties leading to inefficiency in Indonesia's energy supply are lack of economic considerations and the heavy influence of political interests (Asia Times, 2004). An example of this was elaborated by Davice and Cunningham (2011), who argued that, in the case of electricity, in the absence of competition, it is more favorable to invest in short-term energy consumption rather than energy production. Furthermore, Hill (1996) drew attention to the lengthy process of Indonesian policy-making, while Prawiro (1998) argued that policies can appear appealing, but do not touch the real substance of the problems, and so serve no practical purpose.

Muliadiereja (2005) argues for the need of integrated planning covering a range of economic, social, and environmental considerations, in which a tradeoff between different values is evaluated through policy decisions. However, conversely, the 'rational'

comprehensive approach in planning has been widely criticized for sidestepping the political dimension in the policy-making process (Alexander, 1992). As in other countries, politics significantly influences the shaping of energy developments and policies in Indonesia. This can be seen, for instance, in the cancellation of energy subsidies by President Megawati only several weeks after they had been introduced, in the first week of January 2003. They were cancelled to maintain political stability, due to the many protest rallies by university students in Java. The same situation occurred during President Susilo Bambang Yudhoyono's administration in 2011 and 2012. Another example was the postponement of gradual (every quarter year) electricity tariff adjustments, which were to take place in 2004 and 2005, in order to maintain political stability, especially during the parliamentary and presidential elections (Muliadireja, 2005). This policy consequently increased the government's financial burden, as electricity subsidies amounted to US\$ 440 million in 2003 (DPR, 2003). A third example was the cancellation of a proposed nuclear installation to be built in Mount Muria (Central Java) in 1998, due to negative public opinion and protests by environmentalists (Muliadireja, 2005). These examples illustrate how Indonesian energy policy lacks a systematic approach and a grounded analysis.

This thesis attempts to provide a grounded scientific analysis for gas policy in Indonesia. A brief background of the political history of energy policy in Indonesia is helpful in understanding the context of this research.

1.2 Key Characteristics of Indonesian Energy Policy and Planning

The 1945 Constitution, Article 33, Paragraph 3 asserts that land, water, and the natural riches contained therein shall be controlled by the State and used for the maximum prosperity of the people. Every law and regulation in Indonesia refers to the 1945 Constitution as the highest level in the Indonesian legislative hierarchy. The first energy policy was stipulated in 1976, through Presidential Decree No. B-3 1 IPres/9176, called 'The General Policy on Energy' (KUBE), it provides guidance for national and sectoral energy policy measures. It was published as the National Energy Policy in 1980, after the establishment of a new organization, National Energy Co-ordinating Board (BAKOREN). The National Energy Policy encompasses management of energy resources from upstream to downstream, including all energy policy measures, e.g., conservation, diversification, and intensification of energy (Sugiyono, 2004). The policy is revised every five years, in accordance with the five-year national development plan. The last National Energy Policy was established in 2006 with Presidential Decree No. 5 Years 2006. It is the basic (legal) foundation for subsector energy policy planning, such as electricity, oil and gas, coal, and so

on. Included in this blueprint are utilization plans for each energy subsector in the total national energy mix. However, this plan did not work, because it set an overly optimistic target. For example, reducing oil consumption below 20% in 2005 has been regarded as unrealistic (Mujiyanto and Tiess, 2013). Since then, several revised drafts have been made. Unfortunately, a final decision has not yet been reached and the National Energy Policy Year 2006 is still the official energy policy. In this section key characteristics of Indonesia's energy policy are discussed.

According to the *Oxford English Dictionary*, policy means:

"... a course of action adopted and pursued by a government, party, ruler, statesman etc. ; any course of action adopted as advantageous or expedient " (as quoted from Hill, M., 1997, p. 6).

Lindblom et al. (1993, p. 5) describes policy-making as a complex, long, and intricate endeavor. He believes:

"... Understanding these broader aspects of policy making goes a long way toward unraveling the mystery of why governmental problem solving is not more effective ".

This approach views policy-making as a difficult task, surrounded by many barriers that hinder the formation of effective policies. Muliadireja (2005) points out several obstacles that have hampered the Indonesian policy-making process, which we will discuss in the next section.

1.2.1 The Influence of Culture and Tradition

The decision-making process in Indonesia has been much influenced by the culture and traditions from long before Indonesia became an independent nation (the Javanese Kingdom era, and subsequent Dutch colonization; Muliadireja, 2005), such as inefficiencies and lengthy procedures in the process.

The general consensus is that the Dutch did not help in improving this 'inefficiency' and even worsened the attitude of native people in order to prevent the natives from embracing the 'modern' and becoming competitors, especially in international trading markets (Muliadireja, 2005). However, the Dutch argued that they wanted to preserve the traditional values of the Javanese aristocracy (Legge, 1964). It was the famous principle 'asal bapak

senang' or 'for the boss, happiness' (Nolan, 1999) that has been blamed; the intention is to ensure the happiness of the boss rather than concern for the interests or welfare of the people.

It can be argued that many of the energy policies look 'spectacular' on the surface, but serve no real purpose other than ceremonial, and are very weak in implementation (Muliadireja, 2005). National Energy Policies have been issued since 1980, and reformulated every 5 years; however they have hardly been used for guidance by either government or private institutions (national or regional offices) dealing with energy matters. At the regional level, for instance, planners admitted there was a missing link between their regional utility plan and the National Energy Policy or the General Electricity Plan. The argument was that the National Energy Policy was 'too normative' and lacked important information details; hence implementation was difficult.

1.2.2 Inadequacy of Analysis and Information

Information and analysis are important for defining social problems and exploring policy solutions. However, often they are limited by people's capacity. Lindblom (1993, p.10) argues: "policy-making is a complexly interactive process without beginning or end". Despite its important role, Indonesian policy-making often lacks two key elements that could make energy policy more effective in solving social and economic problems: adequate analysis and information (Muliadireja, 2005). This was recognized by the Indonesian government, which has deliberately tried to enhance the supply of organized information and analysis for effective energy policy-making. Lindblom (1993, p.15) acknowledged that information and analysis can be inadequate in a poor, developing country:

"... In a wealthy country like the United States, analysis pertinent to policy goes far beyond the studies conducted by government agencies. There runs a deep and wide river of information and opinion fed by many springs, from formal research projects to letters to the editor, some of which makes its way into the thinking of those with direct influence over policy. The flow of analysis is thinner in poor countries that cannot afford it, of course, and authoritarian government stifles it".

Despite the modernization process of the Indonesian economy and government efforts, an information problem still exists. Often energy analysts and decision-makers must manage tasks beyond their capabilities and not supported with sufficient information. Lindblom (1993, p.16) said that *"too much and too little information are both perilous"*, which explains why many people are puzzled about expert findings. They do not know whom to trust when

given conflicting findings or recommendations, which results in the skepticism and resistance that often characterize the acceptance of policy recommendations (Lindblom et al, 1993).

Complex problems take time and resources to be analyzed, yet many energy decisions in Indonesia must be made in a short time, and especially those related to pricing policy. Hence, it becomes an impossible task. According to Lindblom et al. (1993, p.21) complete analysis and information is not feasible:

" . . .most policy questions therefore are decided by faster, cheaper methods than by analysis; most commonly, by delegating responsibility for decisions to designated officials who must decide, drawing on whatever information is available."

1.2.3 The Role of Politicians and Planners: Decision-Taking versus Decision-Making

In Indonesia, the minister is a political figure; regardless what the results of analysis are, they tend to be ignored if they are contradictory to the political will. It occurs quite often that newly appointed ministers or government officials issue new policies for the purpose of gaining popularity and for political reasons; to show that he/she has the ability to produce new policies during his/her term. For example, consider the policy on using coal briquettes to replace kerosene for cooking purposes in the household sector, which was enacted in February 1993 by the Ministry of Mines and Energy (presidential Instruction no. 17/1993) (Schaeffer, 2008) and the policy on increasing the efficiency of energy use in the energy-consuming sector which had a target of 17% energy savings nationally by the year 2000 (BAKOREN, 1995). Both policies were criticized as being too ambitious and had not undergone any assessment of the practicalities of implementation; later they were shown to be no more than political moves (Muliadireja, 2005).

Every law in prepared Indonesia and formulated by government is supposed to be examined by the House of Representatives in order to ensure minimal risk and the greatest benefit to society. The regulations, policies, or decrees issued by the government should be in accordance with the law and consistent with other policies in the hierarchy. This means that there is a balance of power within the government to provide complete information, alternatives, and analysis to underpin policy, hence minimizing risk. The House of Representatives' role is to ensure that policy is eminently for the greater good. This is relevant to our research, because we want to discover whether certain gas policy decisions indeed add to the "greater good" of Indonesian society.

1.2.4 Successful Implementation

Another problem with energy policy-making in Indonesia is the lack of implementation, or, when implemented, disappointing results. Faludi (1973) argued that successful implementation depends on both knowledge and authority. These two aspects are always limited in the energy decision-making process in Indonesia, and this negatively influences the capability of many energy institutions in both formulating and implementing energy programs. Faludi (1973) also accentuates the urgency for the government to adjust its control variables in order to reduce sources of tensions and eventually to ensure successful implementation. This can be done by diverting resources into control in accordance with a program. Furthermore, he claimed that difficulties during implementation are likely to be caused by flaws in the program's design process. Inadequacies in program formulation could be caused by lack of knowledge about the outside world, or misconceptions about the control process, or even the unavailability of resources. Faludi (1973) points out that it is important to sharpen our images and improve our knowledge of control processes, including diverting resources into control in order to improve institutional planning ability for program implementation.

1.2.5 Limitations on Bureaucratic Intelligence

The capability of many bureaucrats in Kementerian Energi dan Sumber Daya Mineral/KESDM (the Ministry of Energy and Mineral Resources) with respect to knowledge and skills in analyzing social problems is rather inadequate (Muliadireja, 2005). According to Lindblom (1993), bureaucrats frequently emphasize the process rather than the results; personal ambition is more important than the program's goal. They tend to focus on the procedural aspects in an attempt to avoid responsibility, even if it means perpetuating useless actions. Bureaucrats in Indonesia are well known for their sluggishness in responding to public demand and on occasion prefer taking no action because of their own limitations. Moreover, they are notorious for disguising mistakes rather than admitting and correcting them, which weakens their bureaucratic intelligence. This confirms Lindblom's (1993) argument that bureaucrats in general tend to protect their budgets and have a very "short-term, narrow vision" rather than setting "broader, long-term goals".

1.2.6 Emerging Energy Policy Objectives

Several policy objectives have to be taken into consideration in formulating Indonesian energy policy, because these guidelines will apply for the next 20 years. Economic and environmental issues have gained more attention in Indonesia and now have major input into decision-making in the energy sector. The Indonesian energy sector wants to ensure that energy efficiency, economic growth, and protection of the environment are included in the objectives of the national energy policy, as was explicitly stated in the 2006 National Energy

Policy (KESDM, 2006). These important policy objectives can be broken down into specific elements, i.e., energy security, economic efficiency, energy efficiency, CO₂ reduction, energy self-sufficiency, and renewability. These objectives will be applied to policy analysis to ensure that solid and optimal policy options are recommended.

1.3 Natural Gas Sector

The natural gas sector has a strategic role in national development. This role is reflected by the state revenue and multiplier effect it generates, for example, in the growth of employment levels. Based on analysis of linkages between sectors by using Input-Output tables issued by Biro Pusat Statistik (BPS) in 2005, forward linkage in the natural gas sector is 3.14. This means that for every Indonesian Rupiahs (IDR) of natural gas usage output sold, IDR 3.14 was generated in downstream sales. In other words, the natural gas sector supports activity in other sectors using natural gas, and as a result the entire economy expands through increased employment and production. Thus, natural gas is a strategic sector. Its contribution to the national economy is about to 5.55% of Indonesia's total GDP (BPS, 2010).

Natural gas utilization has grown significantly due to the increased price of oil and removal of the gasoline subsidy, but this was not accompanied by an increase in production. This results in a supply and demand imbalance. The government has a strong legal instrument to promote natural gas utilization. However, as we shall see in this section, in practice there are problems that hinder development of the natural gas sector in general, and development of the domestic natural gas market in particular.

According to the 'Law of Oil and Gas No. 22 Years 2001, and 'Ministerial Regulation No. 3 Years 2010', the Indonesian government has sovereignty over national gas resources. Under Article 8, the GOI gives priority to utilization of natural gas for domestic needs, as well as introduction of competition with an open access regime for transmission and distribution pipelines. The government is responsible for constructing gas infrastructure, conducting gas management, enacting gas pricing policy and allocating gas supply among user groups. In addition, the provisions of Article 3 of the Law of Oil and Gas state that oil and gas operations should ensure the efficiency and effectiveness of oil and gas as sources of energy and raw material for Indonesian industries, thereby providing the greatest possible contribution to the national economy and strengthening the position of industry and trade in Indonesia.

Prior to 2001, gas policy prioritized gas utilization for export in order to maximize state revenue, and infrastructure development was directed to support the Trans ASEAN Gas

Pipeline (TAGP) instead of domestic infrastructure. After the new oil and gas law was introduced in 2001, there were some crucial changes in gas policy. The producer had a domestic market obligation (DMO) of 25% to support the domestic market; and big gas reserves were now prioritized for the domestic market. However, the new policy directive could not be easily implemented because of path dependency. Some parts of the reserves were bound by long-term contracts, limited infrastructure connectivity, and lack of clarity about pricing policy. Moreover, efforts to boost gas production were hindered by a non-conducive investment environment.

Liberalization of the gas market in 2001 was expected to stimulate improvement in the gas sector, particularly infrastructure development, which was previously dominated by the state-owned company, PGN, which controlled about 80% of the transmission grid (IEA, 2008). However, it did not work as expected; no new investments in the transmission or distribution networks resulted, partly because of supply uncertainty in the domestic market. Part of the problem was the low domestic gas price.

In this section we have described the dilemma in Indonesian energy policy and planning. This problem affected natural gas policy; in particular the sector suffered from insufficient analysis and information. Investment in gas infrastructure has been lacking for years, and the government response is very late. Similar problems occurred with supply allocation policy. These problems will become the central focus of this thesis.

1.4 Research Question and Outline of the Chapters

The overarching research question of this dissertation is to be found in the debate between two different perspectives on regulation which have different objectives: the neoclassical economics perspective and the political regulation perspective (Table 1). The neoclassical emphasizes the importance of economic efficiency and correcting market failures, while political regulation focuses on social goals.

Table 1.1 Two Regulatory Perspectives

Perspective	Regulatory Focus	Process in the Dissertation
Neoclassical	Economic goals, efficiency, correcting market failure	Energy planning perspective based on market assumptions of sector linkages to generate a model
Political Regulation	Social goals	Integrated approach combining economic efficiency and social goals

In this thesis, the author argues that these two different objectives should not conflict with each other. Instead, an energy planning perspective with a three-layered structure – macro (national economy), meso (energy sector), and micro (prices) – can theoretically integrate the economic efficiency perspective of neo-classical economics and the political regulation perspective of achieving certain social goals (equity). Energy planning requires analysis that links the energy sector to the rest of the economy, national objectives, and the impact of policy on economy concerning availability, prices, and taxes and the like (Munasinghe, 1993).

Most energy policy issues in Indonesia have not been approached using a reliable, integrated energy policy model that clearly takes into account the impact of various policies on economic factors (e.g., prices), technologies, environment, lifestyle, GDP, population, and so forth (Muliadireja, 2005). As a result, many energy problems trigger unintended economic and social consequences. Various issues associated with an increasing population, greater economic activity, and rapid technological change in almost all sectors make the challenges facing energy problems more complex, and provide the impetus for a better modeling approach that integrates changes and provides alternative policy solutions.

We argue, within the context of Indonesia's political and cultural background, that energy planning based on solid scientific grounding is needed in energy policy. Successive Indonesian governments have implemented a series of policies to mitigate domestic natural gas scarcities. However, both the nature and consequences of these policy measures lacked grounding in solid scientific research. Gas policy-making in Indonesia, for example, should take into account the potential benefits of natural gas, such as energy security, economic growth, household welfare, and income distribution. The important questions to be addressed are: How can decision-makers assess the policy impact on each of these dimensions? Will the policy benefit residents, or will they affect them negatively? Economic and social variables have complex direct and indirect linkages; therefore we need a tool for

quantitative economic analysis that enables us to evaluate policy effectiveness and its impact on the economy and welfare (Qin, 2011).

This dissertation's focus and contribution is to provide this type of analysis for natural gas policy. There are many ways to do this, and the approach adopted depends on the objective and scope of the analysis. We have argued that gas policy affects the nation's macroeconomic situation, and that is the focus of our study. Therefore we need a methodology that is able to deal with the macroeconomic implications of a policy; in this dissertation we used a Computable General Equilibrium (CGE) model.

CGE is a model that is able to capture some of the complex interrelations between sectors and agents of the economy, and widespread effects of a policy change or shocks on economic and social variables. Initially, input-output (IO) models were used as a framework to capture interrelations and interdependencies among production sectors and primary factors. The components of final demand and the value added for each specific sector are also involved in the input-output modeling framework. However, input-output models have serious limitations, namely: "lack of market mechanisms or optimization processes, their fixed coefficients that impose fixed relative prices, their poor substitution possibilities, and their lack of agents" (Qin, 2011, p.7).

To overcome the limitations of partial equilibrium approaches, CGE models were developed for analyzing economic and policy linkages. A general equilibrium model attempts to capture complex interlinkages among production sectors, markets, and agents. It also introduces substitution possibilities through a utility and profit maximization behavioral model, and in this it is regarded as superior to the input-output method (Perman et al, 1996). CGE models can be applied to analysis of how an entire economy adapts after a shock and can help provide measures of policy effects by considering integration and interactions among markets.

CGE models are not without limitations (Sue wing, 2009; Diao, 2009). Their strengths are manageability of supply constraints and price changes, non-linearity, and flexibility in input and import substitutions. But it is also argued that the key weakness of CGE models in risk analysis is the assumption that the economy is in equilibrium in each step (Harrison, 1993; de Melo, 1988). After an economic or policy shock, imbalances in the economy are present and often persistent. Moreover, competition is highly coordinated by governmental intervention and equilibrium cannot be achieved by price changes. These limitations are discussed further in Chapter 4 Section 4.1 and are borne in mind in the interpretation of the model.

The overarching question guiding this research is:

Does Indonesian gas policy contribute optimally to macroeconomic development of the country, and, if not, what adjustments are needed?

This question was then divided into a series of subquestions:

- a. How should Indonesia prioritize natural gas allocation for the domestic market to achieve the optimum benefit for the national economy?*
- b. To what extent can the gas price be adjusted/increased to reach an optimum trade-off between economic efficiency and social objectives?*
- c. What impact will natural gas infrastructure development have on Indonesian energy security and economy; and what are the viable policy options to finance it?*

The following chapters of the thesis provide answers to these research questions (Fig 1.1):

Chapter 1 begins with the motivation of this doctoral thesis. It also introduces and contextualizes the research and research question, and justifies the choice of the topic and problems in terms of theoretical, analytical, and methodological relevance.

Chapter 2 reviews the energy policy framework of Indonesia. It initially focuses on the country's institutional and legal frameworks for energy policy formulation. Emerging energy policy objectives (and their operational measurements) are critically discussed, with the aim of providing direct input into the policy-modeling process in Chapter 8.

Chapter 3 presents an overview of the theoretical framework used in this thesis to study energy and economic development. The focus is on the processes that influence policy-making from three different perspectives: neoclassical economics, institutional economics, and political regulation.

Chapter 4 builds on the theoretical reflections of the previous chapters and develops an analytical framework that gives structure to the empirical part of the thesis. The main elements of the conceptual model used in the empirical chapters are introduced and explained.

Chapter 5 develops a methodology for providing estimates of the impacts of natural gas policy throughout the economy. The framework used is a Computable General Equilibrium (CGE) model, which is outlined, together with the equations that make up the model.

Chapter 6 presents a recursive dynamic CGE model, which is developed for analyzing policy effectiveness in mitigating natural gas scarcity issues, for example by re-allocating natural gas from low-value to relatively high-value sectors.

Chapter 7 presents a comparative-static ¹CGE model to assess the broader impact of gas pricing policy. The model is used to evaluate the influence of gas price under different pricing adjustment scenarios.

Chapter 8 presents a comparative-static CGE model to assess the economic consequences of fiscal stimulus to finance the natural gas infrastructure under different scenarios, for example, the effect of fuel subsidy removal on state revenues from oil and gas.

Chapter 9 summarizes the empirical findings presented in the previous chapters and discusses some policy implications of these findings. It provides a brief general conclusion and highlights prospects for further studies.

¹ Comparative Static CGE Model is a model that predicts how an economy will respond to policy change in some future period without explicitly showing the process of adjustment to a new equilibrium. In contrast, a recursive dynamic CGE Model shows the adjustment process explicitly, often at annual interval.

Figure1.1 The Structure Of The Dissertation

Chapter 2 Dilemmas in the Indonesian Natural Gas Market

2.1 Introduction²

Indonesia is a country with abundant natural resources, including natural gas and oil. Exploitation of these energy resources has given rise to a huge oil and gas industry that has made Indonesia a leading world producer of Liquid Natural Gas (LNG). Given the nation's geography – Indonesia is large archipelago – and the diverse and remote locations of the gas fields, Indonesia focused on LNG production and shipping from the beginning of natural gas exploitation. LNG shipping has been the main method of processing natural gas, for both domestic consumption and export. Since the early 1980s Indonesia has exported natural gas to other countries, in particular within the region. Japan, South Korea, and Taiwan were served by LNG tankers; Singapore and Malaysia could be connected to Indonesian gas fields by pipelines.

However, prospects for Indonesian gas have changed following a refocusing of natural gas policy in 2001. In recent years, the implications of this policy change have become apparent and demonstrate the difficulties Indonesia is facing with respect to national natural resource management. Briefly stated, Indonesia wants to further develop its domestic downstream gas market for the benefit of the country's economic prosperity, but is facing serious natural, institutional, and economic barriers (Hyden et al., 2003; OECD, 2011). At the same time, the country is facing similar upstream barriers to the exploration and exploitation of new gas fields. The ultimate consequence is that the country is unable to simultaneously meet increasing future gas demand in both domestic and export markets. Therefore, in some respects, Indonesia is trapped: the country possesses a tremendous natural resource without being able to get the full benefit for the country's economic prosperity.

This chapter briefly reviews the problems and dilemmas Indonesia faces in governing the gas sector and the transformation needed in order to address these problems. This chapter looks at why we need to conduct research in specific areas of gas policy and provides background for the empirical chapters. The chapter is structured as follows. The next section briefly introduces Indonesia's natural gas market and gas industry. Section 2.2 discusses

² This chapter is based on Hutagalung A., Arentsen M.J., Lovett J.C. Regulatory reform in Indonesia Gas Market, paper presented at the 4th annual CRNI conference, 25 November 2011, Brussels.

Indonesian gas policy and the barriers faced by the government. Section 2.3 to 2.5 discuss these barriers in more detail. Section 2.6, the concluding section, summarizes the major findings.

2.2 Natural gas in the Indonesian archipelago

Indonesia is an archipelago consisting of 17,000 islands, inhabited by about 240 million people (2011). Its population and economy are concentrated on the island of Java, with about 130 million inhabitants. Much of the country's surface is covered by tropical rain forests; Indonesia is second only to Brazil in terms of tropical forest cover. Natural resource production makes up a major share of gross domestic product (GDP). In addition to oil and gas, the country has massive coal, bauxite, and nickel reserves. Large parts of the country are not easily accessible and mineral exploration is incomplete. Next to production and export of mineral resources, agriculture makes up a substantial share of Indonesia's GDP. Large areas of rainforest are converted to agricultural cultivation every year in order to keep up with the growing population. Lately, however, Indonesia has started diversifying economic activities by developing industry, and so balancing the country's economic portfolio, national income, and wealth position.

According to the World Bank classification, Indonesia belongs to the lower-middle-income group of countries, with an economic profile showing above-average indebtedness³ (World Bank, 2011). Industry, including the natural resources industry and services, are the country's two largest economic sectors, contributing almost 40% each to the country's GDP for 1989-2009 (World Bank, 2011).

Oil and gas production have been part of Indonesia's economic activity for more than a century, starting in 1883 with the discovery of a gas field in North Sumatra (Wijarso, 1985). Within a few years more oil and gas fields were discovered, among others in South Sumatra and Kalimantan. Initially natural gas was only used as field fuel to facilitate production of the rather thick Indonesian crude oil. Major new gas discoveries were made in the 1970s in Sumatra and Kalimantan, and later in other parts of Indonesia, such as the islands of Natuna, Papua, and Maluka. Indonesian gas reserves and gas fields are distributed throughout the country (Figure 1), and the archipelago's geography creates natural barriers to easy transport. This has been mitigated by distributed LNG production and shipping, combined with localized gas pipeline infrastructures. Indonesia is considered to be the tenth largest holder of natural gas reserves in the world and the second largest in the Asian Pacific

³ Indebtedness is the ratio of debt to GDP

region (IEA, 2008). Indonesian gas fields are also relatively small in size, which makes production costly (Figure 2.1).

Figure 2.1 Indonesian Gas Fields and Potential Gas Reserves in Trillion Standard Cubic Feet (TSCF) in 2010 Proven and Estimated

Source: Ditjen Migas, 2010a

Thus far Indonesia has strongly focused on gas export, but plans to redirect focus to the domestic market. However, during 2000-2010, gas export continued to exceed domestic gas consumption by an average ratio of 60% (Ditjen Migas, 2011c). Most exported gas is supplied to countries in the region, in particular Japan. The Indonesian domestic market is basically an industrial and electricity-production market, apart from the significant usage of natural gas for gas and oil production itself (Figure 2.2).

Figure 2.2 Domestic Natural Gas Consumption 2005-2010

Source: Ditjen Migas 2010b compiled by the authors

Domestic gas demand has shown a consistent increase since 2005. The fertilizer industry and power generation take significant shares in domestic demand. The oil industry also uses substantial volumes of natural gas for oil production (Figure 2.2). Indonesian crude oil can only be produced by steam injection and natural gas is used for on-site steam production. Another significant category is flare gas, which has to be burned to reduce pressure in the petroleum operation system. To avoid wasting the gas, this flare is sold to interested consumers. The total volume is quite significant, between 300-400 Million Standard Cubic Feet per day (MMSCFD), equivalent to 8 – 10 mcm⁴ per day), which is large enough to supply more than one fertilizer plant. However, flare gas is intermittent, thus it is unlikely that a business entity would invest in a new project and base the gas supply solely on it.

Figure 2.3 Indonesian Gas Transmission Infrastructures

Source: Ditjen Migas, 2011f.

The size and island geography are natural barriers to developing a pipeline-based transmission and transportation infrastructure in Indonesia (Figure 2.3). To overcome this, two operational LNG plants have been located to facilitate efficient export. However, given the new focus on the domestic gas market, they are not well located and distance to the domestic market is quite large. Five more LNG trains are planned at different gas fields distributed over the country, but it will take time before they become operational. Indonesia faces a number of problems in the further development of the gas market. The next two sections review these problems.

⁴ Mcm = millions cubic meters

2.3 Natural Gas Policy

Natural gas policy is an integral and coherent part of national energy policy. In accordance with the planned national primary energy mix for 2025, gas will be used to cover reduction in oil use in the present and the future. By 2025 it is expected that oil use can be reduced to 20%, with gas increasing to 30% (KESDM, 2006). Use of gas as both an energy source and a raw material is currently increasing. Utilization is expected to accommodate all the sectors needing to increase production (fertilizer industry, power, and other industries).

The Directorate General of Oil and Gas formulated the blueprint for national gas policy according to this national energy policy framework (Ditjen Migas, 2011e). Natural gas development policies aim to achieve the following goals:

1. Ensure effective implementation and control exploration and exploitation activities;
2. Ensure effective implementation and control efforts for processing, transportation, storage, and commerce;
3. Ensure efficiency and effectiveness of the availability of natural gas, both as a source of energy as well as a raw material for domestic needs;
4. Support and develop national capabilities;
5. Increase revenues to contribute as much as possible to the national economy;
6. Create jobs, improve the welfare and prosperity of the people, and continue to preserve the environment;
7. Safe, reliable, and environmentally friendly oil and gas activities.

To achieve these goals, a set of policies was developed. However, before we analyze the current policy, we have to look back at the history of gas policy, because conditions established in past policies always have effects on present policy.

Gas policy evolved over time and can be divided in three periods, pre-1992, 1992-2001, and post-2001, with respect to five important aspects: reserve utilization, infrastructure development, Domestic Market Obligation (DMO), flare policy, and domestic gas price (Table 2.1). The year 2001 can be seen as a milestone for changes in Indonesian gas policy. Previously, export was given priority in order to maximize state revenue; infrastructure development was directed to support the Trans Asean Gas Pipeline (TAGP) instead of domestic infrastructure. After the new oil and gas law was introduced in 2001, there were some crucial changes in gas policy. The producer has a domestic market obligation (DMO)

of 25 % to support the domestic gas market, and large gas reserves were prioritized for the domestic market.

Table 2.1 Natural Gas Policy Evolution

	Policy	Pre 1992	1992-2001	After 2001
1	Reserves Utilization	Big reserves were used only for export and small reserves for domestic	Big reserves were used for export and small reserves for domestic	Big reserves were for domestic or export, small reserves for domestic
2	Infrastructure Development	The concept of Trans ASEAN Gas Pipeline (TAGP) was introduced	TAGP was used as reference and plan for Indonesian Integrated Gas Pipeline (IIGP) to support TAGP	Priority was given to IIGP as basis of natural gas infrastructure development instead of TAGP
3	Domestic Market Obligation (DMO) Implementation	There was no concept on DMO	Consideration of implementing DMO for gas	Implementation of DMO for gas (25% of PSC share)
4	'No flared gas' policy	There was no concept developed to handle the issue of flare gas	Starting implementation of 'no flare gas' policy	'No flare gas' policy fully implemented
5	Domestic Energy Price	Gas price was not supporting natural gas development	Gas price was not supporting natural gas development	Gas price was gradually adjusted to support utilization of natural gas

Source: Ditjen Migas 2009a

The strong focus on developing the domestic gas market was a drastic change in gas policy orientation and such a substantial change was not easily implemented due to the policy lock-in for export orientation. Natural gas had been planned for export; hence the infrastructure was built to serve this purpose instead of the domestic market. As a consequence, gas infrastructure for the domestic market is very limited in Indonesia, and connections to gas fields for domestic consumption were lacking. Moreover, gas reserves themselves are under long-term contracts that cannot be terminated unilaterally. This is troublesome because the reserves potentially available for the domestic market are insufficient to meet domestic needs. Another obstacle to developing the domestic gas market is domestic energy prices. In the past, gas was not a popular energy source and was sold at a low price to the domestic consumer. As demand rose, the price went up. The price increase was also caused by the lucrative export alternative for natural gas producers, as the export price was higher than the domestic price. If the Indonesian government wanted to implement the gas policy changes to develop the domestic natural gas market, it faced two problems:

1. Finding a solution for the gas price increase, which would not be acceptable in a society used to substantial energy subsidies;
2. Finding a solution to the gas producers' preference for exporting gas instead of supplying the domestic market.

The second problem required at least a balancing of domestic and export prices, but this would increase the domestic price substantially and so, in a circular argument, not be acceptable to Indonesian society.

These two factors have resulted in Indonesia's natural gas supply position being paradoxical. It has substantial natural gas reserves, but is unable to benefit effectively from them. In the following sections we elaborate on the natural gas problems Indonesia is facing. We structure our analysis around three major problems: exploitation of natural gas reserves, the immature domestic gas infrastructure, and energy price problems. These topics are also the focus of the empirical part of the dissertation (Chapters 6, 7, and 8).

2.4 Reserve utilization

This section discusses the problems of reserve utilization. It is divided into three sections: natural barriers, institutional barriers, and investment barriers.

2.4.1 Natural Barriers

Indonesia has huge gas reserves and some basins with high potential have not yet been explored (see Figure 2.1). The current proven reserve is assumed to permit gas production for about 48 years (Ditjen Migas 2010a), but this might be longer if new finds are made. Not all proven gas fields are yet in production. There are several natural reasons for this. First, the remote and distributed locations of proven Indonesian gas fields make them an unattractive investment. Moreover, as Figure 2.1 indicates, there are many gas fields, but most of them are restricted in volume, which challenges their economic feasibility.

Second, there are mixed gas qualities in the fields. In particular, the huge Natuna field (with 51 trillion cubic feet (TCF), equivalent to 1381 billion cubic meters (bcm) recoverable reserves) presents a problem. Exploitation of this huge gas field became problematic when it was discovered that the CO₂ content of the gas is about 71 percent (28% methane, Suhartanto et al. 2001). Commercial application of Natuna gas would require substantial additional investments in cleaning technology to remove and process the CO₂. The costs of developing and operating the field are estimated to be US\$ 8,145 billion and US\$ 9,941

billion, respectively (Ditjen Migas 2008a). Although the Natuna field is currently the largest Indonesian gas field, the low gas quality presents substantial commercial risks to its exploitation.

Third, gas production in remote gas fields sometimes requires expensive on-site stand-alone technology, which also presents challenges to commercial attractiveness. An example is the Masela block (15 TCF), which can only be exploited by floating LNG technology. Production, treatment, liquefaction, and shipping must be concentrated in a remote area far out to sea. Apart from the huge extra investments (approximately US\$ 8 billion, Pradipta 2011), there is also a technological risk; floating LNG train technology is less proven than its onshore equivalent.

Fourth, the remote and distributed locations of the many relatively small gas fields in the Indonesian archipelago, in combination with the economic center of the country being on Java, make it difficult to develop commercial applications for natural gas via a pipeline infrastructure. The sea, large distances, and remoteness of export markets, force Indonesia to continue the LNG route for natural gas exploitation. There are government ambitions to increase gas pipeline infrastructure in some parts of the archipelago, but substantial investments are needed and these are currently lacking. Part of the problem is uncertainty about sustained development of the domestic consumer market (see Section 2.3.2).

In conclusion, Indonesia's natural circumstances act as a barrier by requiring major additional investments, which in turn challenge the commercial attractiveness of Indonesian gas on the international market. Supplying "more expensive" Indonesian gas to the domestic market is not an alternative, because domestic purchasing power is currently too low. This is discussed further in the next section.

2.4.2 Institutional Barriers

Indonesia made a significant change in natural gas policy through the introduction of a new gas law in 2001. The law changed many things, but only a few are relevant for this dissertation. In general, the new law was meant to give the Indonesian gas sector a strong push by liberalizing the downstream market and rebalancing the export/domestic market focus. Indonesia wants a stronger domestic gas market, instead of continuing to export the larger part of Indonesian gas as LNG.

With respect to the upstream market segment, the law was intended to improve the quality of the institutional environment for potential investors in exploration, development, and production of gas fields. The Indonesian government dominates the natural gas sector, but has always worked together with private investors to exploit this natural resource (BPK, 2008). To facilitate the upstream public-private cooperation, Indonesia, almost from the beginning, applied a "Production Sharing Contract" (PSC), which allows the private party full cost recovery in exploitation of the gas field, but at the same time guarantees state revenue. The 2001 law was intended to improve transparency and quality of procedures for private companies obtaining PSCs. One problem to be solved was the double role of the Pertamina organization in the bidding process. Before the new law, Pertamina acted both as a gas company and as the organization responsible for the PSCs. That double role led to corruption and inefficiency (Schulte Nordholdt, 1994).

The new law transformed Pertamina into a profit-oriented limited liability company and transferred the contractual responsibilities to two new public organizations, Ditjen Migas and BP Migas, which now share responsibility for managing the Indonesian gas and oil sector. However, the new law did little to improve the institutional environment for investors. In some respects it worsened conditions, since investors were confronted with new barriers. The new law turned out not to be a *Lex Specialis* like the previous gas law, which presented investors with many diffuse and badly defined competencies and contradictory requests and obligations of public organizations. Instead, the new law extended the number of public organizations investors had to deal with, in particular in sectors and jurisdictions other than the gas sector. The organizations all have their own, often quite contradictory, requirements, which are not coordinated at the governmental level. This has complicated the procedure for obtaining a PSC, which now takes more time than before the 2001 law (DPD RI, 2011).

Another related institutional problem is the quality of geological data available for potential investors in Indonesia. These data are produced by governmental organizations and are the core information for potential investors in the bidding process for a PSC. In general the data quality is rather poor and most of the time only available as hard copy. Under certain conditions, investors are allowed to collect the seismic data in cooperation with the governmental agency (Ditjen Migas), which gives the investor the privilege of having the right to match the "winning" bid in the bidding process. This option is called direct-offer bidding. However, the Indonesian government lacks the money for state-of-the-art seismographic research and has yet to invest in improvement of data quality because of the costs involved. One consequence of poor data quality was demonstrated in 2010, when only

3 of the 14 offered working acreages were successfully tendered. In total, 36 companies bought the tender package with the unreliable data, but only 3 companies continued bidding for a contract. This lack of interest might not be solely due to poor data quality, but could also be caused by other problems, such as geological prospect (see Section 2.4.3 about economic barriers).

A third institutional problem that emerged after introduction of the 2001 gas law is caused by the “Domestic Market Obligation” (DMO). DMO requires producers to offer 25% of their gas production to the domestic market, in order to develop the domestic gas market in conjunction with the export market. However, DMO is basically a paper-based legal obligation with few workable procedures for producers. A related problem is that clear tariffs for the domestic market are missing. Producers are faced with an obligation that is complicated due to lack of transparent rules. Producers are required to offer gas to domestic consumers for a minimum price that reflects cost recovery and a margin. However, if the location of the gas field gives the producer the alternative to export, the producer tends to offer the gas to domestic consumers for a price closer to the export price instead of the price reflecting cost recovery and margin. Since almost all gas fields have the option of export, the DMO is yet another bureaucratic obstacle for production companies (Petroleum Report, 2006).

2.4.3 Investment Barriers

The natural and institutional barriers discussed previously have severe implications for new investments in the gas sector. A major concern is that investments in exploration have been on the same low level for many years now (Ditjen Migas, 2011b). One result of investments not increasing sufficiently is that finding and proving new gas reserves is also not increasing. One cause of lagging investments in exploration are investment risks, because investment costs are not recovered if no gas is found. The natural and geographical conditions of Indonesia are considered a serious drawback; they make investors hesitant, as stated in a study by Price Waterhouse Coopers (PWC) from 2005:

"From a geological prospective, investors expect to discover smaller "finds" in more remote locations which dramatically changes the risk profile of these exploration activities. As previously mentioned this scenario will increase the finding and operating costs thereby lowering profitability without some sort of additional fiscal incentive. To induce investment for exploration operations with such geological risk profile, the GOI must establish regulatory and fiscal measures which are conducive and attractive to potential/existing investors."

(Price Waterhouse Cooper, 2005)

Investments need some form of compensation or risk alleviation for the relatively expensive geographical conditions of Indonesian gas fields. Currently this financial compensation is not available, simply because Indonesia does not have the capital, even though the country's unproven gas reserves are assumed to be quite voluminous, according to a PWC study (Investor Survey of the Indonesian Oil and Gas Industry, 2010). The Indonesian investment climate is considered too risky for many potential investors. Indonesia is facing a real challenge here, since about 20% of the country's budget depends on revenues from the gas (and oil) sector (Ditjen Migas, 2009b). If gas production stagnates or decreases in the coming decades, the country will lose substantial income, thereby limiting its potential for economic development. Stagnating gas production will also hinder further development of the domestic gas market, and this too will affect the country's development potential. The primary idea behind further domestic market development is economic growth, with natural gas as the catalyst.

2.4.4 Regulatory Remedies in the Upstream Segment of the Market

Three meta-principles, Credibility, Legitimacy, and Transparency, should be incorporated in a regulatory system to make it effective (Brown et al, 2006). Both Credibility and Legitimacy have common elements, which give investors and consumers trust in the system. Transparency or regulation is a prerequisite (Brown et al., 2006). Moreover, Francis Fukuyama (1996, p.7) argues that trust is central to economic development, *'nation's well being, as well as its ability to compete, is conditioned by a single pervasive social characteristic: the level of trust inherent in society'*. As will be shown below, current Indonesian regulatory practice does not incorporate these three meta-principles and does not provide fertile ground for trust among investors and consumers. From Sections 2.3.1, 2.3.2, 2.3.3, we have already learned that regulation in the upstream segment of the gas market is rather vague. In this section we analyze the regulatory remedies currently suggested and applied to the three types of barriers in the upstream segment of the market. This will show the lack of transparency in regulation.

2.4.4.1 Regulatory Remedies for Mitigating Natural Barriers

As has been noted, Indonesia's natural gas reserves are not easily accessible. The many fields are relatively small and remotely located, with mixed gas quality. Almost all fields are offshore. Finding and exploiting the fields requires large investments, and an excellent investment environment is a prerequisite. However, we have shown that this is far from reality in Indonesia. The PSC contracts do allow private investors full cost recovery, but, as we have also seen, getting such a contract is not easy, and no guarantee that the contracted field contains natural gas.

Development of a good infrastructure is an important step in dealing with the natural circumstances in the Indonesian upstream segment. Due to the distributed offshore production sites, shipping of LNG is almost the only transport option, but this technology is relatively expensive compared to pipeline transport. In combination with the relatively small scale of the gas fields, it is even more expensive. This presents a serious problem for further exploitation. Creative technological and financial solutions are needed, and these are currently lacking, though clustering transportation infrastructure offshore could be a workable option to handle the infrastructure needs in an economically feasible way.

Figure 2.3 gives some examples of the options. Although new infrastructure projects are planned (localized pipelines, new LNG trains and terminals), investors are lacking. According to a PWC report in 2008 (Investor Survey of the Indonesian Oil and Gas Industry, 2008) and Nugroho (2004), Indonesia should develop an incentive system for infrastructure development both in the upstream and the downstream market segments. In the upstream market, the full-cost recovery scheme is not sufficient to attract investors. But developing an effective and efficient incentive structure is perhaps still a bridge too far for the current governmental bureaucracy, given the institutional problems Indonesia is facing. One of the options Indonesia is considering is a "depletion premium" to finance future exploration of new gas fields (Partowidagdo, 2005). The money should come from a form of taxation on the gas companies' profits. Currently it is unclear if this premium will become reality.

2.4.4.2 Regulatory Remedies to Mitigate Institutional Barriers

The regulatory challenge is to reduce or prevent institutional risks for potential investors. As we have seen, overlapping jurisdictions, contesting competencies and low-quality information are the current institutional risks for investors. With respect to jurisdiction of laws, there are some signs of improvement. Indonesia has mitigated import restrictions on all products and technology for upstream activities, which has clearly improved investment conditions, but

much more needs to be done. For example, producers are still exposed to unclear definitions of the concept of Cost Recovery. This causes uncertainty with respect to workable business cases (Lagaligo, 2011). The same holds for licensing procedures, which require involvement with many governmental organizations in contest with each other, due to inefficient procedures (Lagaligo, 2011). In general, the institutional environment in the Indonesian gas sector requires a high level of professionalism from the government, since all companies active in the upstream segment are large global oil and gas companies. Innovation is needed, including a change in mindset to create a conducive investment climate (Pradipta, 2011).

2.4.4.3 Regulatory Remedies to Mitigate Investment Barriers

As described above, Indonesia faces two serious economic problems: lack of investment in exploration of new gas fields, and a risk of decreasing revenues due to delayed investments in gas field production. Mitigation of both problems requires a system of incentives to stimulate investment. For instance, the government has allowed potential investors to participate in the seismic and geophysics research of gas fields. Investor research effort is compensated by providing them with privileges in the bidding process. In the bidding rounds during 2005 – 2008, 50-80 % of the bidding was privileged, based on joint research between government and the companies. But despite joint cooperation in research, only 30-50 % of the open bidding for gas fields was contracted between 2005 and 2008 (Ditjen Migas, 2009c).

Production could also be stimulated by rethinking the balance between cost recovery and state revenue in the PSC contracts. One option currently being considered is a dynamic split between the investor and the state, based on the producers' cumulative earnings instead of a fixed ratio independent of earnings. Another option is the introduction of a "Gross Production Contract" as an alternative to the PSC contract. In the Gross Production Contract, the state and the producer agree in advance about their share in the profit. This leaves the investor the freedom to increase profit, and the state is certain about state revenue. A third option currently under investigation is a delay in remittance of the state revenue until the field is in full production.

All remedies will need some institutional courage and creativity, in particular on the part of Indonesian governmental bureaucracy. The most difficult task is to encourage all parties to overcome their sectorial tunnel vision for the benefit of a better Indonesian investment climate for the gas market. However, this is quite difficult to realize. Meanwhile, problems in

the Indonesian gas market are accumulating. One of the more serious domestic problems is increasing domestic demand in combination with decreasing production. Even if the remedies are applied and everything runs smoothly, it will require at least 10 years or more before new reserves can be found or converted into production. On the other hand, there is currently a gas supply deficit that needs to be resolved in the near future. To mitigate natural gas scarcity in 2010, the Indonesian government stipulated a gas allocation regulation with consumer priority ranked as follows:

1. Enhance Oil Recovery (EOR)
2. Fertilizer/Petrochemical Industry
3. Electricity
4. Industry

This allocation decision means that the sectors at the top of the list will get priority in fulfilling their gas demand. This policy is not unique; other countries such as India (see Jain and Sain, 2011) and Pakistan (Ministry of Petroleum and Natural Reserves, 2005) have implemented similar policies with different priority preferences. However, this policy instrument does not completely solve the problem because it does not explain why one sector is prioritized over another. A partial explanation has been provided by stating that EOR is needed to keep oil production on track, as this is a source of state revenue; electricity and industry are ranked lower because of their flexibility in being able to change from gas consumption to another energy source.

However, a comparative assessment was never elaborated. It would be reasonable to ask, for example, what the economic losses would be for other sectors when gas supply is reduced. Consumer dissatisfaction is triggered when they feel they should get priority, particularly when it is stated that gas policy (point 6) should: "Create jobs, improve the welfare and prosperity of the people, and continue to preserve the environment". Therefore, we argue here that gas priority needs a scientific grounding to guarantee that gas allocation maximizes welfare gains.

The fundamental question that needs to be answered is: How should Indonesia prioritize natural gas allocation for the domestic market to achieve the optimum benefit for the national economy?

Rank of priority will give consumers in higher ranks the opportunity to meet their gas needs; hence consumers in lower ranks will get less gas or even nothing. To answer this question, we will do an economic wide-impact analysis to investigate the effect of different ways of allocating natural gas to consumers on the national economy. The aim is to determine the gas consumer rankings that give optimum benefits with respect to economic indicators.

2.5 Domestic Energy Price

One of the barriers to balancing domestic demand and supply is the domestic market's low purchasing power. The domestic gas price is subject to top-down regulation by government and is almost three times lower than the export price, so producers lack a strong incentive to supply the domestic market. From a social policy perspective, this is understandable, but it doesn't bring natural gas to the domestic market since producers can get a better price in the export market. Recommendations have been made regarding how Indonesia could solve this problem and make the domestic market attractive for new investments and supply. This implies that the current gas tariff policy should look for inspiration to economic regulation instead of social policy, with tariffs and social policy being in congruence for domestic gas market development⁵ (Petroleum Reports, 2006).

The regulated price by itself does not imply that the price is set below its economic value/price, the distortion is meant as a protection for domestic consumers from price escalation. A market mechanism is still implemented in the sense that the producer and consumer have the opportunity to negotiate, and the government is in a position to approve the price proposed in this negotiation. The problem arises because of different expectations from every party involved. The producer takes a benchmark from the international gas price and expects a price as high as possible, while the consumer wants a low price, knowing that the government will support that as part of its policy to support the domestic market.

The government wants to achieve a dual objective: state revenue from gas sales and support for the domestic market for economic growth. To achieve its social objective, the government can lower its gain from state revenue and thus realize its goal to stimulate economic growth. But this is not favorable for the producer because of loss of opportunity, and in the long term it is not attractive for future investment. In general, there should be price adjustment to a level acceptable for every party; as in other developing countries, pricing policy in general (and natural gas pricing in particular) serves multiple objectives, such as

⁵ The World Bank and the Asian Development Bank (ADB) encouraged Indonesia to adopt a pricing regime that creates greater incentives for companies to operate on the domestic market.

economic efficiency, government revenue, equity, and security of supply (DeLucia and Lesser, 1985; Julius and Mashayekhi, 1990). From standard economic theory we know that, in order to maximize welfare, a good price should be set at its marginal cost or the value of resources needed to produce the last unit of the good. DeLucia and Lesser (1985) labeled this price as “first best pricing” as opposed to “second best pricing”, a real-world pricing that takes into account the non-efficiency objectives, including social objectives, because some sectors of the economy are not priced according to marginal cost pricing. A trade-off must be made between efficiency and social objectives. In the past, energy pricing in Indonesia tended toward the social objectives direction; currently the government tries to deliberately move the price in the efficiency direction. However, the optimal position of this trade-off should be based on scientific analysis and information.

This led us to an important question: To what extent can the gas price be adjusted/increased to reach an optimum trade-off between economic efficiency and social objectives?

To answer this question, we conducted an economic wide-impact analysis of increasing the natural gas price with respect to economic indicators. The analysis will be done from both macro and micro approaches. Macro approaches investigate the impact of gas price adjustment on macroeconomic indicators, while micro approaches analyze the impact on cost structure on natural gas consumers.

2.6 Infrastructure development and the downstream gas market segment

As noted above, Indonesia made a significant change in gas policy in 2001. It was decided that natural gas should not only bring in state revenues, but should also contribute more significantly to the country’s economic development and prosperity. For that reason, further development of the domestic market became a dominant focal point in gas policy. In 2006 oil, natural gas, and coal dominated the nation’s primary energy mix, with oil accounting for about half and natural gas about a quarter. The share of natural gas in the primary energy mix is expected to grow to 30% in 2025. This seems to be a manageable increase, but in reality it is challenging, given the overall growth of primary energy demand. Further development of the domestic market faces serious barriers, which we will discuss in this section. Figure 2.4 gives an overview of projected gas supply and demand until the year 2025.

Figure 2.4 Supply and Demand of Natural Gas 2011-2025 (In MMSCF)

Source: Indonesia Natural Gas Balance 2011

Much of the gas produced already has been contracted (Fig. 2.4) and production and supply of natural gas is predicted to decrease over the years (Fig. 2.4 lower trend line). More important is an increasing gap between demand and supply of natural gas in the near future.

A serious related problem is the lack of market infrastructure, which in turn makes the prospects for further development of the domestic market highly uncertain. This uncertainty keeps investors and producers out of the domestic market. It is difficult to break this vicious circle. Indonesia has tried two solutions: extending gas infrastructure and introducing liberalization in the downstream market. This seriously affects Indonesian ambitions to further develop the domestic gas market. As domestic need for gas grows, gas availability is decreasing, demonstrating how problems in the upstream market segment severely affect gas-policy ambitions downstream. The domestic need for gas has been growing since 2005, when the government stopped the diesel subsidy for industry. Industry, *en masse*, moved to natural gas since its price was still strictly regulated. However, problems are accumulating because of a lack of domestic gas supply. These problems are not only caused upstream problems, but also downstream.

As discussed above, Indonesia faces geographic barriers for infrastructure. LNG is actually the only route for gas to the domestic market. The domestic market is primarily on

Java, where population and economic activity are concentrated. As shown in Figure 2.3, Java has three LNG terminals but the island's pipeline infrastructure is not well developed. Figure 2.3 also shows planning for new infrastructure projects; to date, all these projects exist only on paper and investment funds are lacking.

Institutional reform was the second entry point used by Indonesia to push development of the domestic market. Deregulation and liberalization were introduced in 2001 by the new gas law. The idea was to make a sharper distinction between the role and position of some of the incumbent parties such as Pertamina, the organization that previously had a double role in the bidding for PSC contracts upstream (see above). Pertamina became a gas company and regulation of the open downstream market was taken care of by BPH Migas. The 2001 law also opened the downstream market to third parties, implying that they should have access to the pipeline system on Java.

Now, several years after opening that market, it seems the reform has not worked effectively. The state-owned company PGN, which controls more than 80% of the transmission grid, is a serious barrier to the third-party access model (IEA, 2008). In practice the company provides little access for third parties⁶. This is a clear abuse by PGN as the system operator for most of the pipelines as a commercial gas company. The implication is that companies who want to sell natural gas must develop their own point-to-point pipeline system as soon as this is feasible. This contradicts the government's official ambition to develop a more integrated and freely accessible pipeline infrastructure. The existing point-to-point pipeline is not accessible to third parties. So both institutional reform and infrastructure developments act as serious barriers to further development of the domestic gas market.

2.6.1 Downstream Regulatory Remedies

Currently Indonesia is not putting much effort into mitigating the downstream market problems. In recent years there has been a lack of coordination at the governmental level. Stopping the diesel subsidy for environmental reasons in 2005 led to a switch to natural gas (as the environmentally benign alternative), but a workable program for increasing gas supply to the domestic market was not in place. Indonesia lacks a strategy for mitigating barriers in the development of the domestic market, and there is no incentive scheme for inland infrastructure investments.

⁶ See for example the cases listed in the Ditjen Migas 2008 and 2009 reports on East Java and Sumatra

The 2001 regulatory reform needs to be extended further, but ambition, plans, and practice are also lacking here. Indonesia's Gas Regulation has evolved sluggishly since 2001. The basic conditions for a liberalized consumer market have not been established yet (see Haase, 2008 and Finon, 2002). Among the requirements are unbundling and third-party access. Unbundling transport and supply was only introduced on paper in 2009; eight years after the legal introduction of liberalization meanwhile the incumbent continued dominating domestic supply. However, the unbundling model, introduced on paper in 2009, does not facilitate third-party access, which is a prerequisite for a liberalized gas supply (Arentsen, 2004). Actually the Ministry of Energy and Mineral Resources's Regulation on unbundling created a new problem, by introducing a concept of downstream dedication, which allows companies to construct completely monopolized point-to-point gas pipeline infrastructures. So the unbundling regime is counterproductive for third-party access.

The domestic market is highly uncertain due to a risky institutional, financial, and infrastructure environment, not an attractive prospect for investors, producers, and suppliers of natural gas. If the domestic gas market is to develop further and mature, a lot of change is needed in Indonesia in almost all relevant aspects. Clear rules are but one of the basic ingredients of a productive investment environment (Stern 2007; Brown AC., et al, 2006; Haase, 2008; ERR 2009; Arentsen, 2003). Indonesia is still far away from these basic downstream gas market regulation requirements (IEA, 1999 and, 2012; Spanjer, 2008).

From this section we have learned that Indonesia is lacking a gas infrastructure. However, apart from planning a new infrastructure on paper, implementation is sluggish. The longer infrastructure development is delayed, the bigger the economic losses because of lost opportunity for the market to grow. The magnitude of such losses is unclear because a scientifically grounded impact analysis is still missing. Such an analysis is a prerequisite for effective governmental policies.

Therefore the relevant question is: How significant is the role of gas infrastructure in the Indonesian economy, and what are the viable options for financing it?

To answer this question we need to conduct an economic wide-impact analysis by comparing several alternatives for financing natural gas infrastructure. The aims of this analysis are two-fold; to investigate whether natural gas infrastructure development will have a positive impact on the national economy, and to examine whether there are possible

options for government financing, bearing in mind that money spent on infrastructure will reduce government spending in other sectors.

2.7 Conclusion

Indonesia possesses substantial natural gas resources at remote and distributed locations in the country's large archipelago. Indonesia's gas reserves are ranked tenth globally, and the larger part of the annual natural gas production is exported as LNG to other countries in the region. Slightly less than half is consumed domestically, mainly by the industrial sector and for electricity production. The household segment of the market is negligible.

The review shows the problems Indonesia has to face both in upstream and downstream segments of the gas market. Both segments are exposed to natural, institutional, and economic barriers, making it difficult for Indonesia to get full benefits from the natural gas reserves. The geography of the country acts as a strong barrier both upstream and downstream. The remote and distributed location of the many relatively small gas fields makes it more difficult to exploit this natural resource at a competitive price, in particular in terms of prospects for increased global competition in the gas market. The remoteness also requires advanced island-based (stand-alone) LNG technology, which is not yet fully proven and more expensive than existing LNG technology. This makes exploitation of these remote fields riskier, and, at the same time, the size of the fields and gas quality are very modest. In the downstream segment, geography is also a barrier, due to the large distances between gas fields and load centers. Gas consumption is concentrated on Java, but the gas infrastructure needed to respond to increasing domestic gas demand lags far behind current needs and is LNG based due to lack of an integrated pipeline infrastructure on Java. Incentives to initiate new infrastructure investments are absent or detrimental, as we have seen in several peer-to-peer pipeline projects currently under construction in Java. These pipelines are not under the jurisdiction of the third-party access regime and for that reason do not improve the island's gas infrastructure.

Our analysis shows that the problems in Indonesia's gas market can be grouped into three parts: gas allocation, pricing, and infrastructure. Addressing these will require not only a reform of gas policy objectives on paper (as done in 2001), but also a concrete policy of how to achieve these objectives. Reforms need to answer the questions highlighted throughout this chapter.

1. *How will priority ranking ensure improvement in welfare and prosperity of the people?*

The objective of gas policy is to improve the people's welfare and prosperity, therefore gas allocation priorities need a scientific grounding in order to maximize welfare gains and avoid economic loss.

2. *To what extent can gas prices be adjusted/increased to reach an optimum trade-off between economic efficiency and social objectives?*

For many years energy pricing has been determined solely for the purpose of serving social objectives. As the market starts to grow, the government needs to adjust gas prices to a level that maintains a balance between economic efficiency and social objectives.

3. *How significant is the role of gas infrastructure in the Indonesian economy and what viable options are there to finance it?*

Indonesia lacks gas infrastructure, and obstructions to developing the gas market hinder economic growth potential.

In the empirical part of the dissertation we conduct economic analyses on each of these three problems in an attempt to answer these questions. Our aim is to provide a scientific grounding through economic analysis for policy that needs to be implemented.

Chapter 3 Energy and Economic Development: Theory

Indonesia is a developing country. More than one-third of the population lives below the poverty line, and nearly half the rural population lacks access to a modern energy carrier. Therefore the government's energy policy is crucial to changing this situation. The urgency for enhancing energy access is relevant in the context of *economic policy reforms*, and in particular *energy policy reforms* (Shinha, 2012). The central policy reform question regarding the role of energy in development is: Who can deliver energy more efficiently – the government or the market? (Shinha, 2012).

The market liberalization process during the mid-1980's broke the traditional energy supply pattern, which was based on regulation of monopolistic industry activities, and reduced the dominant involvement of the state (Camperos, et al, 2013). The reasons behind this change were ideological; this was also the case in the United Kingdom during the Margaret Thatcher era (1979-1990), who used privatization to break the power of the trade unions. Efficiency was also improved (see also Gabriel, 2004).

Energy policy reform has become part of a larger discourse and debate on public policy reforms (Sinha, 2012). Energy sector reform in most developing countries, including Indonesia, implements a model stemming from the limited experience of similar reforms in developed countries such as the United States and the United Kingdom (Shinha, 2012; Dhubas, 2005). However, there is a difference in the context and background of energy sectors in developing countries, compared to those in developed countries (Sinha, 2012). It is important to note that energy sector organization, social and economic characteristics of users and non-users, and the policy context in developing countries (social problems such as access, equity, etc.) differ from those in developed countries, which had well-established energy sectors before the reforms took place (Blauvelt, 2004; Williams and Ghanadan, 2006).

Shinha (2012) points out that the implications of these reforms have been questioned, and met resistance from different stakeholders (Ahluwalia and Little, 2012; Chandrasekhar and Ghosh, 2002). However, based on past experience, the question that needs to be addressed

is: can the policy instruments emerging from energy sector reforms be sufficient to improve energy access?

This chapter is based on a review of the literature and presents the building blocks for the theoretical framework that will be used in this study, namely, the relationship between energy supply and the national economy as mediated by energy policy. This thesis presents a scientific basis for revising Indonesian Gas Policy in order to maximize welfare gain. This chapter has three purposes:

1. To present the theoretical background and empirical literature on the economics of energy
2. To present the theoretical perspective of public regulation of energy. Pivotal discussion points are how energy should be managed, and what kind of governance is suggested by theory.
3. Based on these two theoretical components, to develop a framework and policy instruments for analyzing and correcting policy failure.

Section 3.2 addresses the broader context of energy and development linkages. Section 3.3 discusses energy market regulation from two different theoretical perspectives, the neoclassical and political regulation. Section 3.4 develops the concept of Integrated Energy Planning as the building block of the analytical framework, including prescribing policy instruments to correct failures in gas policy. Section 3.5 summarizes and concludes the chapter.

3.2 Energy and Economics

The first part of this section provides a review of economic theory on energy's position in the economic system; the second part covers the empirical study of the economics of energy.

3.2.1 Economic Theory on Energy

Growth is a fundamental part of much discussion in economics. Intuitively, the information that a certain country has a GDP of X million dollars would not tell us anything, unless we compared it, for instance, with previous time periods and asked how much it increased/decreased, and why this happened. This leads to one of the most important question in economics: what creates economic growth?

Economic growth is a function of long-term production output. Increments in output depend on the type of input in the production process. In general, production factors used to produce goods or capital in an economic system can be classified as labor, capital, land, natural resources, technology, and social factors. In mathematical notation, this can be written as (Suparmoko, 1989):

$$Y = f(L, K, R, T, S)$$

Where Y = Production, L= Labor, K= Capital, R = Natural Resources, T = Technology, S = Social Factors

Each input has a positive relation with production level, so an increase in production factor leads to more output. In some situations, production functions are written simply as a function of capital and labor, with the assumption that capital includes land and natural resources. However, land and natural resources are important factors in the economic development of a nation. For example, a nation with abundant water and fertile soil has the potential for high productivity in agricultural sectors, and this sector will affect other sectors such as industry and services. Explanations of economic growth, or opportunity for development, are commonly set in the context of availability of natural resources in the region under consideration.

Figure 3.1 Relationships between Natural Resources and the Economy

Source: Suparmoko (1989)

The relationship between population, economic growth, natural resources, and environment is shown in Figure 3.1. Natural resources are fundamental to economic activity in many ways. When population increases, the economy has to provide goods and services to maintain or improve the standard of living in a nation. However, increases in goods and services demand more natural resources, which can exhaust natural resource reserves. Moreover, this can cause environmental damage, particularly in countries in the early stages of development. So natural resource exploitation has a double impact. The positive side is that it improves the availability of goods and services; on the other hand, it can impact environmental quality and diminish resource reserves.

There are two types of natural resources, renewable and nonrenewable. Goods produced from potentially renewable natural capital/resources include timber and non-timber forest products, fish, etc. Goods produced from nonrenewable natural resources include energy sources such as geological deposits of oil, gas, and minerals. For the purposes of our study we limit our discussion to energy. Recalling the production function from the previous paragraph, let us now introduce the concept of elasticity of substitution, σ . This is a measure of how flexible energy utilization is as an input to the production process. Figure 3.2a shows the isoquant associated with three different values of elasticity of substitution.

In the first case, where $\sigma = 0$, a fixed proportion of technology requires that the composition of input be maintained in constant ratio (isoquant I_1) between energy and non-energy input. In this case, a reduction in energy input cannot be substituted by an increase in non-energy input, thus output will fall. The second has flexibility in terms of input mix at a constant level of output, represented by isoquant I_2 with Cobb-Douglas⁷ production process, at $\sigma = 1$. In the third case, it is assumed that technology is flexible and non-energy inputs are the perfect substitute for energy input (Isoquant I_3), with elasticity $\sigma = \infty$.

Energy's role in macroeconomic change can be determined by analyzing the substitution effect between energy and non-energy input. It has different impacts on the short term and the long term; the short term is relatively inelastic because energy used in automobile, housing facilities, and the like cannot be replaced easily and reduction in energy input will have a significant negative impact on the overall economy. In the long term, the utilization pattern can change, for example, with more efficient engines, automobiles, or housing.

⁷ Cobb-Douglas is a particular functional form of the production function that requires two or more inputs as a factor of production.

Therefore the possibility of energy substitution is much greater in the long term, and the impact of reducing energy consumption is less damaging to the economy.

Figure 3.2 The Role of Energy in Macroeconomic Change.

Source : Griffin (1986)

Figure 3.2b shows a simple model of macroeconomic change as explained by supply and demand curves. At the initial condition, the economy is in equilibrium at production level Y_0 and price level P_0 , with aggregate demand AD_0 . If there is an increase in energy price, it will shift aggregate supply away from AS_0 as the cost of production is higher for the same level of output. How far it shifts from the initial equilibrium depends on the value of substitution elasticity between energy and non-energy input.

In the case $\sigma = 0$, substitution of energy with non-energy input is not possible, resulting in significant shifting to AS_1 , prices rising from P_0 to P_1 and national output declining from Y_0 to Y_1 . In the second case, where $\sigma = 1$, the Cobb-Douglas Production Function aggregate supply curve shifts upward as a result of increasing energy price, but not as much as in the previous case (AS_2); price increases to P_2 and national production falls from Y_0 to Y_2 . The third case is the perfect substitute between energy and non-energy input where $\sigma = \infty$.

The aggregate supply curve will not shift because of an energy shock; the same level of output can be produced at the same price using non-energy input. Hence, the aggregate supply curve AS_3 will coincide with the initial curve, where price and national production remain unchanged. Intuitively, in the short term, energy elasticity is low, because we cannot

change energy utilization technology quickly. In the long term, energy-consuming equipment can be redesigned to allow the possibility of substitution, thus mitigating the impact of an energy shock.

From the theoretical basis of production factor and substitution elasticity, intuitively we can conclude that the significance of energy will vary among countries. In countries with abundant reserves of energy, energy's contribution to the production factor will be higher, whereas a country with low elasticity of energy substitution/inelastic will be very dependent on energy. Natural capital plays an important role in developing countries; it is estimated to account for 26% of total wealth in low-income countries, 13% of wealth in middle-income countries, and only 2% of wealth in industrialized or OECD countries (OECD, 2008). In the following section we examine the empirical research and look at the deviation between theory and practice.

3.2.2 Empirical Studies on the Economics of Energy

Empirical studies on the economics of energy try to reveal causality between the two. There are two methods to test causality among time series variables, Granger causality tests (Granger, 1969) and cointegration analysis (Engle and Granger, 1987). Applications of these models to energy economics can be found in Hendry and Juselius (2000), and they have been used extensively to test for causality and cointegration between energy, GDP, and other variables (see Stern, 2013; Kraft and Kraft, 1978; Ozturk, 2010).

Stern (2000) estimated a dynamic cointegration model for GDP, quality-weighted energy, labor, and capital, using the Johansen⁸ methodology. His analysis shows a cointegrating relation among the four variables, and that energy causes GDP to move unidirectionally or possibly through a mutually causative relationship. Replication of this study by Warr and Ayres (2010) for the United States found both short- and long-term causality between energy and GDP, but not *vice versa*.

Oh and Lee (2004) and Ghali and El-Sakka (2004), who applied Stern's (1993, 2000) methodology to Korea and Canada, respectively, draw the same conclusion, supporting Stern's results beyond the United States. Furthermore, Lee and Chang (2008) and Lee *et al.* (2008) employed panel data cointegration methods to examine the relationship between

⁸ The fundamental difference between the Engle-Granger and the Johansen approaches is that the former is a single-equation methodology, whereas Johansen is a systems technique involving the estimation of more than one equation.

energy, GDP, and capital in 16 Asian and 22 OECD countries for time spans of three and four decades, respectively. A long-run causal relationship from energy to GDP in a group of Asian countries was found by Lee and Chang (2008), while a bi-directional relationship in the OECD sample was found by Lee *et al.* (2008). Altogether, these findings suggest that the inconclusive results of earlier work are probably because non-energy input was omitted.

However, this does not tell the whole story. Baranzine *et al.* (2013), for example, who reviewed literature on this topic, found different results in several studies of Switzerland, and other cases show contradictory results to those of Stern. In the case of a developing country, similar contradictions are found in the literature on Indonesia. Huang and Yoo (2012) and Sambodo and Oyama (2010) do not support the argument that there is a relation between energy consumption and economic growth, while Sari and Soytaz (2007) and Fatai (2004) indicate the opposite.

Research on this topic is still taking place; from what we have seen, consensus in the near future is unlikely. In this dissertation we take a position in favor of the argument that energy is a determining factor in economic growth. First, it is widely accepted that in most nations, and particularly developing ones, energy is expected to provide economic benefits; this can be seen in energy policy objectives. Second, in most economic schools of thought, energy (together with other natural resources) is still considered a determinant of economic growth. Much research has confirmed this relationship, even though some has reached the opposite conclusion, for instance, Akarsa and Long (1980), Yu and Jin (1992), and Altonay and Karagol (2004).

This section has explored the significant linkage between energy and economic growth, where it is expected that energy will maximize /support economic growth. However, economic growth is just one aspect; energy cannot be managed in isolation from other objectives, such as social or political objectives. In the next section we discuss how energy should be governed to accomplish those objectives from a theoretical perspective.

3.3 Regulation of Energy Markets or Energy Policy/Planning

Governance of energy can be viewed from two different theoretical perspectives, the neoclassical economic and public regulation. On one side, the neoclassical approach suggests that the market should allocate goods, while political regulation demands that government should do so in order to protect society. We will look closely at the underlying principles of each theory, before positioning our research within these two dichotomies.

3.3.1 Energy and Economic Development in the Neoclassical Economic Perspective

Neoclassical economics, the dominant school of thought in most Western societies, is based on market solutions to the economic problems of what to produce, how to produce it, and how to distribute resources. How to allocate limited resources to satisfy competing needs in society is, in general, termed an economic problem. It can be examined in greater detail by looking at the specific questions an economic system must answer in order to achieve and maintain efficiency. These questions are: How much should be produced? What goods and services should be produced? How are these goods and services to be produced? Who is to receive them? How can the system be adapted to change? (Tisdell, 2007). According to Weintraub (2007), neoclassical economics relies on three assumptions:

1. People have rational preferences among outcomes.
2. Individuals maximize utility and firms maximize profits.
3. People act independently on the basis of full and relevant information.

William Stanley Jevons described "the problem of economics" as:

"Given, a certain population, with various needs and powers of production, in possession of certain lands and other sources of material: required, the mode of employing their labor which will maximize the utility of their produce." [Jevons, 1879, p. 267]

Utility maximization is the basis of demand and supply curves derivation in the neoclassical theory of consumption (Wicksteed, 1910). The interaction between supply and demand determines equilibrium output and price. Supply and demand determine market output and equilibrium income and the income distribution (Stigler, 1941; Dorfman, 1987; Bliss, 1987). Allocation of resources is called Pareto efficient if it is not possible to make one or more persons better off without making others worse off (Pearman et al., 1996). If there is a certain change in allocation of goods that results in some individuals being "better off" with no individual being worse off, then it is not Pareto efficient and can be more Pareto efficient through a Pareto improvement. Here 'better off' is often interpreted as "put in a preferred position". It is widely accepted that outcomes that are not Pareto efficient should be avoided, and therefore Pareto efficiency is an important criterion for evaluating economic systems and public policies (Napoles, 2014).

With a Pareto improvement, at least one participant's well-being can be improved without reducing any other participant's well-being. In real-world practice, the compensation principle

often appealed to is hypothetical; some alleged losers are not (fully) compensated for certain types of Pareto improvement, for instance, from public regulation of monopolies or removal of tariffs (Sadri, 2012).

Critics of neoclassical economics point out that it does not explain the actual economy, because Pareto optimality is not applicable in the real world. The assumption that individuals act with economic rationality may be viewed as ignoring important aspects of human behavior, because real people act differently in different ways. Many economists, even contemporaries, have criticized this assumption. Thorstein Veblen stated that in neoclassical economics a person is assumed to be:

"a lightning calculator of pleasures and pains, who oscillates like a homogeneous globule of desire of happiness under the impulse of stimuli that shift about the area, but leave him intact." (Veblen 1898, p. 389)

Nevertheless, Arnsperger and Varoufakis (2006) developed models to negate criticisms that the neoclassical approach requires perfectly informed and rational individuals. From their point of view, an economic actor could be imperfectly informed and irrational. They introduce three main axioms, methodological individualism, methodological instrumentalism, and methodological equilibration.

1. Methodological individualism states that all actions are performed by individuals, which implies that individual behavior is at the center of all analysis to explain social phenomena (Spanjer, 2008).
2. Methodological instrumentalism assumes that all behavior is "preference driven where an individual is seen as a bundle of preferences that will maximize his expected utility base on this preference" (Spanjer, 2008). Arnsperger and Varoufakis (2006) argue that the basic concept of methodological instrumentalism is that preference fully determines an individual's actions.
3. Methodological equilibration states that human interaction always tends towards an equilibrium, a condition in economic theory in which supply and demand of goods and services are equalized by price adjustments in the process of competition (Spanjer, 2008).

The axiom explains why competition is described as 'perfect' (Hunt, 2000, pp.7-9). In theory, perfect competition focuses on interaction between consumer and producers. Consumers

buy products and try to maximize their utility, and producers maximize their profit. Consumers have perfect knowledge of the price and quality of all competing products and make their rational choice accordingly. According to Spanjer (2008), the firm is viewed as a production function in which resources are transformed into output; in this mechanism, competition means that firms change the quantity of products produced as a reaction to change in price or resource cost in the short term. In the long term they can adjust production capacity.

In trying to maximize profit, in the short term the firm produce outputs until marginal revenue equals marginal cost. In the long term, equilibrium is achieved if the firm produces the quantity where price equals long-term marginal cost and corresponds to a point at which long-term average costs are minimal. When price equals cost, equilibrium profit is zero. In conclusion, if every firm acts in this manner, and achieves equilibrium by producing at minimum cost and creating efficiency, then allocative efficiency is gained (Spanjer, 2008).

However, certain conditions prevent markets from reaching the basic premise of neoclassical economics, namely, utility – profit maximization at market equilibrium (perfect competition). Conditions that cause the market to deviate from perfect competition are called market failures. There are several possible causes:

Failure of Competition

Without a competitor, a market player can affect price formation. This occurs in a monopoly system where a single firm dominates the market, or in an oligopoly in which the market is controlled by only a few firms. In the context of the gas market, economies of scale in gas infrastructure are cost-sub additive; it is more efficient to have a single operator managing the pipeline as natural monopoly. The natural monopolist can abuse his dominant position by charging excessively high prices for access to its pipeline or even denying access.

Public Goods

“a (good) which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good.”
(Samuelson, 1954)

This is known as being non-rivalrous. Public goods have a second property, non-excludability; it is impossible to exclude any individuals from consuming the good. In a perfectly functioning market, people who are not willing or able to pay for a good have to be excluded from its use and benefit. Under non-excludability there is no possibility of exclusion,

and so a private producer has no incentive to produce the goods. The government may intervene by producing the good.

Incomplete Markets

“A missing market is a condition where a private market fails to provide a good or service, even though supply cost is lower than individuals are willing to pay” (Spanjer, 2008). In the case of natural gas, spot, future, and risk markets are often missing or not sufficiently present (cf. Perman et al., 1999, pp.128, 129, and Stiglitz, 1988, pp. 688-690). This creates uncertainty with respect to current and future gas prices. The market fails because this missing information distorts allocation of resources.

Information Failures

“Information failures may create inefficiencies in product quality and price that lead to market failure” (Spanjer, 2008). He points out that, in the traditional monopoly market, a consumer paying the bundled gas price cannot detect the source of the service cost. Unbundling in a liberalized gas market is expected to improve this by separating trade and network activities. In practice, however, network operators can delay infrastructure investment to lower cost and increase efficiency, and the consumer will not know until actual failure occurs (Spanjer, 2008). Information failure can also happen in the upstream segment of the natural gas market. To be able to optimally deplete a gas field, an operator needs knowledge about future developments in prices, reserves, and government policy.

The above market failures are candidates for government intervention, in order to restore ideal conditions. Most economic debate on the 20th century focuses on division of tasks between market and state. American economists such as Joseph Stiglitz and Paul Krugman reviewed the ‘roaring nineties’ at the beginning of the 21st century (Stiglitz, 2003). They argued that the almost boundless belief in Adam Smith’s ‘Invisible Hand’ that guided the policies of privatization in that decade was responsible for damage in many nations (Stiglitz, 2002, 2003; Krugman, 2003). Conditions for markets to work were simply not met in reality (Stiglitz, 2003, p. 284):

“Underlying the views in favour of a minimalist government was a simplistic ideology, one I referred to earlier as “market fundamentalism”, which said that by and large markets by themselves are both stable and efficient. I call it an ideology because it is a matter of faith: it rests on no acceptable economic theory, and is contradicted by a host of experiences (it would be true, for instance, if there were perfect information, perfect competition, complete markets, etc.—conditions that are simply not true in the most advanced of countries).”

Now we arrive at the question of what should the position of an energy market be? Spanjer (2008) argued that security of energy supply and the environment are categorized as public goods. If one citizen benefits from enhanced supply security, other citizens' benefits will not be reduced. Supply security cannot be split up and sold in the market, thus it meets both non-rivalrous and non-excludable criteria. This can be seen as justification for regulatory intervention, or even government provision, in energy markets. However one has to remember that whether actual intervention is necessary depends on whether the cost of market failure exceeds the cost of government or regulatory failure, and measuring this cost is not an easy task. The focus of the thesis is on correcting the failure of gas policy in Indonesia.

This is only one side of the story. Government policy can be seen as a correction of market failure in the context of economic regulation, but there are other dimensions to consider, e.g., social regulation, which falls under political regulation theory. Economic efficiency is not the objective of political regulation; equity is the main target, and this political element is also a substantial part of Indonesian gas policy. To get a more complete picture, we discuss this theory in the next section, and then put our research in context.

3.3.2 Political Regulation

Regulation is a politically sanctioned intervention in order to achieve specific goals. A common divide in the regulation literature is between economic and social regulation. There are two main reasons for regulating economic activity. First, within neo-classical economic theory, a welfare-economic argument points to various forms of market failure that hinder optimal use of available resources; public regulations are implemented in order to correct the failure. Second, within organization theory and political science, a political-institutional argument points to the values and norms basis of political systems, where specific goals can be realized via regulations. A liberal market-economic regime will minimize the level of intervention, while a Keynesian, mixed-economic regime will rely more on regulations to remedy failures and to support political goals. In general terms, there is a difference between interventions that regulate access to the market and interventions that regulate the market itself.

Acemoglu et al. (2004) divide institutions into two major groups – economic and political. They argue that economic institutions embody the set of rules for resources, including the structure of economic incentives in society. On the other hand, political institutions embody the rules determining the constraints on key actors in the political sphere (Rakhmanto, 2009;

Acemoglu, Johnson, and Robinson, 2004: 4). There are linkages between the two. Having a choice of economic institutions means conflicts of interest among various groups and individuals. Which economic institutions prevail under such conditions is ultimately determined by those with the strongest political power (Rakhmanto, 2009).

Furthermore, Rakhmanto distinguished two components of political power—de jure and de facto. De jure refers to the power of political institutions in society, while de facto refers to the power of groups with control over distribution of resources and the ability to mobilize collective action. The factor that directly bridges the political and economic spheres is the distribution of resources (Acemoglu, Johnson, and Robinson, 2004: 3-6).

The interconnection between these two can be seen in the work of Finon et al. (2004), who pointed out that market design generally develops by focusing on allocative efficiency. Some market solutions, however, which are efficient in economic terms, may be socially unacceptable. Furthermore, in energy sectors, price formation, and availability have a potentially high relevance on the political agenda. They argue that the market process can generate unacceptable prices when that pricing level is needed to attract new investment. In their model (see Figure 3.3) they propose a set of economic equilibria located outside the sociopolitical domain, and a set of political equilibria outside the economic domain.

Figure 3.3 Social Market Equilibria

Source : Finon, Johnsen, and Midttun (2004)

This means there are conditions in which pure market solutions, with high economic efficiency, may not be socially acceptable and do not meet social criteria. On the other hand, there are conditions where socio-political solutions are acceptable but economic realities are

neglected (Midttun, 2005). Sociopolitical equilibria can be a challenge to deregulation when market design is hampered by political decisions, resulting in loss of high efficiency. A good example is the California electricity market collapse, which resulted from a politically introduced price cap. By keeping the consumer price of electricity artificially low, the state government discouraged citizens from practicing conservation. When electricity demand in California rose, utilities had no financial incentive to expand production, because long-term prices were capped. This shows that, if a trade-off between social criteria and market is not properly made, a calamity is possible.

Adding social dimensions to the mix has placed market designers in a difficult position. They may have to choose between a strongly deductive but socially unfavorable design, or a softer but more socially inclusive design with less optimization (Midttun, 2005). Social and political constraints are recognized as a major challenge for deregulation in the electricity industry, and the energy sector in general. The anxiety among market designers is that the price range and duration of high prices needed to stimulate new investment will be obstructed on social grounds, with the market remaining short (Finon, et al. 2004).

These conflicting objectives complicate the decision-making/policy process. Policies favoring 'economic efficiency' will be challenged by politicians in the name of social interest; sometimes the latter is prioritized, so many policy drafts become useless. We need to discover the 'ideal' division of tasks between policy-makers and politicians. Lindblom (1993) contends that politics and analysis are always intertwined in the decision-making process, and all governmental policy-making can be labeled 'political' because it involves the use of authority. Many people distrust the result of democratic majority-based decision-making because it brings contentiousness, not reason (analysis), into policy-making (Lindblom, 1993). Many energy decisions are indeed the result of 'political will' rather than 'analysis'. This characteristic undermines the role of planning and analysis and is summarized by Friend and Jessop (1969) as cited in Faludi (1973, pp. 233):

"Most importantly, it prevents planners from criticizing politicians: the servant does not question the motives and the wisdom of his master. It thus casts planners into an inferior role. They frequently compensate by emphasizing privately their superiority as the providers of the knowledge-base and denouncing the whims and the pettiness of politicians (thus satisfying their psychological needs); and by using subversive tactics to get their way, even against the will of their political masters (thus making the politicians even more suspicious

and insistent on his prerogatives). The result is the lack of mutual respect and of trust which appears to characterize the relationship between planners and politicians."

According to Faludi (1973), decision-taking is undeniably the privilege of politicians; however, they should not control the whole process of decision-making. Both planners and politicians should work together openly as equal partners, equal contributors, and responsible actors throughout all phases of the planning process (Faludi, 1973). He further elaborates:

"The role of the politicians: Acceptance of Risks. Because it is the politicians who must 'carry the can' for assumptions entering the formulation of a programme. His prerogative is therefore not so much that of setting the ends of action towards which planners work as their loyal and unquestioning servants (which is not really feasible, anyway), but more of choosing deliberately to accept the risks of pursuing one course of action in preference to others, including the assumptions on which this course of action is based." (Faludi, 1973, p. 236)

The planner's role is to appraise the risks involved in the politicians' decisions. Lasswell (1971) argued that policy-makers should be able to mobilize the best available knowledge in order to tackle problems on the political agenda successfully. In this way the politician can consider the risks more accurately and take decisions that commit public resources and affect people's welfare (Faludi, 1973). The phrase "speaking truth to power" has been used by political scientists to position themselves as the ones with these capabilities (Hoppe R, 1999). Planners/policy-makers need quality knowledge in policy, which means that they should be able to mediate between different scientific disciplines.

To summarize Sections 3.2.1 and 3.2.2, reasons for government intervention can be classified as follows:

- 1) **Reasons of Efficiency**, i.e., policies aimed at better allocation of resources in order to increase economic system output. These policies include interventions to correct market failures regarding presence of public goods, imperfect information, externalities, etc.
- 2) **Reasons of Equity** such as improving energy security for specific social groups, interventions for poverty reduction and income redistribution, or achieving national resources sustainability (intergenerational equity).

The first can be analyzed using neoclassical economic theory, while the second requires approaches derived from the political economics of regulation. Theoretically, it is rare that a policy places sole emphasis on economic reasoning; instead it is sometimes dominated by equity (social) reasoning. If we recall Midttun's dual equilibria (Midttun, 2005), ideally there should be a balance between the two; when an imbalance occurs, government intervention takes place.

In the next section we build a framework to correct Indonesian gas policy failure. The concept is developed from Integrated Energy Planning (INEP), which is regarded as the most effective and efficient framework for energy planning (Munasinghe, 1993). We use this concept because correction of the failed energy policy cannot be done in an ad hoc manner; we need to look at the underlying principles behind the policy. This concept also allows us to incorporate both efficiency and equity in policy planning.

3.4 Integrated Energy Planning (INEP)

This concept developed in the mid 1970's energy crisis. Munasinghe (1993) points out that the rationale behind national planning and policy-making in developing countries is to ensure the best use of scarce resources in order to improve socioeconomic development, welfare, and quality of life for citizens. Munasinghe (1993, p. 12) argues that:

'Because of the many interactions and non-market forces that shape and affect the energy sectors of every economy, decision-makers in an increasing number of countries have realized that energy sector investment planning, pricing, and management should be carried out within an integrated national energy planning (INEP) framework which helps analyze a whole range of energy policy option over a long period of time.'

He added that the word 'planning' does not necessarily mean a rigid framework in a centralized and fully planned economy; it takes place in every economy, even when free-market forces are superior. The importance of energy planning and policy is to bridge many interrelated and conflicting national objectives. Among these objectives are determining the economy's energy need to support growth and development, minimize unemployment, choose the optimum energy mix sources, supply basic energy needs for the poor, identify specific energy demand/supply in order to contribute to special sector priorities in the economy, and price stability. INEP can be divided in four different levels; these are discussed in the following section.

3.4.1 Global/Transnational level

Figure 3.4 shows the scope of INEP using a hierarchical framework developed by Munasinghe (1980, 1988). It starts with the global context of energy used, in which individual countries are embedded in the international economy and environment. World economy, via trade and financial linkages and natural resources, puts constraints and conditions on national decision-making, and affects outputs such as electricity petroleum prices; these impact economic policies.

Figure 3.4 Hierarchical Conceptual Framework for Integrated National Energy Planning (INEP)

Source: Munasinghe and Meier (1993)

3.4.2 Macro Level

In a 'macroeconomic' hierarchy, energy is treated as part of the whole economy. Thus, integrated energy planning is required to analyze the link between the energy sector and the rest of the economy, including inputs needed for the energy sector, such as capital, labor, raw material, and energy. During the 70's, the sharp oil price increase had a macroeconomic impact on developing countries. It was a major problem for energy and macroeconomic planners; modeling and quantifying policy impact to mitigate macroeconomic consequences is difficult. Some impacts are easy to predict; energy price triggers conservation in the medium and long term because of price elasticity of demand. But there are more complex questions, such as domestic inflation and drop in output, and how to mitigate the impact with government policies. Does price increase affect the poor? What kind of policy option is effective? Should government have an expansionary fiscal policy to stimulate the economy?

Energy's fundamental role makes it difficult to distinguish clear boundaries for planning responsibility, for instance, in the case of transportation, or fuel wood that can be considered both as rural planning and energy planning.

3.4.3 Intermediate Level

In the third level of INEP, the energy sector is treated as a separate entity containing integrated subsectors such as electricity, petroleum, etc. In this level, each energy sector is analyzed with respect to interaction between different energy subsectors and substitution possibility, or policy conflict between energy sources, such as competition between natural gas, diesel fuel, or coal for electricity, diesel and gasoline for transport, kerosene and electricity for lightning, or wood and kerosene for cooking.

3.4.4 Micro Level

The last level of INEP is planning within energy subsectors. It concerns detailed energy supply evaluation, modeling and planning, risk management, and project implementation, as well as detailed energy demand evaluation, modeling and management, pricing and non-pricing tools. For instance, the electricity subsector must set its own demand forecast and long-term investment program; the petroleum subsector, its supply and refinery output; the wood fuel subsector its consumption projection and detailed plans for reforestation, harvesting, and so on.

We can now expand our discussion of the relationship between energy and economic development within the context of INEP. The linkages between energy and the macroeconomy are shown in Figure 3.5:

Figure 3.5 Energy-Economic Linkages

Source: adapted from Munasinghe (1993)

This framework shows a close circular relation of how energy and the economy affect each other. It is complex and difficult to solve the whole puzzle, isolate the individual elements, and construct a logical model of energy-economy interactions (Munasinghe, 1980). The common starting point is future growth of GDP. Estimating associated energy demands is the next logical step. From these demands, energy supply, investment, and prices are derived, which are the basis for estimating investment levels, foreign debt, and current accounts associated with energy imports. These linkages (macroeconomic impact on the energy sector) are represented with solid arrows in Figure 3.5, and are referred to as forward linkages.

On the other hand, it is more difficult to quantify the impact of the energy sector on the national economy; these backward linkages are indicated by broken blue arrows in Figure 3.5. Questions about the inflationary impact of increasing energy price, or the degree by which energy investment detracts from investment elsewhere in the country, are difficult to measure with precision.

In the context of Indonesian gas policy, the macro level is already clear; government wants to maximize economic efficiency and equity. The intermediate level is clear as well, where the contribution of the gas sector has been determined in national energy-mix planning, together with the other energy sectors. What is left is the micro level, the policy of natural gas. In the

next section we will discuss available policy instruments for natural gas, starting from the general theory of policy instruments. The policy instrument will be the main tool used in the micro-level analysis to determine the direction of energy policy.

3.4.5 Policy Instruments

Policy instruments are used by the government to achieve policy objectives, such as removing access barriers and lowering transaction costs (Shinha, 2012). Policy instruments can be categorized based on how they affect the relevant actors' actions and decisions; these include regulatory (e.g., standards, limits, and mandatory norms or quotas), economic (e.g., tradable quotas, taxes, and subsidies), and assuasive (such as awareness creation) instruments. These tools may be used in isolation or in combinations (Opschoor and Turner, 1994).

Policy-making and policy implementation have a mutual relationship. One reinforces the other, because most policy cannot work in a vacuum and must be adapted to local situations in order to be functional (Shinha, 2012). This mutual relationship should be reflected in the policy-making process; a mutual learning process is needed instead of a one-sided relationship in which policy-making dominates and the local situation is ignored (Bressers, 2004; Bressers and O'Toole, 2005).

Different policy instruments may be chosen by decision-makers (supply side) who are involved in design and implementation with the relevant interest groups (demand side), depending on interest and motivation (Keohane et al., 1997). Therefore, social and political acceptability, in addition to administrative feasibility, are crucial factors.

How policy instruments perform depends on various factors, such as their design and characteristics, the context in which they are applied, the institution involved, the actors, and political intervention (Shinha, 2012). Regulatory instruments such as entitlements, quotes, and economic instruments, can be important in resolving cases of limited access to modern energy among low-capacity end users (Shinha, 2012).

The regulating power of economic policy instruments has been the subject of much scientific literature since 1970. Bressers and Huitema (1994) point out that cost effectiveness might not be the primary concern for bureaucrats or politicians when choosing instruments for implementation. Numerous other criteria are also applied, explicitly or implicitly, to test

proposals for both policy-making and realization (Bressers and Honigh, 1986: 281–282). To mention only a few:

- Effects on competitiveness at home and abroad;
- Distribution effects: for example, which groups are burdened with the initial policy costs at the beginning as well as at later stages (can costs be translated into prices of goods and services?);
- The proposal's "implementability": is a well-motivated and well-equipped implementation regime available? Are the implementation costs for the government, as well as other transaction costs on both sides, possibly too high? What are the objectives and resources of the target group? And so on.
- Existing regulations and regulation traditions: Is the policy instrument in alignment with these?
- Flexibility of the instrument: What is the extent to which it can be adapted to different circumstances of time and place, and to uncertainties?

Determining the appropriate instrument based on those criteria is not easy; a 'negative' in one dimension can be a 'positive' in another dimension.

Policy instruments in the energy sector can be categorized in many ways (Radetzki, 2004). Among those used most often are taxes, subsidies, physical control (of energy supply), investment, investment-influencing policy, and pricing (Munasinghe, 1993). Physical control can take various forms, such as reducing or rationing supply, or load shedding in the power sector, which is commonly used for short-term energy shortages. Investment policy instruments include expanding gas distribution networks and building new power plants; they have major long-term effects on energy supply and consumption patterns. Pricing policy, or regulating price by authority, can take the form of setting a floor or ceiling price, and is determined based on the trade-offs between conflicting objectives, such as economic efficiency and social objectives.

There is no one theory in the literature that provides a specific policy instrument for natural gas policy; instead policy was built based on common practice. The common instruments are supply policy, pricing policy, and infrastructure policy (see Jain, 2011, China Gas Policy, 2009). These three types share similarities with the general energy policy instruments discussed above.

Supply policy is an instrument that allows the government to regulate utilization of gas reserves for domestic or export/domestic market obligations, and to prioritize who gets gas. Pricing policy regulates the floor/ceiling prices of natural gas, while infrastructure policy regulates gas infrastructure planning. The range of policy measures listed above impacts different parts of a socioeconomic system. The circular flow of different system elements (shown in Figure 3.5), gives rise to “multiplier” effects, in which other parts of the economic system are activated due to changes in one part. For example, increasing gas supply may induce demand in industrial sectors, which then triggers an increase in demand of industrial inputs and factors. This activity generates employment, which in turn increases household income, which means more money is spent and demand for other goods increases. In addition, capital accumulation and production efficiency are enhanced after investment, which can also intensify the “multiplier” effect.

3.4 Knowledge Gaps and The Value of Studies

This dissertation differs from previous work in several aspects. First, it contributes to the natural gas development strategy through a systematic analysis of supply, pricing, and infrastructure. Prior work on this topic usually took into account only one or two of those three aspects. Filling in the gaps with actual cases incorporating these three aspects will help improve natural gas policy.

Second, this research emphasizes the importance of energy planning in policy decisions. The author realizes that political will is still a strong determinant in deciding policy; however, a scientific approach has a role in providing adequate analysis and information. Taking a scientific approach does not have to conflict with political decisions. In fact, energy planning should mediate two different objectives by seeking the optimum decision that serves both sides best. This kind of process is necessary for several reasons.

As discussed in Chapter 1, many energy sector policies are never implemented because they were adopted based only on political popularity, and this can have serious consequences. A good example is fuel subsidy, which was a political commodity for years, and every proposal to remove it was rejected. However, when Indonesia’s economic capacity was no longer able to fund it, due to extreme increases in crude oil prices in 2008 and 2013, the government received parliament’s support to adjust the fuel price after lengthy discussion and debate.

Such situations can be avoided by improving the scientific knowledge base for energy planning. Better knowledge supports effective political decision making, although it is not realistic to assume politicians will take unpopular measures when analysis requires them. Grounded energy planning is already apparent in Indonesia; given that the Ministry of Energy and Mineral Resources' energy planning strategy tends toward '*rational comprehensive*' planning that identifies and evaluates every action and risk (Muliadiredja, 2005). Despite its weaknesses, this approach has never been discarded (Scolesbury, 1974), and is worth maintaining and improving (Muliadiredja, 2005). This dissertation may contribute to improving the ministry's strategy.

The third point the dissertation emphasizes is using quantitative analysis as an energy planning tool. This method offers easier comparison between various alternatives with greater precision; it helps to identify the optimum policy/policy mix, while avoiding inconsistent or counterproductive combinations. And it helps to achieve a trade-off between different and potentially conflicting objectives (Perman et al., 1996). Because CGE has the ability to simulate the economy-wide impact of policy measures, it serves that purpose well. Every model has limitations, because of overly simplified and/or simplistic assumptions. The methodological strengths and weaknesses of this model have been taken into account and will be discussed further in Chapters 4 and 5.

This dissertation aims to fill the knowledge gap associated with these three areas, provide a starting point for future research, and contribute to the energy policy debate in general and gas policy in particular by presenting empirical evidence and analytical analysis.

3.5 Conclusion

This chapter discussed a range of theoretical perspectives relevant for our research on the link between energy and the economy, and energy policy. The first part discussed the energy-economy relationship, from both theoretical and empirical perspectives; we reviewed the debate in the literature and developed our position that energy is a determinant of economic growth. The second part provided a theoretical background on how energy should be governed to achieve objectives from both neoclassical economic and political regulation theories. Together, both parts give a foundation for national energy planning, or "INEP", which will be our analytical framework. In the following chapter we elaborate in detail how the INEP concept can be applied to the Indonesian gas sector.

Chapter 4 Energy and The Economy: Analytical Framework

This chapter introduces the analytical framework for the empirical chapters. The literature on energy and development tells us that energy access is critical for economic growth and social development. Public-sector policy reforms are the government's response to perceived market failure. When markets do not work well in achieving social and developmental objectives, the government's role in developing policies to bring about economic development and social equity is critical. Public-sector reforms, in contrast, rely on principles of market economy to implement policies, and regard government intervention as the cause of problems affecting the market. Choosing the appropriate policy is critical in establishing the right balance between providing energy access and achieving economic efficiency.

Since public policies are fundamental tools for achieving socioeconomic development objectives, it is important to assess the potential effectiveness of each policy measure for a pre-fixed development objective before deciding to implement it (ex-ante). Given the complexity of real socioeconomic systems, including inter-sectoral and inter-agent linkages, multiplier effects, and dynamic impacts of investment, it is important to have adequate tools during the decision-making process in order to gain insights into the impact a policy may have.

How policy instruments perform depends heavily on the way they are designed, implemented, enforced, and monitored. It is essential to consider the full range of policy instruments available, both regulatory and non-regulatory, if the aim is to map out the best-most efficient, effective, equitable, acceptable (to government and community)-instruments of intervention (Australian Government, 2009). Bressers et al. (2011) emphasized the importance of negotiation between policy-maker and stakeholder. Furthermore, Azuela and Barroso (2011) argued that successful reforms of key regulatory incentives depend on feedback from design and implementation experience in the context of a dynamic system. The choice of policy instrument itself is ideally based on criteria that result in the highest efficacy, fewest side-effects, and greatest feasibility, given existing power and institutional dynamics, (UNEP, 2004). In reality, most of the time a trade-off must be made between various goals.

In this dissertation, the effectiveness of a policy design is determined by whether or not it has resulted in supporting economic development. The focus is on how appropriate a gas sector public-policy design (including its instruments) has been for improving the national economy.

This thesis contributes to economic literature by studying the relationship between gas policy and economic development, and providing a framework for scientifically analyzing this relationship. In this chapter we introduce and discuss the framework for analyzing the macroeconomic impacts of national gas policy.

This framework is based on Integrated Energy Planning (INEP), as elaborated in Chapter 3. Section 4.1 discusses various energy-modeling approaches, including the CGE model used in this dissertation. Section 4.2 discusses the concept of counterfactual analysis and methods of measuring policy impact, Section 4.3 discusses the analytical framework used and how it is applied to gas policy. This is followed by the conclusion.

4.1 Energy Modeling

This section begins by reviewing some INEP concepts from Chapter 3. Well-designed natural gas planning should use a variety of available policy instruments. We know from the theoretical chapter that policy instruments affect the entire economic system, thus a model is needed that can explain the system and predict the impacts of changes in the economic system. The model itself is constructed using a mathematical equation derived from energy-economics theory. There are many models for energy; Beeck (1999) introduced nine ways to classify energy modeling (see Table 4.1).

Table 4.1 Classification of Energy Modeling

<ul style="list-style-type: none">• Perspective on the Future, Forecasting, Exploring, Backcasting (looking back from the future)• Specific Purpose : Energy demand, energy supply, impacts, appraisal, integrated approach, modular build-up• The Model Structure: Internal Assumptions and External Assumptions Degree of endogenization, Description of non-energy sectors, Description of energy end-uses, Description of supply technologies.• The Analytical Approach : Top-Down, Bottom-Up• The Underlying Methodology : Econometric, Macroeconomic, Economic Equilibrium, Optimization, Simulation, Spreadsheet, Toolbox, Backcasting, Multi-Criteria	<ul style="list-style-type: none">• The Mathematical Approach : Linear programming, Mixed-Integer programming, Dynamic programming• Geographical Coverage, Global, Regional, National, Local, Project• Sectoral Coverage: Energy sectors, Overall economy• The Time Horizon : Short-Term, Medium-Term, Long-Term• Data Requirements : Qualitative, Quantitative, Monetary, Aggregated, Disaggregated
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Source: Beeck (1999).

The above classification divides the models based on their purposes, for instance, forecasting, geographical targets (local, regional), and even technical, such as a mathematical approach. There can be intersections within this model, for instance, geographical target and time horizon target; the same model can also fall into several different categories. In the next section, we focus on top-down and bottom-up models relevant for this thesis. Grubb et al. (1993, 423-446) were the first to use this terminology in energy modeling. Bottom-up models use engineering approaches to analyze technologies and look for the least-cost way to meet energy demands, subject to technological restrictions and energy-input constraints. They include such areas as the impacts of change in fuel usage, energy efficiency, and emission-control technologies on energy consumption and the environment. Bottom-up models generally lack interactions with the rest of the economy (Kat B, 2011). Furthermore, Sathaye and Sanstad (2004) classify bottom-up models into the following four main categories:

- Energy accounting models
- Engineering optimization models
- Iterative equilibrium models
- Hybrid models

Energy accounting models rely on input-output relations, in which energy supplies are determined from energy demand projections using the energy intensities of activities. In this

model, there is no feedback between the energy sector and the rest of the economy. Various scenarios include different projections for energy costs, activities, and intensities. Engineering optimization models utilize linear programming in order to obtain least-cost energy under supply, demand, and resource constraints. Macroeconomic factors can be incorporated in these models through demand projections or via constraints, e.g., constraints on foreign exchange or capital resources.

Iterative equilibrium models attempt to reach equilibrium by iteratively adjusting prices and quantities in the energy sector. They are similar to optimization models; macroeconomic variables are exogenous, for instance, energy demand is forecast based on exogenous macroeconomic indicators, and there is no two-way linkage between energy and the rest of the economy. Hybrid models allow a two-way linkage between energy activities and the rest of the economy; they establish relationships between energy and other production factors (capital and labor) using an aggregate production function. The objective of these models is to maximize the consumers' discounted utility, which is generally represented by consumption amounts. Energy demand and some macroeconomic variables (e.g., GDP growth rate and investment amounts) are endogenous variables, contrary to the practice in accounting, optimization, or iterative equilibrium models. Hybrid models, on the other hand, show less detail.

Top-down models use aggregate macroeconomic variables. These models are criticized for not providing energy-sector details, as well as current and future technological options. These are the macroeconometric or Computable General Equilibrium (CGE) models. Their key parameters are estimated by econometric tools using historical data, or by calibration (estimation of parameters using data for the selected base year). Table 4.1 lists the main features of top-down and bottom-up models (Beeck, 1999). Lanza and Bosello (2004) have an even more comprehensive comparison of top-down and bottom-up modeling approaches.

Table 4.2 Distinction between Top-Down vs Bottom-Up Models

Top-Down Models	Bottom-Up Models
<ul style="list-style-type: none"> • Use an 'economic approach' • Give pessimistic estimates on 'best' performance • Cannot explicitly represent technologies • Reflect available technologies adopted by the market • The 'most efficient' technologies are given by the production frontier (which is set by market behavior) • Use aggregated data for prediction purposes • Are based on observed market behavior • Disregard the technically most efficient technologies available, thus underestimate potential for efficiency improvements • Determine energy demand through aggregate economic indices (GNP, price elasticity), but vary in addressing energy supply • Endogenize behavioral relationships • Assume there are no discontinuities in historical trends 	<ul style="list-style-type: none"> • Use an 'engineering approach' • Give optimistic estimates on 'best' performance • Allow for detailed descriptions of technologies • Reflect technical potential • Efficient technologies can be beyond the economic production frontier suggested by market behavior • Use disaggregated data for exploration purposes • Are independent of observed market behavior • Disregard market thresholds (hidden cost and other constraints) thus overestimate the potential for efficiency improvements • Represent supply technologies in detail using disaggregated data, but vary in addressing energy consumption • Assess cost of technological option directly • Negligible assess interaction between energy sector and other sectors

Source: Beeck (1999).

In order to measure the impacts of energy policy, a model that represents a complex socioeconomic system in a stylized way is needed, one that highlights possible linkages between the different elements. As can be seen in Table 4.2, a bottom-up model neglects the interaction between energy and other sectors, which is the central focus of this thesis. Therefore we examined our case study with a top-down model.

The Computable General Equilibrium Model (CGE) fits this purpose. Computable models are so named because, for a given policy change or any other exogenous shock, they 'compute' results, in the sense that they return a new set of information about prices, wages, incomes, and equilibrium quantities of goods and services, all endogenously determined by the model during the simulation exercise. They are constructed as a set of simultaneous equations describing the behavior of several economic factors (e.g. utility-maximizing households, profit-maximizing or cost-minimizing firms). Therefore, they usually describe how demand and supply decisions made by different economic agents can determine the prices for commodities and factors. Depending on the specification, they can show equilibrium conditions in a given system, including equations to describe how prices adjust to clear the markets.

Many parameters in a computable model are built with reference to a “benchmark”, or a state of the economic system in which the policy measures under assessment are not implemented. For most CGE models, for example, the benchmark is a Social Accounting Matrix, or SAM. If a SAM-based CGE is solved without any change, it “replicates” the benchmark (provides the same values of SAM), because it is “calibrated” on SAM. This means that some parameters are calculated on the basis of the values included in SAM. Together with “calibrated” parameters, computable models also make use of information derived from econometric models; key parameters and elasticities can, in fact, be estimated using regression analysis outside the model. This constitutes an important link between the two families of models.

As mentioned before, a large number of computable models are General Equilibrium Models (CGEs). Together with “accounting models”, they form the majority of quantitative models used to assess socioeconomic policy impacts. CGEs describe equilibrium relations among the different agents and components in an economic system, taking into account feedback and indirect effects generated by policy changes.

4.2 Counterfactual Analysis

The previous section explained why we chose CGE as our methodology. In this section we elaborate how a CGE model is applied in our case study. In a general equilibrium framework, the distributional impact of any exogenous shocks to the model (policy change or external shocks) works through the market mechanisms. However, most CGE models conform only loosely to the theoretical general equilibrium paradigm. For example, they may allow for:

- non-market clearing, especially for labor (unemployment) or for commodities (inventories)
- imperfect competition (e.g., monopoly pricing)
- demands not influenced by price (e.g., government demands)
- a range of taxes
- externalities, such as pollution

At the initial condition, the model mimics the actual condition of the economy through a SAM database. An economic system consists of various markets, both competitive and regulated, such as the gas market; the system includes every economic distortion, such as fuel subsidies. A competitive market will respond based on market mechanisms, which assumes cost-minimizing behavior by producers, average-cost pricing, and household demands based

on optimizing behavior according to neoclassical principles. However, a regulated market will not be affected, as that kind of restriction has been incorporated in the model.

A CGE model can analyze the impact of changes in policy variables across multiple markets. The model's parameters can be price-based (e.g., taxes and subsidies) or quantity-based (e.g., constraints on demand and/or supply), and the values can be exogenously determined by the analyst (Wing IS, 2004). A disturbance in prices, activity levels, and demands caused by changing the values of these parameters induces a shift from the old equilibrium to a new, distorted equilibrium (Wing IS, 2004).

By comparing the pre- and post-change equilibria, the policy can be evaluated, subject, of course, to the accuracy and realism of the model's assumptions (Wing IS, 2004). The CGE model provides the answer to "what if". What could possibly happen in the absence of a certain policy or if a new policy is implemented? Note that this model may not analyze a regulated market very well, as it violates market mechanism assumptions. The CGE model measures the interaction between markets, and how a market can affect the entire economic system.

Suppose a simple economic system consists of only two markets; a flour market, which is regulated, and a bread market, which is competitive. If the policy-maker decides to increase the price of flour, it is easy to predict that the bread market will respond by adjusting the price of bread. The bread producer is trying to maximize profit; if the cost of production increases, then the producer should increase the price of the product, depending on how significant a component flour is to bread's production. In a more complex economic system, a change in the price of bread may affect other sectors as well, creating "a chain reaction" or "domino effect". The CGE model's role is to quantify the impact of this change (change in flour price, in this case) on the whole economic system (either positive or negative) through economic indicators, for instance, GDP.

If flour production needs an input product from another sector, then no matter how expensive the price of input from that sector, the price of flour will not change, as it is subject to regulation. This kind of assumption has been taken into account in the construction of this model; therefore this model can be used to analyze regulated markets as well.

This type of analysis, in which a change of policy is imposed and its impact is analyzed, is called "counterfactual" analysis. It follows a logical process, as shown in Figure 4.1, starting

with construction of a base scenario, a stylized description of the socioeconomic system without policy intervention (WoP), i.e. the assumed state of the socioeconomic system if the policy measure is not implemented.

This is the reference scenario (also known as a benchmark or baseline) for impact analysis of various policies. The reference scenario is delineated using indicators chosen on the basis of the type of policy one wants to analyze. If, for example, the policy measure aims at poverty alleviation and food security, one uses poverty and food security indicators, e.g. poverty headcount rate, poverty gap, per capita intake of calories and proteins or their distribution (per different deciles or quintiles of population), and so on. These indicators calculated for the reference scenario are used as reference indicators.

After building the reference scenario, a scenario is constructed that integrates the expected socioeconomic impacts of the policy option. This is the scenario with policy (WiP). If more than one policy option will be analyzed, the analyst builds different scenarios “with” policy. WiP scenarios are usually built as modifications of WoP scenarios.

In order to move from one scenario to the other, one needs a *model for socioeconomic impacts* that allows for identifying, describing, and quantifying the changes in a socioeconomic system most likely to be induced by the policy measure. An impact model highlights causal links, or *transmission mechanisms*, among different socioeconomic variables, and specifically among variables directly influenced by a policy intervention, i.e. the *policy instrument* and the variables directly related to the objectives of the intervention, i.e. the *policy objective*. The impact model is therefore a simulation device for studying the effects of changes in variables controlled by policy measures on selected socioeconomic variables relevant to the policy objective; see Figure 4.1.

Figure 4.1 Counterfactual Approach for Policy Impact Analysis

Source: FAO (2009)

After constructing the WiP scenario using the impacts model, indicators similar to those used in the reference scenario can be chosen. If, for example, one used poverty indicators (poverty headcount rate and the like), one then uses the same indicators for the WiP scenario, thus allowing comparison of results before and after the policy change.

The analysis of the “counterfact” is essential for measuring impacts. Comparing indicators from the WiP scenario with those from the WoP scenario underlines changes in the socio-economic system introduced by policy measures. Different scenarios for different policy options can be constructed.

4.3 Limitations of The CGE Model

Despite its advantages, the CGE model has some limitations:

1. Dependency of the model on a calibrated parameter. The CGE model does not estimate this parameter, but instead uses estimations outside the model, mostly from previous research. Sometimes these data are not available for developing countries.
2. The CGE model is complex and uses many assumptions, making it difficult to explain the results if they do not fit economic theory or the expected prediction.
3. Unlike the econometric model, there is no validation process. This makes it less convincing for people who emphasize model validity.
4. The CGE model cannot accurately capture extreme shock (more than 100%).

In this study, the impact of these limitations was minimized as follows:

1. The calibration parameter is taken from the GTAP database of countries having characteristics similar to this case study.
2. The closure of the model is chosen deliberately based on relevant assumptions in order to capture the policy shock we want to simulate.
3. Policy change scenario is less than 100% to ensure accuracy of the result.

These points will be discussed in more detail in Chapter 5, in the construction process.

4.4 Analytical Framework for The Natural Gas Sector

The analytical framework of this dissertation is constructed using the Munasinghe INEP (1980), introduced in Chapter 3, which has been adapted for our research on natural gas policy. The left side of Figure 4.2 shows how natural gas as an energy source is linked with the economy. On the micro level, as discussed in Chapter 3, there are three gas policy instruments: supply policy, pricing policy, and infrastructure policy. Each of these policies is used to answer our three different research questions.

Figure 4.2 Analytical Framework For Natural Gas Policy

Source: Authors Own Model Adapted From Munasinghe (1993)

The INEP concept for gas policy is translated into a counterfactual analysis, introduced in Section 4.2. Our research questions (see Chapters 1 and 2) are:

- d. *How should Indonesia prioritize natural gas allocation for the domestic market to achieve the optimum benefit for the national economy?*
- e. *To what extent can gas price be adjusted/increased to reach an optimum trade-off between economic efficiency and social objectives?*
- f. *What impact will natural gas infrastructure development have on Indonesian energy security and economy, and what are the viable policy options to finance it?*

Comparative analysis is done using the CGE model; the output from this model is the percentage change of an economic indicator relative to a baseline set by a policy scenario. There are three main economic indicators used in this dissertation, macro indicator, sectoral indicator, and energy indicator.

Table 4.3 Policy Indicators

No.	Indicator
1	Macro <ul style="list-style-type: none"> • GDP • Household Consumption • Investment • Export • Employment
2	Sectoral <ul style="list-style-type: none"> • Sectoral Output • Sectoral Employment
3	Energy Consumption

Different policy scenarios are developed for each research question.

4.3.1 Gas Allocation

We built several scenarios for reduced gas consumption by different consumers; in each scenario we imposed a reduction of the same amount of gas plus a scenario reducing the amount of gas proportionally, based on the consumption level for each consumer. Supply reduction scenarios ranged from 20 to 40 percent reduction from 2011 up to the year 2025. Simulation results of economic indicators are used to rank consumer priority. The sector showing the worst economic indicator as an effect of gas supply reduction will get first priority, because this indicates that particular sector can have the most impact on the Indonesian economy.

4.3.2 Gas Pricing

We develop various scenarios of increasing gas prices above the current average level. The economic indicators simulation result is used to determine how high the gas price can be adjusted without seriously impacting the economy. In addition to a macroeconomic analysis with CGE, we also conduct microanalysis with net back value. Basically this method measures the sensitivity of the gas prices on the cost structure of a consumer. Together with macroanalysis, the result is used to propose a new level of gas pricing.

4.3.3 Gas Infrastructure Development

Several scenarios of public spending to finance infrastructure are simulated and analyzed. The objective is to compare which public funding scenario is the most feasible option for financing natural gas infrastructure. A second objective is to measure the impact of infrastructure development on the Indonesian economy.

4.4 Conclusion

This chapter outlined an analytical framework for our empirical chapter. In the first section we elaborated different types of energy modeling and the reasons for choosing the CGE model. The second section discussed how the model is used for a case study. The third section presented how we apply the model to the case of Indonesian gas policy, including the kind of policy scenario developed and the assessment indicators. This chapter discussed principles underlying our empirical Chapters, 6, 7, and 8. In the following chapter we elaborate the mathematical and economic theory behind the CGE model in more detail.

Chapter 5 Energy and The Economy: A Macroeconomic Model

5.1 A Formalized Model of the Conceptual Framework

Chapter 4 discussed the conceptual framework of this thesis. In this chapter we elaborate this framework into a mathematical model that enables us to provide a counterfactual analysis of current gas policy. We use the CGE model. The general equilibrium model describes the relationship between goods and services in a theoretical market economy. Each market should be in equilibrium, so that all markets are linked to the supply/demand balance in each market. Therefore, any change in the market balance results in a reaction or reactions in other markets.

CGE uses general equilibrium theory to perform empirical analysis of resource allocation issues in a market economy (Bergman 2005). In Figure 4.5 in Chapter 4, the left column shows the interrelation between the macroeconomy and energy. The structure of the CGE model provides us with a mathematical model derived from microeconomic theory that links these two. This is a useful tool for analyzing this relationship, and how policy changes based on our three research questions affect the entire system. To operationalize the model, we need to build scenarios based on those three questions introduced in Chapter 1. Each scenario is simulated separately with the model, and a comparative analysis (*with* versus *without* policy changes) of economic performance indicators is provided.

One notable difference of the CGE model, in contrast to other forecasting/impact analysis models, (e.g., econometric models), is that the CGE model does not use historical time series data. An example of econometric models is time series analysis, where simple extrapolation of past trends is used to predict population growth (Pyndyck and Rubinfeld, 1998). Instead, the CGE model uses a Social Accounting Matrix (SAM) data as the database to conduct simulations (see Section 5.3 for more detail). One contribution of this thesis to the CGE model is modifying the SAM database published by the Indonesian Agency of Statistics, and developing policy scenarios in order to evaluate natural gas policy. This has not been done in previous research using the CGE model. In Section 5.2 we discuss the general structure of the CGE model; Section 5.3 discusses the SAM database. Section 5.4 discusses how different models are used for the three research questions. The last section discusses how to interpret results of the model.

5.2 Building the Model

The model was constructed in five main steps (Figure 5.1). These are: database preparation (SAM, IO, and GTAP), database construction (MakeData), and model modification and construction (MakeModel). The data were then used to construct a static model, which was expanded to a dynamic model.

Figure 5.1 The Model-Building Process

We discuss each step of the process in the following section. First, we elaborate on the database used, and then give the detailed structure of the model.

5.3 Database Preparation and Construction

In this section, we elaborate Steps 1 and 2 of the model-building process, which comprise database preparation and construction; Figure 5.2 shows the flow. First the database (consisting of an Input Output (IO) and Social Accounting Matrix (SAM), and GTAP database) is prepared. After the data are ready, we prepare it for the model.

Figure 5.2 The Database Construction Process

A SAM is a comprehensive, economy-wide data framework, typically representing a national economy. It is a square matrix in which each account is represented by a row and a column.

Table 5.1 A General Schematic of SAM

	Activities	Commodities	Land	Labor	Capital	Households	Government	Change in stocks	Savings: investment	Rest of the world
Activities		Supply matrix								
Commodities	Intermediate consumption					Final private consumption	Final public consumption	Change in stocks	Fixed investment	Exports
Land	Value added by land									
Labor	Value added by labor									
Capital	Value added by capital									
Households			Payment from land to households	Payment from labor to households	Payment from capital to households		Transfers from government to households			Remittance to households
Government		Sales and imports tax			Payment from capital to public sector	Direct taxes				Transfers from nonresidents to government
Change in stocks									Change in stocks	
Savings: investment						Household savings	Government savings			Foreign savings
Rest of the world		Imports			Repatriation of dividends and utilities		Government payments to nonresidents			

Source : Based on Robinson et al (2001)

Table 5.1 is the generic structures of a SAM database that can be varied from one country to another. Every column in the SAM has its corresponding row, and each cell shows the payment from the account of its column to the account of its row. As an example, in red circled cell we have information of “payment from land to household”, which shows the flow of the money from the account “land” in the column of the table, to the account “household” in the row of the table.

In this thesis we use Indonesia’s SAM of 2008 as the database for the CGE model; it is the last SAM published by the Bureau of Statistics, available at the Indonesian Central Agencies of Statistics (BPS). BPS has published a SAM every five years since 1975. The validity and reliability of the Indonesian SAM are discussed in several studies using earlier versions, for example, Hartono and Resosudarmo (2008), Lewis (1991), Thorbecke (1992), Azis (2000) and Clement et al. (2003).

SAM 2008 was deliberately designed to accommodate a variety of important information not captured by the IO tables, such as transfers between institutions. This is done by adding information from SAM 2008 (BPS). Information taken from that SAM includes ownership share of factors, share of factors used abroad, indirect tax share, share transfers between

institutions, and factor use. The combination of Data Input Output 2008 (BPS) with SAM 2008 (BPS) is used in the CGE models.

The standard SAM table, the central database needed for the model, has only 23 sectors and commodities. The table was expanded to 44 sectors and commodities to get a more detailed view of the energy sector. Our modification is the disaggregation of the energy resource sector—coal, natural gas, crude oil, and geothermal—and mining, the separation of the petrochemical sector from refinery in general, and the distinction between electricity and urban water and gas.

We considered this disaggregation necessary since we focus on energy-intensive sectors of the economy. After disaggregation, our analysis covered 44 economic sectors, which we considered sufficient for reliable and valid statistical results. Another modification is household type, which is aggregated in one type of household. The modification can only be conducted when all necessary and supporting datasets are available; for that purpose we needed to gather information from various sources such energy statistics and data published by state-owned companies (Figure 5.3).

Figure 5.3 Database Preparation

With this information, we disaggregated the sectors as in Table 5.2 :

Table 5.2 Sector List in CGE

Sector Classification	Sector Classification
1. Food crops	26. Subsidized LPG
2. Estate crops	27. Non-Subsidized LPG
3. Livestock	28. Liquefied Natural Gas
4. Forestry and hunting	29. Subsidized Electricity (Electricity)
5. Fishery	30. Non-Subsidized Electricity
6. Metal (ore)	31. Hydro
7. Coal Mining	32. Urban Gas
8. Crude Oil (Crude)	33. Clean Water
9. Natural Gas (Gas)	34. Construction
10. Geothermal	35. Trade and Storage
11. Other Mining	36. Restaurant & Hotel
12. Food Processing (Food)	37. Train
13. Textile and Leather (Textile)	38. Land Transportation
14. Wood Processing	39. Air-Water Transportation and Communication
15. Paper, Metal and other industry (PMI)	40. Supporting Services
16. Petrochemical	41. Bank and Insurance
17. Bio Ethanol	42. Real Estate
18. Biodiesel	43. Public Service
19. Other Refinery	44. Personal Service
20. Gasoline	
21. Bio-Gasoline	
22. Kerosene	
23. High Speed Diesel Oil	
24. Bio HSDO	
25. Non-Subsidized Gasoline	

Source: Author

The values for some sets of parameters had to be estimated or borrowed from the literature or other models. Those sets are: (1) Armington elasticity between domestic and import commodity, σ_c , (2) export elasticity, ε_c , (3) elasticity of substitution between expertise, σ_i^{1lab} , (4) elasticity of primary factor substitution, σ_i^{1prim} , (5) elasticity of transformation CET for industry with multiple commodity, Ω_i , (6) elasticity of expenditure of household LES, η_{ih} , and (7) Frisch parameter or elasticity of marginal utility from household income, ϕ_h .

Table 5.3. Parameter in CGE model

No	Name of the Parameter
1	CES substitution between skill types
2	CES substitution, primary factors
3	Armington elasticities: intermediate
4	CET transformation elasticities
5	Armington elasticities: investment
6	Armington elasticities: households
7	Frisch LES 'parameter
8	>0.5 For individual export commodities
9	Export demand elasticities: typical value -5.0
10	Collective export demand elasticity
11	Rates of Depreciation (i.e. 0.08)
12	Addition to CAPSTOK from last year investment
13	(Max/trend) investment/capital ratio: i.e 4
14	Investment elasticity
15	Initial PK/PI
16	Initial expected gross rate of return
17	Initial (actual/trend) employment
18	Elasticity of wage to employment: i.e. 0.5

Source: COPS, 2012

Once all datasets were ready, we moved to the next step—MakeData. We combined, read, and converted all the information for model naming and classification. The output of this process is a single database file for the model named indorani08land.har.

Figure 5.4. Flow of Database Input Output Model CGE

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
Size		$\leftarrow I \rightarrow$	$\leftarrow I \rightarrow$	$\leftarrow 1 \rightarrow$	$\leftarrow 1 \rightarrow$	$\leftarrow 1 \rightarrow$	$\leftarrow 1 \rightarrow$
Basic Flows	$\begin{matrix} \uparrow \\ C \times S \\ \downarrow \end{matrix}$	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	$\begin{matrix} \uparrow \\ C \times S \times M \\ \downarrow \end{matrix}$	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	$\begin{matrix} \uparrow \\ C \times S \\ \downarrow \end{matrix}$	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	$\begin{matrix} \uparrow \\ O \\ \downarrow \end{matrix}$	V1LAB	C = Number of Commodities I = Number of Industries S = 2: Domestic, Imported, O = Number of Occupation Types M = Number of Commodities used as Margins				
Capital	$\begin{matrix} \uparrow \\ 1 \\ \downarrow \end{matrix}$	V1CAP					
Land	$\begin{matrix} \uparrow \\ 1 \\ \downarrow \end{matrix}$	V1LAND					
Production Tax	$\begin{matrix} \uparrow \\ 1 \\ \downarrow \end{matrix}$	V1PTX					
Other Costs	$\begin{matrix} \uparrow \\ 1 \\ \downarrow \end{matrix}$	V1OCT					

Source : COPS, 2012

5.4 Model Structure

In this section we discuss Steps 3 to 5 in the model-building process, which are model structure, static version, and dynamic version. There are two CGE models used in this dissertation, Orani-G and Orani-GRD. The only difference is that the latter is a recursive

dynamic model that incorporates a dynamic equation of labor and capital accumulation. The forerunner of CGE models used in this study is based on the CGE models of economic equilibrium used in Australia Orani-G models. This is a static model, in which the main equations explain various linkages between a number of factors:

- Demand input factors of production by industry
- Special commodities
- Demand input for capital formation
- Household demand
- Demand for export
- Demand from the government
- The linkage between the basic values of the cost of production and producer prices
- Market-clearing conditions for commodities and primary factors
- A number of macroeconomic variables and price indices (Horridge 2000).

Some assumptions in this model suggest that all markets are in equilibrium. Therefore, the concepts of optimization for all equations are consistent with the concepts of neoclassical economics. Utility maximization and cost minimization are applied as constraints to the model, so that the output generated by the common equation always refers to the concept of efficiency. Other assumptions applied to CGE models are that all economic agents are price-takers and the manufacturers have perfect competition by a margin of normal or zero-profit condition.

The CGE model applications in this study have the following properties:

1. The model is multi-sectoral, consisting of 44 sectors.
2. There are three kinds of production inputs, namely, capital, land, and labor.
3. Following the production structure in the standard ORANIG model, this model has several labor types that are optimized through CES function. This also explains the decision to choose the primary inputs, intermediate demand, as well as commodity sourcing (domestic and import). However, the ratio between value added and the composite sourcing of intermediate demand is optimized with the Leontief production function.
4. The database for the model is based on the Input-Output (IO) table, which requires some information from the social accounting matrix (SAM). For example, the additional data needed during construction of the model includes undistributed earnings from enterprise and inter-institution transfer, such as from government to household. These features cannot be gathered from the IO table, hence this model is

modified to include these features, especially the transfer from government to household. There are three types of institutions, government, household, and enterprise (corporate).

In the next part we explain the theoretical structure of CGE models through the mathematical equations in the model.

5.4.1 Conventions

In describing the model's structure, some definitions and conventions need to be clarified. First, a variable in level⁹ is in capital letters; the percentage change in the variables is lowercase. For example, the number of people working in the sector *i* can be written *Li* while *li* represents the percentage change from *Li* or $li = 100 \frac{\Delta Li}{Li}$. In addition to percentage change, there are variables in ordinary change¹⁰, which are marked at the beginning by 'del'.

Second, the definition of a set is written as a variable subscript. As shown in Table 5.4, this model has 20 industries and 20 commodities. The model also has two classifications of labor and one household.

Third, the pattern of variable-naming in Orani-G models is followed. These variables include:

1. Percentage changes from real variables are usually denoted by variables beginning with the letter x or q.
2. Percentage changes in the price of commodities and production inputs are represented by a variable beginning with the letter p.
3. Percentage changes from nominal variables are represented by variables beginning with the letter w.
4. Nominal initial value (initial nominal value) of a transaction is represented by coefficients beginning with the letter V.
5. On some variables there is a numerical superscript 0, 1, 2, 3, 4, 5, 6. For more details, see Table 5.3.

⁹ Level means variable's absolute value based on SAM database.

¹⁰ Ordinary change is a mathematical expression containing a multiplication, for instance $5 \times 10^2 = 5 \times 100 = 500$

Table 5.4 Definition of Set

Set	Definition
$i \in \text{IND}$	Set of industries
$c \in \text{COM}$	Set commodities
$s \in \text{SRC}$	Set from 2 sources, domestic and imported
$o \in \text{OCC}$	Set of labor

Source : COPS, 2012

Table 5.5 Definition of Superscript

Superscript	Indication commodity or input user
0, example: p^0	Basic Value, contoh harga dasar/ awal
1, example: x^1	Industry, example, intermediate input
2, example: x^2	Investor, example, private investment
3, example: x^3	Household, example, commodity demand
4, example: x^4	Export, example, export demand
5, example: x^5	Government, example, commodity demand by government
6, example: x^6	Stock, example, commodity demand as inventory

Source : COPS, 2012

5.4.2 Equation Statement of Orani G and Orani G-RD

In a statement equation, structural equations are written as statements. The basic equation is divided into several sections as follows:

1. Production sector. The equation relating the production of goods and services, the demand for intermediate inputs, primary inputs, and producers' supplies of commodities.
2. Domestic import sourcing (related to the composition of demand by source, namely domestic-imported, based on the Armington specification).
3. Demands for inputs to capital formation.
4. Household demands. The equation associated with the demand for goods by different users.
5. Export demand.
6. Government demand.
7. Purchaser's price and production costs. The equation linking producer prices, or the international price, to the price of the buyer.
8. Market clearing. The equation associated with the market-clearing condition where supply equals demand for both commodities and factors of production.
9. Factor income. The equation summing factor income.

10. Institutions. The equation associated with the receipt / income and expenditure of institutions, namely: households, government, corporate, and overseas.
11. Some index and macroeconomic variables.

5.4.3 Production Structure

Production activity sectors are described by the production function, which transforms inputs into outputs. The production function is assumed to be separated, and this can be rewritten as a union of some subset of the input. For example, output (Y) is a function of capital (K) and labor (L). Inseparable means Y can also be written as a function of a combination of primary factors (V) (a function of K and L) or $Y = f(K, L) = f(V(K, L))$; this is referred to as a nested production function. The structure of nested production functions for each industry is shown in Figure 5.5. The Firm¹¹ further calculates optimization at each stage and seeks to minimize the total cost of purchasing inputs. Optimization at each stage provides a solution in the form of input demand,

For a composite of labor, each firm minimizes the total cost of labor with different skills (skilled and unskilled). Composite labor is an aggregation of various labor types on the production function constant elasticity of substitution (CES). The solution of this cost minimization will determine the optimal composition of various types of labor and this will then determine the level of labor demand for each industry (i) and each expertise classification and the job type (o), and will also determine the price level of the composite employment in each industry. The function of the demand for labor by an industry (i) and the labor skills (o) (in percentage change) is determined by:

$$x_{io}^{lab} = x_i^{lab-o} - \sigma_i^{lab} (p_{io}^{lab} - p_i^{lab-o}) \quad (1)$$

¹¹ Firm refers to private sector/enterprises, one of three institutions in the SAM database along with household and government. It is assumed that the firm will behave to maximize profit and minimize cost of production in each stage of the production process.

Figure 5.5 Production Structure

Source: Yusuf and Resosudarmo, 2008

Where x_{io}^{1lab} is labor demand with expertise o by industry i , x_i^{1lab-o} is labor composite, σ_i^{1lab} is elasticity of labor substitution on every expertise, p_{io}^{1lab} is price of labor with expertise o in industry i , and p_i^{1lab-o} is effective price of labor composite for every industry defined as:

$$V_i^{1lab-o} \cdot p_i^{1lab-o} = \sum_{o \in OCC} V_{io}^{1lab} \cdot p_{io}^{1lab} \quad (2)$$

Where V_{io}^{1lab} is total payment for labor by industry i for every expertise o , and $V_i^{1lab-o} = \sum_o V_{io}^{1lab}$. Equation (2) simply defines the effective price of labor as a weighted average of each labor price with various expertise, while Equation (1) states that labor demand with specific expertise changes proportional to labor composite and demand will decrease alongside increase in relative wage because of substitution effects. The substitution level will depend on elasticity of labor between expertise.

In the next optimization steps, every firm minimizes the total of primary input cost for a certain primary input composite. Primary input consists of labor (x_i^{lab-o}), capital (x_i^{1cap}), and land (x_i^{1lnd}). Solution of optimization problems yields the demand for every primary input. Industrial demand of labor is given by the equation:

$$x_i^{lab-o} = x_i^{1prim} - \sigma_i^{1prim} (p_i^{lab-o} - p_i^{1prim}) \quad (3)$$

5.4.4. Source of Intermediate Input

Where x_i^{1prim} is demand for primary input composite, σ_i^{1prim} is elasticity of substitution between primary input, and p_i^{1prim} is effective price of primary input, industrial demand for capital is represented with:

$$x_i^{1cap} = x_i^{1prim} - \sigma_i^{1prim} (p_i^{1cap} - p_i^{1prim}) \quad (4)$$

Industrial demand for land:

$$x_i^{1lnd} = x_i^{1prim} - \sigma_i^{1prim} (p_i^{1lnd} - p_i^{1prim}) \quad (5)$$

Effective price of primary input is given by :

$$V_i^{1prim} \cdot p_i^{1prim} = V_i^{lab-o} p_i^{lab-o} + V_i^{1cap} p_i^{1cap} + V_i^{1lnd} p_i^{1lnd} \quad (6)$$

Where V_i^{lab-o} is initial value of labor cost, V_i^{1cap} is land cost, and V_i^{1prim} is total cost of primary input. The equation below defines change in total cost of primary input:

$$100 \cdot \Delta V_i^{1prim} = V_i^{1cap} (p_i^{1cap} + x_i^{1cap}) + V_i^{1lnd} (p_i^{1lnd} + x_i^{1lnd}) + \sum_{o \in OCC} V_{io}^{lab} (p_{io}^{lab} + x_{io}^{lab}) \quad (7)$$

As shown in Figure 5.5, the firm uses both domestic and imported commodities as intermediate inputs. For each commodity, the firm performs an optimization to determine the ratio between domestic and imported commodities in order to minimize the total cost of procuring commodities from these two sources. The solution of the optimization problem is generating demand for commodities for each source.

$$x_{csi}^1 = x_{ci}^{1-s} - \sigma_c (p_{csi}^1 - p_{ci}^{1-s}) \quad (8)$$

Where x_{csi}^1 is commodity demand c from source s by industry i, x_{ci}^{1-s} is domestic-import composite of commodity c, p_{csi}^1 is price of commodity c from source s that is received by industry i, p_{ci}^{1-s} is effective price composite of domestic-import commodity and σ_c is Armington elasticity between domestic-import commodity. Effective price of the commodity composite is defined as:

$$p_{ci}^{1-s} = \sum_{s \in SRC} S_{csi}^1 p_{csi}^1 \quad (9)$$

Where S_{csi}^1 is share of commodity purchase (c) from domestic or import by industry i.

Substitution among energy commodities

$$x_{fi}^{1-s} = x_{ci}^{1ener} - \sigma_i^{1ener} (p_{fi}^{1-s} - p_i^{1ener}) \quad (10)$$

where x_{fi}^{1-s} is the demand for energy or fuel type f by industry i, x_i^{1ener} is the energy composite, p_{fi}^{1-s} is the price of energy f faced by industry i, p_i^{1ener} is the effective or average price of energy, and σ_i^{1ener} is the elasticity of substitution among energy commodities (Yusuf, 2008).

Substitution between energy and primary factors

$$x_{fi}^{1ener} = x_{ci}^{1eprim} - \sigma_i^{1eprim} (p_{fi}^{1ener} - p_i^{1eprim}) \quad (11)$$

where x_i^{1ener} is the demand for energy composite, x_i^{1eprim} is the primary factor and energy bundle (composite), p_i^{1eprim} is the effective price of primary factor and energy composite, and σ_i^{1eprim} is the elasticity of substitution between energy composite and primary factor composite. The demand for primary factor composite (x_i^{1prim}) is given as:

$$x_{fi}^{1prim} = x_{ci}^{1eprim} - \sigma_i^{1eprim} (p_{fi}^{1prim} - p_i^{1eprim}) \quad (12)$$

where p^{1prim}_i is the effective price of primary factor composite (Yusuf, 2008).

5.4.5. Top production nest

On top of the production nest, the firm determines demand of various intermediate and composites of primary input by minimizing the total cost base on Leontief function. Optimization determines demand of commodities as follows:

$$x_{ci}^{1-s} = x_i^{1tot} \quad (13)$$

Where x_{ci}^{1-s} is primary input demand of commodity c by industry i and x_i^{1tot} is total output produced by industry i. Equation (13) implements the Leontief¹² production function, where demand for intermediate input is directly proportional to total output without substitution effect of intermediate input.

Demand of primary input composite is determined by:

$$x_i^{1eprim} = x_i^{1tot} \quad (14)$$

Cost of purchasing primary inputs and intermediate inputs will form the total cost of production and can be written as follows:

$$\Delta V_i^{1tot} = \Delta V_i^{1prim} + \sum_{c \in COM} \sum_{s \in SRC} \frac{1}{100} V_{csi}^{1pur} (p_{csi}^1 + x_{csi}^1) \quad (15)$$

Where ΔV_i^{1tot} is change of total production cost, ΔV_i^{1prim} is total primary input cost as defined in equation (6), and ΔV_{icsi}^{1pur} is purchasing value of commodity c by industry i, either from domestic or import. This model enables a producer (or industry) to produce more than one commodity. In this case, a producer maximizes revenue from sales of various commodities with the function *constant elasticity of transformation (CET)*. Supply of commodity c by industry i (q_{ci}^1) determined by:

¹² In the Leontief production function, input is used in fixed proportion. For instance, one farmer always works with one tractor; one carpenter requires a toolbox with 30 tools.

$$q_{ci}^1 = x_i^{1tot} + \sigma_i^{1out} (p_c^{0com} - p_i^{1tot}) \quad (16)$$

Where (σ_i^{1out}) is elasticity of transformation and (p_i^{1tot}) is average price received by industry defined as:

$$p_i^{1tot} = \sum_{o \in COM} \frac{V_{ci}^{make}}{V_i^{make_c}} p_{ci}^{q1} \quad (17)$$

Where (V_{ci}^{make}) is a matrix composed of values of commodity c produced by industry i, and this matrix and $V_i^{make_c} = \sum_c V_{ci}^{make}$, while p_{ci}^{q1} is the price received by industry i for the commodity produced. Every industry faces the same price levels for every commodity, and follows equation:

$$p_{ci}^{q1} = p_c^{0com} \quad (18)$$

The zero profit condition below balances industry revenue from commodity sales with total of production and eliminates profit excess.

$$V_i^{1tot} (p_i^{1tot} + x_i^{1tot}) = 100 \Delta V_i^{1tot}$$

Total of output of commodity c produced by the whole industry (x_c^{0com}) is the sum of the whole industry

$$x_c^{0com} = \sum_{i \in IND} \frac{V_{ci}^{make}}{V_c^{make_i}} p_{ci}^{q1} \quad (19)$$

Where $V_c^{make_i} = \sum_c V_{ci}^{make}$

Industry sales commodities for both domestic and export, supply for export market (x_c^4) is given by:

$$\tau_c (x_c^{0dom} - x_c^4) = p_c^{0dom} - p_c^e \quad (20)$$

Where x_c^{0dom} and (p_c^{0com}) is output and commodity price in the domestic market. p_c^e is export price for every commodity c , and τ_c is inverse of elasticity of transformation between export and domestic commodities. Supply of commodity in the domestic market (x_c^{0com}) is determined by equation:

$$x_c^{0com} = (1 - S_c^{exp}) x_c^{0dom} + S_c^{exp} x_c^4 \quad (21)$$

Where S_c^{exp} is proportion of sales commodity c in the export market. Transformation of the commodity can ensure the condition of *zero profit*¹³, which is:

$$p_c^{0com} = (1 - S_c^{exp}) p_c^{0dom} + S_c^{exp} p_c^e \quad (22)$$

5.4.6. Demand for Investment Goods

Figure 5.2 shows the structure of capital formation. Capital is assumed to be produced using the input in the form of commodities produced domestically or imported. The production function has the same structure as the input selection process in current production. In addition, there are no primary inputs used directly in capital formation.

¹³ Zero profit condition occurs when an industry or type of business has an extremely low (near-zero) cost of entry, which makes it attractive for many people to join the industry, looking for the opportunity to make money until there is no more money to make (supply exceeds demand). The large amount of competition limits each person's share of the market; this represents the "perfect competition" condition.

Figure 5.6 Structure of Capital Demand

Source : Yusuf (2008)

The above equation is the solution of the optimization investors (two-part cost-minimization). At the bottom level, the total cost of commodity i (domestic and imported) is minimized with the constraints of the CES production function. Later, in the upper level, the total cost of the composite commodity is minimized with Leontief production function constraints. The total investment in each industry, $X2TOT(i)$, in the cost minimization problem above, is an exogenous variable.

5.4.7. Household Demand

The household demand system is based on a linear expenditure system (LES). However, demand is only used in the LES for composite commodities (imported and domestic). Therefore, a combination of imported and domestic commodities to be modeled is done using a composite Armington aggregation, as it is also done on the formation of composite intermediate input. In response, the structure of the query uses a nested demand function (see Figure 5.3). At the first level, for each commodity c , each household determines the optimal combination of imported and domestic commodities to be consumed by minimizing the total expenditure for a certain amount of the composite commodity.

A Stone-Geary function is used in optimizing the utility. This function is often used to model problems involving subsistence-level consumption. To replicate the features of demand for household goods in the economy, basic needs (subsistence) must be incorporated into their utility functions. In this case, a minimum level of consumption for some goods is determined, regardless of the price or income of consumers.

Figure 5.7 Structure of Household Demand

Source : Yusuf (2008)

The optimization procedure for composition of household demand for commodities both imported and domestic is:

$$x_{csh}^3 = x_{ch}^{3-s} - \sigma_c \left(p_{csh}^3 - p_{ch}^{3-s} \right) \quad (23)$$

Where x_{csh}^3 and p_{csh}^3 are demand and commodity price from source s (import or domestic) by household h , x_{ch}^{3-s} is composite of commodity import-domestic, σ_c is elasticity of Armington, and p_{ch}^{3-s} is the effective price of the composite commodity defined as:

$$p_{ch}^{3-s} = \sum_{s \in SRC} S_{csh}^3 p_{csh}^3 \quad (24)$$

Where S_{csh}^3 is the proportion of household expenditure for commodity c from source s . On the last level, every household maximizes its utility function, by choosing budget constraints. Specifically, the optimization problem for household h is:

$$\max_{X_{ch}^{3-S}} = \prod_c \left(X_{ch}^{3-S} - X_{ch}^{3SUB} \right)^{S_{ch}^{3LUX}} \quad s.t. \sum_c X_{ch}^{3-S} P_{ch}^{3-S} = V_h^{3-TOT} \quad (25)$$

Where X_{ch}^{3-S} is quantity of composite commodity c, X_{ch}^{3SUB} is *subsistence quantity* of commodity, S_{ch}^{3LUX} is *marginal budget share* for commodity c, and V_h^{3-TOT} is total disposable income of household. The optimization solution results in a *linear expenditure system* (LES) as follow:

$$P_{ch}^{3-S} X_{ch}^{3-S} = P_{ch}^{3-S} X_{ch}^{3SUB} S_{ch}^{3LUX} \left(V_h^{3-TOT} - \sum_k P_{kh}^{3SUB} X_{kh}^{3SUB} \right) \quad (26)$$

The total of composite quantity commodity (X_{ch}^{3-S}) consists of a *subsistence component* and a luxury component, or $X_{ch}^{3-S} = X_{ch}^{3SUB} + X_{ch}^{3LUX}$. Demand for luxury commodity is the second part of above equation, or

$$\begin{aligned} P_{ch}^{3-S} X_{ch}^{3LUX} &= S_{ch}^{3LUX} \left(V_h^{3-TOT} - \sum_k P_{kh}^{3SUB} X_{kh}^{3SUB} \right) \\ &= S_{ch}^{3LUX} V_h^{3LUX} \end{aligned} \quad (27)$$

Where $V_h^{3LUX} = V_h^{3-TOT} - \sum_k P_{kh}^{3SUB} X_{kh}^{3SUB}$. Therefore in terms of percentage change, luxury demand can be written as:

$$x_{ch}^{3LUX} + p_{ch}^{3-S} = w_h^{3lux} \quad (28)$$

Where w_h^{3lux} is percentage change of V_h^{3LUX} . The total of household demand for composite goods is:

$$x_{ch}^{3-S} = B_{ch}^{3lux} x_{ch}^{3lux} + (1 - B_{ch}^{3lux}) x_{ch}^{3sub} \quad (29)$$

Where B_{ch}^{3LUX} is the ratio of luxury good expenditure to total expenditure. The total real consumption of household h (x_h^{3tot}) can be defined as:

$$V_h^{3tot} x_h^{3tot} = \sum_{c \in COM} \sum_{s \in SRC} V_{csh}^{3pur} x_{csh}^3 \quad (30)$$

Household price consumer index is calculated from:

$$V_h^{3tot} \cdot p_h^{3tot} = \sum_{c \in COM} \sum_{s \in SRC} V_{csh}^{3pur} p_{csh}^3 \quad (31)$$

Where budget constraints for a household are:

$$w_h^{3tot} = p_h^{3tot} + x_h^{3tot} \quad (32)$$

5.4.8. Market clearing and other equations

Market-clearing equations ensure supply of a commodity will be equal to the demand. Commodity exports and domestic demand come from each user, the manufacturer or the user industry intermediate inputs, households, governments, and investors. The market-clearing equation for each commodity c is the total sum of requests by each user equal to the total bid. This equation ensures market equilibrium and determines the commodity price.

There are also market-clearing equations for primary inputs that determine the price or return on the factors of production. For example, for each type of labor, there is a market-clearing condition, a condition that satisfies the demand for labor by industry with total labor supplied by households.

In addition to market-clearing functions, many other equations count variables at macro level / aggregate¹⁴, and also some identity equations and definitions. In addition, some parameters in this model are used as part of an applied model of GTAP data for Indonesia (Purdue University).

5.4.9. Dynamic Recursive Model Extension

The base model described earlier can be used to construct dynamic models that can forecast the policy impact scenario year by year¹⁵. The algorithm of the dynamic system is equal to the dynamic model in general, the simulation results on the initial data generate new data sets that are used to perform the simulation again, and this continues for the following years. Simulations can be set for each year, so the impact of simulation in the first year pushes the impact on simulation in the following years. The model's dynamic component has three mechanisms (Hermawan, 2013):

¹⁴ Such variables measure changes at the aggregate level. For instance, each industry has its own employment; one industry can have a positive employment trend while others are declining, thus macro variables measure the aggregate employment trend.

¹⁵ In a dynamic model, one can determine the policy scenario impact for specific years. This cannot be done in a static model.

- a) stock-flow relationship between investment and capital stock, which has a one-year lag assumption
- b) a positive relationship between investment and the rate of profit (rate of profit)
- c) the relationship between wage growth and labor.

Each of the above mechanisms can be easily changed as needed. The model is dynamic and can be useful for :

- a) Establishing a robust forecasting basis for a period of ten years or more. This serves as baseline condition for policy impact scenarios. This simulation models the growth of the economy over time in the absence of the policy change (Hermawan, 2013).
- b) Establishing forecasting of policy impact scenarios, where several policy instruments are imposed on the baseline condition, for instance, carbon tax, and power plant investments (Hermawan, 2013).

The main basis for forecasting as above is to produce a realistic estimate of the differences between two scenarios (e.g., with or without shock). This difference can be interpreted as the impact of policy change. The emphasis on policy analysis provides a space for us to use a model with only one closure (closure structural / policy). Model closure can be used for each year in the base scenario and as desired.

5.4.10. Capital Accumulation and Investment Allocation in CGE

This section describes the main equations and variables added to the model in order to implement a recursive dynamic model year, based on the work of Horridge (2002). The capital stock's growth rate is associated with the investment; investment, in turn, is guided by the rate of return. In the "annual recursive model" any settlement model is a change from one year to subsequent years. The initial database is the starting point for each calculation, which represents the economy at the end of the previous period and the early period of the current year. Similarly, the 'update' of the database generated from each economic calculation represents either end of the initial period of the current year or next year's period. Changes in these variables can be used to compare scores at the end of the year with the value at the beginning of the current year.

Although the equations described below apply to each individual industry, the industrial identity is omitted to simplify the explanation. For the same reason, we use the language of algebra. Capital accumulation in every period is calculated by subtracting investment level at the beginning of the period with depreciation:

$$\Delta K = Y_0 - DK_0, \text{ or} \quad (33)$$

$$\Delta K \Pi_0 = Y_0 \Pi_0 - DK_0 \Pi_0 \quad (34)$$

Where: Y = investment
K = capital
D = depreciation level
 Π = price of every unit of new capital

Subscript "0" shows start-of-period. Hence, change of investment in the current period does not affect the rate of capital growth in the current period, but in the next period. Both sides of Equations (33) and (32) have been multiplied by Π_0 to connect Y_0 and K_0 with their value in initial database: $Y_0 \Pi_0$ $K_0 \Pi_0$.

In the form of change in percentage, we have:

$$0.01[K \Pi_0].k = [Y_0 \Pi_0 - DK_0 \Pi_0].\text{delUnity} \quad (35)$$

Where k is change in percentage of K ($kK/100 = \Delta K$).

Investment Allocation Investment

The investment allocation mechanism has two components, namely:

- The ratio of investment / capital, which is positively related to expected returns.
- Expected returns going back to the actual rate of return through a partial adjustment mechanism.

Investment and Rate of Return

Given:

P_k price unit of capital rent
 P_a price unit of capital asset
Y investment
K amount of capital

Therefore the next equation:

$$R = P_k/P_a \quad (36)$$

$$G = Y/K \quad (37)$$

Equation (36) is the actual level of gross return. Equation (37) is the level of gross capital growth for the next period. E is the level of gross return expected for the next period. The level of capital growth depends on the level of expected return, which is determined as

$$G = F(E) \quad \text{where } F_E > 0 \quad (38)$$

Both G or R must be > 0 . In the case of R, this can be solved by another model equation in which capital always results in positive rent. In this model we also assume that every industry has a level of long-term return or normal return R_{normal} and when E, expected return, is the same as R_{normal} , then $G = G_{\text{trend}}$ where G_{trend} is normal growth (Horridge, 2002).

$$G_{\text{trend}} = F(R_{\text{normal}}) \quad (39)$$

The *logistic curve* for the function is:

$$G = Q \cdot G_{\text{trend}} \cdot M / (Q + M) \quad (40)$$

$$M = E / R_{\text{normal}} \quad (41)$$

If $M = 1$ then $G = G_{\text{trend}}$

If M is higher than $G = Q \cdot G_{\text{trend}} = G_{\text{max}}$ then Q biasnya = 4.

If M equals 0 then $G = 0$

We can use Equation (40) to conclude that at the end of the period the initial value of M and E is:

$$M_0 \alpha = [G_0 Q - G_0] / [Q \cdot G_{\text{trend}} - G_0] \quad (42)$$

In percentage change, Equation (8) becomes:

$$-g_{\text{trend}} = [1 - G/G_{\text{max}}] \alpha m \quad (43)$$

Partial Adjustment of the Actual Rate of Return Expected

The rate of return at the end of the period, E_1 , is the average of initial (start-of-period) expected rate of return, E_0 , and the actual rate of return on the end of the period, R_1 . This shows that for investors, either conservative or myopic ones, it is only past rate of return or current rate of return that influences the next period's rate of return, where

$$E_1 = (1-a)E_0 + aR_1 \quad 0 < a < 1 \quad (44)$$

$$E_0 + \Delta E = (1-a)E_0 + a(R_0 + \Delta R)$$

$$\Delta E = a(R_0 - E_0 + \Delta R) \quad (45)$$

with $M = E / R_{\text{normal}}$, then:

$$m + r_{\text{normal}} = e = 100. \Delta E/E \quad (46)$$

$$\Delta E = 0.01E(m + r_{\text{normal}}) \quad (47)$$

$$0.01[K\pi_0].k = [Y_0\pi_0 - DK_0\pi_0].\text{delUnity} \quad \text{capital accumulation} \quad (48)$$

$$g = y - k \quad \text{capital growth level for the next period} \quad (49)$$

$$g - g_{\text{trend}} = [1 - G/G_{\text{max}}]\alpha m \quad \text{Logistic Relation} \quad (50)$$

$$\Delta E = a(R_0 - E_0 + \Delta R) \quad \text{partial adjustment} \quad (51)$$

$$\Delta E = 0.01E(m + r_{\text{normal}}) \quad \text{M definition} \quad (52)$$

Where from Equation (50):

$$\begin{aligned} E = M.R_{\text{normal}} &= R_{\text{normal}}\{[GQ-G]/[Q.G_{\text{trend}} - G]\}^{1/\alpha} \\ &= R_{\text{normal}}\{[Q-1]/[Q.G_{\text{trend}}/G - 1]\}^{1/\alpha} \end{aligned} \quad (53)$$

From Equation (34), $R = P_k/\pi$:

$$\Delta R = 0.01.R(p_k - \pi) \quad (54)$$

Real Wage Adjustment Equation

In this study, it is possible to adjust real wages. If the period of employment exceeds some trend rate of $x\%$, then real wages will rise during the period, with $\gamma.x\%$. Employment will adjust towards the trend level because employment is negatively related to real wages; this may be thought of as the level of employment corresponding to NAIRU¹⁶(Horridge, 2002).

The equation is written as :

$$\Delta W/W_0 = \gamma [(L_0/T_0) - 1] + \gamma \Delta (L / T)$$

Where :

L : actual employment

T : trend employment

W : real wage

¹⁶ Non-Accelerating Inflation Rate of Unemployment

The base model can be modified for the benefit of dynamic applications, but it takes a few extra equations in the model. The section below describes the modifications made to the model,

5.4.11. Closure

In CGE models, the number of equations must equal the number of endogenous variables. Generally, the number of variables is greater than the number of equations¹⁷. Therefore some exogenous variables are needed to close the model, or what is called a 'closure'. This model is a long-run closure; supply of factors of production to all factors (labor, capital, and land) are exogenous; economy is in full employment, and factor of production can move across sectors. Therefore the price of factor of production is the same for all sectors. Part of the closure is the assertion that variables such as taxes, tariffs, various transfers (for instance, energy subsidy), and technology parameters, are exogenous. In the standard CGE closure, the nominal exchange rate (ϕ) becomes the numeraire.

5.5 Simulation

We conducted three different simulations for each of our research questions; there is no integrated analysis of all three measures, and we need to measure the impact separately. In each simulation we develop a counterfactual scenario based on current policy conditions.

We used a static CGE Model (Orani G) for the case studies on Natural Gas Pricing and Natural Gas Infrastructure, and a dynamic CGE model (Orani GRD) for Natural Gas Allocation. The reason behind this is that we have an official roadmap of natural gas supply and demand (up to 2025) so that we can set a specific time horizon in the model simulation.

However, we do not have the same road map for gas pricing and gas infrastructure, hence the use of a static model. The only difference between the static and recursive dynamic models is that, in the dynamic model, we can set certain time periods and track year-by-year trajectories of the policy shock impact. In the static model, we can only estimate that, in the short run (up to 5 years) or in the long run (10-15 years), the economy will reach certain conditions without an exact time as to the target, or providing a year-by-year trajectory.

¹⁷ The number of variable has to be greater than the number of equation to enable simulation scenario. If the number of variables is lower than the number of equations, the model cannot be solved; if the number of variables and equations is the same, simulation cannot be done. This is the role of closure, to make the model "closed".

In each of these simulations we analyze the impact of various scenarios with respect to macroeconomic and economic sectoral indicators. We also take into account the impact on energy utilization, since natural gas is part of the energy mix portfolio. Details of calculations are discussed in the empirical chapters (6, 7, and 8).

5.6 Output and Interpretation of the Model Results

The previous section discussed a mathematical presentation of the CGE model; however, general equilibrium cannot be computed only using a mathematical model. Instead, to solve the mathematical equation of CGE models, we need a software package, The General Equilibrium Modelling PACKage (GEMPACK) is used to solve the model equation. In keeping with the purpose of this research, certain variables related to the economy's performance, especially the energy sector, are the main focus. These variables are the benchmarks for gas policy changes to be discussed. Outputs of the variables generated by the model are read as a percentage change. For example, if the variable output shows 2.3%, then it should be read as a 2.3 percent increase from the baseline. If the model is dynamic, which is recursive, then it should be read as an increase in the variable of 2.3% from 2011 to 2025 relative to the baseline.

Table 5.6 shows the variables produced by a model showing the performance of the national economy; it will be a reference for the research results of the analysis in Chapters 6-8. Each resulting figure is the percentage change from the previous year's database. Simulations will refer to the baseline scenario that will be made based on certain assumptions about the economy in each year.

Table 5.6 Macro Variables

No	Variable	
1	delB	(Balance of trade)/GDP (change)
2	delV0tar_c	Aggregate tariff revenue (change)
3	Delwagerate	Change in real wage index (change)
4	employ_i	Aggregate employment: wage bill weights
5	Emptrend	Trend employment
6	p0gdpexp	GDP price index, expenditure side
7	p0toft	Terms of trade
8	p3tot	Consumer price index
9	Phi	Exchange rate, local currency/\$world
10	Q	Number of households
11	Realwage	Average real wage
12	x0cif_c	Import volume index, C.I.F. weights
13	x0gdpexp	Real GDP from expenditure side
14	x0gdpinc	Real GDP from the income side
15	x0imp_c	Import volume index, duty-paid weights
16	x3tot	Real household consumption
17	x4tot	Export volume index

Table 5.7 shows the variables used, based on a set of industries, commodities, and types of jobs. Several variables are used to create the baseline scenario, which functions as a reference for the scenarios created to solve the research questions.

Table 5.7 Sectoral Variable

No	Variable	SET	Description of Variable
1	a1tot	IND	All input augmenting technical change
2	contGDPexp	EXPMAC	Contributions to real expenditure-side GDP
3	employ	IND	Employment by industry
4	p0dom	COM	Basic price of domestic goods = $p0(c, "dom")$
5	p0imp	COM	Basic price of imported goods = $p0(c, "imp")$
6	p1cap	IND	Rental price of capital
7	p1lab	IND*OCC	Wages by industry and occupation
8	p1lab_o	IND	Price to each industry of labor composite
9	p1lnd	IND	Rental price of land
10	p1tot	IND	Average input/output price
11	pf0cif	COM	C.I.F. foreign currency import prices
12	q1	COM*IND	Output by commodity and industry
13	t0imp	COM	Power of tariff
14	x0dom	COM	Output of commodities for local market
15	x0imp	COM	Total supplies of imported goods
16	x1cap	IND	Current capital stock
17	x1lab	IND*OCC	Employment by industry and occupation
18	x1lab_i	OCC	Employment by occupation
19	x1lab_o	IND	Effective labour input
20	x1lnd	IND	Use of land
21	x1prim	IND	Primary factor composite
22	x1tot	IND	Activity level or value-added
23	x3_s	COM	Household use of imp/dom composite

All outputs are displayed in the GEMPACK program output; however, only the most relevant to our research are discussed in the empirical chapters. Figure 5.5 shows how the results of a CGE model are interpreted. Real GDP occurs at baseline Y1 if there is no disturbance (shock) in the economy, or the economy is running as usual (business as usual). When there is interference in scenario simulations, for example, an increase in government spending through higher subsidies, then GDP changes to the Y1 scenario.

Figure 5.8 How to Interpret Change in the CGE Model

The model (both static and dynamic) provides an overview of the impact of various economic disturbances (shocks), for example, if there are additional indirect taxes that impact the workers employed, the gross output of various sectors, exports, and imports. Each of these results should be interpreted in a manner similar to that depicted in Figure 5.5. In a dynamic model we can examine the impact of the shock in a specific time frame (this cannot be done in static model). An alternative way to interpret CGE models is to see them as a question-and-answer, "what ... if ... ?" For example, 'what will be the changes in real GDP and level of employment, if agricultural productivity increases by percent x '

Chapter 6 The Economic Impact Of Natural Gas Allocation Policy In Indonesia

6.1 Introduction¹⁸

There is a strong emphasis on shifting natural gas management from export to the domestic market, as discussed in Chapter 2. However, a mismatch occurred when an increase in domestic demand was not supported by supply, particularly when there was already a decline in production. In order to resolve this gap, the Ministry of Energy and Mineral Resources established Ministerial Regulation No. 3 concerning natural gas allocation for the domestic market.

This regulation set the rules for prioritizing natural gas allocation among the four biggest domestic gas consumers in Indonesia: the Petroleum Operations sector, the Fertilizer Production sector, the Power Generation sector, and other industries. According to ministerial regulation, the available natural gas for the domestic market had to be allocated in a hierarchical order, giving priority to the Petroleum Operations sector, to the Fertilizer sector next, and so on. The regulation was intended to regulate allocation of the scarce resource.

However, the reasoning behind this hierarchical order of sectors was never explained and remains unclear. According to the official explanation, natural gas should support economic development and prosperity in Indonesia. This argument has also been used to legitimate the regulatory instrument for gas allocation, but the instrument does not explain why one sector is prioritized over another. Allocation is applied without adequate scientific grounding in its economic effects on the national economy.

6.2. Indonesia's Natural Gas Supply And Demand

Domestic consumption of natural gas and electricity are concentrated in the industrial sector; the household sector is still negligible. In 2006, oil, natural gas, and coal dominated Indonesia's primary energy mix, with oil accounting for about 50%, and natural gas about 25%. The share of natural gas in this energy mix is expected to grow to 30% by 2025. This

¹⁸ The material presented in this chapter has been published as a conference paper. Hutagalung A., Hartono D., Arentsent M.J. The Economic-Wide Impact of Natural Gas Allocation in Indonesia: An Analysis Using Recursive Dynamic Computable General Equilibrium Model presented at the 5th Annual Conference on Competition and Regulation in Network Industries, Brussels, 2012.

seems to be a manageable increase, but in reality it is a huge challenge, given the overall growth of primary energy demand.

6.2.1 Natural Gas Demand and Consumers

Figure 6.1 shows a projection of natural gas supply and demand in Indonesia through 2025. The production forecast is based on information from gas producers on their reservoir simulations with expected volumes. Data on gas demand are based on already contracted gas sale agreements and projections of gas demand.

Figure 6.1 Forecast of Natural Gas Supply and Demand

Source: Ditjen Migas, 2011e

The figure clearly shows a significant gap between supply and demand of natural gas on the domestic market, which is a serious problem for several reasons. The gap cannot be narrowed by additional natural gas production; see Hutagalung et al. (2011).

Natural gas demand started to increase in 2005, when the government removed a subsidy on diesel fuel (HSD) for the industrial sectors. This encouraged a significant shift from diesel to natural gas in all industrial sectors, causing a significant shortage of natural gas in the domestic market. The sudden rise in demand could not be met by the natural gas contracted for the domestic market, and production could not be increased for several reasons (Hutagalung et al., 2011). Consequently, the domestic shortage of natural gas has been serious since 2011, endangering crucial economic sectors that are heavily dependant on a secure and reliable supply of natural gas. The major economic sectors for which natural gas is crucial are the following:

- *Oil Production/Enhanced Oil Recovery.*

Enhanced Oil Recovery (EOR) is a method used to increase the oil production by injecting heat (by burning the natural gas) into the oil reservoir in order to reduce the viscosity of the oil. The resulting additional crude oil production is significant (more than 50 thousand barrels per day), which requires 250 MMSCFD¹⁹ of natural gas as a heat source. This additional production brings in additional state revenues. Due to specific characteristics of Indonesian oil fields and Indonesian oil, there is no alternative for natural gas in EOR.

- *Fertilizer/Petrochemical Industry*

The Indonesian fertilizer industry consumed about 11% of the total domestic gas supply in 2011. Currently, revitalization of old fertilizer plants, as well as new ones, is planned; this is expected to require 300 MMSCFD of natural gas in the period 2013-2030. If these plans are implemented, the current volume of fertilizer production would increase by more than 4 million tons a year²⁰.

Fertilizers are very significant for Indonesian agriculture and natural gas is a crucial resource for their production. There is no alternative feedstock available. Fertilizer demand is growing; new production facilities are needed, thereby increasing the demand for natural gas.

- *Electricity*

Previously, diesel fuel dominated the energy mix for power plants; however, the electricity subsidy increased steadily every year and eventually became a burden for the state budget. Coal is expected to become the dominant fuel again in Indonesian electricity production in the coming decade (DJK, 2008). In 2008 the energy mix for electricity production was oil 36%, coal 35%, natural gas 17%, followed by geothermal and hydropower, 3% and 9%, respectively (PLN, 2010). According to the last projection by PLN²¹, the share of natural gas in 2020 will be approximately at the same level as 2008. Without additional gas supplies, it will be very difficult to achieve this. *Industry/Manufacture Industry*

The industry category refers to all industries other than fertilizer and petrochemical using natural gas as fuel. Included in this sector are food and beverages, textiles, paper, ceramics, glass, cement, and metal. Total gas demand of industry in 2011 (Yusgiantoro, 2012) is 1522 MMSCFD; metal and paper have the largest share, 60%

¹⁹ MMSCFD = Million Standar Cubic Feed per Day.

²⁰ Ministry of Industry reported that fertilizer production in 2011 is 7.137 million tons.

²¹ The state-owned company that monopolizes the electricity market.

and 16%, respectively. Other industries are ceramics and glass (9% and 4%); the remaining industries use negligible volumes of natural gas.

This overview shows how a number of crucial economic activities in Indonesia are dependent on natural gas. It also shows the significance of several of these sectors for Indonesia's GDP, such as the manufacturing industry, which contributes 24% to Indonesia's GDP (BPS, 2012). A constant supply of natural gas is crucial for continued development of Indonesia's economy. We have already indicated that increasing domestic gas demand cannot be met by supply in the coming years. The expected gas shortage in the domestic market requires an adequate policy response in order to minimize negative economic impact. Indonesia's policy response is national gas allocation, and the question is how an economically effective allocation policy can be achieved. This question is investigated in this chapter. Gas allocation as a policy instrument is discussed in the next section.

6.2.2 Natural Gas Allocation Policy

National gas allocation policy was first implemented in 2010. It was a contingency plan for natural gas supply shortage; its aim was the efficient and effective allocation of natural gas for national benefit (KESDM, 2010). The allocation order is based on the importance of gas for an economic sector; a sector with a higher rank gets priority in obtaining gas.

The rationale behind this ranking system is unclear. For instance, the decision to give Petroleum Operations top priority has been criticized by industrialist and energy experts (Tempo, 2012), because natural gas is only used to boost oil production to maximize state revenue. The economy would benefit more if gas were more available for industrial production. The stated aim of prosperity for the national economy, in addition to generation of state revenues, is not reflected in the national gas allocation policy, and this inconsistency has been debated since gas allocation began in 2010.

To analyze this problem, it is necessary to look back at the basic concept of resource management. It is common for a developing country with a planned economy²² such as Indonesia to apply planning for the benefit of economic development (Munasinghe and Meier, 1993). Moreover, Munasinghe (1980, 1988) introduced a hierarchical framework, the "Integrated National Energy Planning", linking energy inputs with economic effects in the national economy.

²² Alec Nove (1987), "planned economy," *The New Palgrave: A Dictionary of Economics*, v. 3, pp. 879–80.

To achieve development goals, a range of policy instruments can be applied, such as physical controls, technical methods, investment-influencing policy, pricing, tax, subsidy, and other incentives (Munasinghe and Meier, 1993). According to Munasinghe and Meier, physical control is most effective in circumstances of energy shortage, both in the short and the long run:

“The most fundamental task of energy analysis is to define alternative options and quantify their impacts on objectives established for national energy planning”. (Munasinghe and Meier, 1993)

Gas allocation can be considered an instrument of national energy planning; this is common practice in nations such as India (see Jain and Sain, 2011), Pakistan, and even the United States, (see Koplin, 1955). We found a similar sector ranking in Pakistan and India, with the fertilizer industry and power sector heading the rankings in natural gas allocation. India considers the fertilizer industry crucial for food production and the agricultural sector, and also gives priority to power production (Jain and Sain, 2011). Pakistan has a slightly different ranking, in which priority is given to the commercial sector, followed by the fertilizer sector and electricity generation. The United States has no specific rank of priority. Unfortunately, none of these countries justifies the priority settings in gas allocation in a scientifically rational way. We need to provide the arguments from our own analysis of the economic effects of prioritizing gas allocation in Indonesia.

We came across only one attempt in the literature to scientifically analyze the priority settings in Indonesian gas allocation. It is an unpublished masters thesis applying Input-Output analysis (I-O); Wibowo (2008). Wibowo evaluates the output multiplier of each gas consumer as a basis for priority ranking. The major limitations of I-O analysis in this context is that it assumes a linear correlation, and it cannot analyze short- or long-term effects. The I-O analysis cannot deal with the dynamics in the economic system. In this chapter we fill this gap by providing a dynamic analysis using a Computable General Equilibrium (CGE) model. CGE is able to analyze links between all economic sectors in a dynamic way. Application of CGE in energy planning can be found in Seddighi (1985) for optimal planning in an oil-producing country, and Nagvi (1998) for energy supply and demand modeling; no specific case study on natural gas could be found in the literature. An analog study for water allocation can be found in Qin (2011) and Hatano (2006), who investigated the impact of water allocation on a national economy. A similar study was conducted by Juana (2006) for intersectoral water reallocation. All these applications of CGE share the idea of estimating

“The economy wide impact of reallocation of a natural resource among the production sectors for the benefit of efficiency improvement” (Juana, 2006). This is how we used CGE in our own analysis of natural gas allocation in Indonesia. The next section introduces the methodology.

6.3 Methodology and Simulation Scenarios

In this chapter we use a dynamic CGE model; the details of the model and the database are given in this chapter. In this section we emphasize the scenario and closure used. The model used long-run closure, in which supply of production factors (labor, capital, and land) are exogenous (fully employed), and production factors can be moved across sectors, therefore the factor price is the same for all sectors. Part of the closure is a statement that variables such as tax, tariff, various transfers, and technology parameters are exogenous, and the nominal exchange rate becomes the numeraire.

First, we need to set a baseline scenario putting economic growth within the time frame 2008-2025 without any policy changes. This baseline scenario can be compared with other scenarios including the allocation priority rankings. GDP growth for the baseline scenario is taken from actual data for the period 2008-2011 and government planning for 2012-2025, as in Table 6.1. Then we develop several scenarios with curtailment of gas supply in different sectors: Oil Production, Petrochemical, Electricity, and Industry, which consists of three industrial clusters, textiles, food industry, and paper, metal and other industry which will be referred as PMI throughout the thesis for simplicity).

Table 6.1 GDP Growth 2008-2025

Years	GDP Growth
2008	6.01%
2009	4.63%
2010	6.2%
2011	6.46%
2012-2014	6.4-7.5%
2015-2025	8-9%

Source: Kementerian Koordinator Bidang Perekonomian, 2011

In our simulation, we compare the impact of reducing gas consumption proportionally to all consumers, with reducing the same amount of gas consumption to only certain consumers. Reducing gas consumption decreases the output of sectors, which is set as an exogenous variable in the model. The elasticity²³ of output with gas consumption is determined under

²³ Elasticity in this context is defined as the amount of output drop because of reduction in gas consumption.

different assumptions for each sector because of differences in sector characteristics in gas utilization. Those assumptions are:

1. Every 10 MMSCFD of gas consumption will help to increase oil production by 6,500 Barrels/day (Ditjen Migas, 2011), and loss of this amount of oil is converted from a physical unit into a monetary unit for the purpose of simulation.
2. Elasticity for the Petrochemical sector is estimated from the output multiplier from the Indonesian Input Output Table of 2008. The output multiplier for Petrochemical is 1.0039, which means that for every 1 percent drop in gas consumption, Petrochemical output will decline by 1.0039 percent and so on.
3. Elasticity of the Industry sector is estimated from the output multiplier from the *Input Output Table* 2008. Output multipliers for textiles, food industry, and PMI are 1.27, 1.06, and 1.37, respectively.
4. Elasticity for the Electricity sector is based on the equality of heat rate between High Speed Diesel (HSD) and natural gas. This means that a reduction in gas consumption will not decrease electricity output, but it would change the primary energy source from natural gas to (HSD) as the most likely energy substitute. Heat rate of 1 liter HSD is equivalent with 38887.7193 BTU²⁴ of natural gas, and from this conversion rate we can calculate the increase in HSD consumption for every 1 MMSCF gas supply that has been cut.

We carried out two different simulation scenarios for each of the four prioritized sectors (Table 6.2). The column 'gas level' shows the reduced amount of gas consumption, which is then converted into percentage of decline in output. Output decrease is the drop in production of a sector caused by restricting gas consumption. The gas level column shows the absolute volume of gas consumption to be reduced in a particular sector. However, since it is not possible to use an absolute number in a CGE model, this gas amount must be converted into a percentage of relative share of overall gas consumption in the sector. For instance, if we run a scenario of cutting 50 MMSCF from petrochemical industries, we calculate the percentage of 50 MMSCF gas in its total gas consumption; this percentage is then used to calculate the amount of output drop of petrochemical base on Assumption 2 (see above). Our calculation shows that it is equivalent to a 4.76% drop in petrochemical output. This output decrease is used as an exogenous variable in our CGE model, which is run continuously for every single year from 2012 to 2025.

²⁴ 1 MMSCF = 1000 MMBTU, BTU = British Thermal Unit,

Table 6.2 Simulation Scenario (Output Decrease)

Sim	Gas Level	Proportional	Crude	Petrochemical	Electricity	Industry		
						Textile	Food	PMI
A1	50	2%	4%	4.76%	3%	12%	10%	12%
A2	100	4%	8%	9.51%	6%	24%	20%	25%

Source : Author's calculations

6.4 Results and Discussion

In this part, we elaborate and analyze the simulation results. Three different effects were analyzed:

1. The macroeconomic effects for Indonesia in terms of GDP, employment, consumption, and investment
2. The effects on sectoral output
3. The effects on national energy consumption

6.4.1 Macroeconomic Effects for Indonesia

6.4.1.1 Gross Domestic Product (GDP)

The first analysis assesses the impact of the two gas reduction scenarios on GDP. The first scenario (A1) is a gas reduction of 50 MMSCF for each sector and the second is a gas reduction of 100 MMSCF (A2). Figure 6.2 shows the effects on GDP of these two sectoral gas reductions. The GDP effects of both scenarios are deviations from the baseline scenario, or the business-as-usual scenario in which there is no policy intervention. Taking the food sector as an example, a gas reduction of 50 MMSCF led to a decrease in GDP of 7.8% in 2012.

Restriction of gas supply to the production of crude oil and electricity causes only less than 1% decrease in GDP. However the opposite impact occurred for the petrochemical, food, textile, and PMI sectors. The national economy will suffer more than average 7% if gas supply for food is cut, followed by PMI and textiles, with 3.6 and 1.8 % drops, respectively. This is because those industries have the most added values, compared to crude oil production and electricity (Input-Output Table, 2008) per volume of gas utilization, therefore a reduction in gas supply reduces sector output and GDP. Based on the effects on Indonesian GDP, gas allocation should be prioritized as follows:

1. Industrial sector (food, textiles, PMI)
2. Petrochemical
3. Crude oil production
4. Electricity.

Figure 6.2 Impact on GDP of Scenarios A1 and A2

Source: Author's calculations

6.4.1.2 The Effects on National Employment

Employment shows a massive decrease in the short term (2012-2015) due to the decrease in GDP because of reduced sectoral output and corresponding employment levels. So the effect on national employment follows the pattern of GDP, analyzed above. The biggest effect on employment results from reducing the availability of gas for food, textile, and PMI, with averages of 2.8, 0.9, and 0.3 %, respectively, followed by petrochemicals. These are labor-intensive sectors in Indonesia. Nevertheless, the effect on employment is short term; in the long term there is potential for labor movement across sectors, which explains the lower unemployment levels from 2017 onwards. Whether this is possible in practice due to transferability of skills is another question.

Figure 6.3 Impact on Employment on Scenarios A1 and A2

Source: Author's calculations

6.4.1.3 Household Consumption

A negative trend similar to employment is shown in household consumption, where a large consumption loss occurs in food, textiles, PMI, and petrochemical gas reduction scenarios. Those industries produce goods that satisfy primary consumption needs; a downturn in sectoral output decreases household consumption. Apart from the direct impact on consumption, there is also an indirect effect of decreasing employment on consumption. When employment goes down, consumers lose income and have less money to spend.

Figure 6.4 Impact on Household Consumption in Scenarios A1 and A2

Source: Author's calculations

6.4.1.4 Investments

As Figure 6.5 shows, level of investment is affected by changes in gas allocation. The effect is indirect, via a decline in GDP, which decreases level of investment. The strongest negative impact occurs when gas supplies to the petrochemical and PMI industries are restricted. This is not surprising, because both sectors are capital intensive. A restriction in gas supply decreases both industrial production and investment levels in these sectors.

Figure 6.5 Impact on Investment in Scenarios A1 and A2

Source: Author's calculations

6.4.2 Sector Output

This section explores the effects at the economic sectors level. The results of the A1 and A2 scenarios are shown in more detail in the tables in Appendix B. Here we only present the summary of results of the A1 scenarios on several Indonesian economic sectors. We chose to concentrate on the most significant sectors for the national economy. According to our estimation, these sectors are: food crop production, food industry, textiles, PMI, petrochemical, construction, trade, restaurant, bank, real estate, public sectors, and services.

Figure 6.6 shows that food and PMI have the biggest impact on sector output performance, compared to other sectors with output decreases in the range of 4-15%, indicating that these sectors have strong economic linkages with other sectors (see Section 6.6 for more details). Textiles and petrochemicals show more moderate impacts, an average 1 and 0.5%,

respectively; however, for crude oil and electricity, other sectors are almost unaffected. Crude oil is not consumed by industry or other sectors; in most cases it is refined or exported. Electricity, on the other hand, is barely affected due to fuel flexibility in electricity production. However, the impact can become significant if electricity prices rise due to higher fuel prices. In that case, the higher price will affect almost all sectors of the economy, since all consume electricity. We should also point out that even if a particular sector consumes natural gas at a medium to low volume level, this does not mean curtailment will have a low impact. The food industry, for example, uses a relatively small volume of gas, but the economic impact on sector output is significant, as can be seen from macro indicators and sector outputs (within the range of a 5-10% decrease).

Scenario A2 uses higher restrictions in gas consumption, which have larger negative impacts on output performance (see Appendix B), almost doubling the impact of Scenario A1. Sector output decreases in the range of 11-27% for the food and PMI scenarios, with textiles and petrochemical showing average 2.5 and 2% declines, respectively. The impact on crude oil scenarios increases slightly from Scenario A1, however, but is still at a moderate level, within 0.2 - 0.4%,.

Figure 6.6 Impact on sectors output for scenario A1

Source : Author's calculations

6.4.3 Substitution of Energy Resources

Table 6.3 shows the substitution effects of restricting natural gas, illustrates that the change to other fuels is rather modest (columns 2 and 3), which means that consumers cannot easily replace gas with other energy sources. The table gives the average change in gas consumption for both scenarios during 2012-2025, and indicates how much the consumption of other energy sources can increase as a spillover of the impact of reducing gas utilization. It shows that the average effect is limited to 1-2%.

Table 6.3 Average Change in Energy Consumption (2012-2025)

Scenario	Gas	Crude	Petrochemical	Electricity	Food	PMI	Textile
Gas	-2	-0.77	-0.09	0.01	-0.89	-1.07	-0.17
Coal	0.08	0.16	0.34	-0.002	-1.51	-0.68	-0.45
Geo	-0.02	-0.46	-1.14	-0.06	-4.13	-1.62	0.33
HSD	-0.02	-0.21	-1.63	0.00	0.08	-1.88	0.04

Source: Author's calculations

In the case of the petrochemical sector, where natural gas is used as feedstock, the substitution of coal as an energy carrier is minimal, because it cannot be replaced with other energy sources except for some part of the processes that consume gas as fuel. For food and textiles, there is only a small increase in HSD, because HSD has a higher price than natural gas, and this increases the production costs. With higher product price, consumers consume less, and in the end sector outputs are cut, as discussed in Section 6.4.2.

6.6. Discussions

Overall, our analysis shows a major impact on the economy if natural gas supply for industry is restricted, whereas restricting gas supply for electricity production has hardly any negative effects. Furthermore, our analysis shows that, based on the economic effects, a national gas allocation policy should take the following ranking into consideration (from the highest to lowest priority):

1. Industry²⁵
2. Petrochemical sector
3. Crude oil production
4. Electricity

This ranking does not come as a surprise; intuitively we can predict that the industrial sector with food, textiles, metal industry, and petrochemicals is the backbone of the Indonesian economy and has strong backward and forward linkages. Backward linkages result from the industrial sector's reliance on development in other industries providing inputs (raw materials) for this sector. Forward linkages refer to other industries using their products as inputs (raw materials). Combined, these linkages provide multiplier effects for the whole economy; gas supply restrictions in a particular sector can affect the whole economy by reducing one sector's output. The stronger a sector's linkages, the stronger its potential negative impact on the economy.

This is the case with the industrial sector in Indonesia. The oil production sector does not generate high linkages; most of the product (crude oil) is exported and therefore only contributes to state revenues without any direct negative impact on the domestic economy. The electricity sector has strong linkages, but the potential to switch to other fuels is high. The substitution of other fuels only affects the level of energy subsidies in Indonesia.

It is inevitable that gas supply will be cut if there is a shortage, hence a rational choice must be made. From our analysis, the optimum way to allocate natural gas based on macroeconomic effects is according to the following ranking: Industry, Petrochemical, Crude Oil, and Electricity. In the current government natural gas allocation, production of crude oil is given priority; this differs from our results. Our assumption is that finance could be a reason

²⁵ The government defines, the industry category as encompassing food, textiles, and PMI, although in this chapter it is broken into separate sectors and then analyzed. Those three "subsectors" show the most significant economic impact in their cluster. This is why "industry" is given first priority in government policy.

for this priority ranking: crude oil production brings in state revenues and this money is needed by government. It is also worth noting that production in only one oil field, the Duri Oil Field, is given priority. All other production fields can produce oil without natural gas. According to the government, the petrochemical sector (along with fertilizer production) tops the ranking in natural gas allocation. Again, according to the government, electricity and industrial production are flexible enough to switch to alternative fuels and therefore are not given priority over crude oil and fertilizer production in the current national gas allocation policy. Our analysis shows that, from a macroeconomic perspective, this argument needs to be reconsidered, given the industrial sector's strong backward and forward linkages.

Based on our findings, we conclude that the Indonesian government's national gas allocation prioritization needs reworking, based on proper scientific analysis.

6.7. Conclusion

This chapter reviewed the problems and dilemmas Indonesia is facing in allocating natural gas resources and suggests remedies to mitigate the problems. The following question was raised and answered:

How should Indonesia prioritize natural gas allocation for the domestic market in order to achieve the optimum benefit for the national economy?

We used the CGE model to analyze the economic impacts of restrictions to natural gas supply in various sectors. Based on the macroeconomic implications, we identified the sectors that should have the greatest priority in natural gas allocation, based on economic effects. They are, from high to low priority: Industry, Petrochemical, Crude Oil Production, and Electricity.

Our suggested ranking differs from that currently used in Indonesia's gas allocation policy. The government gives priority to crude oil production, and to the petrochemical industry for fertilizer production. We have shown that the industrial sector of Indonesia should have priority because of the relatively large macroeconomic effects when gas supply is restricted in this sector. We are not able to assess the economic loss of the government's current gas allocation rankings. However, we do know that a one-month gas restriction in 2011 in Indonesia's industrial sector because of termination of gas supply from PGN (the state-owned company) caused a total loss of US\$ 500 million (IFT, 2011). Despite this, it is not expected that the Indonesian government will change its current gas allocation policy. A

switch from gas to coal in the fertilizer industry would require an investment of US\$ 400 million (Kementerian Perindustrian, 2007). This money is simply not available and therefore changes in the short term seem unlikely.

This study's limitation is that it used the Indonesian SAM of 2008, which was made 6 years ago. Future studies can use the most recently published SAM, and develop different scenarios that bring additional perspectives to the topic.

Chapter 7 The Economic Impact of Natural Gas Pricing Policy in Indonesia

7.1 Introduction²⁶

In Chapter 2, we discussed how Indonesia's gas pricing has to serve both economic efficiency and social objectives. Economic efficiency means the gas price should reflect all costs involved in its production and transport (Julius and Mashayekhi 1990); social equity means the pricing of natural gas should not exclude certain groups from consumption, in particular lower-income groups (Julius and Mashayekhi 1990). In addition, gas pricing is also expected to generate a constant flow of state revenues, which are needed for the country's sustainable development (Ditjen Migas 2011e).

The current gas price is a market price,²⁷ in the sense that it has gone through producer-consumer negotiation. However, the domestic market price is not favorable to the gas producer when compared to the export/international price. The export price is determined based on the LNG price on the international market, therefore it is much higher than the domestic price. The lower domestic price level provides no incentives for gas producers to redirect their export focus in favor of the domestic market. At the same time, natural gas demand in Indonesia is growing significantly and is expected to grow even more in the near future.

Natural gas pricing policy has created a dilemma for the government. Domestic gas demand is growing, which should be reflected in an increase in gas price to control demand, yet at the same time the price must be in line with the goals for equity and development. Without a change in government policy, Indonesia's natural gas will continue to be exported; this will have severe consequences for economic development in general and development of the natural gas market in particular. Currently there is already a shortage of domestic gas supply, and this deficit will increase if gas producers continue to export.

²⁶ The material presented in this chapter has been published as a chapter in the IRSA Book Series on Regional Development, No. 11 as Hutagalung A., Hartono D. (2013) Regional Development, Natural Resources and Public Goods in Indonesia during the Global Financial Crisis in Imansyah, M.H., Resosudarmo, B.P, Suryani, Siregar,S., Priyarsono,D.S, Yusuf, A.A., Ed., Macroeconomic Implication of Natural Gas Pricing in Indonesia, UI Press, pp 219

²⁷ The price proposed by both producer and consumer has to be approved by the government, which tends to approve a low price.

Meanwhile, because of the investment requirements for new gas fields, there is a need to adjust price levels. Due to the remote locations, relatively small field sizes, and specific composition of Indonesian natural gas, exploration of new gas fields requires substantial investment. If prices do not reflect all these costs, it is uncertain whether gas from new fields will reach the market; no one will want to make such a risky investment. In one way or another, Indonesia must change its natural gas pricing policy in order to respond to increasing domestic demand. The crucial question in this regard is:

To what extent can gas price be adjusted to reach an optimum trade-off between economic efficiency and social objectives?

What price levels can the national economy carry without exerting a negative impact on economic development? Natural gas, like oil, is a crucial resource for Indonesia; if prices increase too much (to the export price level), this will negatively impact the economy. The major natural gas consuming sectors are crucial to the national economy; higher gas prices will ultimately have a negative effect on the lives of all Indonesian citizens. Changes to natural gas prices are thus a very sensitive issue, from both an economic and a political perspective.

Drawing on current Indonesian practices, this chapter examines ranges in gas pricing for several sectors that are vital for economic development. Large consumers of natural gas that need an increasing gas supply are also examined. The focus is on exploring the short- and long-term economic effects of gas price adjustments based on macro- and micro-analysis. Section 7.2 discusses Indonesian gas pricing policy; Section 7.3 elaborates the methodology and simulation scenarios; Sections 7.4 and 7.5 present the results and discussion, respectively. Section 7.6 summarizes the conclusions.

7.2. Indonesian Gas Pricing Policy

Current natural gas pricing in Indonesia is a mixture of market mechanism and state intervention. According to Law No. 22/2001 concerning oil and gas, Chapter 28 (after the verdict of the Constitution Court), gas price is decided by the government (before the verdict the statute stated that oil and gas prices are determined by the market mechanism), but on the basis of what producer and consumer have negotiated with each other. The government acts as a gatekeeper, particularly if there is a deadlock or if a producer proposes an extremely high price. In theory, the Indonesian government applies a general formula for its gas-pricing approval

$$IGP = H_{Go} \times (1 + a)^i + b \text{ Oil price} + c \text{ Product price}$$

Where:

IGP = Indonesian Gas Price

H_{Go} = Basic gas price at years 0

a = Escalation for inflation adjustment factor (economic growth and rising oil prices) as well as balancing decrease in production rate

b = Slope of gas prices to oil prices

c = Slope of gas prices to the price of products produced, such as urea or ammonia

Such a general formula could function as an effective tool for pricing natural gas in Indonesia, in the sense that it protects the interests of both producer and consumer. However, its actual application presents several problems. The formula provides the basis for price negotiations between producer and consumer, yet the two have completely opposite approaches in applying it. The producer uses export prices/international price as a reference point for setting his price expectation. If the consumer is willing to pay that export price, then he has the deal. The consumer, however, wants a low price and knows the Indonesian government supports him. So the consumer sticks to a low price reference point, knowing his position is supported by the government, whose aim is mainly to protect the domestic market.

The Indonesian government uses two different criteria when assessing gas price negotiations by producers and consumers. First, the government wants a price level that generates enough revenue for the state and supports domestic economic development; this in turn supports export of Indonesian natural gas due to high export prices. Second, the agreed price should reflect the interests of both producer and consumer (Ditjen Migas 2011a). Hence, the government's position is not only export (because of high prices and maximizing state revenues), but also protecting the consumers' interests and the implications for domestic market development (Ditjen Migas 2011a). From the government's perspective, the price level should be high enough to generate state revenue, but still affordable for domestic consumers.

In practice, the formalities of natural gas pricing – application of the formula and negotiations between producers and consumers – do not necessarily determine the domestic gas price at all. In the end, the government only approves gas prices that are as low as possible, because this serves the interests of consumers and the Indonesian economy. In practice, the

criterion that the gas price should support economic development in Indonesia is interpreted predominantly as “a low gas price for the consumer”. The general formula was intended as a guide for price negotiations, by providing a possible reference price; however, the price level approved using this formula was often set far below the international market price. For example, if the LNG price is USD 11/MMBTU,²⁸ then the domestic consumer price will be placed below USD 11/MMBTU.

The “low gas price for consumer” is a market price since it is arrived at after producer negotiation, which is economically efficient, although there is a lost opportunity for the producer to gain more benefit compared to the export price. In the short term, these practices do not encourage producers to refocus their current export orientation in favor of domestic supply, and in the long term investors will be reluctant to invest in exploration of new gas fields.

This low price is reflected in the historical prices between 2000 and 2010 for different domestic consumer groups, and the export price. Figure 7.1 shows the disparity between domestic and export prices. The highest price refers to highest gas price in particular years, which in all years is the export price, while the lowest is the opposite, in this case, the domestic price. The average price was calculated as a weighted average²⁹ of all gas prices, while average sector (e.g., fertilizer, electricity) was a weighted average of gas price in that sector.

²⁸ MMBTU = Million British Thermal Unit

²⁹ Weighted average is the sum of multiplying gas price by its calorific value divided by the total calorific value of gas. For example, if there are two contracts, A with price USD 3/MMBTU and volume 10 MMBTU, and B with price USD 5/MMBTU and volume 2 MMBTU, then the weighted average is calculated by $(3 \times 10 + 5 \times 2) / 12 = \text{USD } 3.33/\text{MMBTU}$.

Figure 7.1. Indonesian Natural Gas Price 2000-2010 (in USD/MMBTU)

Source: Ditjen Migas (2011a)

In 2008, the weighted average gas price for fertilizer was USD 3/MMBTU, USD 3.9 /MMBTU for the electricity sector, USD 5/MMBTU for the petrochemical industry, and USD 2.22 /MMBTU for the gas trader. The export price at that time was USD 15.67/MMBTU.

Until recently, the pricing policy in favor of lowering the price for domestic consumers was no problem, since producers had enough opportunities to sell large volumes of their gas abroad. However, domestic demand has grown significantly, while the availability has hardly grown due to the high investment costs needed in Indonesia. The available gas partly serves ongoing export contracts and can only partly fill increasing domestic demand, but only if the domestic gas price increases to export price levels. This means the price disparity with export should not be too great, otherwise it is not attractive for producers to change their export orientation in favor of domestic market.

There are indications that domestic consumers are willing to pay higher gas prices, even though so far consumers have been neither willing nor able to pay gas prices at the export level. The announcement of a gas price rise of 50% by the state-owned gas company PGN has already attracted a major protest from the industrial sector (Pitakasar, AR. 2012).

Although the increase is substantial, it would still keep the domestic gas price far below the export price.

If Indonesia wants to attract more natural gas to the domestic market, it should accept higher prices for domestic consumption. Given the recent signals in Indonesia, new gas prices should be somewhere between current domestic prices and export prices. The current weighted average of gas price is USD 4.19/MMBTU, while the LNG price is USD 16/MMBTU, therefore the possible range for price adjustment should lie between USD 4.19/MMBTU and USD 16/MMBTU. The aim of this adjustment is to move the domestic price closer to the export price as an incentive for gas producers to sell to the domestic market; this adjustment should also be kept below the export price, for domestic consumer protection.

This shows that the current procedure for gas price approval by the government, as well as the criteria for gas price approval, need revision. The important question is: On the basis of what criteria should domestic gas prices be approved by the government? Our suggestion is that the Indonesian government should take account of two aspects in deciding gas price levels for domestic consumption:

1. At the macroeconomic level: the effect of increasing gas price levels on the national economy, with respect to macroeconomic indicators (Nugroho et al. 2004).
2. At the microeconomic level: the willingness of specific natural gas consumer sectors to pay higher gas prices (Nugroho et al. 2004), taking into account the range of costs for different gas-consuming sectors.

The macroeconomic aspect is very important; the literature shows significant effects from abrupt price level changes, such as oil shocks, on the economic performance of nations (Rafiq et al. 2009), Zhang (2008), and Huang et al. (2005). Any adjustment in fuel price should therefore be preceded by a clear assessment of the macro-economic implications. Unlike fuel for transportation, e.g. gasoline, natural gas is not consumed by households; it is, however, utilized by industrial and electricity sectors. Price level changes will lead to significant impacts due to these sectors' linkages to other sectors.

The second aspect accounts for differences in the cost structures of economic sectors and the related differences in their willingness to pay, and differences in ceiling prices between sectors. This is something that cannot be observed from a macroanalysis, which only measures the wide impact of price adjustment; we cannot know how it would affect

consumer cost structure. For example, the current average gas price is USD 4.19/MMBTU; some consumers have paid around USD 2/MMBTU but others have already paid USD 5-6/MMBTU and might be willing to pay more.

The next sections discuss the macroeconomic effects of different price levels, as well as the implications of different natural gas price levels on individual sectors in Indonesia. This shows that Indonesian gas pricing can be designed and applied more precisely in reference to economic theory. We use the CGE approach for our assessment of the macroeconomic implications, and the netback value for the assessment of microimplications. Netback is the price determination based on comparison with substitute energy price (see Section 7.3 for more details).

7.3. Methodology and Simulation Scenarios

7.3.1 Computable General Equilibrium for Macroanalysis

In this chapter we use a static CGE model to analyze the macroeconomic impact of pricing policy (see Chapter 5). We set a short-and long-run closure; in the short run capital is specific and cannot be mobile across sectors, and labor is mobile across industries. This is done by creating a variable exogenous demand for capital in all industries. In addition, employment can change, allowing for unemployment. For formal labor, the wage is set to be exogenous, while informal labor is not as rigid. In long-run closure, capital and aggregate employment are exogenous and can move across sectors.

As presented in Table 7.1, we developed several different scenarios for price adjustments³⁰, where all adjustments were compared relative to the weighted average of natural gas price in 2008 (USD 4.19/MMBTU), the year in which Indonesia published the SAM table.

Table 7.1 Simulation Scenarios

	SIM A1	SIM A2	SIM A3	SIM A4	SIM A5
Percentage	34%	43%	55%	67%	91%
Price Level	5.6	6	6.5	7	8

Source: Author's calculation

³⁰ Basically price is an endogenous variable; in this chapter we have made gas price an exogenous variable by swapping the price with a tax shifter. This is how we handle the adjustment scenario in our model; we cannot directly increase the price, hence a manipulation with a tax shifter is needed.

Tax shifter is done in the model by imposing certain percentage of tax to a commodity (natural gas in this case) until the price goes up to the desired level

7.3.2 Netback Value Concept for Microanalysis

Netback value is defined as the cost the consumer saves on alternative fuel, i.e., what he would have purchased had gas not been available, or the maximum price consumers are willing to pay for the alternative fuel. Alternatively, the maximum price for gas that can be charged to consumers is the price of the substitute fuel (Siddayao 1997). The aim of netback value is to measure how much a consumer wants to pay for a particular energy commodity, knowing the price of other energy commodities that can be used as substitutes. If the price of the current consumed energy is higher than the substitute energy, the consumer will switch to substitute energy. Netback value analysis provides analysis at the microlevel, and links natural gas to energy prices at the production-level process (Groenendaal and de Gram 1994). It provides more detailed information on how gas price adjustment can affect a particular sector.

We calculated netback value for electricity and fertilizer in two different ways, following the methodology used previously in a study conducted by Ditjen Migas (2011d, unpublished), which is actually a simplification of the common netback value methodology. The simplification is that the time frame is not included in the calculation. The original netback value takes the time frame into account and the assessment covers different types of projects. For example, the capacity of a fertilizer plant and the generating capacity of a power plant are different and result in different cost structures for both industries. Therefore the netback value should be different for both sectors. Due to data limitations we cannot account for these differences in our analysis and therefore applied a simplified variation of the method.

7.3.2.1 Netback Value for Electricity

Netback value for electricity was calculated by comparing the tariff of electricity produced in a gas-fired power plant for different gas price scenarios with the tariff of electricity produced in a diesel-fueled power plant. The electricity tariff is given by:

$$\text{Electricity Tariff} = \text{Fuel Cost} + \text{Operation and Maintenance} + \text{Tax}$$

All variables are measured in USD; in our calculations we assumed the fuel costs, the operation costs, and taxes are fixed in all scenarios.

7.3.2.2 Netback Value for Fertilizer

Netback pricing for the fertilizer plant is calculated for different gas price scenarios, assuming value Capital Expenditure (Capex) and Operation Expenditure (Opex) costs as fixed for all scenarios. The formula is given by:

$$\text{Netback Value} = (\text{Fertilizer Price} - \text{Capex} - \text{Transportation Cost}) / \text{Gas Consumption}$$

Where all variables are measured in USD.

7.4. Impacts of Different Gas Price Levels

We analyzed the effects of different gas price levels in several runs. We developed several different scenarios for price adjustments relative to the weighted average of natural gas price in 2008, the base year. The highest increase in the price scenario is 91%, which is set as close as possible to the export price. We analyzed the short-and long-term effects of gas price levels on various macro indicators.

7.4.1 Influences on Macro Indicators

As discussed previously, the closure for this chapter is set for short run (SR) and long run (LR). The impacts of gas price increases are summarized in Table 7.2. Almost all macro indicators show a negative impact of gas price increases in every scenario. The effects on GDP are modest in the long run. This is caused by reallocation of capital and skilled labor to other sectors of the economy, where they expect to optimize their gains better. On the other hand, investments go down due to a decline in sectoral output (see Figure 7.2 for details).

Household consumption shows an overall decrease in all gas price scenarios. This is consistent with a decrease in the level of employment, which is the source of household income. However, the effect is less than 1%, which is explained by an output growth of capital-intensive sectors such as oil and coal. Our analysis also shows that increasing gas prices up to 91% still has a relatively modest impact, with all macro indicators showing decreases of less than 1%.

Table 7.2 Macro Indicators in the Short and Long Run (Change in %)

Simulation/ Price Level	SIM A1 (34%) 5.6		SIM A2 (43%) 6		SIM A3 (55%) 6.5		SIM A4 (67%) 7		SIM A5 (91%) 8	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
GDP	-0.30	-0.13	-0.43	-0.22	-0.65	-0.41	-0.88	-0.61	-1.11	-0.81
House' Cons	-0.23	-0.07	-0.34	-0.15	-0.56	-0.33	-0.79	-0.53	-1.02	-0.73
Investment	-0.79	-0.66	-0.79	-0.78	-1.08	-0.90	-1.18	-0.96	-1.24	-1.01
Gov dmd	-0.23	-0.07	-0.23	-0.15	-0.56	-0.33	-0.79	-0.53	-1.02	-0.73
Export	0.77	0.67	1.05	0.92	1.52	1.34	1.97	1.76	3.28	3.59
Employment	-0.28	0	-0.34	0	-0.41	0	-0.46	0	-0.50	0

Source: Author's calculation

7.4.2 Influences on Sectoral Output and Employment

In this section we discuss sectoral indicators from production output and employment. The output of the gas-intensive sector (electricity, petrochemical, PMI) shows a downturn of less than 2% for all scenarios because the effects are mitigated by Indonesia's subsidy policy (Figure 7.2). Petrochemical suffers the most because it consumes gas as a non-substitutable feedstock.

However, less intensive gas sectors (e.g. wood, textiles, and the food industry) are hardly affected by gas price increases. Most of the non-gas-intensive sectors displayed in Figure 3b are also negatively affected by gas price increases due to the indirect effects from the gas-intensive industry. In general, the short-run output impacts are slightly worse than in the long run, due to adjustments in production structure because of capital mobility in the long run.

Figure 7.2 Short-Run and Long-Run Outputs

Source: Author's Calculation

Figure 7.3 shows that the effects on employment are different from the effects on sectoral output. This is surprising, since one would expect similar effects, namely, a decrease in output accompanied by a decrease in employment. Our analysis shows that this does not apply to electricity, petrochemical, PMI and other industry because in these sectors the relationship between output and employment is mitigated by subsidy (electricity and fertilizers are still subsidized by the government). Price increases therefore hardly affect demand for these products. On the other hand, in all non-gas-using sectors, a decrease in output is accompanied by a decrease in employment, irrespective of the labor intensity of the sectors.

Figure 7.3 Short-Run and Long-Run Employment

Source: Author's calculation

7.4.3 Netback Value

The Netback value approach allows us to find adequate gas price levels, which account for all costs, for specific economic sectors. We applied this approach to gas prices in the electricity and fertilizer sectors. It is worth noting that this section uses only net gas prices, excluding all other parts of the gas price charged to the consumer (e.g. transportation costs, taxation, etc.). The data on these additional parts are unreliable and are therefore excluded from the analysis. Our assumption is that the consumer buys the gas directly from a gas producer.

7.4.3.1 Gas Price for Electricity/Power Plants

In this section, we estimate the netback value of the gas price for electricity by comparing the costs of electricity produced by a gas-fired power plant with the costs of electricity produced by a diesel-fuelled power plant. We used general information on generating costs, operation and maintenance, and taxes by Ditjen Migas (2011d) for the different prices of natural gas. With all other costs fixed, we estimated the costs of electricity with a gas price of USD4/MMBTU up to USD 9/MMBTU.

As shown in Table 7.3, the highest total cost of electricity is USD 12.2 cent/Kwh. As a benchmark, the cost of electricity produced in a diesel-fuelled power plant is USD 12.2 cent/Kwh at HSD price of USD 15.24/MMBTU (Hakim and Sumardi 2007). This is equal to the cost of electricity produced in a gas-fired power plant using natural gas priced at USD 9/MMBTU.

Table 7.3 Electricity Cost of a Gas-Fired Power Plant for Different Gas Prices (\$ cent/Kwh)

Cost Component	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Plant	1.8	1.8	1.8	1.8	1.8	1.8
Fuel (Gas)	4	5	6	7	8	9
O&M	0.8	0.8	0.8	0.8	0.8	0.8
Tax	0.6	0.6	0.6	0.6	0.6	0.6
Total Cost	7.2	8.2	9.2	10.2	11.2	12.2

Source: Ditjen Migas 2011d (compiled by author)

The analysis shows that a gas price of USD 9/MMBTU is still acceptable for electricity. This gas price level is higher than the current natural gas price for electricity of USD 3.9/MMBTU.

7.4.3.2 Gas Prices for a Fertilizer Plant

In a similar way we estimated the netback value of gas for the fertilizer industry. We developed three scenarios for different consumption levels of natural gas, with all other costs fixed (Ditjen Migas 2011c). The netback value is calculated on the basis of gas utilization given by the above formula. The netback formula for fertilizer is different from that for electricity because the fertilizer industry uses natural gas as a feedstock instead of as an energy source. Gas used as feedstock has no substitute in the model, so we lack a reference price for a substitute, unlike in the case of electricity, in which diesel is a substitute for natural gas.

Therefore a different methodology is needed for fertilizers. We applied different levels of gas prices, which give varying netback values based on the gas input per ton of fertilizer

produced. We assume the fertilizer plant to be gas-consumption efficient within the range of 14 to 25 MMBTU/ton. To understand how the netback is calculated, let us take an example for Scenario 1 in Table 7.4 below, calculating the netback value as:

$(\text{Gas Consumption} \times \text{Gas Price}) + \text{Capex} + \text{Transportation} = \text{Fertilizer Price}$

$(25 \text{ MMBTU} \times \text{Gas Price}) + \text{USD}22 + \text{USD}22.5 = \text{USD}178$

$\text{Gas Price} = (\text{USD}178 - \text{USD}22 - \text{USD}22.5) / 25 = \text{USD } 5.34 / \text{MMBTU}$

As shown in Table 7.4, we calculated the netback value in a similar manner, assuming a gas intake of 21.4 MMBTU/ton and a gas intake of 14.87 MMBTU/ton. The methodology reflects production efficiency in terms of gas price increases, assuming more efficiency at higher gas prices under equal levels of output. Our analysis shows that the netback value of gas for fertilizer is within the range USD 5.34/MMBTU to USD 8.98/MMBTU. This means that the current gas price for the fertilizer industry of USD 4.16/MMBTU is too low and could be increased up to USD 8.98/MMBTU without significant negative economic impacts.

Table 7.4 Netback Value of Gas for the Fertilizer Industry

Cost Component	Scenario 1	Scenario 2	Scenario 3
Fertilizer price, \$/ton	178	178	178
MMBTU gas/ton	25	21.4	14.87
Capex & Opex, \$/ton	22	22	22
Transportation, \$/ton	22.5	22.5	22.5
Netback	5.34	6.24	8.98

Source: Ditjen Migas, 2011d (modified by author)

7.4.4 Energy Consumption

A change in price for one type of energy commodity affects other energy consumption because of substitution impact. The magnitude of this impact depends on how elastic that particular energy utilization is, as it adapts with the price change. In our case, overall energy consumption decreases less than 1%, as does energy intensity (Table 7.5), and there is not much difference between the short and the long run. This table shows the average change for all energy types; the detail per energy sector can be seen in Figure 7.4. This indicates that gas consumption is easily replaced with other energy sources; this is consistent with our findings in Chapter 6, where a decrease in gas supply was not followed by substitution with other types of energy carrier.

Table 7.5 Energy Consumption and Energy Intensity

Simulation	SIM A1 (34%)		SIM A2 (43%)		SIM A3 (55%)		SIM A4 (67%)		SIM A5 (91%)	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
Energy Cons	-0.30	-0.13	-0.43	-0.22	-0.65	-0.41	-0.88	-0.61	-1.11	-0.81
Energy Int	-0.23	-0.07	-0.34	-0.15	-0.56	-0.33	-0.79	-0.53	-1.02	-0.73

Source: Author's calculation

Gas is most affected by price adjustment, with almost 2% decrease in gas utilization (Figure 7.4), so it is no surprise that sectoral output shows a downturn; consumers reduce their consumption. Coal consumption increases slightly because of turnover from gas consumption; however, there is no shift to geothermal, suggesting that its price is still not low enough to compete with gas.

Figure 7.4 Short- and Long-Run Energy Consumption

Source: Author's calculation

7.5. Acceptable Gas Price Adjustments

As discussed previously, price adjustments should be within the range of USD 4.19 (current weighted average domestic price) to USD16/MMBTU (export price). Our analysis has shown that current gas prices in Indonesia can be increased without harming the economy or the output of certain industrial sectors too much. Our simulation showed that price adjustments up to 91% will have only a moderate effect on the Indonesian economy, which equals an adjusted gas price of USD 8/MMBTU. This will serve as a floor price, or the minimum gas price that can be implemented in every new contract.

Figure 7.5 Proposed Price Structure Based on Macro- and Micro-level Analysis

Source: Ditjen Migas, 2011a (modified by author)

In addition to the macroanalysis using a CGE model, we conducted a microanalysis using the netback value technique. Based on this analysis, we refined the price structure of natural gas; see Figure 7.5. The export price is already at USD 16/MMBTU while the current average price for domestic is at USD 4.19/MMBTU. Our macroanalysis shows that price can be adjusted up to USD 8/MMBTU. However, our micro analysis also shows that this adjustment has different impacts on the cost structures of different consumers. Based on the analysis of two consumers, fertilizer and electricity, gas prices can be adjusted even higher, up to USD 8.98/MMBTU and USD 9/MMBTU.

We argue that different ceiling prices can, and should, be applied for different consumers. The definition of price ceiling is not a ceiling per se as the maximum allowed price, but rather an indication that a consumer can bear an increase of gas price up to a certain level. For instance, our netback calculation for electricity results in USD\$ 9/MMBTU, with current price USD 4.19/MMBTU, so it is acceptable for the electricity sector to pay up to USD 9/MMBTU. Therefore, apart from the macro result, which sets gas price at USD 8/MMBTU, for certain consumers there is still room to increase the price.

Changing the energy price remains a sensitive issue for many aspects of a country's economy (Nugroho, et al 2004). The Indonesian government should be careful in adjusting energy prices. Certain considerations must be borne in mind. For example, is it better to

adjust the price gradually? or to adjust it swiftly? Will the government really enforce higher prices on a particular sector if it is not politically feasible? However, these aspects are beyond the scope of this chapter.

Our suggested concept and approach could serve as a generic conceptual model for gas price determination by the Indonesian government. However, our analysis has some limitations. Due to data limitations, the calculations used simplified methodologies, for instance in the calculation of netback value. It is important to improve the reliability and validity of these kinds of calculations, and this requires better and more reliable data. It is also important to refine the analysis of the need and impact of pricing subsidies in Indonesia, and the position of state revenues on Indonesian gas policy.

7.6. Conclusion

This chapter provided macro- and microanalysis of Indonesian gas pricing. Indonesia regulates gas prices because the government is mandated to do so by law. However, this has resulted in a trap for the government. On the one hand, it has to fulfill its obligation to guarantee energy access at reasonable prices for sustainable economic growth. On the other hand, keeping energy prices low is a disincentive for gas producers, a discouragement to investments in energy efficiency on the demand side, and also encourages inefficiency in gas usage.

Indonesia needs a clear gas-pricing policy. More specifically, the government should develop pricing mechanisms that can act as guidelines. The problem is to determine the base standard rates that are reasonable for both producers and consumers. In this chapter we suggested deciding possible gas price levels on the basis of macro- and micro-analysis. We used the CGE model in combination with the netback value method to show how these price levels can be calculated. Macroanalysis is used to evaluate the aggregate impact in economic terms, while microanalysis evaluated the impact at the consumer level.

Our analysis shows that the macroeconomic effects of even significant gas price increases are still modest in the short term. Macroeconomic indicators such as GDP, employment, or household consumption, show a decline in a range of less than 1 percent, which is tolerable. It also suggests a ceiling price for different consumers, based on cost structures in their utilization of natural gas. In this case, it is possible to increase gas prices in Indonesia without shock effects on the national economy.

Chapter 8 The Economic Impact of Natural Gas Infrastructure Investments

8.1 Introduction³¹

Natural gas infrastructure problems were introduced in Chapter 2. The lack of gas transmission and distribution infrastructures is a major constraint on natural gas taking a larger role in supplying national energy demands and gas-based industry development (Nugroho 2004).

Indonesia liberalized its natural gas market in 2001, with the goal of stimulating investment in gas infrastructure in order to resolve the problem. In line with this process, every year the government issues a natural gas master plan indicating needed extensions to the national pipeline system. With liberalization, the government's intention was to give private investors an incentive to invest in the bidding process for new gas infrastructure. This turned out to be wishful thinking; private willingness to invest was minimal and extending the national gas pipeline infrastructure remains far behind the planning.

Since 2002, only three bids for gas pipeline segments have been tendered, Gresik-Semarang (2005), Cirebon-Semarang (2006), and Bontang-Semarang (2005, Kalimantan to Java pipeline). To date, none of these segments has gas supply certainty. There are no new infrastructure tenders nor any additional interest in infrastructure investment from private companies. Transmission lines of 3,762.315 km and 4,554.542³² km along the distribution network are relatively sparse when compared to similar facilities owned by developed nations (UK, 19,000 km; Netherlands, 11,600 km; and even Japan, 3,000 km) and are very small compared to the size of Indonesia (Nugroho, 2004).

Natural gas contributes about 20% to primary energy consumption; it is utilized by key sectors in Indonesia, namely the petrochemical sector and industry, hence the lack of

³¹ The material presented in this chapter has been presented as Hutagalung A., Hartono D., Arentsen M.J. The Role of Natural Gas Infrastructure in Promoting Energy Security and Economic Growth in Indonesia at the PRSCO Conference, 2013.

³² The length of transmission is not a proper proxy for connectivity, but it can be used as a rough estimation of how mature a nation's network is. Here the proportion of the transmission length and distribution with the size of the country is relatively small if compared to smaller nations like the UK or the Netherlands, which have longer transmission lines.

infrastructure threatens energy security and economic growth. Therefore the government must either mobilize the appropriate funds or set clear paths and guidelines to promote development by the private sector.

This chapter analyzes Indonesia's gas infrastructure needs to ascertain the requirements for continued economic development and growth. Indonesia's options for financing the needed gas infrastructure investments are also assessed.

We propose three options for financing infrastructure investments: foreign loans, removal of the gasoline subsidy, and state revenues from the oil and gas sector. Our analysis is guided by the idea that natural gas should contribute to the nation's economic development, increased employment, and energy security. This chapter therefore addresses the following research question:

How significant is the role of gas infrastructure in supporting Indonesian economic growth and energy security, and what are the viable options for financing it?

Section 8.2 briefly discusses the general outlook of Indonesian natural gas demand and infrastructure, and Section 8.3 discusses the methodology and simulation scenarios. Section 8.4 discusses the results, followed by Section 8.5, which summarizes the major findings.

8.2. Indonesian Natural Gas Overview

8.2.1 The role of natural gas

The Indonesian government's 'Master Plan of Acceleration and Expansion of Indonesia's Economic Development 2011-2025' aims to accelerate development of various existing economic programs. In particular, the goal is to increase the value added from prime economic sectors, and in particular energy supply. The target is Indonesian GDP growth of 4-7.5% for the period 2011-2014, and 8-9% for the period 2015-2025 (MP3EI, 2011). This can only be achieved with sufficient available energy resources, including natural gas. Natural gas plays a vital role in Indonesian economic development as a source of energy, feedstock, and state revenue. Apart from increasing economic growth, natural gas also has an important role in ensuring energy security. In the current energy mix, gas contributes 20% of total primary energy consumption (KESDM, 2012a), and this trend is expected to continue until 2025.

However, the industrial natural gas load centers are unevenly spread across the country. Figure 8.1 shows the supply-demand profile in each region according to Indonesia's National

Gas Balance (Ditjen Migas, 2011). Only 68% of gas demand (including potential demand) can be met from the current production rate. Figure 8.1 shows huge deficits in East and West Java of more than 2,000 and 1,000 MMSCFD,³³ respectively. Apart from the lack of gas supply, the lack of gas pipelines and/or tanker infrastructure is another crucial problem.

Figure 8.1 Natural Gas Supply and Demand 2011-2025

Source: Ditjen Migas, 2011c

8.2.2 Natural Gas Infrastructure

Figure 8.2 shows the existing and planned natural gas infrastructure. New infrastructure is required to transport natural gas from regions where production is expected to increase (eastern Indonesia) to areas where demand is expected to increase (the western part, in particular Java). The infrastructure needed cannot be met only through pipeline construction. Significant parts of the infrastructure should include LNG and tankers, given the distances between producers and consumer island regions.

Not all areas need new pipeline infrastructure, but some areas, even those with a large existing pipeline capacity, may require significant investment to connect new supplies to the markets. Northern Sumatra, western Java, and eastern and central Java are regions that need additional gas supply because local production is not sufficient. Gas supply is expected to come from the Natuna block, Senoro (Sulawesi), Masela (Maluku), and Tangguh/Wiriagar (Papua); these are remote areas in eastern Indonesia with no gas infrastructure.

³³ MMSCFD= Million Standard Cubic Feet per Day

The Indonesian government, mandated by the Oil and Gas Statute, prepares a natural gas master plan every year, including a gas infrastructure development plan to bridge the gap between domestic natural gas demand and supply. Despite lofty planning ambitions, actual infrastructure investments lag behind. Bids for only three segments of gas pipeline have been tendered since 2002, and there are no gas supply contracts to date. We have identified two problems related to the government master plan's failure. The first is a lack of coordination between government agencies, where Badan Pengatur Hilir³⁴ BPH tends to doubt the feasibility of government planning, including gas supply certainty. Therefore, no new segment bids have been tendered³⁵ since 2006 (Ditjen Migas, 2010).

Figure 8.2 Existing and Planned Natural Gas Infrastructure

Source : Ditjen Migas, 2011f

The second problem is that liberalization in the downstream market increases potential investors' uncertainty, due a lack of long-term contracts for gas supply. The liberalization

³⁴ BPH is regulatory body who has the responsibility for regulating and supervising the business activities of fuel supply and natural gas transportation business through the pipeline (LNG and other type of gas transportation mode are not included).

³⁵ BPH, which has the authority to hold auctions, has been reluctant to do so for years, because it doubts the reliability of government infrastructure plans. There is an official letter from BPH (No. 202./07/Ka.BPH/2012) to the Directorate General of Oil and Gas demanding that BPH be allowed to take over the gas master plan. BPH considered government planning on the master plan as not applicable because of too much uncertainty regarding technical details: no information about volumes, pipe dimensions, pressure, etc. This means that BPH wants to plan the infrastructure itself and hold the auction. This proposal has been rejected, which means the status quo continues, because BPH is unlikely to hold the auction.

rules are unclear, which keeps infrastructure investors from investing and suppliers from agreeing long-term supply contracts.

This uncertainty adds to the difficulty in securing adequate financing, because it demands large capital inputs, a long payback period, and high technology. Hence, business prefers to build point-to point-pipelines (see Hutagalung et al., 2011) instead of investing in an open transmission segment without supply contracts. Since 2010, there have been discussions about infrastructure planning proposed by the private sector, mostly related to an LNG terminal, but apart from the West Java LNG terminal in 2012, no investments have been realized.

The lack of interest from the private sector leads us to ask whether public investments in gas infrastructure projects are feasible. Would it make sense for the Indonesian government to invest in natural gas infrastructure in order to stimulate the domestic natural gas market? Answering this question is only possible if we compare the economic impact of natural gas infrastructure investment with the economic impact of current public spending on economic development. This comparative analysis is the central focus of the present chapter (see Section 3.4.1.2 regarding the scenario).

Our assumption is that public investment in natural gas infrastructure will be beneficial to the Indonesian economy. In what follows, this assumption is tested with the help of the Computable General Equilibrium (CGE) Model. This model enables us to analyze the economic implications of public financing for natural gas infrastructure investments in Indonesia.

Previous literature on the impact of infrastructure can be found in Bohme, et al. (2010), who argued that decisions about public investment are made on the basis of their growth and poverty effect. From that perspective, it is important to know in advance where to invest. There is broad agreement in the economic development literature that productivity-enhancing public investments to support the private sector are key for growth and job creation (Syrquin 1988; World Bank 1993; Collier 2006; Breisinger and Diao 2009). Agenor and Moreno-Dogson (2006) and Fouire (2006) argue that infrastructure can impact economic growth in some ways, lower the cost of input factors, improve worker productivity, and also creates job multipliers during the period of construction. Caloghirou (1996) estimated the macroeconomic impact of investment in gas infrastructure using Input-Output Analysis. A similar study, not limited to gas infrastructure, was conducted by Lu et al. (2010), who

analyzed the impact of energy investment on economic growth using a CGE Model. Energy investment itself comprises (though is not limited to) resource exploitation, storage investment, conversion investment, including transmission and distribution (pipeline) investment (Samouilidis and Mitropoulos, 1983).

8.3. Methodologies and Simulation Scenarios

In this chapter we use a static CGE model (see Chapter 5) to simulate the impact of natural gas infrastructure financing. Before setting the scenarios, we examine the need for gas infrastructure. Tjandranegara (2012) identified and mapped the infrastructure needed to improve domestic consumption of natural gas in Indonesia. He developed an infrastructure plan drawing on the previous study of Zawier (2010), who estimated the investment costs of gas pipelines and LNG terminals (Gary dan Handwerk, 2001; Perry dan Green, 1997). He took domestic fulfillment of the natural gas projection for the years 2015-2030 as a reference point for his estimation, tackling the investment problem from an optimization perspective.

We have taken two important infrastructure projects from Tjandranegara's infrastructure planning as our reference point. Among the most important infrastructures are two new LNG receiving terminals in Java that will add additional capacity for 750 MMSCFD (250+500) from domestic production or imports, and the pipeline network for Natuna-West Java, which connects the giant gas fields of Natuna to West Java. Infrastructure planning details are presented in Table 8.3. Both projects represent an investment of US\$ 9.76 billion..

Table 8.1 Three Scenarios for Natural Gas Infrastructure Development Planning

Scenario 1

Infrastructure	Capacity (mmstcd)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Natuna - West Java pipeline	2x1200				0.88	1.47	0.59				0.61	1.02	0.41	0.88	1.47	0.59				
East Kat-East Java pipeline	900																			
Cirebon-Semarang pipeline	400										0.08	0.14	0.06							
LNG Recv Term West Java	250	0.22																		
LNG Recv Term East Java	250				0.04	0.11	0.07													
TOTAL CUMULATIVE		0.22	0.22	0.22	1.14	2.72	3.37	3.37	3.37	3.37	4.07	5.22	5.68	6.56	8.03	8.62	8.62	8.62	8.62	8.62

Scenario 2

Infrastructure	Capacity (mmstcd)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Natuna - West Java pipeline	3x1200		0.88	1.47				0.88	1.47	0.59							0.88	1.47	0.59	
East Kat-East Java pipeline	900		0.61	1.02																
Cirebon - Semarang pipeline	400		0.08	0.14																
Semarang - Surabaya pipeline	400										0.05	0.08	0.03	0.41	0.68	0.27	0.47	0.78	0.78	
SSWJ I & II Compressor exp	650 -> 1100																0.37	0.62	0.25	
LNG Plant Papua expansion	534																			
LNG Plant Maluku-south	534																			
LNG Plant Sulawesi	356																			
LNG Recv Term North - Sumatra	250	0.04	0.11																	
LNG Recv Term West Java	250	0.22																		
LNG Recv Term East Java	2x250													0.07	0.18	0.11	0.07	0.18	0.11	
TOTAL CUMULATIVE		1.84	4.57	5.68	5.68	5.68	5.68	6.56	8.03	8.62	8.66	8.74	8.77	9.24	10.2	10.74	12.59	15.63	16.88	16.88

Scenario 3

Infrastructure	Capacity (mmstcd)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Natuna - West Java pipeline	3x1200		0.88	1.47	0.59			0.88	1.47	0.59							0.88	1.47	0.59	
East Kat-East Java pipeline	900		0.61	1.02	0.41				0.61	1.02	0.41									
Cirebon - Semarang pipeline	400		0.08	0.14	0.06															
Semarang - Surabaya pipeline	400										0.1	0.17	0.07							
SSWJ I & II Compressor exp	650 -> 1100				0.05	0.08	0.03													
Pipa SSWJ III	1200								0.28	0.47	0.19									
LNG Plant Papua expansion	534							0.41	0.68	0.27										
LNG Plant Maluku-south	534													0.47	0.78	0.31	0.37	0.62	0.25	
LNG Plant Sulawesi	356																			
LNG Recv Term North - Sumatra	250+2x500	0.04	0.11	0.07										0.11	0.18	0.07	0.11	0.18	0.07	
LNG Recv Term West Java	250	0.22									0.11	0.18	0.07	0.11	0.18	0.07	0.11	0.18	0.07	
LNG Recv Term East Java	3x250																			
TOTAL CUMULATIVE		1.84	4.57	5.68	5.73	5.8	5.83	7.42	10.15	12.5	13.3	13.64	13.78	15.33	17.93	18.96	19.54	20.51	20.9	20.9

Source : Tjandranegara (2012)

We distinguished and analyzed three different financing scenarios for the infrastructure investments :

- A. In the first scenario, we assume that the investment will be financed by a foreign loan and therefore the financing will not affect the government budget for other sectors, other than in the form of interest payments.
- B. In the second scenario, the investment is financed from a reallocation of the gasoline subsidy budget. This scenario is based on the assumption that the economic impact of the gasoline subsidy can be improved by using the money on energy infrastructure instead of gasoline consumption.
- C. In the third scenario, financing comes from a reallocation of government revenues from oil and gas production. This scenario draws on recent debates in Indonesia about spending part of those revenues on oil and gas sector development, instead of using all revenues for the general economy. The proposed percentage for petroleum is 5% of state revenue from oil and gas. We considered this to be a reasonable source of funds for natural gas infrastructure.

Table 8.2 Simulation Scenario³⁶

No	Scenario A		Scenario B			Scenario C		
	Investment	Capital percentage	Investment	Capital percentage	Subsidy Removal	Investment	Capital Percentage	Government Share
1	4.8	8%	4.8	8%	11%	4.8	8%	0.7%
2	9.4	15%	9.4	15%	22%	9.4	15%	1.4%
3	17.4	28%	17.4	28%	40%	17.4	28%	2.7%

Source: Author's calculation

In the model used in this chapter, we set a long-run closure, where capital and aggregate employment are exogenous and can move across sectors. Gas-sector capital is assumed to be exogenous and is set as a shock variable in the simulation. The amount of money needed annually to build gas infrastructure as proposed in the plans is in the investment column in Table 8.1. There are three different planning scenarios and the investment amount corresponds to the amount of money proposed for each planning option. This amount of investment is then translated into change in gas-sector capital in the model. Increasing this amount of capital means that money must be taken from other sectors to finance it. In Scenario B, the amount of investment is equivalent to the percentage amount of subsidy removed, and for Scenario C it is equal to percentage change in government share. We set

³⁶ In Trillion Rupiahs

the LNG output as fixed, as well as urban gas (gas for household consumption) and LPG, because we want to propose a policy that focuses on development of domestic industry.

8.4. Results

8.4.1 Influences on Macro Indicators

The long-term effects of gas infrastructure investment are summarized in Table 8.3. Almost all macro indicators show positive impacts in every scenario. GDP increases gradually; this is caused by expansion of gas-intensive user sectors, namely industry and electricity, and is followed by increase in investment. Household consumption shows overall increase in all gas price increase scenarios. This is consistent with increase in employment levels in labor-intensive sectors (see Section 8.4.2), which is the source of household income.

Scenario B, reallocation of the gasoline subsidy, shows the highest increments in macro indicators. This supports the argument that this subsidy is a fiscal burden and would be better spent on infrastructure. Scenarios A and C show almost similar positive trends, although somewhat smaller than in Scenario B. It is no surprise that reallocation of state revenue from oil and gas reduces the government's spending capacity.

Table 8.3 LongRun Macro Indicators (Change in %)

Indicators	Scenario A			Scenario B			Scenario C		
	A1	A2	A3	B1	B2	B3	C1	C2	C3
GDP	0.10	0.18	0.34	0.14	0.25	0.43	0.10	0.18	0.33
House Cons	0.05	0.12	0.27	0.14	0.27	0.50	0.05	0.11	0.25
Investment	0.16	0.34	0.72	-0.04	-0.04	0.03	0.19	0.40	0.84
Export	0.20	0.31	0.48	0.19	0.31	0.49	0.34	0.61	1.07
CO2 Emit	0.21	0.36	0.60	-0.13	-0.26	-0.42	0.20	0.34	0.57

Source: Author's calculation

8.4.2 Influence on Sectoral Output and Employment

This section discusses the sectoral indicators of production output and employment. The output of the gas-intensive sector, electricity, petrochemical, PMI increases slightly with an average of 0.25% for all scenarios. However, food and textile production decreases. Some non-gas-intensive sectors also show positive change as a result of an indirect impact from gas-intensive industry. Land transportation decreases almost 0.4% in Scenario B, which is explained by the impact of gasoline subsidy removal.

Figure 8.3 Long-Run Output

Source: Author's calculation

Figure 8.4 shows that employment has the opposite trend with sectoral output. Employment levels decrease in all scenarios, except C. In Scenario B, the gas-intensive sectors like electricity, chemical, and paper/metal also show decline in employment. This might be due to change in production costs in the industrial sectors, where subsidy removal will increase costs that lead to labor adjustments.

Figure 8.4 Long-Run Employment

Source: Author's calculation

8.4.3 Influence on Energy Consumption

In long-term energy consumption changes in utilization pattern (Figure 6), gas shows a significant increment, with an average 1 to 2% increase in utilization, while coal consumption decreases slightly because of shifts from industry or electricity to natural gas. The same condition applies for HSDO consumption. Gasoline decreases tremendously in Scenario B, particularly B3, as an impact of subsidy removal. Renewables increase slightly, particularly in the subsidy removal scenario, which supports the proposition that gasoline subsidy hinders renewable energy development. In general, all scenarios have the same trend in energy utilization pattern.

Figure 8.5 Energy Consumption in the Long Run

Source: Author's compilation

8.5 Conclusion

Our simulation shows that public financing of gas infrastructure investment will stimulate economic growth. It is worth noting that all financing scenarios have a positive impact on the various macroeconomic indicators, as well as on sectoral output and employment. It also shows that gas consumption will increase. It confirms our initial assumption that gas infrastructure investment is productive for economic growth and energy security.

Scenario B, subsidy removal, shows the most positive impact on macro indicators; followed by Scenarios A and C with somewhat similar results. This finding supports opinions in Indonesia suggesting a reallocation of fuel subsidies in favor of more economically productive spending. However, Scenario C, reallocating government revenue from oil and

gas in favor of natural gas infrastructure investment, has the largest positive economic impact on sectoral performance (output and employment), followed by Scenario A, foreign aid.

With respect to the feasibility of policy implementation, financing the investments through foreign loans is actually not a viable option, because the loan is outside control of the Indonesian government. On the other hand, subsidy removal has been a politically sensitive issue in energy policy discussions. Here, the decision depends on the priority of the policy-maker. Whatever the chosen policy, our results show that public financing of natural gas infrastructure investment is beneficial for Indonesia's economic development.

Our findings are encouraging for private investment in Indonesian natural gas infrastructure. Our results show that significant economic gains are associated with such investments. This might help to improve the investment climate in the gas sector. Natural gas is very important for Indonesia's economic development. For this reason, new natural gas infrastructure investments should start as soon as possible. We have shown that it is advantageous for the Indonesian government to take the lead and not to wait for private investors.

Chapter 9 Conclusion

9.1 General Summary

This dissertation explored the economic aspects of natural gas policy. The main research question addressed the optimal allocation of natural gas supply, gas pricing, and financing investment in gas infrastructure by using a modeling framework. The model presented a unifying approach to the question of allocation. Our main objective was to explore options for correcting market and policy failures in the Indonesian gas sector by providing scientific grounding for policy selection, and to provide counterfactual analysis of how the gas sector should be governed. A framework and economic model was developed; computable general models then investigated interrelationships between gas policy and the economy. An attempt was made to assess the economy-wide effects of gas management for proposed allocations in order to maximize welfare gain. This study is a research contribution to the issue of natural resource management in Indonesia.

The general introduction and Chapter 2 presented an overview of the problems in the energy sector in Indonesia, especially the gas sector, and the threats and challenges posed by these problems. Chapter 1 discussed the significant role politics plays in determining energy developments and energy policies, and how policy is implemented without adequate analysis and information. We emphasized the importance of analysis and information as the foundation for energy planning and policy.

Chapter 2 reviewed current conditions in the Indonesian gas sector, its contribution to Indonesian economic activity, and the direction of policy since the new oil and gas law of 2001. Declining production trends and lack of new investment are contrasted with growing domestic demand and gas scarcity issues. New policy directions reorient the aims and objectives of the gas sector, and are intended to address this problem. However, policy implementation is still not optimal. Our analysis showed that the problems facing the Indonesian gas market fall into three groups: gas allocation, pricing, and infrastructure. These were the central components of analysis in the empirical chapters (6, 7, and 8). The objective of gas policy is to support economic growth, and to improve welfare and security of the people. Based on these objectives, three different problems and their corresponding mitigation measures, different economic models were developed to investigate the

interrelationship between energy and the economy, and to analyze the impacts of each different measure/policy on economic and social indicators.

In Chapter 3, a theoretical framework was developed based on linkages between energy and development. Access to energy is a critical input for achieving social development and economic growth, and this link is mediated by energy policy. Two paradigms were discussed: neoclassical economic theory and political regulation. The role of government is to ensure an effective balance between economic efficiency and social objectives, and this is the principle underlying our analysis. This concept was the cornerstone for the integrated energy-planning analytical framework used in the thesis. It enabled us to build a model of relationships between the energy sector and the rest of the economy. This model was constructed in multiple planning levels, from macro to intermediate to micro level. Micro level is where subsector planning takes place; in our case, where gas policy planning is defined by policy instruments.

In Chapter 4, the general concept of Integrated Energy Planning (INEP) was adopted for a specific energy sector, natural gas. The analytical framework led to the formation of counterfactual analysis using a Computable General Equilibrium or CGE model to answer the three main research questions. This provided the foundation for Chapter 5, which detailed the methodology used. We constructed a Social Accounting Matrix SAM database that was used in the CGE model. The structure of the model consists of a mathematical formulation derived from economic theory.

9.2 How should Indonesia prioritize natural gas allocation for the domestic market in order to achieve optimum benefit for the national economy?

In Chapter 6, a recursive dynamic CGE model was used to analyze the relationship between the economy and natural gas consumption, with natural gas as an explicit factor of production. The model was used to evaluate the effectiveness of gas allocation policies for mitigating scarcity issues through three different group scenarios, reducing gas consumption for each particular sector. The time frame for this analysis was 2011-2025, based on data for natural gas supply and demand published by KESDM. This method helped to determine the key sectors with the highest impact on gas consumption, and to reallocate gas from low-value to relatively high-value sectors. The results indicate that gas allocation priority should be ranked as follows: Industry, Petrochemical Sector, Crude Oil Production, and Electricity. Macroeconomic indicators clearly demonstrate that the most negative effects occur when natural gas is not allocated in that order. This counterfactual result shows that the

government's current natural gas allocation does not maximize welfare, and needs to be revised.

9.3 To what extent can gas prices be adjusted to reach an optimum trade-off between economic efficiency and social objectives?

Chapter 7 presented a macro- and microanalysis of natural gas pricing. Macroanalysis was carried out using a comparative-static CGE model of the Indonesian economy, while microanalysis was assessed with Netback value. Price shocks were simulated in both short- and long-run scenarios. This model was suitable for evaluating the broad impact of gas pricing policy with respect to economic indicators and cost structures of gas consumers. The baseline for the simulation scenario was the current weighted average of natural gas price; several scenarios of increasing gas prices at different percentages above the current price were run. The results showed that increasing natural gas price up to 91% will not critically damage the Indonesian economy. GDP and household consumption decrease less than 1%, as does employment level. From a microanalysis of two gas consumers (fertilizer and electricity), we showed that price adjustment is still within an acceptable range for their cost structures. This result gave a potential new range of floor-to-ceiling prices for natural gas that can serve as a generic conceptual model for gas price determination by the Indonesian government.

9.4 What impact will natural gas infrastructure development have on Indonesian energy security and economy; and what are the viable policy options for financing it?

In Chapter 8, we used a comparative static CGE model to evaluate the role of natural gas infrastructure in supporting Indonesian economic growth, and presented various scenarios for financing it. We showed that, without sufficient infrastructure connectivity, there will be a deficit in every region; this is important for energy security. Based on natural gas supply-and-demand projections and engineering designs for natural gas infrastructure, we simulated three different sources of financing public investment in natural gas infrastructure. These options are: foreign loan, removal of gasoline subsidy, and state revenue from oil and gas. The results showed that public investment will stimulate economic growth, as indicated by positive trends in various macroeconomic indicators, as well as in sectoral output and employment. Natural gas utilization increased 1 - 2 %; because of shifts from industry or electricity to natural gas. These three options have different effects on the economy. Subsidy removal is far more positive with respect to macro indicators; however, reallocation of state revenue from oil and gas has more positive impacts in terms of sectoral indicators (economic output and employment), followed by foreign loans. On the other hand, subsidy removal is

politically difficult to implement; it has been a ‘never-ending’ debate in Indonesian energy policy. A trade-off should be made, but what this is very much depends on the policy-maker’s priorities. It could be a combination of these three options. One thing is clear: the government should take the initiative and use public spending to finance natural gas infrastructure.

9.5 Central Research Question: Does Indonesian gas policy contribute optimally to macroeconomic development of the nation; if not, what adjustments are needed?

The answer to this central research question was provided as a set of policy recommendations that can bring substantial change to natural gas policy to improve welfare and energy security. The insights generated through studying these research questions can provide at least a partial answer to the main research question. The results indicate there is still a gap between current policy and energy policy objectives. Evaluating socioeconomic data gives better prospects for changing the current policy. Though the result was obtained from a case study of a single nation, it is intuitively logical and it may be possible to apply in other nations.

Economic efficiency has gained much attention from Indonesian policymakers recently, partly because excessive exploitation of natural resources (in particular oil and gas) did not improve the nation’s welfare (Muliadireja, 2005). Ever since energy analysts revealed that domestic oil reserves are no longer adequate to support domestic need and the nation must rely on imports, policy-makers have considered “economic efficiency” as an important issue (Muliadireja, 2005). Sooner or later, Indonesia will have to rely on foreign oil.

The nation’s dependence on revenues from exported oil and gas must be reduced because of this looming problem of scarcity. This pushed policy-makers to optimize the added value of oil and gas utilization by prioritizing its consumption in the domestic market. This can be done formally by introducing regulations prohibiting oil and gas export, if it is more economically beneficial to use them domestically (Muliadireja, 2005).

Modeling enabled us to answer the central research question: *Does Indonesian gas policy contribute optimally to macroeconomic development of the nation, and if not what adjustments are needed?* The answer is expected to bring *genuine* changes, or **at** least stimulate changes, in relevant elements of natural gas policies that would improve welfare and energy security. The objective of this research was to understand circumstances under which policy reforms in the gas sector can be improved. The proposed recommendations fall under three headings:

1. Revising Gas Allocation Policy

2. Adjusting Natural Gas Price
3. Public Investment for Infrastructure

9.6 Contribution to Academic Literature

This dissertation constructed a framework from an existing body of literature and applied it in an empirical case study to give in-depth analysis. It provided a fresh perspective on the natural gas sector in the context of the political economy of energy sector reforms in general, and the oil and gas sector in Indonesia in particular. As explained in Chapter 2, natural gas policy reforms and redirection were expected to bring changes and to address the problems of top-down policy design and implementation.

Even after nearly a decade of reforms, the gaps in policy design and objectives remain unresolved. The reason is lack of knowledge of economic, social, technological, and historical influences (Muliadireja, 2005). The process of policy formulation requires a solid scientific grounding. Political interests dominate policy decisions, which leads to inefficiency and market failure. This has become a widely discussed topic among academics, policy-makers, industry economists, and regulators. On one side, decision-making cannot be separated from political intervention, yet empirical analysis shows that this domination can lead to calamity, for example, the California electricity market (de Vries, 2005; see Chapter 3, Section 3.3.2). The main issue in this contentious debate is whether economic efficiency is necessary, and the result is compromise, or something in between.

We presented a general economic framework to assess regulatory remedies and applied it to the gas sector. This dissertation has provided integrative analysis in the sense that it connects a wide range of information on interlinkages in the economy-energy system. This kind of approach required the development of mathematical models that are quite often of limited practical use; they project future policy scenarios that do not consider the information necessary to shape policy decision-making. Therefore, we constructed a counterfactual scenario as close as possible to reality, in the sense that our proposed policy options were based on actual circumstances. This dissertation provides a framework and tool for the scientific grounding of energy policy for Indonesia.

9.7 Limitation and Future Research Prospects

The discussion in this dissertation shows that some research topics still remain to be investigated. There are several recommendations for future research that would improve our knowledge and understanding of the interrelations among economy, society, and resource usage in Indonesia. The limitation of data is one critical issue to be resolved when using the

CGE model. Availability and completeness of data for the Indonesian economy is the most difficult problem facing the modeler. This is true for developing countries in general. For instance, elasticity data had to be taken from similar studies in other countries, or from the correlation between energy consumption and sectoral output.

The level of aggregation used in the model's construction reduces its accuracy. The author used aggregated household and industrial sector data. The database of SAM used in this dissertation is from 2008; future research can use the latest published SAM, and develop different possible scenarios to gain more insight or examine another aspect of policy in the natural gas sector.

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Appendix

Appendix A Input Program for ORANI G and ORANI G-RD

*! Excerpt 1 of TABLO input file: !
! Files and sets !*

File BASEDATA # Input data file #,
(new) SUMMARY # Output for summary and checking data #,

Set

COM # Commodities # read elements from file BASEDATA header "COM"; ! c !
SRC # Source of commodities # (dom,imp); ! s !
IND # Industries # read elements from file BASEDATA header "IND"; ! i !
OCC # Occupations # read elements from file BASEDATA header "OCC"; ! o !

*! Excerpt 2 of TABLO input file: !
! Data coefficients and variables relating to basic commodity flows !*

Coefficient *! Basic flows of commodities !*

(all,c,COM)(all,s,SRC)(all,i,IND) V1BAS(c,s,i) # Intermediate basic flows #,
(all,c,COM)(all,s,SRC)(all,i,IND) V2BAS(c,s,i) # Investment basic flows #,
(all,c,COM)(all,s,SRC) V3BAS(c,s) # Household basic flows #,
(all,c,COM) V4BAS(c) # Export basic flows #,
(all,c,COM)(all,s,SRC) V5BAS(c,s) # Government basic flows #,
(all,c,COM)(all,s,SRC) V6BAS(c,s) # Inventories basic flows #,

Read

V1BAS from file BASEDATA header "1BAS";
V2BAS from file BASEDATA header "2BAS";
V3BAS from file BASEDATA header "3BAS";
V4BAS from file BASEDATA header "4BAS";
V5BAS from file BASEDATA header "5BAS";
V6BAS from file BASEDATA header "6BAS";

Variable *! Variables used to update above flows !*

(all,c,COM)(all,s,SRC)(all,i,IND) x1(c,s,i) # Intermediate basic demands #,
(all,c,COM)(all,s,SRC)(all,i,IND) x2(c,s,i) # Investment basic demands #,
(all,c,COM)(all,s,SRC) x3(c,s) # Household basic demands #,
(all,c,COM) x4(c) # Export basic demands #,
(all,c,COM)(all,s,SRC) x5(c,s) # Government basic demands #,
(change) (all,c,COM)(all,s,SRC) delx6(c,s) # Inventories demands #,
(all,c,COM)(all,s,SRC) p0(c,s) # Basic prices for local users #,
(all,c,COM) pe(c) # Basic price of exportables #,
(change)(all,c,COM)(all,s,SRC) delV6(c,s) # Value of inventories #,

Update

```
(all,c,COM)(all,s,SRC)(all,i,IND) V1BAS(c,s,i) = p0(c,s)*x1(c,s,i);
(all,c,COM)(all,s,SRC)(all,i,IND) V2BAS(c,s,i) = p0(c,s)*x2(c,s,i);
(all,c,COM)(all,s,SRC)      V3BAS(c,s) = p0(c,s)*x3(c,s);
(all,c,COM)      V4BAS(c) = pe(c)*x4(c);
(all,c,COM)(all,s,SRC)      V5BAS(c,s) = p0(c,s)*x5(c,s);
(change)(all,c,COM)(all,s,SRC) V6BAS(c,s) = delV6(c,s);
```

Variable

```
(all,c,COM)      p0dom(c) # Basic price of domestic goods = p0(c,"dom") #;
```

! Excerpt 4 of TABLO input file: !

! Data coefficients and variables relating to commodity taxes !

Coefficient *! Taxes on Basic Flows!*

```
(all,c,COM)(all,s,SRC)(all,i,IND) V1TAX(c,s,i) # Taxes on intermediate #;
(all,c,COM)(all,s,SRC)(all,i,IND) V2TAX(c,s,i) # Taxes on investment #;
(all,c,COM)(all,s,SRC)      V3TAX(c,s) # Taxes on households #;
(all,c,COM)      V4TAX(c) # Taxes on export #;
(all,c,COM)(all,s,SRC)      V5TAX(c,s) # Taxes on government #;
```

Read

```
V1TAX from file BASEDATA header "1TAX";
V2TAX from file BASEDATA header "2TAX";
V3TAX from file BASEDATA header "3TAX";
V4TAX from file BASEDATA header "4TAX";
V5TAX from file BASEDATA header "5TAX";
```

Variable

```
(change)(all,c,COM)(all,s,SRC)(all,i,IND) delV1TAX(c,s,i) # Interm tax rev #;
(change)(all,c,COM)(all,s,SRC)(all,i,IND) delV2TAX(c,s,i) # Invest tax rev #;
(change)(all,c,COM)(all,s,SRC)      delV3TAX(c,s) # H'hold tax rev #;
(change)(all,c,COM)      delV4TAX(c) # Export tax rev #;
(change)(all,c,COM)(all,s,SRC)      delV5TAX(c,s) # Govmnt tax rev #;
```

Update

```
(change)(all,c,COM)(all,s,SRC)(all,i,IND) V1TAX(c,s,i) = delV1TAX(c,s,i);
(change)(all,c,COM)(all,s,SRC)(all,i,IND) V2TAX(c,s,i) = delV2TAX(c,s,i);
(change)(all,c,COM)(all,s,SRC)      V3TAX(c,s) = delV3TAX(c,s);
(change)(all,c,COM)      V4TAX(c) = delV4TAX(c);
(change)(all,c,COM)(all,s,SRC)      V5TAX(c,s) = delV5TAX(c,s);
```

! Excerpt 5 of TABLO input file: !

! Data coefficients for primary-factor flows, other industry costs, and tariffs!

Coefficient

```
(all,i,IND)(all,o,OCC) V1LAB(i,o) # Wage bill matrix #;
(all,i,IND)      V1CAP(i) # Capital rentals #;
(all,i,IND)      V1LND(i) # Land rentals #;
(all,i,IND)      V1PTX(i) # Production tax #;
```

```

(all,i,IND)      V1OCT(i)  # Other cost tickets #,
Read
V1LAB from file BASEDATA header "1LAB",
V1CAP from file BASEDATA header "1CAP",
V1LND from file BASEDATA header "1LND",
V1PTX from file BASEDATA header "1PTX",
V1OCT from file BASEDATA header "1OCT",
Variable
(all,i,IND)(all,o,OCC) x1lab(i,o) # Employment by industry and occupation #,
(all,i,IND)(all,o,OCC) p1lab(i,o) # Wages by industry and occupation #,
(all,i,IND) x1cap(i)      # Current capital stock #,
(all,i,IND) p1cap(i)      # Rental price of capital #,
(all,i,IND) x1lnd(i)      # Use of land #,
(all,i,IND) p1lnd(i)      # Rental price of land #,
(change)(all,i,IND) delV1PTX(i) # Ordinary change in production tax revenue #,
(all,i,IND) x1oct(i)      # Demand for "other cost" tickets #,
(all,i,IND) p1oct(i)      # Price of "other cost" tickets #,
Update
(all,i,IND)(all,o,OCC) V1LAB(i,o) = p1lab(i,o)*x1lab(i,o);
(all,i,IND)      V1CAP(i) = p1cap(i)*x1cap(i);
(all,i,IND)      V1LND(i) = p1lnd(i)*x1lnd(i);
(change)(all,i,IND) V1PTX(i) = delV1PTX(i);
(all,i,IND)      V1OCT(i) = p1oct(i)*x1oct(i);

! Data coefficients relating to import duties !
Coefficient (all,c,COM) V0TAR(c) # Tariff revenue #,
Read V0TAR from file BASEDATA header "0TAR",
Variable (all,c,COM) (change) delV0TAR(c) # Ordinary change in tariff revenue #,
Update (change) (all,c,COM) V0TAR(c) = delV0TAR(c);

! Excerpt 6 of TABLO input file: !
! Coefficients and variables for purchaser's prices (basic + taxes) !

Coefficient ! Flows at purchasers prices !
(all,c,COM)(all,s,SRC)(all,i,IND) V1PUR(c,s,i) # Intermediate purch. value #,
(all,c,COM)(all,s,SRC)(all,i,IND) V2PUR(c,s,i) # Investment purch. value #,
(all,c,COM)(all,s,SRC)      V3PUR(c,s) # Households purch. value #,
(all,c,COM)      V4PUR(c) # Export purch. value #,
(all,c,COM)(all,s,SRC)      V5PUR(c,s) # Government purch. value #,
Formula
(all,c,COM)(all,s,SRC)(all,i,IND)
V1PUR(c,s,i) = V1BAS(c,s,i) + V1TAX(c,s,i);
(all,c,COM)(all,s,SRC)(all,i,IND)
V2PUR(c,s,i) = V2BAS(c,s,i) + V2TAX(c,s,i);
(all,c,COM)(all,s,SRC)
V3PUR(c,s) = V3BAS(c,s) + V3TAX(c,s);
(all,c,COM)

```

```

V4PUR(c) = V4BAS(c) + V4TAX(c);
(all,c,COM)(all,s,SRC)
V5PUR(c,s) = V5BAS(c,s) + V5TAX(c,s);
Variable ! Purchasers prices !
(all,c,COM)(all,s,SRC)(all,i,IND) p1(c,s,i) # Purchaser's price, intermediate #,
(all,c,COM)(all,s,SRC)(all,i,IND) p2(c,s,i) # Purchaser's price, investment #,
(all,c,COM)(all,s,SRC) p3(c,s) # Purchaser's price, household #,
(all,c,COM) p4(c) # Purchaser's price, exports, loc$ #,
(all,c,COM)(all,s,SRC) p5(c,s) # Purchaser's price, government #,

```

```

! Excerpt 7 of TABLO input file: !
! Occupational composition of labour demand !
!$ Problem: for each industry i, minimize labour cost !
!$ sum{o,OCC, P1LAB(i,o)*X1LAB(i,o)} !
!$ such that X1LAB_O(i) = CES( All,o,OCC: X1LAB(i,o) ) !

```

Coefficient

```

(parameter)(all,i,IND) SIGMA1LAB(i) # CES substitution between skill types #,
(all,i,IND) V1LAB_O(i) # Total labour bill in industry i #,
TINY # Small number to prevent zerodivides or singular matrix #,

```

Read SIGMA1LAB from file BASEDATA header "SLAB";

Formula

```

(all,i,IND) V1LAB_O(i) = sum{o,OCC, V1LAB(i,o)};
TINY = 0.0000000000001;

```

Variable

```

(all,i,IND) p1lab_o(i) # Price to each industry of labour composite #,
(all,i,IND) x1lab_o(i) # Effective labour input #,

```

Equation

```

E_x1lab # Demand for labour by industry and skill group #
(all,i,IND)(all,o,OCC)
x1lab(i,o) = x1lab_o(i) - SIGMA1LAB(i)*[p1lab(i,o) - p1lab_o(i)];
E_p1lab_o # Price to each industry of labour composite #
(all,i,IND) [TINY+V1LAB_O(i)]*p1lab_o(i) = sum{o,OCC, V1LAB(i,o)*p1lab(i,o)};

```

```

! Excerpt 8 of TABLO input file: !
! Primary factor proportions !
!$ X1PRIM(i) = !
!$ CES( X1LAB_O(i)/A1LAB_O(i), X1CAP(i)/A1CAP(i), X1LND(i)/A1LND(i) ) !

```

Coefficient

```

(parameter)(all,i,IND) SIGMA1PRIM(i) # CES substitution, primary factors #,

```

Read SIGMA1PRIM from file BASEDATA header "P028";

Coefficient (all,i,IND) V1PRIM(i) # Total factor input to industry i#;

Formula (all,i,IND) V1PRIM(i) = V1LAB_O(i)+ V1CAP(i) + V1LND(i);

Variable

```

(all,i,IND) p1prim(i) # Effective price of primary factor composite #,
(all,i,IND) x1prim(i) # Primary factor composite #,

```

(all,i,IND) a1lab_o(i) # Labor-augmenting technical change #,
 (all,i,IND) a1cap(i) # Capital-augmenting technical change #,
 (all,i,IND) a1lnd(i) # Land-augmenting technical change #,
 (change)(all,i,IND) delV1PRIM(i) # Ordinary change in cost of primary factors #,

Equation

E_x1lab_o # Industry demands for effective labour #
 (all,i,IND) x1lab_o(i) - a1lab_o(i) =
 x1prim(i) - SIGMA1PRIM(i)*[p1lab_o(i) + a1lab_o(i) - p1prim(i)];

E_p1cap # Industry demands for capital #
 (all,i,IND) x1cap(i) - a1cap(i) =
 x1prim(i) - SIGMA1PRIM(i)*[p1cap(i) + a1cap(i) - p1prim(i)];

E_p1lnd # Industry demands for land #
 (all,i,IND) x1lnd(i) - a1lnd(i) =
 x1prim(i) - SIGMA1PRIM(i)*[p1lnd(i) + a1lnd(i) - p1prim(i)];

E_p1prim # Effective price term for factor demand equations #
 (all,i,IND) V1PRIM(i)*p1prim(i) = V1LAB_O(i)*[p1lab_o(i) + a1lab_o(i)]
 + V1CAP(i)*[p1cap(i) + a1cap(i)] + V1LND(i)*[p1lnd(i) + a1lnd(i)];

E_delV1PRIM # Ordinary change in total cost of primary factors #
 (all,i,IND) 100*delV1PRIM(i) = V1CAP(i) * [p1cap(i) + x1cap(i)]
 + V1LND(i) * [p1lnd(i) + x1lnd(i)]
 + sum{o,OCC, V1LAB(i,o)* [p1lab(i,o) + x1lab(i,o)]};

! Excerpt 9 of TABLO input file: !

! Import/domestic composition of intermediate demands !

!\$ X1_S(c,i) = CES(All,s, SRC: X1(c,s,i)/A1(c,s,i)) !

Variable

(all,c,COM)(all,s,SRC)(all,i,IND) a1(c,s,i) # Intermediate basic tech change #,
 (all,c,COM)(all,i,IND) x1_s(c,i) # Intermediate use of imp/dom composite #,
 (all,c,COM)(all,i,IND) p1_s(c,i) # Price, intermediate imp/dom composite #,
 (all,i,IND) p1mat(i) # Intermediate cost price index #,

Coefficient

(parameter)(all,c,COM) SIGMA1(c) # Armington elasticities: intermediate #,
 (all,c,COM)(all,i,IND) V1PUR_S(c,i) # Dom+imp intermediate purch. value #,
 (all,c,COM)(all,s,SRC)(all,i,IND) S1(c,s,i) # Intermediate source shares #,
 (all,i,IND) V1MAT(i) # Total intermediate cost for industry i #,

Read SIGMA1 from file BASEDATA header "1ARM";

Zerodivide default 0.5;

Formula

(all,c,COM)(all,i,IND) V1PUR_S(c,i) = sum{s,SRC, V1PUR(c,s,i)};
 (all,c,COM)(all,s,SRC)(all,i,IND) S1(c,s,i) = V1PUR(c,s,i) / V1PUR_S(c,i);
 (all,i,IND) V1MAT(i) = sum{c,COM, V1PUR_S(c,i)};

Zerodivide off;

Equation E_x1 # Source-specific commodity demands #

(all,c,COM)(all,s,SRC)(all,i,IND)

$x1(c,s,i) - a1(c,s,i) = x1_s(c,i) - \text{SIGMA1}(c) * [p1(c,s,i) + a1(c,s,i) - p1_s(c,i)];$

Equation E_p1_s # Effective price of commodity composite #

(all,c,COM)(all,i,IND)

$p1_s(c,i) = \text{sum}\{s, \text{SRC}, S1(c,s,i) * [p1(c,s,i) + a1(c,s,i)];\};$

Equation E_p1mat # Intermediate cost price index #

(all,i,IND)

$[TINY + V1MAT(i)] * p1mat(i) = \text{sum}\{c, \text{COM}, \text{sum}\{s, \text{SRC}, V1PUR(c,s,i) * p1(c,s,i)\}\};$

! Excerpt 10 of TABLO input file: !

! Top nest of industry input demands !

*!\$ X1TOT(i) = MIN(All,c,COM: X1_S(c,i)/[A1_S(c,s,i)*A1TOT(i)], !*

*!\$ X1PRIM(i)/[A1PRIM(i)*A1TOT(i)], !*

*!\$ X1OCT(i)/[A1OCT(i)*A1TOT(i)]) !*

Variable

(all,i,IND) x1tot(i) # Activity level or value-added #,

(all,i,IND) a1prim(i) # All factor augmenting technical change #,

(all,i,IND) a1tot(i) # All input augmenting technical change #,

(all,i,IND) p1tot(i) # Average input/output price #,

(all,i,IND) a1oct(i) # "Other cost" ticket augmenting technical change #,

(all,c,COM)(all,i,IND) a1_s(c,i) # Tech change, intermediate imp/dom composite #,

! Add energy substitution !

Variable

(all,i,IND) a1ener(i) # Energy-using tech change #,

(all,i,IND) p1ener(i) # Average price of energy #,

(all,i,IND) p1enerprim(i) # Average of p1prim and p1ener #,

Coefficient

(parameter) SIGMA1ENR # Elasticity of substitution within energy sources #,

(all,c,COM) ISENERGY(c) # 1 If c is in energy set, else 0 #,

(all,i,IND) V1ENERGY(i) # Expenditure on energy #,

(parameter) SIGMA1EPRIM # Elasticity of substitution primary/energy #,

read SIGMA1ENR from file BASEDATA header "SENR",

read SIGMA1EPRIM from file BASEDATA header "ENPR",

set ENR read elements from file BASEDATA header "ENR",

subset ENR is subset of COM;

set NENR = COM - ENR;

Formula

(all,c,COM) ISENERGY(c) = 0;
(all,c,ENR) ISENERGY(c) = 1;

Equation E_x1_s # Demands for Commodity Composites

(all,c,COM)(all,i,IND) x1_s(c,i) - [a1_s(c,i) + a1tot(i)] = x1tot(i)
+ IF (ISENERGY(c)=1, a1ener(i)
- SIGMA1ENR*[p1_s(c,i) - p1ener(i)]
- SIGMA1EPRIM*[p1ener(i)+a1ener(i)-p1enerprim(i)]);

Equation E_x1prim # Demands for primary factor composite

(all,i,IND) x1prim(i) = x1tot(i) + {a1prim(i) + a1tot(i)}
- SIGMA1EPRIM*[p1prim(i)+a1prim(i) - p1enerprim(i)];

Formula

(all,i,IND) V1ENERGY(i) = sum{c,ENR,V1PUR_S(c,i)};

Equation E_p1ener # Average price of Energy to Industry i#

(all,i,IND) [TINY + V1ENERGY(i)]*p1ener(i) =
sum{c,ENR,V1PUR_S(c,i)*{p1_s(c,i)+a1_s(c,i)}};

Equation E_p1enerprim # Average price of p1ener and p1prim

(all,i,IND) {V1ENERGY(i)+V1PRIM(i)}*p1enerprim(i) =
V1ENERGY(i)*{p1ener(i)+a1ener(i)} + V1PRIM(i)*{p1prim(i)+a1prim(i)};

! end of adding energy substitution !

![[removed from energy substitution

Equation E_x1_s # Demands for commodity composites

(all,c,COM)(all,i,IND) x1_s(c,i) - [a1_s(c,i) + a1tot(i)] = x1tot(i);

Equation E_x1prim # Demands for primary factor composite

(all,i,IND) x1prim(i) - [a1prim(i) + a1tot(i)] = x1tot(i);

!]]!

Equation E_x1oct # Demands for other cost tickets

(all,i,IND) x1oct(i) - [a1oct(i) + a1tot(i)] = x1tot(i);

! Excerpt 11 of TABLO input file: !

! Output cost inclusive of production tax !

Coefficient

(all,i,IND) V1CST(i) # Total cost of industry i #,
(all,i,IND) V1TOT(i) # Total industry cost plus tax #,
(all,i,IND) PTXRATE(i) # Rate of production tax #,

Formula

(all,i,IND) V1CST(i) = V1PRIM(i) + V1OCT(i) + V1MAT(i);

```

(all,i,IND) V1TOT(i) = V1CST(i) + V1PTX(i);
![[
(all,i,IND) PTXRATE(i) = V1PTX(i)/V1PRIM(i); ! VAT alternative !
!]]
(all,i,IND) PTXRATE(i) = V1PTX(i)/V1CST(i);
Write PTXRATE to file SUMMARY header "PTXR";
Variable
(change)(all,i,IND) delV1CST(i) # Change in ex-tax cost of production #,
(change)(all,i,IND) delV1TOT(i) # Change in tax-inc cost of production #,
(change)(all,i,IND) delPTXRATE(i) # Change in rate of production tax #,

```

Equation

```

E_delV1CST (all,i,IND) delV1CST(i) = delV1PRIM(i) +
0.01*sum{c,COM,sum{s,SRC, V1PUR(c,s,i)*[p1(c,s,i) + x1(c,s,i)]}}
+ 0.01*V1OCT(i) *[p1oct(i) + x1oct(i)];

```

```

E_delV1PTX (all,i,IND) delV1PTX(i) = ! ad valorem tax !
PTXRATE(i)*delV1CST(i) + V1CST(i) * delPTXRATE(i);

```

```
![[
```

```
E_delV1PTX (all,i,IND) delV1PTX(i) = ! VAT alternative !
```

```
PTXRATE(i)*delV1PRIM(i) + V1PRIM(i)* delPTXRATE(i);
```

```
!]]
```

```
E_delV1TOT (all,i,IND) delV1TOT(i) = delV1CST(i) + delV1PTX(i);
```

```
E_p1tot (all,i,IND) V1TOT(i)*[p1tot(i) + x1tot(i)] = 100*delV1TOT(i);
```

! Excerpt 12 of TABLO input file: !

! Output mix of commodities !

```

Coefficient (all,c,COM)(all,i,IND) MAKE(c,i) # Multiproduction matrix #,
Variable (all,c,COM)(all,i,IND) q1(c,i) # Output by commodity and industry #,
(all,c,COM) p0com(c) # Output price of locally-produced commodity #,
Read MAKE from file BASEDATA header "MAKE";
Update (all,c,COM)(all,i,IND) MAKE(c,i)= p0com(c)*q1(c,i);
Variable
(all,c,COM) x0com(c) # Output of commodities #,
Coefficient
(parameter)(all,i,IND) SIGMA1OUT(i) # CET transformation elasticities #,
Read SIGMA1OUT from file BASEDATA header "SCET";
Equation E_q1 # Supplies of commodities by industries #
(all,c,COM)(all,i,IND)
q1(c,i) = x1tot(i) + SIGMA1OUT(i)*[p0com(c) - p1tot(i)];
Coefficient
(all,i,IND) MAKE_C(i) # All production by industry i #,

```

(all,c,COM) MAKE_I(c) # Total production of commodities #;

Formula

(all,i,IND) MAKE_C(i) = sum{c,COM, MAKE(c,i)};

(all,c,COM) MAKE_I(c) = sum{i,IND, MAKE(c,i)};

Equation E_x1tot # Average price received by industries #

(all,i,IND) MAKE_C(i)*p1tot(i) = sum{c,COM, MAKE(c,i)*p0com(c)};

Equation E_x0com # Total output of commodities #

(all,c,COM) MAKE_I(c)*x0com(c) = sum{i,IND, MAKE(c,i)*q1(c,i)};

! Excerpt 13 of TABLO input file: !

! CET between outputs for local and export markets !

Variable

(all,c,COM) x0dom(c) # Output of commodities for local market #;

Coefficient

(all, c,COM) EXPSHR(c) # Share going to exports #;

(all, c,COM) TAU(c) # 1/Elast. of transformation, exportable/locally used #;

Zerodivide default 0.5;

Formula

(all,c,COM) EXPSHR(c) = V4BAS(c)/MAKE_I(c);

(all,c,COM) TAU(c) = 0.0; *! if zero, p0dom = pe, and CET is nullified !*

Zerodivide off;

Equation E_x0dom # Supply of commodities to export market #

(all,c,COM) TAU(c)*[x0dom(c) - x4(c)] = p0dom(c) - pe(c);

Equation E_pe # Supply of commodities to domestic market #

(all,c,COM) x0com(c) = [1.0-EXPSHR(c)]*x0dom(c) + EXPSHR(c)*x4(c);

Equation E_p0com # Zero pure profits in transformation #

(all,c,COM) p0com(c) = [1.0-EXPSHR(c)]*p0dom(c) + EXPSHR(c)*pe(c);

! Excerpt 14 of TABLO input file: !

! Investment demands !

!\$ X2_S(c,i) = CES(All,s, SRC: X2(c,s,i)/A2(c,s,i)) !

Variable

(all,c,COM)(all,i,IND) x2_s(c,i) # Investment use of imp/dom composite #;

(all,c,COM)(all,i,IND) p2_s(c,i) # Price, investment imp/dom composite #;

(all,c,COM)(all,s, SRC)(all,i,IND) a2(c,s,i) # Investment basic tech change #;

Coefficient

(parameter) (all,c,COM) SIGMA2(c) # Armington elasticities: investment #;

Read SIGMA2 from file BASEDATA header "2ARM";

Coefficient ! Source Shares in Flows at Purchaser's prices !

(all,c,COM)(all,i,IND) V2PUR_S(c,i) # Dom+imp investment purch. value #;

(all,c,COM)(all,s, SRC)(all,i,IND) S2(c,s,i) # Investment source shares #;

Zerodivide default 0.5;

Formula

(all,c,COM)(all,i,IND) V2PUR_S(c,i) = sum{s, SRC, V2PUR(c,s,i)};

(all,c,COM)(all,s,SRC)(all,i,IND) S2(c,s,i) = V2PUR(c,s,i) / V2PUR_S(c,i);
 Zerodivide off;

Equation E_x2 # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)(all,i,IND)
 $x2(c,s,i) - a2(c,s,i) - x2_s(c,i) = - \text{SIGMA2}(c) * [p2(c,s,i) + a2(c,s,i) - p2_s(c,i)];$

Equation E_p2_s # Effective price of commodity composite #
 (all,c,COM)(all,i,IND)
 $p2_s(c,i) = \text{sum}\{s, \text{SRC}, S2(c,s,i) * [p2(c,s,i) + a2(c,s,i)]\};$

! Investment top nest !
 !\$ X2TOT(i) = MIN(All,c,COM: X2_S(c,i)/[A2_S(c,s,i)*A2TOT(i)]) !

Variable
 (all,i,IND) a2tot(i) # Neutral technical change - investment #,
 (all,i,IND) p2tot(i) # Cost of unit of capital #,
 (all,i,IND) x2tot(i) # Investment by using industry #,
 (all,c,COM)(all,i,IND) a2_s(c,i) # Tech change, investment imp/dom composite #,
Coefficient (all,i,IND) V2TOT(i) # Total capital created for industry i #,
Formula (all,i,IND) V2TOT(i) = $\text{sum}\{c, \text{COM}, V2PUR_S(c,i)\};$
Equation
 $E_x2_s \text{ (all,c,COM)(all,i,IND) } x2_s(c,i) - [a2_s(c,i) + a2tot(i)] = x2tot(i);$
 $E_p2tot \text{ (all,i,IND) } V2TOT(i) * p2tot(i) = \text{sum}\{c, \text{COM}, V2PUR_S(c,i) * [p2_s(c,i) + a2_s(c,i) + a2tot(i)]\};$

! Excerpt 15 of TABLO input file: !
 ! Import/domestic composition of household demands !
 !\$ X3_S(c,i) = CES(All,s,SRC: X3(c,s)/A3(c,s)) !

Variable
 (all,c,COM)(all,s,SRC) a3(c,s) # Household basic taste change #,
 (all,c,COM) x3_s(c) # Household use of imp/dom composite #,
 (all,c,COM) p3_s(c) # Price, household imp/dom composite #,
Coefficient
 (parameter)(all,c,COM) SIGMA3(c) # Armington elasticities: households #,
 Read SIGMA3 from file BASEDATA header "3ARM";

Coefficient ! Source Shares in Flows at Purchaser's prices !
 (all,c,COM) V3PUR_S(c) # Dom+imp households purch. value #,
 (all,c,COM)(all,s,SRC) S3(c,s) # Household source shares #,
 Zerodivide default 0.5;
Formula
 (all,c,COM) V3PUR_S(c) = $\text{sum}\{s, \text{SRC}, V3PUR(c,s)\};$
 (all,c,COM)(all,s,SRC) S3(c,s) = $V3PUR(c,s) / V3PUR_S(c);$
 Zerodivide off;

Equation E_x3 # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)
 $x3(c,s) - a3(c,s) = x3_s(c) - \text{SIGMA}3(c) * [p3(c,s) + a3(c,s) - p3_s(c)]$;

Equation E_p3_s # Effective price of commodity composite #
 (all,c,COM) $p3_s(c) = \text{sum}\{s, \text{SRC}, S3(c,s) * [p3(c,s) + a3(c,s)]\}$;

! Excerpt 16 of TABLO input file: !

! Household demands for composite commodities !

Variable $p3_{tot}$ # Consumer price index #,
 $x3_{tot}$ # Real household consumption #,
 $w3_{lux}$ # Total nominal supernumerary household expenditure #,
 $w3_{tot}$ # Nominal total household consumption #,
 q # Number of households #,
 $utility$ # Utility per household #,
 (all,c,COM) $x3_{lux}(c)$ # Household - supernumerary demands #,
 (all,c,COM) $x3_{sub}(c)$ # Household - subsistence demands #,
 (all,c,COM) $a3_{lux}(c)$ # Taste change, supernumerary demands #,
 (all,c,COM) $a3_{sub}(c)$ # Taste change, subsistence demands #,
 (all,c,COM) $a3_s(c)$ # Taste change, household imp/dom composite #,
Coefficient
 $V3_{TOT}$ # Total purchases by households #,
 $FRISCH$ # Frisch LES 'parameter' = - (total/luxury) #,
 (all,c,COM) $EPS(c)$ # Household expenditure elasticities #,
 (all,c,COM) $S3_S(c)$ # Household average budget shares #,
 (all,c,COM) $B3_{LUX}(c)$ # Ratio, (supernumerary expenditure/total expenditure) #,
 (all,c,COM) $S3_{LUX}(c)$ # Marginal household budget shares #,
Read $FRISCH$ from file **BASEDATA** header "*P021*";
 EPS from file **BASEDATA** header "*XPEL*";
Update (change) $FRISCH = FRISCH * [w3_{tot} - w3_{lux}] / 100.0$;
 (change)(all,c,COM) $EPS(c) = EPS(c) * [x3_{lux}(c) - x3_s(c) + w3_{tot} - w3_{lux}] / 100.0$;
Formula
 $V3_{TOT} = \text{sum}\{c, \text{COM}, V3_{PUR_S}(c)\}$;
 (all,c,COM) $S3_S(c) = V3_{PUR_S}(c) / V3_{TOT}$;
 (all,c,COM) $B3_{LUX}(c) = -EPS(c) / FRISCH$;
 (all,c,COM) $S3_{LUX}(c) = EPS(c) * S3_S(c)$;
Write $S3_{LUX}$ to file **SUMMARY** header "*L SHR*";
 $S3_S$ to file **SUMMARY** header "*CSHR*";

Equation
 E_x3_{sub} # Subsistence demand for composite commodities #
 (all,c,COM) $x3_{sub}(c) = q + a3_{sub}(c)$;

E_x3_{lux} # Luxury demand for composite commodities #
 (all,c,COM) $x3_{lux}(c) + p3_s(c) = w3_{lux} + a3_{lux}(c)$;

E_x3_s # Total household demand for composite commodities #
 (all,c,COM) $x3_s(c) = B3_{LUX}(c) * x3_{lux}(c) + [1 - B3_{LUX}(c)] * x3_{sub}(c)$;

```

E_utility # Change in utility disregarding taste change terms #
utility + q = sum{c,COM, S3LUX(c)*x3lux(c)};

E_a3lux # Default setting for luxury taste shifter #
(all,c,COM) a3lux(c) = a3sub(c) - sum{k,COM, S3LUX(k)*a3sub(k)};

E_a3sub # Default setting for subsistence taste shifter #
(all,c,COM) a3sub(c) = a3_s(c) - sum{k,COM, S3_S(k)*a3_s(k)};

E_x3tot # Real consumption #
V3TOT*x3tot = sum{c,COM, sum{s,SRC, V3PUR(c,s)*x3(c,s)}};

E_p3tot # Consumer price index #
V3TOT*p3tot = sum{c,COM, sum{s,SRC, V3PUR(c,s)*p3(c,s)}};

E_w3tot # Household budget constraint: determines w3lux #
w3tot = x3tot + p3tot;

```

! Excerpt 17 of TABLO input file: !
! Export demands !

Coefficient

```

(parameter)(all,c,COM) IsIndivExp(c) # >0.5 For individual export commodities#;
Read IsIndivExp from file BASEDATA header "ITEX";
! This way of defining a set facilitates aggregation of the data base !
Set TRADEXP # Individual export commodities # = (all,c,COM: IsIndivExp(c)>0.5);
Write (Set) TRADEXP to file SUMMARY header "TEXP";

```

Variable

```

phi # Exchange rate, local currency/$world #;
(all,c,COM) f4p(c) # Price (upward) shift in export demand schedule #;
(all,c,COM) f4q(c) # Quantity (right) shift in export demands #;
Coefficient (parameter)(all,c,COM) EXP_ELAST(c)
# Export demand elasticities: typical value -5.0 #;
Read EXP_ELAST from file BASEDATA header "P018";
Equation E_x4A # Individual export demand functions #
(all,c,TRADEXP) x4(c) - f4q(c) = EXP_ELAST(c)*[p4(c) - phi - f4p(c)];

```

```

Set NTRADEXP # Collective Export Commodities # = COM - TRADEXP;
Write (Set) NTRADEXP to file SUMMARY header "NTXP";

```

Variable

```

x4_ntrad # Quantity, collective export aggregate #;
f4p_ntrad # Upward demand shift, collective export aggregate #;
f4q_ntrad # Right demand shift, collective export aggregate #;
p4_ntrad # Price, collective export aggregate #;

```

Coefficient V4NTRADEXP # Total collective export earnings #;

Formula V4NTRADEXP = sum{c,NTRADEXP, V4PUR(c)};

Equation E_X4B # Collective export demand functions #

(all,c,NTRADEXP) x4(c) - f4q(c) = x4_ntrad;

Equation E_p4_ntrad # Average price of collective exports #

[TINY+V4NTRADEXP]*p4_ntrad = sum{c,NTRADEXP, V4PUR(c)*p4(c)};

Coefficient (parameter) EXP_ELAST_NT # Collective export demand elasticity #;

Read EXP_ELAST_NT from file BASEDATA header "EXNT";

Equation E_x4_ntrad # Demand for collective export aggregate #

x4_ntrad - f4q_ntrad = EXP_ELAST_NT*[p4_ntrad - phi - f4p_ntrad];

! Excerpt 18 of TABLO input file: !

! Government and inventory demands !

Variable

f5tot # Overall shift term for government demands #;

f5tot2 # Ratio between f5tot and x3tot #;

(all,c,COM)(all,s,SRC) f5(c,s) # Government demand shift #;

(change) (all,c,COM)(all,s,SRC) fx6(c,s) # Shifter on rule for stocks #;

Equation

E_x5 # Government demands # (all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + f5tot;

E_f5tot # Overall government demands shift # f5tot = x3tot + f5tot2;

Coefficient (all,c,COM)(all,s,SRC) LEVP0(c,s) # Levels basic prices #;

Formula (initial) (all,c,COM)(all,s,SRC) LEVP0(c,s) = 1; *! arbitrary setting !*

Update (all,c,COM)(all,s,SRC) LEVP0(c,s) = p0(c,s);

Equation

E_delx6 # Stocks follow domestic output # (all,c,COM)(all,s,SRC)

100*LEVP0(c,s)*delx6(c,s) = V6BAS(c,s)*x0com(c) + fx6(c,s);

E_delV6 # Update formula for stocks # (all,c,COM)(all,s,SRC)

delV6(c,s) = 0.01*V6BAS(c,s)*p0(c,s) + LEVP0(c,s)*delx6(c,s);

! Excerpt 20 of TABLO input file: !

! Sales Aggregates !

Set DEST # Sale Categories #

(Interm, Invest, HouseH, Export, GovGE, Stocks);

Coefficient (all,c,COM)(all,s,SRC)(all,d,DEST) SALE(c,s,d) # Sales aggregates #;

Formula

(all,c,COM)(all,s,SRC) SALE(c,s,"Interm") = sum{i,IND, V1BAS(c,s,i)};

(all,c,COM)(all,s,SRC) SALE(c,s,"Invest") = sum{i,IND, V2BAS(c,s,i)};

(all,c,COM)(all,s,SRC) SALE(c,s,"HouseH") = V3BAS(c,s);

(all,c,COM) SALE(c,"dom","Export") = V4BAS(c);

(all,c,COM) SALE(c,"imp","Export") = 0;

(all,c,COM)(all,s,SRC) SALE(c,s,"GovGE") = V5BAS(c,s);
 (all,c,COM)(all,s,SRC) SALE(c,s,"Stocks") = V6BAS(c,s);

Write SALE to file SUMMARY header "SALE";

Coefficient (all,c,COM) V0IMP(c) # Total basic-value imports of good c #;
Formula (all,c,COM) V0IMP(c) = sum{d,DEST, SALE(c,"imp",d)};
Coefficient (all,c,COM) SALES(c) # Total sales of domestic commodities #;
Formula (all,c,COM) SALES(c) = sum{d,DEST, SALE(c,"dom",d)};
Coefficient (all,c,COM) DOMSALES(c) # Total sales to local market #;
Formula (all,c,COM) DOMSALES(c) = SALES(c) - V4BAS(c);

! Excerpt 21 of TABLO input file: !

! Market clearing equations !

Variable (change)

(all,c,COM)(all,s,SRC)(all,d,DEST) delSale(c,s,d) # Sales aggregates #;

Equation

E_delSaleA (all,c,COM)(all,s,SRC) delSale(c,s,"Interm") =
 0.01*sum{i,IND,V1BAS(c,s,i)*x1(c,s,i)};
 E_delSaleB (all,c,COM)(all,s,SRC) delSale(c,s,"Invest") =
 0.01*sum{i,IND,V2BAS(c,s,i)*x2(c,s,i)};
 E_delSaleC (all,c,COM)(all,s,SRC) delSale(c,s,"HouseH")=0.01*V3BAS(c,s)*x3(c,s);
 E_delSaleD (all,c,COM) delSale(c,"dom","Export")=0.01*V4BAS(c)*x4(c);
 E_delSaleE (all,c,COM) delSale(c,"imp","Export")= 0;
 E_delSaleF (all,c,COM)(all,s,SRC) delSale(c,s,"GovGE")=0.01*V5BAS(c,s)*x5(c,s);
 E_delSaleG (all,c,COM)(all,s,SRC) delSale(c,s,"Stocks") = LEVP0(c,s)*delx6(c,s);

Set LOCUSER # Non-export users #(Interm, Invest, HouseH, GovGE, Stocks);

Subset LOCUSER is subset of DEST;

Equation E_p0A # Supply = Demand for domestic commodities #

(all,c,COM) 0.01*[TINY+DOMSALES(c)]*x0dom(c) =sum{u,LOCUSER,delSale(c,"dom",u)};

Variable (all,c,COM) x0imp(c) # Total supplies of imported goods #;

Equation E_x0imp # Import volumes #

(all,c,COM) 0.01*[TINY+V0IMP(c)]*x0imp(c) = sum{u,LOCUSER,delSale(c,"imp",u)};

! Excerpt 22 of TABLO input file: !

! Purchasers prices !

Variable ! Powers of Commodity Taxes on Basic Flows !

(all,c,COM)(all,s,SRC)(all,i,IND) t1(c,s,i) # Power of tax on intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND) t2(c,s,i) # Power of tax on investment #;
 (all,c,COM)(all,s,SRC) t3(c,s) # Power of tax on household #;
 (all,c,COM) t4(c) # Power of tax on export #;
 (all,c,COM)(all,s,SRC) t5(c,s) # Power of tax on government #;

Equation E_p1 # Purchasers prices - producers #
 $(all,c,COM)(all,s,src)(all,i,IND)$
 $ID01[V1PUR(c,s,i)+TINY]*p1(c,s,i) =$
 $[V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ t1(c,s,i)];$

Equation E_p2 # Purchasers prices - capital creators #
 $(all,c,COM)(all,s,src)(all,i,IND)$
 $[V2PUR(c,s,i)+TINY]*p2(c,s,i) =$
 $[V2BAS(c,s,i)+V2TAX(c,s,i)]*[p0(c,s)+ t2(c,s,i)];$

Equation E_p3 # Purchasers prices - households #
 $(all,c,COM)(all,s,src)$
 $ID01[V3PUR(c,s)+TINY]*p3(c,s) =$
 $[V3BAS(c,s)+V3TAX(c,s)]*[p0(c,s)+ t3(c,s)];$

Equation E_p4 # Zero pure profits in exporting #
 (all,c,COM)
 $[V4PUR(c)+TINY]*p4(c) =$
 $[V4BAS(c)+V4TAX(c)]*[pe(c)+ t4(c)];$

! note that we refer to export taxes, not subsidies !

Equation E_p5 # Zero pure profits in distribution to government #
 $(all,c,COM)(all,s,src)$
 $[V5PUR(c,s)+TINY]*p5(c,s) =$
 $[V5BAS(c,s)+V5TAX(c,s)]*[p0(c,s)+ t5(c,s)];$

! alternate form

Equation E_p5q # Zero pure profits in distribution to government #
 $(all,c,COM)(all,s,src)$
 $[V5PUR(c,s)+TINY]*p5(c,s) =$
 $[V5BAS(c,s)+V5TAX(c,s)]*p0(c,s)$
 $+ 100*V5BAS(c,s)*delt5(c,s)$
 $+ sum\{m, MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)]\}; !$

! Excerpt 23 of TABLO input file: !

! Tax rate equations !

Variable

$f1tax_csi$ # Uniform % change in powers of taxes on intermediate usage #,
 $f2tax_csi$ # Uniform % change in powers of taxes on investment #,
 $f3tax_cs$ # Uniform % change in powers of taxes on household usage #,
 $f4tax_ntrad$ # Uniform % change in powers of taxes on nontradtnl exports #,
 $f4tax_trad$ # Uniform % change in powers of taxes on tradtnl exports #,
 $f5tax_cs$ # Uniform % change in powers of taxes on government usage #,
 $(all,c,COM) f0tax_s(c)$ # General sales tax shifter #,
 $(all,c,COM)(all,s,src)(all,i,IND) f1tax(c,s,i)$ # industry tax shifter #,
 $(all,c,COM)(all,s,src) f3tax(c,s)$ # Household tax shifter #,

f0tax_csi # overall tax shifter #,

! Add power of sales tax coming from carbon tax !

variable (all,c,ENR)(all,s,SRC)(all,i,IND) fuelp1tax(c,s,i)
power of sales tax: industry #,

variable (all,c,ENR)(all,s,SRC) fuelp3tax(c,s)
power of sales tax: household #,

Equation

E_t1a # Power of tax on sales to intermediate #
(all,c,NENR)(all,s,SRC)(all,i,IND) t1(c,s,i) = f0tax_s(c) + f1tax_csi
+ f1tax(c,s,i) + f0tax_csi;

E_t1b # Power of tax on sales to intermediate #
(all,c,ENR)(all,s,SRC)(all,i,IND) t1(c,s,i) = f0tax_s(c) + f1tax_csi
+ f1tax(c,s,i) + f0tax_csi
+ fuelp1tax(c,s,i);

E_t2 # Power of tax on sales to investment #
(all,c,COM)(all,s,SRC)(all,i,IND) t2(c,s,i) = f0tax_s(c) + f2tax_csi
+ f0tax_csi;

E_t3a # Power of tax on sales to households #
(all,c,NENR)(all,s,SRC) t3(c,s) = f0tax_s(c) + f3tax_cs
+ f3tax(c,s) + f0tax_csi;

E_t3b # Power of tax on sales to households #
(all,c,ENR)(all,s,SRC) t3(c,s) = f0tax_s(c) + f3tax_cs
+ f3tax(c,s) + f0tax_csi
+ fuelp3tax(c,s);

E_t4A # Power of tax on sales to individual exports #
(all,c,TRADEXP) t4(c) = f0tax_s(c) + f4tax_trad
+ f0tax_csi;

E_t4B # Power of tax on sales to collective exports #
(all,c,NTRADEXP) t4(c) = f0tax_s(c) + f4tax_ntrad
+ f0tax_csi;

E_t5 # Power of tax on sales to government #
(all,c,COM)(all,s,SRC) t5(c,s) = f0tax_s(c) + f5tax_cs
+ f0tax_csi;

! Excerpt 24 of TABLO input file: !

! Update formulae for commodity taxes !

Equation

E_deIV1TAX (all,c,COM)(all,s,SRC)(all,i,IND)
deIV1TAX(c,s,i) = 0.01*V1TAX(c,s,i)* [x1(c,s,i) + p0(c,s)] +

```

0.01*[V1BAS(c,s,i)+V1TAX(c,s,i)]*t1(c,s,i);
E_delV2TAX (all,c,COM)(all,s,SRC)(all,i,IND)
delV2TAX(c,s,i)= 0.01*V2TAX(c,s,i)* [x2(c,s,i) + p0(c,s)] +
0.01*[V2BAS(c,s,i)+V2TAX(c,s,i)]*t2(c,s,i);
E_delV3TAX (all,c,COM)(all,s,SRC)
delV3TAX(c,s) = 0.01*V3TAX(c,s)* [x3(c,s) + p0(c,s)] +
0.01*[V3BAS(c,s)+V3TAX(c,s)]*t3(c,s);
E_delV4TAX (all,c,COM)
delV4TAX(c) = 0.01*V4TAX(c)* [x4(c) + pe(c)] +
0.01*[V4BAS(c)+V4TAX(c)]*t4(c);
E_delV5TAX (all,c,COM)(all,s,SRC)
delV5TAX(c,s) = 0.01*V5TAX(c,s)*[x5(c,s) + p0(c,s)] +
0.01*[V5BAS(c,s)+V5TAX(c,s)]*t5(c,s);

```

! alternate form

```

E_delV5TAX (all,c,COM)(all,s,SRC)
delV5TAX(c,s) = 0.01*V5TAX(c,s)*[x5(c,s) + p0(c,s)] +
V5BAS(c,s)*delt5(c,s); !

```

! Excerpt 25 of TABLO input file: !

! Import prices and tariff revenue !

Variable

(all,c,COM) pf0cif(c) # C.I.F. foreign currency import prices #,
(all,c,COM) t0imp(c) # Power of tariff #,

Equation E_p0B # Zero pure profits in importing #

(all,c,COM) p0(c, "imp") = pf0cif(c) + phi + t0imp(c);

Equation E_delV0TAR (all,c,COM)

delV0TAR(c) = 0.01*V0TAR(c)*[x0imp(c)+pf0cif(c)+phi] + 0.01*V0IMP(c)*t0imp(c);

! Excerpt 26 of TABLO input file: !

! Indirect tax revenue aggregates !

Coefficient

V1TAX_CSI # Total intermediate tax revenue #,
V2TAX_CSI # Total investment tax revenue #,
V3TAX_CS # Total households tax revenue #,
V4TAX_C # Total export tax revenue #,
V5TAX_CS # Total government tax revenue #,
V0TAR_C # Total tariff revenue #,

Formula

V1TAX_CSI = sum{c,COM, sum{s,SRC, sum{i,IND, V1TAX(c,s,i)}}};
V2TAX_CSI = sum{c,COM, sum{s,SRC, sum{i,IND, V2TAX(c,s,i)}}};
V3TAX_CS = sum{c,COM, sum{s,SRC, V3TAX(c,s)}};
V4TAX_C = sum{c,COM, V4TAX(c)};
V5TAX_CS = sum{c,COM, sum{s,SRC, V5TAX(c,s)}};

$V0TAR_C = \text{sum}\{c, COM, V0TAR(c)\};$

Variable

(change) delV1tax_csi # Aggregate revenue from indirect taxes on intermediate #,
 (change) delV2tax_csi # Aggregate revenue from indirect taxes on investment #,
 (change) delV3tax_cs # Aggregate revenue from indirect taxes on households #,
 (change) delV4tax_c # Aggregate revenue from indirect taxes on export #,
 (change) delV5tax_cs # Aggregate revenue from indirect taxes on government #,
 (change) delV0tar_c # Aggregate tariff revenue #,

Equation

$E_delV1tax_csi \text{ delV1tax_csi} = \text{sum}\{c, COM, \text{sum}\{s, SRC, \text{sum}\{i, IND, delV1TAX(c, s, i)\}\}\};$
 $E_delV2tax_csi \text{ delV2tax_csi} = \text{sum}\{c, COM, \text{sum}\{s, SRC, \text{sum}\{i, IND, delV2TAX(c, s, i)\}\}\};$
 $E_delV3tax_cs \text{ delV3tax_cs} = \text{sum}\{c, COM, \text{sum}\{s, SRC, delV3TAX(c, s)\}\};$
 $E_delV4tax_c \text{ delV4tax_c} = \text{sum}\{c, COM, delV4TAX(c)\};$
 $E_delV5tax_cs \text{ delV5tax_cs} = \text{sum}\{c, COM, \text{sum}\{s, SRC, delV5TAX(c, s)\}\};$
 $E_delV0tar_c \text{ delV0tar_c} = \text{sum}\{c, COM, delV0TAR(c)\};$

! Excerpt 27 of TABLO input file: !

! Factor incomes and GDP !

Coefficient

V1CAP_I # Total payments to capital #,
 V1LAB_IO # Total payments to labour #,
 V1LND_I # Total payments to land #,
 V1PTX_I # Total production tax/subsidy #,
 V1OCT_I # Total other cost ticket payments #,
 V1PRIM_I # Total primary factor payments #,
 V0GDPINC # Nominal GDP from income side #,
 V0TAX_CSI # Total indirect tax revenue #,

Formula

$V1CAP_I = \text{sum}\{i, IND, V1CAP(i)\};$
 $V1LAB_IO = \text{sum}\{i, IND, V1LAB_O(i)\};$
 $V1LND_I = \text{sum}\{i, IND, V1LND(i)\};$
 $V1PTX_I = \text{sum}\{i, IND, V1PTX(i)\};$
 $V1OCT_I = \text{sum}\{i, IND, V1OCT(i)\};$
 $V1PRIM_I = V1LAB_IO + V1CAP_I + V1LND_I;$
 $V0TAX_CSI = V1TAX_CSI + V2TAX_CSI + V3TAX_CS + V4TAX_C + V5TAX_CS$
 $\quad + V0TAR_C + V1OCT_I + V1PTX_I;$
 $V0GDPINC = V1PRIM_I + V0TAX_CSI;$

Variable

w1lab_io # Aggregate payments to labour #,
 w1cap_i # Aggregate payments to capital #,
 w1lnd_i # Aggregate payments to land #,
 w1oct_i # Aggregate "other cost" ticket payments #,
 (change) delV1PTX_i # Ordinary change in all-industry production tax revenue #,
 (change) delV0tax_csi # Aggregate revenue from all indirect taxes #,

$w0tax_csi$ # Aggregate revenue from all indirect taxes #,
 $w0gdpinc$ # Nominal GDP from income side #,
Equation
 $E_w1lab_io \ V1LAB_IO * w1lab_io =$
 $\quad \text{sum}\{i, IND, \text{sum}\{o, OCC, V1LAB(i,o) * [x1lab(i,o) + p1lab(i,o)]\}\};$
 $E_w1cap_i \ V1CAP_I * w1cap_i = \text{sum}\{i, IND, V1CAP(i) * [x1cap(i) + p1cap(i)]\};$
 $E_w1lnd_i \ ID01[V1LND_I] * w1lnd_i = \text{sum}\{i, IND, V1LND(i) * [x1lnd(i) + p1lnd(i)]\};$
 $E_w1oct_i \ ID01[V1OCT_I] * w1oct_i = \text{sum}\{i, IND, V1OCT(i) * [x1oct(i) + p1oct(i)]\};$
 $E_delV1PTX_i \ delV1PTX_i = \text{sum}\{i, IND, delV1PTX(i)\};$
 $E_delV0tax_csi \ delV0tax_csi =$
 $\quad delV1tax_csi + delV2tax_csi + delV3tax_cs + delV4tax_c + delV5tax_cs$
 $\quad + delV0tar_c + delV1PTX_i + 0.01 * V1OCT_I * w1oct_i;$
 $E_w0tax_csi \ [TINY + V0TAX_CSI] * w0tax_csi = 100 * delV0tax_csi;$
 $E_w0gdpinc \ V0GDPINC * w0gdpinc =$
 $\quad V1LND_I * w1lnd_i + V1CAP_I * w1cap_i + V1LAB_IO * w1lab_io + 100 * delV0tax_csi;$

! Excerpt 28 of TABLO input file: !
! GDP expenditure aggregates !

Coefficient ! Expenditure Aggregates at Purchaser's Prices !

$(all, c, COM) \ V0CIF(c)$ # Total ex-duty imports of good c #,
 $V0CIF_C$ # Total local currency import costs, excluding tariffs #,
 $V0IMP_C$ # Total basic-value imports (includes tariffs) #,
 $V2TOT_I$ # Total investment usage #,
 $V4TOT$ # Total export earnings #,
 $V5TOT$ # Total value of government demands #,
 $V6TOT$ # Total value of inventories #,
 $V0GDPEXP$ # Nominal GDP from expenditure side #,

Formula

$(all, c, COM) \ V0CIF(c) = V0IMP(c) - V0TAR(c);$
 $V0CIF_C = \text{sum}\{c, COM, V0CIF(c)\};$
 $V0IMP_C = \text{sum}\{c, COM, V0IMP(c)\};$
 $V2TOT_I = \text{sum}\{i, IND, V2TOT(i)\};$
 $V4TOT = \text{sum}\{c, COM, V4PUR(c)\};$
 $V5TOT = \text{sum}\{c, COM, \text{sum}\{s, SRC, V5PUR(c,s)\}\};$
 $V6TOT = \text{sum}\{c, COM, \text{sum}\{s, SRC, V6BAS(c,s)\}\};$
 $V0GDPEXP = V3TOT + V2TOT_I + V5TOT + V6TOT + V4TOT - V0CIF_C;$

Variable

$x2tot_i$ # Aggregate real investment expenditure #,
 $p2tot_i$ # Aggregate investment price index #,
 $w2tot_i$ # Aggregate nominal investment #,

Equation

$E_x2tot_i \ V2TOT_I * x2tot_i = \text{sum}\{i, IND, V2TOT(i) * x2tot(i)\};$
 $E_p2tot_i \ V2TOT_I * p2tot_i = \text{sum}\{i, IND, V2TOT(i) * p2tot(i)\};$
 $E_w2tot_i \ w2tot_i = x2tot_i + p2tot_i;$

Variable

x4tot # Export volume index #,
p4tot # Exports price index, local currency #,
w4tot # Local currency border value of exports #,

Equation

E_x4tot $V4TOT \cdot x4tot = \text{sum}\{c, COM, V4PUR(c) \cdot x4(c)\};$
E_p4tot $V4TOT \cdot p4tot = \text{sum}\{c, COM, V4PUR(c) \cdot p4(c)\};$
E_w4tot $w4tot = x4tot + p4tot;$

Variable

x5tot # Aggregate real government demands #,
p5tot # Government price index #,
w5tot # Aggregate nominal value of government demands #,

Equation

E_x5tot $V5TOT \cdot x5tot = \text{sum}\{c, COM, \text{sum}\{s, SRC, V5PUR(c,s) \cdot x5(c,s)\}\};$
E_p5tot $V5TOT \cdot p5tot = \text{sum}\{c, COM, \text{sum}\{s, SRC, V5PUR(c,s) \cdot p5(c,s)\}\};$
E_w5tot $w5tot = x5tot + p5tot;$

Variable

x6tot # Aggregate real inventories #,
p6tot # Inventories price index #,
w6tot # Aggregate nominal value of inventories #,

Equation

E_x6tot $[TINY + V6TOT] \cdot x6tot = 100 \cdot \text{sum}\{c, COM, \text{sum}\{s, SRC, LEVP0(c,s) \cdot delx6(c,s)\}\};$
E_p6tot $[TINY + V6TOT] \cdot p6tot = \text{sum}\{c, COM, \text{sum}\{s, SRC, V6BAS(c,s) \cdot p0(c,s)\}\};$
E_w6tot $w6tot = x6tot + p6tot;$

Variable

x0cif_c # Import volume index, C.I.F. weights #,
p0cif_c # Imports price index, C.I.F., local currency #,
w0cif_c # C.I.F. local currency value of imports #,

Equation

E_x0cif_c $V0CIF_C \cdot x0cif_c = \text{sum}\{c, COM, V0CIF(c) \cdot x0imp(c)\};$
E_p0cif_c $V0CIF_C \cdot p0cif_c = \text{sum}\{c, COM, V0CIF(c) \cdot [\phi + pf0cif(c)]\};$
E_w0cif_c $w0cif_c = x0cif_c + p0cif_c;$

Variable

x0gdpexp # Real GDP from expenditure side #,
p0gdpexp # GDP price index, expenditure side #,
w0gdpexp # Nominal GDP from expenditure side #,

Equation

E_x0gdpexp $V0GDPEXP \cdot x0gdpexp = V3TOT \cdot x3tot + V2TOT_I \cdot x2tot_i + V5TOT \cdot x5tot$
 $+ V6TOT \cdot x6tot + V4TOT \cdot x4tot - V0CIF_C \cdot x0cif_c;$
E_p0gdpexp $V0GDPEXP \cdot p0gdpexp = V3TOT \cdot p3tot + V2TOT_I \cdot p2tot_i + V5TOT \cdot p5tot$
 $+ V6TOT \cdot p6tot + V4TOT \cdot p4tot - V0CIF_C \cdot p0cif_c;$
E_w0gdpexp $w0gdpexp = x0gdpexp + p0gdpexp;$

! Excerpt 29 of TABLO input file: !
! Trade balance and other indices !

Variable

(change) delB # (Balance of trade)/GDP #;
x0imp_c # Import volume index, duty-paid weights #;
w0imp_c # Value of imports plus duty #;
p0imp_c # Duty-paid imports price index, local currency #;
p0realdev # Real devaluation #;
p0toft # Terms of trade #;

Equation

E_delB 100*V0GDPEXP*delB=V4TOT*w4tot -V0CIF_C*w0cif_c-(V4TOT-V0CIF_C)*w0gdpexp;
E_x0imp_c V0IMP_C*x0imp_c = sum{c,COM, V0IMP(c)*x0imp(c)};
E_p0imp_c V0IMP_C*p0imp_c = sum{c,COM, V0IMP(c)*p0(c,"imp")};
E_w0imp_c w0imp_c = x0imp_c + p0imp_c;
E_p0toft p0toft = p4tot - p0cif_c;
E_p0realdev p0realdev = p0cif_c - p0gdpexp;

! Excerpt 30 of TABLO input file: !
! Primary factor aggregates !

Variable

(all,i,IND) employ(i) # Employment by industry #;
employ_i # Aggregate employment: wage bill weights #;
x1cap_i # Aggregate capital stock, rental weights #;
x1lnd_i # Aggregate land stock, rental weights #;
x1prim_i # Aggregate output: value-added weights #;
p1lab_io # Average nominal wage #;
realwage # Average real wage #;
p1cap_i # Average capital rental #;
p1lnd_i # Average land rental #;

Equation

E_employ (all,i,IND) V1LAB_O(i)*employ(i) = sum{o,OCC, V1LAB(i,o)*x1lab(i,o)};
E_employ_i V1LAB_IO*employ_i = sum{i,IND, V1LAB_O(i)*employ(i)};
E_x1cap_i V1CAP_I*x1cap_i = sum{i,IND, V1CAP(i)*x1cap(i)};
E_x1lnd_i ID01[V1LND_I]*x1lnd_i = sum{i,IND, V1LND(i)*x1lnd(i)};
E_x1prim_i V1PRIM_I*x1prim_i = sum{i,IND, V1PRIM(i)*x1tot(i)};
E_p1lab_io V1LAB_IO*p1lab_io = sum{i,IND, sum{o,OCC, V1LAB(i,o)*p1lab(i,o)}};
E_realwage realwage = p1lab_io - p3tot;
E_p1cap_i V1CAP_I*p1cap_i = sum{i,IND, V1CAP(i)*p1cap(i)};
E_p1lnd_i ID01[V1LND_I]*p1lnd_i = sum{i,IND, V1LND(i)*p1lnd(i)};

! Excerpt 31 of TABLO input file: !
! Investment equations !

Variable

(all,i,IND) ggro(i) # Gross growth rate of capital = Investment/capital #,
 (all,i,IND) gret(i) # Gross rate of return = Rental/[Price of new capital] #,

Equation

E_ggro (all,i,IND) ggro(i) = x2tot(i) - x1cap(i);
 E_gret (all,i,IND) gret(i) = p1cap(i) - p2tot(i);

! Three alternative rules for investment:

Choose which applies to each industry by setting JUST ONE of the corresponding elements of x2tot, finv1, finv2, or finv3 exogenous.

Iff aggregate investment x2tot_i is exogenous, invslack must be endogenous. !

Variable

(all,i,IND) finv1(i) # Shifter to enforce DPSV investment rule #,
 (all,i,IND) finv2(i) # Shifter for "exogenous" investment rule #,
 (all,i,IND) finv3(i) # Shifter for longrun investment rule #,
 invslack # Investment slack variable for exogenizing aggregate investment #,

! Rule 1: Follows Section 19 of DPSV. The ratios Q and G are treated as parameters, just as in the original ORANI implementation. Attempts to improve the theory by updating these parameters have been found to occasionally lead to perversely signed coefficients !

Equation E_finv1 # DPSV investment rule #

(all,i,IND) ggro(i) = finv1(i) + 0.33*[2.0*gret(i) - invslack];

! Note: above equation comes from substituting together DPSV equations 19.7-9. The value 0.33 and 2.0 correspond to the DPSV ratios [1/G.Beta] and Q (= ratio, gross to net rate of return) and are typical values of this ratio. In DPSV invslack was called "omega" and was interpreted as the "economy-wide rate of return" !

! Rule 2: For industries where investment is not mainly driven by current profits (eg, Education) make investment follow aggregate investment. !

Equation E_finv2 # Alternative rule for "exogenous" investment industries #

(all,i,IND) x2tot(i) = x2tot_i + finv2(i);

! NB: you must not set ALL of finv2 exogenous else above would conflict with Equation E_x2tot_i !

! Rule 3: longrun investment rule: investment/capital ratios are exogenous !

Equation E_finv3 # Alternative long-run investment rule #

(all,i,IND) ggro(i) = finv3(i) + invslack;

Variable f2tot # Ratio, investment/consumption #,

Equation E_f2tot x2tot_i = x3tot + f2tot;

! set f2tot exogenous and invslack endogenous to link aggregate investment to real consumption !

! Excerpt 32 of TABLO input file: !

! Labour market !

Variable

(all,i,IND)(all,o,OCC) f1lab(i,o) # Wage shift variable #,
 (all,o,OCC) f1lab_i(o) # Occupation-specific wage shifter #,
 (all,o,OCC) x1lab_i(o) # Employment by occupation #,
 (all,i,IND) f1lab_o(i) # Industry-specific wage shifter #,
 f1lab_io # Overall wage shifter #,

Coefficient (all,o,OCC) V1LAB_I(o) # Total wages, occupation o #,

Formula (all,o,OCC) V1LAB_I(o) = sum{i,IND, V1LAB(i,o)};

Equation

E_x1lab_i # Demand equals supply for labour of each skill #
 (all,o,OCC) V1LAB_I(o)*x1lab_i(o) = sum{i,IND, V1LAB(i,o)*x1lab(i,o)};

E_p1lab # Flexible setting of money wages #

(all,i,IND)(all,o,OCC)
 p1lab(i,o)= p3tot + f1lab_io + f1lab_o(i) + f1lab_i(o) + f1lab(i,o);

! Excerpt 33 of TABLO input file: !

! Miscellaneous equations !

Variable (all,i,IND) f1oct(i) # Shift in price of "other cost" tickets #,

Equation E_p1oct # Indexing of prices of "other cost" tickets #

(all,i,IND) p1oct(i) = p3tot + f1oct(i); *! assumes full indexation !*

Variable f3tot # Ratio, consumption/ GDP #,

Equation E_f3tot # Consumption function #

w3tot = w0gdpexp + f3tot ;

! Map between vector and matrix forms of basic price variables !

Variable

(all,c,COM) p0imp(c) # Basic price of imported goods = p0(c,"imp") #,

Equation E_p0dom # Basic price of domestic goods = p0(c,"dom") #

(all,c,COM) p0dom(c) = p0(c,"dom");

Equation E_p0imp # Basic price of imported goods = p0(c,"imp") #

(all,c,COM) p0imp(c) = p0(c,"imp");

! Excerpt 34 of TABLO input file: !

! Decomposition of sales change by destination !

Coefficient

(all,c,COM) INITSALES(c) # Initial volume of SALES at current prices #,

Formula

(initial) (all,c,COM) INITSALES(c) = SALES(c);

Update (all,c,COM) INITSALES(c) = p0com(c);

Set DESTPLUS # Sale Categories #

(Interm, Invest, HouseH, Export, GovGE, Stocks, Total);

Subset DEST is subset of DESTPLUS;

Variable (change)

(all,c,COM)(all,d,DESTPLUS) SalesDecomp(c,d) # Sales decomposition #;

Equation

E_SalesDecompA

(all,c,COM)(all,d,DEST) INITSALES(c)*SalesDecomp(c,d) = 100*delSale(c,"dom",d);

E_SalesDecompB

(all,c,COM) SalesDecomp(c,"Total")= sum{d,DEST, SalesDecomp(c,d)};

! Excerpt 35 of TABLO input file: !

! Decomposition of Fan !

Set FANCAT # Parts of Fan decomposition #

(LocalMarket, DomShare, Export, Total);

Variable

(all,c,COM) x0loc(c) # Real percent change in LOCSALES (dom+imp) #;

(change)(all,c,COM)(all,f,FANCAT) fandecomp(c,f) # Fan decomposition #;

Coefficient (all,c,COM) LOCSALES(c) # Total local sales of dom + imp good c #;

Formula (all,c,COM) LOCSALES(c) = DOMSALES(c) + V0IMP(c);

Equation

E_x0loc # %Growth in local market #

(all,c,COM) LOCSALES(c)*x0loc(c) = DOMSALES(c)*x0dom(c) + V0IMP(c)*x0imp(c);

E_fandecompA # Growth in local market effect #

(all,c,COM) INITSALES(c)*fandecomp(c,"LocalMarket") = DOMSALES(c)*x0loc(c);

! The local market effect is the % change in output that would have occurred

if local sales of the domestic product had followed dom+imp sales (x0loc) !

E_fandecompB # Export effect #

(all,c,COM) INITSALES(c)*fandecomp(c,"Export") = V4BAS(c)*x4(c);

E_fandecompC # Import leakage effect - via residual #

(all,c,COM) fandecomp(c,"Total") = fandecomp(c,"LocalMarket")
+ fandecomp(c,"DomShare") + fandecomp(c,"Export");

E_fandecompD # Fan total = x0com #

(all,c,COM) INITSALES(c)*fandecomp(c,"Total") = SALES(c)*x0com(c);

! Excerpt 36 of TABLO input file: !

! GDP decomposition !

Set EXPMAC # Expenditure Aggregates #

(Consumption, Investment, Government, Stocks, Exports, Imports);

Variable (change) (all,e,EXPAC)

contGDPexp(e) # Contributions to real expenditure-side GDP #;

Coefficient INITGDP # Initial real GDP at current prices #;

Formula (initial) INITGDP = V0GDPEXP;

Update INITGDP = p0gdpexp;

Equation

E_contGDPexpA INITGDP*contGDPexp("Consumption") = V3TOT*x3tot;
E_contGDPexpB INITGDP*contGDPexp("Investment") = V2TOT_I*x2tot_i;
E_contGDPexpC INITGDP*contGDPexp("Government") = V5TOT*x5tot;
E_contGDPexpD INITGDP*contGDPexp("Stocks") = V6TOT*x6tot;
E_contGDPexpE INITGDP*contGDPexp("Exports") = V4TOT*x4tot;
E_contGDPexpF INITGDP*contGDPexp("Imports") = - V0CIF_C*x0cif_c;

Variable (change) contBOT # Contribution of BOT to real expenditure-side GDP #;

Equation E_contBOT contBOT = contGDPexp("Exports") + contGDPexp("Imports");

! Excerpt 37 of TABLO input file: !

! Check identities !

Coefficient *! coefficients for checking !*

(all,i,IND) DIFFIND(i) # COSTS-MAKE_C : should be zero #;

(all,c,COM) DIFFCOM(c) # SALES-MAKE_I : should be zero #;

EPSTOT # Average Engel elasticity: should = 1 #;

Formula

(all,i,IND) DIFFIND(i) = V1TOT(i) - MAKE_C(i);

(all,c,COM) DIFFCOM(c) = SALES(c) - MAKE_I(c);

EPSTOT = sum{c,COM, S3_S(c)*EPS(c)};

Write ! we file these numbers BEFORE the assertions below !

DIFFIND to file SUMMARY header "DIND";

DIFFCOM to file SUMMARY header "DCOM";

EPSTOT to file SUMMARY header "ETOT";

Assertion ! if below not true, program will stop with message !

DIFFIND = V1TOT-MAKE_C = tiny # (all,i,IND) ABS(DIFFIND(i)/V1TOT(i)) <0.01;

DIFFCOM = SALES-MAKE_I = tiny # (all,c,COM) ABS(DIFFCOM(c)/SALES(c)) <0.01;

(initial) # Average Engel elasticity = 1 # ABS(1-EPSTOT) <0.05;

! Excerpt 38 of TABLO input file: !

! Summary: components of GDP from income and expenditure sides !

Coefficient (all,e,EXPMAC) EXPGDP(e) # Expenditure Aggregates #;

Formula

EXPGDP("Consumption") = V3TOT;

EXPGDP("Investment") = V2TOT_I;

EXPGDP("Government") = V5TOT;

EXPGDP("Stocks") = V6TOT;

EXPGDP("Exports") = V4TOT;

EXPGDP("Imports") = -V0CIF_C;

Write EXPGDP to file SUMMARY header "EMAC";

Set INCMAC # *Income Aggregates* #
 (Land, Labour, Capital, IndirectTax);
Coefficient (all,i,INCMAC) INCGDP(i) # *Income Aggregates* #,
Formula
 INCGDP("Land") = V1LND_I;
 INCGDP("Labour") = V1LAB_IO;
 INCGDP("Capital") = V1CAP_I;
 INCGDP("IndirectTax") = V0TAX_CSI;
Write INCGDP to file SUMMARY header "IMAC";

Set TAXMAC # *Tax Aggregates* #
 (Intermediate,Investment,Consumption,Exports,Government,OCT,ProdTax,Tariff);
Coefficient (all,t,TAXMAC) TAX(t) # *Tax Aggregates* #,
Formula
 TAX("Intermediate") = V1TAX_CSI;
 TAX("Investment") = V2TAX_CSI;
 TAX("Consumption") = V3TAX_CS;
 TAX("Exports") = V4TAX_C;
 TAX("Government") = V5TAX_CS;
 TAX("OCT") = V1OCT_I;
 TAX("ProdTax") = V1PTX_I;
 TAX("Tariff") = V0TAR_C;
Write TAX to file SUMMARY header "TMAC";

! Excerpt 39 of TABLO input file: !
! Summary: matrix of industry costs !

Set COSTCAT # *Cost Categories* #
 (IntDom, Intlmp,ComTax, Lab, Cap, Lnd, ProdTax, OCT);
Coefficient (all,i,IND)(all,co,COSTCAT) COSTMAT(i,co) # *Cost Matrix* #,
Formula
 (all,i,IND) COSTMAT(i,"IntDom") = sum{c,COM, V1BAS(c,"dom",i)};
 (all,i,IND) COSTMAT(i,"Intlmp") = sum{c,COM, V1BAS(c,"imp",i)};
 (all,i,IND) COSTMAT(i,"ComTax") = sum{c,COM, sum{s,SRC, V1TAX(c,s,i)}};
 (all,i,IND) COSTMAT(i,"Lab") = V1LAB_O(i);
 (all,i,IND) COSTMAT(i,"Cap") = V1CAP(i);
 (all,i,IND) COSTMAT(i,"Lnd") = V1LND(i);
 (all,i,IND) COSTMAT(i,"ProdTax") = V1PTX(i);
 (all,i,IND) COSTMAT(i,"OCT") = V1OCT(i);
Write COSTMAT to file SUMMARY header "CSTM";

! Excerpt 40 of TABLO input file: !
! Summary: basic and taxes !

Set
SALECAT2 # *SALE Categories* # (Interm, Invest, HouseH, Export, GovGE, Stocks);
FLOWTYPE # *Type of flow* # (Basic, TAX);
Coefficient

(all,c,COM)(all,f,FLOWTYPE)(all,s,SRC)(all,sa,SALECAT2) SALEMAT2(c,f,s,sa)
Basic and tax components of purchasers' values

Formula

(all,c,COM)(all,f,FLOWTYPE)(all,s,SRC)(all,sa,SALECAT2) SALEMAT2(c,f,s,sa)=0;
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Interm") = sum{i,IND,V1BAS(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax" ,s,"Interm") = sum{i,IND,V1TAX(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Invest") = sum{i,IND,V2BAS(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax" ,s,"Invest") = sum{i,IND,V2TAX(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"HouseH") = V3BAS(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax" ,s,"HouseH") = V3TAX(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"GovGE") = V5BAS(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax" ,s,"GovGE") = V5TAX(c,s);
(all,c,COM) SALEMAT2(c,"Basic","dom","Export") = V4BAS(c);
(all,c,COM) SALEMAT2(c,"Tax" ,"dom","Export") = V4TAX(c);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Stocks") = V6BAS(c,s);

Write SALEMAT2 to file SUMMARY header "MKUP";

! Excerpt 41 of TABLO input file: !

! Import shares and short-run supply elasticities !

Coefficient (all,c,COM) IMPSHR(c) # Share of imports in local market #;

Formula (all,c,COM) IMPSHR(c) = V0IMP(c)/[TINY+DOMSALES(c)+V0IMP(c)];

Write IMPSHR to file SUMMARY header "MSHR";

Coefficient (all,i,IND) SUPPLYELAST(i) # Short-run supply elasticity #;

Zerodivide default 999;

Formula (all,i,IND) SUPPLYELAST(i) =

SIGMA1PRIM(i)*V1LAB_O(i)*V1CST(i)/[V1PRIM(i)*{V1CAP(i)+V1LND(i)}];

Zerodivide off;

Write SUPPLYELAST to file SUMMARY header "SRSE";

! Excerpt 42 of TABLO input file: !

! Weight vectors for use in aggregation and other calculations !

Coefficient (all,c,COM) V1PUR_SI(c) # Dom+imp intermediate purch. value #;

(all,c,COM) V2PUR_SI(c) # Dom+imp investment purch. value #;

(all,c,COM) V5PUR_S(c) # Dom+imp government purch. value #;

(all,c,COM) V6BAS_S(c) # Dom+imp inventories #;

Formula (all,c,COM) V1PUR_SI(c) = sum{i,IND, V1PUR_S(c,i)};

(all,c,COM) V2PUR_SI(c) = sum{i,IND, V2PUR_S(c,i)};

(all,c,COM) V5PUR_S(c) = sum{s,SRC, V5PUR(c,s)};

(all,c,COM) V6BAS_S(c) = sum{s,SRC, V6BAS(c,s)};

Write

V1TOT to file SUMMARY header "1TOT";

V2TOT to file SUMMARY header "2TOT";

V1PUR_SI to file SUMMARY header "1PUR";

V2PUR_SI to file SUMMARY header "2PUR";
V3PUR_S to file SUMMARY header "3PUR";
V4PUR to file SUMMARY header "4PUR";
V5PUR_S to file SUMMARY header "5PUR";
V6BAS_S to file SUMMARY header "6BSS";
V1LAB_O to file SUMMARY header "LAB1";
V1CAP to file SUMMARY header "1CAP";
V1PRIM to file SUMMARY header "VLAD";

Coefficient (all,c,COM) TARFRATE(c) # Ad valorem tariff rate #;
Formula (all,c,COM) TARFRATE(c) = V0TAR(c)/[TINY+V0CIF(c)];

Write

TARFRATE to file SUMMARY header "TRAT";
V0TAR to file SUMMARY header "0TAR";
V0CIF to file SUMMARY header "0CIF";
V0IMP to file SUMMARY header "0IMP";

*!***** Beginning of Modification *****!*
!Additions to ORANIGNM.TAB!
*!*****!*
!Dynamic Extension!

*!*****!*
*!**** Capital Accumulation Mechanism ****!*
!This year, capital grows by amount equal
to investment last year less depreciation!

Coefficient

(parameter) (all,i,IND) DPRC(i) #Rates of Depreciation (i.e. 0.08)#;
(all,i,IND) CAPSTOK(i) #Current capstok measured in current prices#;

Read

CAPSTOK from file BASEDATA header "STOK";
DPRC from file BASEDATA header "DPRC";

Write

CAPSTOK to file SUMMARY header "STOK"; *!for aggregation weights!*

Update

(all,i,IND) CAPSTOK(i) = x1cap(i)*p2tot(i);

Coefficient *!both of the 2 below are measured in last year price units!*

(parameter) (all,i,IND)

CAPADD(i) # Addition to CAPSTOK from last year investment #;
(all,i,IND) CAPSTOK_OLDP(i) # Current capstok measured in last years prices #;

Formula

(initial)(all,i,IND) CAPADD(i)=V2TOT(i)-DPRC(i)*CAPSTOK(i); *!not updated!*

(initial)(all,i,IND) CAPSTOK_OLDP(i)=CAPSTOK(i);

Update

(all,i,IND) CAPSTOK_OLDP(i)=x1cap(i);

Variable

(all,i,IND) faccum(i) # Shifter to switch on accumulation equation #;

(change) delUnity # Dummy variable, always exogenously set to one #;

Equation E_faccum # Capital accumulation equation #

(all,i,IND) 0.01*CAPSTOK_OLDP(i)*x1cap(i)=CAPADD(i)*delUnity +faccum(i);

Note: When above equation is active,

faccum is exogenous and zero; delUnity is shocked to 1.0.

Then RHS (like LHS) is the change in capital stock from last year investment

both LHS and RHS are measured at start-of-period prices

to swidch off, put faccum endogenous; delUnity is exogenous but unshocked!

Coefficient (all,i,IND) RNORMAL(i) # Normal gross rate of return (SET AS 0.1) #;

Variable (all,i,IND) rnorm(i) # Normal gross rate of return #;

Read RNORMAL from file BASEDATA header "TARG";

Update (all,i,IND) RNORMAL(i)=rnorm(i);

Coefficient (all,i,IND) GROTREND(i) # Trend investment/capital ratio #;

Variable (all,i,IND) gtrend(i) # Trend investment/capital ratio #;

Read GROTREND from file BASEDATA header "TFRO";

Update (all,i,IND) GROTREND(i)=gtrend(i);

Coefficient

(parameter)(all,i,IND) QRATIO(i) # (Max/trend) investment/capital ratio:i.e 4 #;

Read QRATIO from file BASEDATA header "QRAT";

Coefficient (parameter)(all,i,IND) ALPHA(i) # Investment elasticity #;

Read ALPHA from file BASEDATA header "ALFA";

Coefficient (all,i,IND) GROMAX(i) # Maximum investment/capital ratio #;

Formula (all,i,IND) GROMAX(i)=QRATIO(i)*GROTREND(i);

Coefficient (all,i,IND) GROSSRET(i) # PK/PI #;

Formula (all,i,IND) GROSSRET(i)=V1CAP(i)/CAPSTOK(i);

Coefficient (parameter)(all,i,IND) GROSSRET0(i) # Initial PK/PI #;

Formula (initial) (all,i,IND) GROSSRET0(i)=GROSSRET(i);

Variable

(change) (all,i,IND) delgret(i) # Ordinary change in gross rate of return #;

Equation E_delgret # Gross rate of return #

(all,i,IND) delgret(i)=0.01*GROSSRET(i)*[p1cap(i)-p2tot(i)];

Coefficient (all,i,IND) GROSSGRO(i) # Investment/capital ratio #;

Formula (all,i,IND) GROSSGRO(i)=V2TOT(i)/CAPSTOK(i);

Variable


```

(all,i,IND) gro(i) # Planned investment/capital ratio #;
(all,i,IND) finv4(i) # Shifter to toggle long run investment rule #;
Equation E_finv4 # Planned investment/capital ratio #
(all,i,IND) gro(i)=x2tot(i)-x1cap(i)+finv4(i);

```

Coefficient (all,i,IND) GRETEXP(i) # Expected gross rate of return #;

Variable

(change) (all,i,IND) delgretextp(i) # Ordinary change in expected rate of return#;

Read GRETEXP from file BASEDATA header "REXP";

Update (change)(all,i,IND) GRETEXP(i) = delgretextp(i);

![[following alternative system calculates GRETEXP
! next part avoids error from raising negative number to a power !
Coefficient (all,i,IND) DENOM(i) # denominator in GRETEXP formula #;
Formula (all,i,IND) DENOM(i) = [GROMAX(i)/GROSSGRO(i)]-1.0;
Formula (all,i,IND: DENOM(i) LE 0) DENOM(i) = 0.001;
Formula (all,i,IND) GRETEXP(i)=RNORMAL(i)*
([QRATIO(i)-1.0]/DENOM(i))^[1.0/ALPHA(i)]; !]]!

Coefficient

(parameter)(all,i,IND) GRETEXP0(i) # Initial expected gross rate of return #;

Formula (initial) (all,i,IND) GRETEXP0(i)=GRETEXP(i);

Variable

(all,i,IND) gretxp(i) # Percent change in expected rate of return #;

(all,i,IND) mratio(i) # Ratio, (expected/normal) rate of return #;

Equation E_mratio # Ratio,(expected/normal) rate of return #

(all,i,IND) mratio(i)=gretxp(i)-rnorm(i);

Equation E_gretxp # Percent change in expected rate of return #

(all,i,IND) delgretextp(i)=0.01*GRETEXP(i)*gretxp(i);

Equation E_delgretextp # Partial adjustment of expected rate of return #

(all,i,IND) delgretextp(i)
= 0.33*[{GROSSRET0(i)-GRETEXP0(i)}*delUnity +delgret(i)];

Equation E_gro # Planned investment/capital ratio #

(all,i,IND) gro(i)=gtrend(i) + invslack
! endogenous invslack if aggregate investment is exogenous !
+ ALPHA(i)*[1.0-(GROSSGRO(i)/GROMAX(i))]*mratio(i);

!*****!
!Compute and store on summary file
various numbers for diagnostic purposes!

Coefficient

```
(all,i,IND) VALRAT(i) # V1CAP/V2TOT#;  
(all,i,IND) NETGRO(i) # Net capital growth rate #;  
(all,i,IND) NETRET(i) # Net rate of return #;  
(all,i,IND) ISEXOGINV(i) # 1 If in EXOGINV set else 0 #;
```

Formula

```
(all,i,IND) VALRAT(i)= V1CAP(i)/V2TOT(i);  
(all,i,IND) NETGRO(i)= GROSSGRO(i)-DPRC(i);  
(all,i,IND) NETRET(i)= GROSSRET(i)-DPRC(i);  
(all,i,IND) ISEXOGINV(i)=0;  
(all,i,IND) ISEXOGINV(i)=1;
```

Set

```
CAPFACTS # Useful numbers for dynamic extension #  
(CAPSTOK, V2TOT, V1CAP, CAPADD, RNORMAL, GRETEXP, QRATIO,  
GROTREND, DPRC, EXOG, VALRAT, GROSSGRO, NETGRO, GROSSRET, NETRET);
```

Coefficient

```
(all,i,IND) (all,c,CAPFACTS) CAPFACT(i,c);
```

Formula

```
(all,i,IND) (all,c,CAPFACTS) CAPFACT(i,c)=0;  
(all,i,IND) CAPFACT(i,"CAPSTOK")=CAPSTOK(i);  
(all,i,IND) CAPFACT(i,"V2TOT")=V2TOT(i);  
(all,i,IND) CAPFACT(i,"V1CAP")=V1CAP(i);  
(all,i,IND) CAPFACT(i,"CAPADD")=CAPADD(i);  
(all,i,IND) CAPFACT(i,"RNORMAL")=100*RNORMAL(i);  
(all,i,IND) CAPFACT(i,"GRETEXP")=100*GRETEXP(i);  
(all,i,IND) CAPFACT(i,"QRATIO")=QRATIO(i);  
(all,i,IND) CAPFACT(i,"GROTREND")=100*GROTREND(i);  
(all,i,IND) CAPFACT(i,"DPRC")=100*DPRC(i);  
(all,i,IND) CAPFACT(i,"EXOG")=ISEXOGINV(i);  
(all,i,IND) CAPFACT(i,"VALRAT")=100*VALRAT(i);  
(all,i,IND) CAPFACT(i,"GROSSGRO")=100*GROSSGRO(i);  
(all,i,IND) CAPFACT(i,"NETGRO")=100*NETGRO(i);  
(all,i,IND) CAPFACT(i,"GROSSRET")=100*GROSSRET(i);  
(all,i,IND) CAPFACT(i,"NETRET")=100*NETRET(i);
```

Write CAPFACT to file SUMMARY header "CFAC"

longname "useful numbers for dynamic extension";

Write GROSSGRO to file SUMMARY header "GGRO"

longname "gross growth rate";

!compute some aggregates!

Coefficient CAPSTOK_i # Agg K #;

Formula CAPSTOK_i=SUM{i,IND,CAPSTOK(i)};

Coefficient CAPSTOK1_i # Next period agg K #;

Formula CAPSTOK1_i=CAPSTOK_i+SUM{i,IND,CAPADD(i)};

Coefficient GROSSGRO_i # Z #;

Formula GROSSGRO_i=V2TOT_I/CAPSTOK_i;

Coefficient NETGRO_i # Z #;

Formula NETGRO_i=(CAPSTOK1_i/CAPSTOK_i)-1.0;

Coefficient DPRC_i # Agg K. PI #;

Formula DPRC_i=GROSSGRO_i-NETGRO_i;

Coefficient GROSSRET_i # Z #;

Formula GROSSRET_i=V1CAP_I/CAPSTOK_i;

Coefficient NETRET_i # Z #;

Formula NETRET_i=GROSSRET_i-DPRC_i;

Coefficient

(all,c,CAPFACTS) CAPFACT_I(c);

Formula

(all,c,CAPFACTS) CAPFACT_I(c)=0;

CAPFACT_I("CAPSTOK")=CAPSTOK_i;

CAPFACT_I("V2TOT")=V2TOT_I;

CAPFACT_I("V1CAP")=V1CAP_I;

CAPFACT_I("CAPADD")=SUM{i,IND,CAPADD(i)};

CAPFACT_I("DPRC")=DPRC_i;

CAPFACT_I("VALRAT")=V1CAP_I/V2TOT_I;

CAPFACT_I("GROSSGRO")=GROSSGRO_i;

CAPFACT_I("NETGRO")=NETGRO_i;

CAPFACT_I("GROSSRET")=GROSSRET_i;

CAPFACT_I("NETRET")=NETRET_i;

Write CAPFACT_I to file SUMMARY header "CFCI"

longname "useful macros for dynamic extension";

*!***** real wage adjustment mechanism *****!*

Variable emptrend # Trend employment #;

Variable (change)

delempratio # Ordinary change in (actual/trend) employment #;

Coefficient

EMPRAT # (Actual/trend) employment:i.e in steady state => 1 #;

Read EMPRAT from file BASEDATA header "EMPR";

Update (change) EMPRAT=delempratio;
Coefficient (parameter) EMPRAT0 # Initial (actual/trend) employment #,
Formula (initial) EMPRAT0=EMPRAT;
Equation E_delempratio # Ordinary change in (actual/trend) employment #
delempratio=0.01*EMPRAT*[employ_i-emptrend];

Variable (change) delwagerate # Change in real wage index #,
Coefficient WAGERATE # Index of real wages #,
Formula (initial) WAGERATE=1.0; *!index is rebased each period!*
Update (change) WAGERATE=delwagerate;
Equation E_delwagerate # Change in real wage index #
delwagerate=0.01*WAGERATE*realwage;

Coefficient (parameter) ELASTWAGE # Elasticity of wage to employment:i.e. 0.5 #,
Read ELASTWAGE from file BASEDATA header "ELWG";

Variable (change) delfwage # Shifter for real wage adjustment mechanism #,
Equation E_delfwage # Real wage adjustment mechanism #
delfwage=delwage+ELASTWAGE*{[EMPRAT0-1.0]*delUnity+delempratio};

!To use, set delfwage exogenous and shock emptrend by labour force growth rate. Both the real wage and employment are endogenous. The final equation then works an upward sloping labour supply schedule, which continually moves to the right (up) as long as actual employment exceeds trend.
To switch off, set delfwage endogenous and exogenize either the real wage or employment.!
*!**** End of real wage adjustment mechanism ****!*
*!**** End of Capital Accumulation Mechanism ****!*

!end of addition!

*!******
*!***** End of Modification ******
*!******

! additional stuffs !
! decomposition of nominal change in GDP !
set DELGDP COM (CONS, INVES, STOCK, GOVT, TRAD, TOTAL);
variable (change)
(all,i,DELGDP COM) delGDP(i) # Nominal Change in GDP Decomposition #,
equation
e_delGDP1 delGDP("CONS") = 0.01*V3TOT*w3tot;
e_delGDP2 delGDP("INVES") = 0.01*V2TOT_I*w2tot_i;
e_delGDP3 delGDP("STOCK") = 0.01*V6TOT*w6tot;
e_delGDP4 delGDP("GOVT") = 0.01*V5TOT*w5tot;
e_delGDP5 delGDP("TRAD") = 0.01*[V4TOT*w4tot - V0CIF_C*w0cif_c];

$e_delGDP6 \text{ delGDP}("TOTAL") = 0.01 * V0GDPEXP * w0gdpexp;$

Variable

(all,c,COM) $p5_s(c)$ # Composite government price #;
 (all,c,COM) $p0pur_dom(c)$ # Average purchasers price domestic c #;
 (all,c,COM) $p0pur_imp(c)$ # Average purchasers price imported c #;
 (all,c,COM) $p0pur_src(c)$ # Average purchasers price dom/imp c #;
 (all,c,COM) $p3pur_dom(c)$ # Average HH purchasers price domestic c #;
 (all,c,COM) $p3pur_imp(c)$ # Average HH purchasers price imported c #;
 (all,c,COM) $p3pur_src(c)$ # Average HH purchasers price dom/imp c #;

Coefficient

(all,c,COM)(all,s,SRC) $V0PUR(c,s)$ # Local purchases #;
 (all,c,COM) $V0PUR_s(c)$ # Local purchases #;

formula

(all,c,COM)(all,s,SRC)
 $V0PUR(c,s) = \text{sum}\{i, IND, V1PUR(c,s,i) + V2PUR(c,s,i) + V3PUR(c,s) + V5PUR(c,s);\}$
 (all,c,COM) $V0PUR_s(c) = \text{sum}\{s, SRC, V0PUR(c,s);\}$;

equation

$e_p5_s(\text{all},c,COM) \text{ ID01}[V5PUR_S(c)] * p5_s(c) = \text{sum}\{s, SRC, V5PUR(c,s) * p5(c,s);\}$;
 $e_p0pur_dom(\text{all},c,COM) \text{ ID01}[V0PUR(c, "dom")] * p0pur_dom(c)$
 $= \text{sum}\{i, IND, V1PUR(c, "dom", i) * p1(c, "dom", i) + V2PUR(c, "dom", i) * p2(c, "dom", i)\}$
 $+ V3PUR(c, "dom") * p3(c, "dom") + V5PUR(c, "dom") * p5(c, "dom");$

$e_p0pur_imp(\text{all},c,COM) \text{ ID01}[V0PUR(c, "imp")] * p0pur_imp(c)$
 $= \text{sum}\{i, IND, V1PUR(c, "imp", i) * p1(c, "imp", i) + V2PUR(c, "imp", i) * p2(c, "imp", i)\}$
 $+ V3PUR(c, "imp") * p3(c, "imp") + V5PUR(c, "imp") * p5(c, "imp");$

$e_p0pur_src(\text{all},c,COM) \text{ ID01}[V0PUR_S(c)] * p0pur_src(c)$
 $= \text{sum}\{i, IND, V1PUR_S(c,i) * p1_s(c,i) + V2PUR_S(c,i) * p2_s(c,i)\}$
 $+ V3PUR_S(c) * p3_s(c) + V5PUR_S(c) * p5_s(c);$

$e_p3pur_dom(\text{all},c,COM) \text{ ID01}[V3PUR(c, "dom")] * p3pur_dom(c)$
 $= V3PUR(c, "dom") * p3(c, "dom");$

$e_p3pur_imp(\text{all},c,COM) \text{ ID01}[V3PUR(c, "imp")] * p3pur_imp(c)$
 $= V3PUR(c, "imp") * p3(c, "imp");$

$e_p3pur_src(\text{all},c,COM) \text{ ID01}[V3PUR_S(c)] * p3pur_src(c)$
 $= V3PUR_S(c) * p3_s(c);$

! Carbon emissions and carbon taxation !

! CO2 EMISSION !

set HH (Household); **set** FUS = IND + HH;

coefficient (all,f,ENR)(all,s,SRC)(all,u,FUS) CO2(f,s,u);
read CO2 from file BASEDATA header "CO2";
variable
(all,f,ENR)(all,s,SRC)(all,u,FUS) xco2(f,s,u);
update
(all,f,ENR)(all,s,SRC)(all,u,FUS) CO2(f,s,u) = xco2(f,s,u);

Equation

E_xco2_1 # CO2 emission by industry #
(all,f,ENR)(all,s,SRC)(all,i,IND) xco2(f,s,i) = x1(f,s,i);
E_xco2_3 # CO2 emission by households #
(all,f,ENR)(all,s,SRC)xco2(f,s,"Household") = x3(f,s);

variable

(all,f,ENR) xco2f(f) # co2 emission by ENR #,
xco2_tot # total co2 emission #;

Equation

E_xco2f (all,f,ENR) [tiny + sum{s, SRC, sum{u, FUS, CO2(f,s,u)}}] * xco2f(f) =
sum{s, SRC, sum{u, FUS, CO2(f,s,u)*xco2(f,s,u)}};
E_xco2_tot ID01[sum{s, SRC, sum{f, ENR, sum{u, FUS, CO2(f,s,u)}}}] *
xco2_tot = sum{s, SRC, sum{f, ENR, sum{u, FUS, CO2(f,s,u)*xco2(f,s,u)}}};

! Price to which CO2 tax is indexed !

Coefficient

ENERINDEX # Price to which gas tax is indexed #;

Variable

co2taxindex # Price to which gas tax is indexed #,
Read ENERINDEX from file BASEDATA header "ENDX";
Update
ENERINDEX = co2taxindex;

! Specific rate of gas tax !

Coefficient

(all,f,ENR)(all,s,SRC)(all,u,FUS)
ETAXRATE(f,s,u) # Specific rate of carbon tax #;

Variable

(change)(all,f,ENR)(all,s,SRC)(all,u,FUS)
delco2tax(f,s,u) # Specific tax on emissions #,
Read ETAXRATE from file BASEDATA header "ETXR";
Update
(change)(all,f,ENR)(all,s,SRC)(all,u,FUS)
ETAXRATE(f,s,u) = delco2tax(f,s,u);

Coefficient

(all,f,ENR)(all,s,SRC)(all,u,FUS)
ETAX(f,s,u) # Revenue from new CO2 tax #;

Read ETAX from file BASEDATA header "ETAX";

Update

```
(change)(all,f,ENR)(all,s,SRC)(all,u,FUS)
ETAX(f,s,u)= ENERINDEX*CO2(f,s,u)*delco2tax(f,s,u)
+ ETAX(f,s,u)*0.01*[xco2(f,s,u)+co2taxindex];
```

! Indexed emissions per dollar of use - combustion emissions !

! Data for the ratio EI/PQ (indexed emissions per dollar of use) for emissions from fuel used by users !

Coefficient

```
(all,f,ENR)(all,s,SRC)(all,u,FUS)
EIOVERPQ(f,s,u) # Indexed emissions per dollar of use #,
Read EIOVERPQ from file BASEDATA header "EIPQ";
Update
(change)(all,f,ENR)(all,s,SRC)(all,i,IND)
EIOVERPQ(f,s,i) = 0.01*EIOVERPQ(f,s,i)*
{xco2(f,s,i) + co2taxindex - [x1(f,s,i)+p0(f,s)]};
(change)(all,f,ENR)(all,s,SRC)
EIOVERPQ(f,s,"Household") = 0.01*EIOVERPQ(f,s,"Household")*
{xco2(f,s,"Household") + co2taxindex - [x3(f,s)+p0(f,s)]};
```

Variable

(change)deletaxrv # Ordinary change in energy tax revenue #,

Equation

```
E_deletaxrv
deletaxrv =
sum{f,ENR, sum{s,SRC, sum {u,FUS,
ENERINDEX*CO2(f,s,u)*delco2tax(f,s,u)
+ ETAX(f,s,u)*0.01*[xco2(f,s,u)+co2taxindex]}}};
```

Variable

```
(change)(all,f,ENR)(all,u,FUS)
delco2tax_s(f,u) # Specific tax on emissions by fuel type and FUS #,
(change) delco2tax_a;
```

Equation

```
E_delco2tax
(all,f,ENR)(all,s,SRC)(all,u,FUS)
delco2tax(f,s,u) = delco2tax_s(f,u)+delco2tax_a;
```

! The following equations express the change in the specific tax on emissions as a change in the ad valorem rate of tax
delV = ... + S.E.I/[P.Q][e+i-p-q] + 100.E.I/[P.Q].delS !*

variable

```
(change)(all,c,ENR)(all,s,SRC)(all,i,IND) fueltax1(c,s,i)
# Ad valorem equivalent of specific fuel tax rate, user 1 #,
```

(change)(all,c,ENR)(all,s,SRC) fueltax3(c,s)
 # Ad valorem equivalent of specific fuel tax rate, user 3 #;

Equation

E_fueltax1 # AV equivalent of specific fuel tax rate user industry #

(all,c,ENR)(all,s,SRC)(all,i,IND)
 fueltax1(c,s,i) = EIOVERPQ(c,s,i)*{
 ETAXRATE(c,s,i)*[xco2(c,s,i)+co2taxindex -x1(c,s,i)-p0(c,s)]
 +100*delco2tax(c,s,i)};

E_fueltax3 # AV equivalent of specific fuel tax rate user households #

(all,c,ENR)(all,s,SRC)
 fueltax3(c,s) = EIOVERPQ(c,s,"Household")*{
 ETAXRATE(c,s,"Household")*[xco2(c,s,"Household")+co2taxindex
 -x3(c,s)-p0(c,s)] +100*delco2tax(c,s,"Household")};

E_co2taxindex co2taxindex = p3tot;

! End of carbon emission and carbon taxation !

! Translate advalorem energy tax into power of sales tax !

!coefficient (all,e,ENR)(all,s,SRC)(all,u,FUS) ENRSTAX(e,s,u)
 # Revenue from energy sales tax #;
 read ENRSTAX from file BASEDATA header "ESTX";!

Equation e_fuelp1tax (all,c,ENR)(all,s,SRC)(all,i,IND) fuelp1tax(c,s,i) =
 [V1BAS(c,s,i)/(ID01(V1BAS(c,s,i)+ETAX(c,s,i)))]*fueltax1(c,s,i);

Equation e_fuelp3tax (all,c,ENR)(all,s,SRC) fuelp3tax(c,s) =
 [V3BAS(c,s)/(ID01(V3BAS(c,s)+ETAX(c,s,"Household")))]*fueltax3(c,s);

!

coefficient (all,c,ENR)(all,s,SRC)(all,u,FUS) ENRSTAXRT(c,s,u)
 # rate of sales tax of energy #;

formula (all,c,ENR)(all,s,SRC)(all,u,IND) ENRSTAXRT(c,s,u)
 = ETAX(c,s,u)/V1BAS(c,s,u);

formula (all,c,ENR)(all,s,SRC) ENRSTAXRT(c,s,"Household")
 = ETAX(c,s,"Household")/V3BAS(c,s);

!

!

update

(change) (all,c,ENR)(all,s,SRC)(all,i,IND) ENRSTAX(c,s,i) =
 ENRSTAXRT(c,s,i)*0.01*V1BAS(c,s,i)*[p0(c,s)+x1(c,s,i)]
 + 0.01*V1BAS(c,s,i)*fueltax1(c,s,i);

(change) (all,c,ENR)(all,s,SRC) ENRSTAX(c,s,"Household") =
 ENRSTAXRT(c,s,"Household")*0.01*V3BAS(c,s)*[p0(c,s)+x3(c,s)]
 + 0.01*V3BAS(c,s)*fueltax3(c,s);

!

variable

x0ener # energy consumption #,

x0enerint # energy intensity #,

coefficient TOTENER # total energy consumption #,

formula TOTENER = $\sum\{i, IND, \sum\{f, ENR, \sum\{s, SRC, V1BAS(f, s, i)\}\}$
+ $\sum\{f, ENR, \sum\{s, SRC, V3BAS(f, s)\}\}$;

equation e_x0ener # energy consumption #

TOTENER*x0ener = $\sum\{i, IND, \sum\{f, ENR, \sum\{s, SRC, V1BAS(f, s, i)*x1(f, s, i)\}\}$
+ $\sum\{f, ENR, \sum\{s, SRC, V3BAS(f, s)*x3(f, s)\}\}$;

equation e_x0enerint x0enerint = x0ener - x0gdpxp;

!set BBMSUB (GASOL, KERO, HSDO, LPGSUB); subset BBMSUB is subset of COM;!

set BBMSUB (GASOL, KERO, HSDO); **subset** BBMSUB is subset of COM;

coefficient VSUBBBM # total subsidy BBM #,

formula VSUBBBM = $\sum\{s, SRC, \sum\{i, IND, \sum\{b, BBMSUB, V1TAX(b, s, i)\}\}$
+ $\sum\{b, BBMSUB, V3TAX(b, s)\}\}$;

write VSUBBBM to file SUMMARY header "SBBM";

!variable wfuelsub # total fuel subsidy #;!

variable

(change) delFUELSUB # change in total fuel subsidy #,

!equation e_wfuelsub wfuelsub = 100[1/VSUBBBM]**
sum{s, SRC, sum{i, IND, sum{b, BBMSUB, delV1TAX(b, s, i)}}}
+ sum{s, SRC, sum{b, BBMSUB, delV3TAX(b, s)}};!

equation e_delFUELSUB delFUELSUB =
 $\sum\{s, SRC, \sum\{i, IND, \sum\{b, BBMSUB, delV1TAX(b, s, i)\}\}$
+ $\sum\{s, SRC, \sum\{b, BBMSUB, delV3TAX(b, s)\}\}$;

! average subsidy rate !

coefficient FSUBRATE # average fuel subsidy rate #,

formula FSUBRATE = VSUBBBM/ $\sum\{s, SRC, \sum\{i, IND, \sum\{b, BBMSUB, V1BAS(b, s, i)\}\}$
+ $\sum\{b, BBMSUB, V3BAS(b, s)\}\}$;

write FSUBRATE to file SUMMARY header "FSRT";

set EBT # Energy terbarukan # (GEO, BIOPRE, HIDRO);

subset EBT is subset of ENR;

coefficient TOTEBT # total renewable energy consumption #,

formula TOTEBT = $\sum\{i, IND, \sum\{f, EBT, \sum\{s, SRC, V1BAS(f, s, i)\}\}$
+ $\sum\{f, EBT, \sum\{s, SRC, V3BAS(f, s)\}\}$;

variable x0ebt # consumption of renewable energy #,

equation e_x0ebt # energy consumption #

TOTEBT*x0ebt = $\sum\{i, IND, \sum\{f, EBT, \sum\{s, SRC, V1BAS(f, s, i)*x1(f, s, i)\}\}$

```

+ sum{f,EBT,sum{s,SRC,V3BAS(f,s)*x3(f,s)}};

set OIL # oil types # (GASOL, KERO, HSDO, NSUBBBM, LPGSUB, LPGNSUB, OTHREF);
subset OIL is subset of ENR;
coefficient TOTOIL # total oil energy consumption #;
formula TOTOIL = sum{i,IND,sum{f,OIL,sum{s,SRC,V1BAS(f,s,i)}}}
+ sum{f,OIL,sum{s,SRC,V3BAS(f,s)}};

variable x0oil # consumption of renewable energy #;
equation e_x0oil # energy consumption #
TOTOIL*x0oil = sum{i,IND,sum{f,OIL,sum{s,SRC,V1BAS(f,s,i)*x1(f,s,i)}}}
+ sum{f,OIL,sum{s,SRC,V3BAS(f,s)*x3(f,s)}};

set COALS # oil types # (COAL);
subset COALS is subset of ENR;
coefficient TOTCOALS # total oil energy consumption #;
formula TOTCOALS = sum{i,IND,sum{f,COALS,sum{s,SRC,V1BAS(f,s,i)}}}
+ sum{f,COALS,sum{s,SRC,V3BAS(f,s)}};

variable x0coals # consumption of renewable energy #;
equation e_x0coals # energy consumption #
TOTCOALS*x0coals = sum{i,IND,sum{f,COALS,sum{s,SRC,V1BAS(f,s,i)*x1(f,s,i)}}}
+ sum{f,COALS,sum{s,SRC,V3BAS(f,s)*x3(f,s)}};

set GASES # oil types # (GAS, GASKOTA);
subset GASES is subset of ENR;
coefficient TOTGASES # total gas energy consumption #;
formula TOTGASES = sum{i,IND,sum{f,GASES,sum{s,SRC,V1BAS(f,s,i)}}}
+ sum{f,GASES,sum{s,SRC,V3BAS(f,s)}};

variable x0gases # consumption of renewable energy #;
equation e_x0gases # energy consumption #
TOTGASES*x0gases = sum{i,IND,sum{f,GASES,sum{s,SRC,V1BAS(f,s,i)*x1(f,s,i)}}}
+ sum{f,GASES,sum{s,SRC,V3BAS(f,s)*x3(f,s)}};

set EMIX # energy mix # (COAL, OIL, GAS, EBT);
variable (all,c,EMIX) x0emix(c) # energy mix #;
equation
e_x0emix1 x0emix("COAL") = x0coals;
e_x0emix2 x0emix("OIL") = x0oil;
e_x0emix3 x0emix("GAS") = x0gases;
e_x0emix4 x0emix("EBT") = x0ebt;

![[[
! ----- SAM Extension ----- !
set NLABOR # non labor factors # (Capital, Land);
set FACTOR # all primary factors # = NLABOR + OCC;

```

```

coefficient (all,f,FACTOR) V1FACINC(f) # Factor income #;
formula
V1FACINC("Capital") = sum{i,IND,V1CAP(i)};
V1FACINC("Land") = sum{i,IND,V1LND(i)};
(all,o,OCC) V1FACINC(o) = sum{i,IND,V1LAB(i,o)};
write V1FACINC to file SUMMARY header "1FIN";

set INST # Institution # (Household, Corporate, Government, RoW);
coefficient (all,i,FACTOR)(all,i,INST) V0FACINC(f,i) # institution fac. inc. #;
read V0FACINC from file BASEDATA header "0FAC";
variable (all,f,FACTOR)(all,i,INST) w0facinc(f,i) # institution fac. inc. #;
update (all,f,FACTOR)(all,i,INST) V0FACINC(f,i) = w0facinc(f,i);
coefficient (all,i,INST)(all,n,INST) V0TRNINC(i,n) # inter-inst-transfers inc #;
read V0TRNINC from file BASEDATA header "0TRN";
variable (all,i,INST)(all,n,INST) w0trninc(i,n) # inter-inst-transfers inc #;
update (all,i,INST)(all,n,INST) V0TRNINC(i,n) = w0trninc(i,n);

coefficient (all,i,INST) V0TOTINC(i) # total income institutions #;
formula
V0TOTINC("Household") = sum{f,FACTOR,V0FACINC(f,"Household")}
+ sum{n,INST,V0TRNINC("Household",n)};

V0TOTINC("Government") = sum{f,FACTOR,V0FACINC(f,"Government")}
+ sum{n,INST,V0TRNINC("Government",n)} + V0TAX_CSI;

V0TOTINC("Corporate") = sum{f,FACTOR,V0FACINC(f,"Corporate")}
+ sum{n,INST,V0TRNINC("Corporate",n)};

V0TOTINC("RoW") = sum{f,FACTOR,V0FACINC(f,"RoW")}
+ sum{n,INST,V0TRNINC("RoW",n)} + V0CIF_C;

variable (all,f,FACTOR) w1facinc(f) # total factor income #;
equation
e_w1facinc1 # capital income # w1facinc("Capital") = w1cap_i;
e_w1facinc2 # land income # w1facinc("Land") = w1lnd_i;
e_w1facinc3 # labor income # (all,o,OCC)
ID01[sum{i,IND,V1LAB(i,o)}*w1facinc(o)
= sum{i,IND,V1LAB(i,o)*[x1lab(i,o)+p1lab(i,o)}];

e_w0facinc (all,f,FACTOR)(all,i,INST) w0facinc(f,i) = w1facinc(f);

variable (all,i,INST) w0totinc(i) # total income institution #;
equation
e_w0totinc1 # total income - household #
V0TOTINC("Household")*w0totinc("Household") =
sum{f,FACTOR,V0FACINC(f,"Household")*w0facinc(f,"Household")}

```

```

+ sum{n,INST,V0TRNINC("Household",n)*w0trninc("Household",n)};

e_w0totinc2 # total income - Government #
V0TOTINC("Government")*w0totinc("Government") =
  sum{f,FACTOR,V0FACINC(f,"Government")*w0facinc(f,"Government")}
+ sum{n,INST,V0TRNINC("Government",n)*w0trninc("Government",n)}
+ V0TAX_CSI*w0tax_csi;

e_w0totinc3 # total income - Corporate #
V0TOTINC("Corporate")*w0totinc("Corporate") =
  sum{f,FACTOR,V0FACINC(f,"Corporate")*w0facinc(f,"Corporate")}
+ sum{n,INST,V0TRNINC("Corporate",n)*w0trninc("Corporate",n)};

e_w0totinc4 # total income - RoW #
V0TOTINC("RoW")*w0totinc("RoW") =
  sum{f,FACTOR,V0FACINC(f,"RoW")*w0facinc(f,"RoW")}
+ sum{n,INST,V0TRNINC("RoW",n)*w0trninc("RoW",n)}
+ V0CIF_C*w0cif_c;

variable (all,i,INST)(all,n,INST) f0totinc(i,n) # shifter transfers #;
equation
e_w0trninc # transfer institution # (all,i,INST)(all,n,INST)
  w0trninc(i,n) = w0totinc(n) + f0totinc(i,n);

coefficient (all,i,INST) V0TOTEXP(i) # instituion expenditure, excl. saving #;
formula
V0TOTEXP("Household") = V3TOT + sum{n,INST,V0TRNINC(n,"Household")};
V0TOTEXP("Government") = V5TOT + sum{n,INST,V0TRNINC(n,"Government")};
V0TOTEXP("Corporate") = sum{n,INST,V0TRNINC(n,"Corporate")};
V0TOTEXP("Row") = V4TOT + sum{n,INST,V0TRNINC(n,"RoW")};

coefficient (all,i,INST) V0SAVING(i) # institution's saving #;
formula (all,i,INST) V0SAVING(i) = V0TOTINC(i) - V0TOTEXP(i);
write V0SAVING to file SUMMARY header "0SAV";

coefficient V0INVEST # total investment #;
formula V0INVEST = V2TOT_I + V6TOT;
write V0INVEST to file SUMMARY header "0INV";

variable (all,i,INST) w0totexp(i) # institution expenditure, excl. saving #;
equation
e_w0totexp1 # household expenditure, excl. saving #
  V0TOTEXP("Household")*w0totexp("Household") = V3TOT*w3tot
  + sum{n,INST,V0TRNINC(n,"Household")*w0trninc(n,"Household")};

e_w0totexp2 # Government expenditure, excl. saving #
  V0TOTEXP("Government")*w0totexp("Government") = V5TOT*w5tot

```

```

+ sum{n,INST,V0TRNINC(n,"Government")*w0trninc(n,"Government")});

e_w0totexp3 # Corporate expenditure, excl. saving #
V0TOTEXP("Corporate")*w0totexp("Corporate") =
sum{n,INST,V0TRNINC(n,"Corporate")*w0trninc(n,"Corporate")});

e_w0totexp4 # RoW expenditure, excl. saving #
V0TOTEXP("Row")*w0totexp("RoW") = V4TOT*w4tot
+ sum{n,INST,V0TRNINC(n,"RoW")*w0trninc(n,"RoW")});

coefficient V0HDISINC # household disposable income #;
formula V0HDISINC = V0TOTINC("Household") - sum{n,INST,V0TRNINC(n,"Household")};
variable w0hdisinc # household disposable income #;
equation e_w0hdisinc # household disposable income #
V0HDISINC*w0hdisinc = V0TOTINC("Household")*w0totinc("Household")
- sum{n,INST,V0TRNINC(n,"Household")*w0trninc(n,"Household")};

!Variable f3tot # Ratio, consumption/ GDP #;
Equation E_f3tot # Consumption function #
w3tot = w0gdpexp + f3tot ;!
Variable f3tot # average propensity to consume/saving rate #;
Equation E_f3tot # Consumption function #
w3tot = f3tot + w0hdisinc;

variable
(change) (all,i,INST) del0SAV(i) # institutions' saving #;
(change) del0SAV_I # total saving #;
(change) del0INV # total investment #;
(all,i,INST) w0sav(i) # instituion's saving #;

set HOU (Household); subset HOU is subset of INST; set NHH = INST - HOU;
equation
e_w0sav1 w0sav("Household") = w0hdisinc;
e_w0sav2 (all,i,NHH) w0sav(i) = w0totinc(i);
! e_delSAV (all,i,INST) 100*del0SAV(i) = V0TOTINC(i)*w0totinc(i)
- V0TOTEXP(i)*w0totexp(i);!
e_delSAV (all,i,INST) del0SAV(i) = 0.01*[V0TOTINC(i)-V0TOTEXP(i)]*w0sav(i);
e_delSAV_I del0SAV_I = sum{i,INST,del0SAV(i)};
e_del0INV 100*del0INV = V2TOT_I*w2tot_i + V6TOT*w6tot;

!]]!

Variable
x0gdpinc # Real GDP from the income side #;
continctax # Tax part of income side real GDP decomposition #;
continctech # Tech change part of income side real GDP decomposition #;
Equation E_x0gdpinc # Decomposition of real GDP from income side #

```

```
x0gdpinc = [V1LAB_IO/V0GDPINC]*employ_i + [V1CAP_I/V0GDPINC]*x1cap_i
            + [V1LND_I/V0GDPINC]*x1lnd_i + continctax + continctech;
```

```
E_continctax continctax =
    sum{i,IND, [V1OCT(i)/V0GDPINC]*x1oct(i)}
  + sum{i,IND, [V1PTX(i)/V0GDPINC]*x1tot(i)}
  + sum{c,COM, [V0TAR(c)/V0GDPINC]*x0imp(c)}
  + sum{c,COM,sum{s,SRC, sum{i,IND, [V1TAX(c,s,i)/V0GDPINC]*x1(c,s,i)}}}
  + sum{c,COM,sum{s,SRC, sum{i,IND, [V2TAX(c,s,i)/V0GDPINC]*x2(c,s,i)}}}
  + sum{c,COM,sum{s,SRC, [V3TAX(c,s)/V0GDPINC]*x3(c,s)}}
  + sum{c,COM, [V4TAX(c)/V0GDPINC]*x4(c)}
  + sum{c,COM,sum{s,SRC, [V5TAX(c,s)/V0GDPINC]*x5(c,s)}};
```

```
E_continctech continctech =
-sum{c,COM,sum{s,SRC, sum{i,IND,[V1PUR(c,s,i)/V0GDPINC]*[a1(c,s,i)+a1_s(c,i)]}}}
-sum{c,COM,sum{s,SRC, sum{i,IND,[V2PUR(c,s,i)/V0GDPINC]*[a2(c,s,i)+a2_s(c,i)]}}}
-sum{i,IND,[V1LAB_O(i)/V0GDPINC]*a1lab_o(i)}
-sum{i,IND,[V1CAP(i)/V0GDPINC]*a1cap(i)}
-sum{i,IND,[V1LND(i)/V0GDPINC]*a1lnd(i)}
-sum{i,IND,[V1OCT(i)/V0GDPINC]*a1oct(i)}
-sum{i,IND,[V1PRIM(i)/V0GDPINC]*a1prim(i)}
-sum{i,IND,[V2TOT(i)/V0GDPINC]*a2tot(i)}
-sum{i,IND,[V1CST(i)/V0GDPINC]*a1tot(i)};
```

! Land in hectare !

```
coefficient NFORAREA # Natural forest/ uncultivated land #,
read NFORAREA from file BASEDATA header "NFOR";
```

```
coefficient (all,i,IND)LANDAREA(i) # land area in 000 Ha #,
read LANDAREA from file BASEDATA header "AREA";
```

```
variable
(change) (all,i,IND) delLANDAREA(i) # change in land area in 000 Ha #,
```

```
equation
e_delLANDAREA (all,i,IND)
delLANDAREA(i) = 0.01*LANDAREA(i)*x1lnd(i);
```

```
update (change) (all,i,IND)LANDAREA(i) = delLANDAREA(i);
```

```
variable (change) delNFORAREA # Change in uncultivated land #,
equation e_delNFORAREA delNFORAREA =-0.01*sum{i,IND,LANDAREA(i)}*x1lnd_i;
```

```
update (change) NFORAREA = delNFORAREA;
```

!

```

equation e_p1lndrall # price of composite land = market clearing for land #
sum{i,IND,LANDAREA(i)*x1lnd(i)} = sum{i,IND,LANDAREA(i)*x1lnd_i;
!
!carbon emission calculation of land cultivation !
coefficient(parameter) (all,i,IND)CSTOCK(i) # TCO2 Stock per Ha #,
read CSTOCK from file BASEDATA header "CSTK",
coefficient(parameter) NCSTOCK # natural forest TCO2 Stock per Ha #,
read NCSTOCK from file BASEDATA header "CSTN",
Coefficient CO2F # Baseline Total CO2 Emissions from Land Use Change (WRI) #,
read CO2F from file BASEDATA header "CO2F",

variable(change) delXCO2LUSE # carbon emissions from land use change #,
variable xco2luse # carbon emissions from land use change #,

equation e_delXCO2LUSE delXCO2LUSE =
    -(1000/1000000)*[NCSTOCK*delINFORAREA
    + sum{i,IND,CSTOCK(i)*delLANDAREA(i)}];
equation e_xco2luse xco2luse = (100/CO2F)*delXCO2LUSE;
update(change) CO2F = delXCO2LUSE;

```

Appendix B Impact on Sectors Output for Scenario A1 in percentage

1. Food Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-0.8074	0.8061	2.05352	3.16932	4.14829	4.89671	5.40618	5.72219	5.9145	6.04701	6.14268	6.20004	6.22732	6.24482
x1tot(OTHCROPS)	0.59717	2.90115	4.53756	5.97315	7.27323	8.30513	9.02269	9.46077	9.71033	9.8734	9.98948	10.051	10.062	10.0506
x1tot(LSTOCK)	-8.7066	-8.3358	-8.1495	-8.0624	-8.0207	-8.016	-8.0253	-8.0291	-8.0202	-8.0043	-7.9902	-7.9814	-7.9765	-7.9745
x1tot(FOREST)	-4.0648	-4.0871	-4.06	-3.0672	-1.7908	-1.1341	-1.1157	-1.4051	-1.5483	-1.3136	-0.949	-0.7447	-0.746	-0.8271
x1tot(FISH)	-3.1352	-2.7931	-2.5821	-2.0921	-1.4454	-0.9668	-0.7444	-0.7046	-0.7111	-0.6557	-0.5421	-0.4428	-0.3999	-0.4018
x1tot(METAL)	-0.4541	-1.1078	-2.0241	-2.864	-3.4242	-3.5905	-3.3735	-2.8953	-2.3265	-1.8118	-1.4262	-1.1829	-1.0631	-1.0389
x1tot(COAL)	-0.2613	-0.4671	-0.8059	-1.1926	-1.5674	-1.865	-2.0472	-2.1149	-2.0968	-2.0244	-1.9125	-1.7652	-1.5903	-1.4043
x1tot(MINYAK)	-0.1118	-0.2517	-0.4511	-0.7084	-1.0037	-1.2832	-1.5037	-1.6519	-1.7398	-1.7854	-1.7951	-1.7676	-1.707	-1.6264
x1tot(GAS)	-0.0705	-0.2078	-0.3938	-0.6307	-0.8972	-1.1351	-1.298	-1.3714	-1.3682	-1.3088	-1.2029	-1.0543	-0.8744	-0.6859
x1tot(GEO)	-0.623	-2.5372	-5.0614	-7.0774	-7.8138	-7.1353	-5.5717	-3.8932	-2.7088	-2.2659	-2.4631	-3.0141	-3.6201	-4.0704
x1tot(OTHMIN)	-3.4318	-3.0335	-1.6998	-0.3506	0.46457	0.73363	0.74711	0.74695	0.83134	0.96289	1.07033	1.14142	1.21063	1.29982
x1tot(FOODPROC)	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
x1tot(TEXTILE)	-6.0583	-5.0179	-5.0563	-5.458	-5.8224	-6.0589	-6.1947	-6.2742	-6.3177	-6.3135	-6.2576	-6.1712	-6.0808	-6.0019
x1tot(WOOD)	-4.8558	-4.7012	-5.3704	-4.6071	-3.0325	-2.0658	-1.9512	-2.3513	-2.6058	-2.2907	-1.746	-1.4427	-1.4878	-1.6915
x1tot(PMI)	-5.0864	-4.1043	-3.8181	-3.7625	-3.7242	-3.6544	-3.5322	-3.3624	-3.1561	-2.9233	-2.6908	-2.4873	-2.326	-2.2065
x1tot(CHEMIC)	-6.0329	-4.8272	-4.296	-3.9955	-3.7408	-3.5177	-3.3158	-3.1322	-2.9601	-2.7893	-2.6325	-2.512	-2.4342	-2.3895
x1tot(BIOETHA)	-1.4669	-1.5405	-0.57	0.42049	0.91534	0.99962	0.97418	1.03098	1.20026	1.38743	1.51141	1.58906	1.67724	1.79811
x1tot(BIODIES)	-53.337	-54.907	-56.232	-57.35	-58.192	-58.793	-59.252	-59.649	-60.028	-60.389	-60.708	-60.968	-61.17	-61.328
x1tot(OTHREF)	-1.7787	-1.2121	-1.0166	-0.9373	-0.8635	-0.7604	-0.6071	-0.4027	-0.1567	0.12057	0.41262	0.69903	0.96185	1.18711
x1tot(GASOL)	-3.0054	-2.7832	-2.1852	-1.6625	-1.402	-1.3024	-1.1891	-0.9812	-0.6968	-0.4165	-0.2012	-0.0474	0.07742	0.18937
x1tot(BIOPRE)	-1.4669	-1.5405	-0.57	0.42049	0.91534	0.99962	0.97418	1.03098	1.20026	1.38743	1.51141	1.58906	1.67724	1.79811
x1tot(KERO)	-5.815	-5.8157	-6.1528	-6.6727	-7.2448	-7.7607	-8.1306	-8.3215	-8.3525	-8.2731	-8.1345	-7.9728	-7.8119	-7.6714
x1tot(HSDO)	-1.5601	-1.1399	-0.8837	-0.6623	-0.453	-0.2534	-0.0383	0.19986	0.45421	0.70886	0.9389	1.12831	1.27656	1.38991
x1tot(BIOSOL)	-1.6554	-1.4695	-1.2599	-0.9984	-0.7618	-0.595	-0.4644	-0.3371	-0.1925	-0.0345	0.10786	0.21873	0.30711	0.38838
x1tot(NSUBBBM)	-3.2166	-2.8853	-2.7284	-2.7321	-2.8153	-2.8604	-2.7969	-2.6226	-2.3849	-2.1483	-1.9458	-1.7724	-1.616	-1.4766
x1tot(LPGSUB)	-4.7402	-5.4022	-6.6292	-8.0364	-9.2979	-10.184	-10.596	-10.586	-10.295	-9.8887	-9.4982	-9.1992	-8.9205	-8.9585
x1tot(LPGNSUB)	-3.6397	-4.0592	-4.9951	-6.0963	-7.1016	-7.8351	-8.2108	-8.2486	-8.0407	-7.7035	-7.3392	-7.0187	-6.7818	-6.6431
x1tot(LNG)	-0.034	-0.0415	-0.0946	-0.2077	-0.3656	-0.5164	-0.6214	-0.6702	-0.6758	-0.6535	-0.6034	-0.5184	-0.4008	-0.2659
x1tot(LISTRKSUB)	-5.3976	-5.024	-4.9794	-4.9707	-4.8991	-4.777	-4.6176	-4.4451	-4.2801	-4.1378	-4.0355	-3.9768	-3.9476	-3.9284
x1tot(LISTRKNSUB)	-5.7335	-6.182	-6.804	-7.3982	-7.8264	-8.0209	-7.9933	-7.8268	-7.6259	-7.4753	-7.4068	-7.401	-7.4207	-7.438
x1tot(HIDRO)	-3.338	-3.7914	-4.7066	-5.5031	-5.8418	-5.6523	-5.0925	-4.4317	-3.9004	-3.6094	-3.5502	-3.6392	-3.7748	-3.8803
x1tot(GASKOTA)	-1.8663	-1.2759	-0.996	-0.7757	-0.581	-0.4415	-0.328	-0.2011	-0.0339	0.17787	0.40701	0.62079	0.80167	0.94503
x1tot(AIRBERSIH)	-6.0385	-5.3178	-4.8644	-4.5256	-4.2637	-4.0862	-3.9595	-3.8536	-3.7499	-3.6474	-3.5634	-3.5085	-3.4765	-3.4544
x1tot(CONSTRUCT)	-3.0851	-2.7439	-1.2062	0.2674	1.04713	1.23173	1.19694	1.20665	1.32937	1.47477	1.55788	1.59923	1.66298	1.77325
x1tot(TRADE)	-2.3697	-0.773	0.19157	1.02561	1.82795	2.4903	2.97122	3.28661	3.49854	3.67475	3.82219	3.91644	3.95621	3.9674
x1tot(RESTHOT)	-14.157	-13.898	-13.907	-14.021	-14.135	-14.253	-14.365	-14.46	-14.532	-14.581	-14.619	-14.657	-14.701	-14.751
x1tot(TRAIN)	-5.8145	-5.3425	-5.3772	-5.4601	-5.4125	-5.2537	-5.037	-4.8246	-4.6489	-4.5117	-4.4196	-4.3789	-4.3778	-4.3915
x1tot(LANDTRAN)	-4.8311	-3.8859	-3.3136	-2.8388	-2.4269	-2.1311	-1.9297	-1.7823	-1.646	-1.4985	-1.363	-1.2669	-1.2102	-1.1752
x1tot(WATTTRAN)	-5.4542	-4.5967	-4.2501	-4.0046	-3.7142	-3.4202	-3.1676	-2.9765	-2.8354	-2.7187	-2.6234	-2.5621	-2.5353	-2.5277
x1tot(SUPSERV)	-5.7853	-4.2569	-3.5744	-3.057	-2.4954	-1.9812	-1.5805	-1.3101	-1.1275	-0.9706	-0.8389	-0.7655	-0.7553	-0.7796
x1tot(BANK)	-4.7065	-3.8713	-3.3485	-2.8571	-2.3786	-2.0055	-1.7467	-1.5685	-1.4198	-1.2652	-1.1192	-1.0103	-0.9423	-0.8975
x1tot(RESTATE)	-4.6759	-4.0529	-3.6833	-3.3504	-3.0171	-2.7357	-2.517	-2.347	-2.2011	-2.0631	-1.9415	-1.8485	-1.7817	-1.728
x1tot(PUBLIC)	-10.724	-10.336	-10.143	-10.092	-10.127	-10.205	-10.27	-10.29	-10.271	-10.237	-10.21	-10.197	-10.191	-10.19
x1tot(OTHSERV)	-6.9717	-6.3544	-5.8957	-5.5324	-5.2776	-5.1404	-5.0589	-4.9802	-4.8789	-4.7635	-4.6641	-4.5953	-4.5494	-4.513

2. Textile Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-1.15512	-0.965913	-0.888771	-0.820921	-0.747438	-0.684549	-0.640711	-0.611933	-0.587682	-0.560438	-0.532668	-0.512876	-0.506722	-0.513114
x1tot(OTHCROPS)	-1.0787	-0.827202	-0.711819	-0.593045	-0.454636	-0.327974	-0.235898	-0.179717	-0.145	-0.117068	-9.36E-02	-8.14E-02	-8.57E-02	-0.104133
x1tot(LSTOCK)	-0.691324	-0.490369	-0.374928	-0.278694	-0.196701	-0.14162	-0.113453	-0.101568	-9.30E-02	-8.04E-02	-6.54E-02	-5.47E-02	-5.23E-02	-5.66E-02
x1tot(FOREST)	-0.590471	-0.51699	-0.399645	-0.156786	6.83E-02	0.156387	0.110142	2.16E-02	-1.03E-02	3.34E-02	9.81E-02	0.128639	0.114866	8.54E-02
x1tot(FISH)	-0.778144	-0.780687	-0.833786	-0.797481	-0.691966	-0.599243	-0.56439	-0.577967	-0.598324	-0.590088	-0.552186	-0.510015	-0.487507	-0.490194
x1tot(METAL)	-9.32E-02	-0.253329	-0.482931	-0.69222	-0.818297	-0.829459	-0.733703	-0.570381	-0.389148	-0.229861	-0.113377	-4.37E-02	-1.49E-02	-1.70E-02
x1tot(COAL)	-5.33E-02	-0.112503	-0.215966	-0.339578	-0.46144	-0.561286	-0.62688	-0.656415	-0.655206	-0.630132	-0.586495	-0.528698	-0.461855	-0.392301
x1tot(MNYAK)	-2.11E-02	-6.31E-02	-0.136373	-0.230978	-0.331825	-0.421561	-0.48825	-0.528584	-0.545615	-0.54398	-0.526609	-0.496216	-0.455907	-0.410097
x1tot(GAS)	-1.02E-02	-4.29E-02	-9.89E-02	-0.170888	-0.244738	-0.303183	-0.334201	-0.33467	-0.308215	-0.260443	-0.196227	-0.120353	-3.90E-02	4.01E-02
x1tot(GEO)	-2.95E-02	-0.114081	-0.171314	-0.126645	3.66E-02	0.277477	0.518981	0.68894	0.752389	0.720112	0.633773	0.540687	0.473823	0.444509
x1tot(OTHMIN)	-0.191512	0.140653	0.497403	0.7449	0.831063	0.795383	0.715627	0.652839	0.628062	0.627841	0.629411	0.622808	0.613342	0.610728
x1tot(FOODPROC)	-1.0886	-0.931544	-0.895855	-0.848413	-0.770985	-0.69099	-0.628331	-0.584588	-0.5483	-0.508589	-0.467523	-0.436807	-0.425552	-0.433565
x1tot(TEXTILE)	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12
x1tot(WOOD)	-1.12914	-1.15264	-1.16322	-0.927174	-0.617829	-0.436579	-0.431598	-0.506776	-0.526359	-0.450816	-0.347854	-0.295189	-0.311985	-0.360196
x1tot(PMI)	-1.09485	-0.917845	-0.866086	-0.835224	-0.798801	-0.755036	-0.703549	-0.64281	-0.572243	-0.496096	-0.423904	-0.365105	-0.324065	-0.299854
x1tot(CHEMIC)	-0.861287	-0.599538	-0.450228	-0.319902	-0.197623	-9.42E-02	-1.31E-02	5.05E-02	0.104908	0.153735	0.192981	0.216943	0.224755	0.220918
x1tot(BIOETHA)	0.232219	0.45938	0.733426	0.909975	0.947783	0.892752	0.816859	0.767672	0.75272	0.752904	0.749432	0.739384	0.731533	0.734129
x1tot(BIODIES)	-1.33743	-1.11978	-1.14017	-1.06873	-0.856349	-0.5835	-0.337484	-0.159281	-3.82E-02	5.61E-02	0.134548	0.184423	0.191647	0.157423
x1tot(OTHREF)	-7.92E-02	6.34E-02	0.176963	0.293862	0.414959	0.534196	0.647409	0.752332	0.84806	0.933882	1.00817	1.06908	1.11578	1.14875
x1tot(KERO)	-0.311409	-0.110088	8.09E-02	0.214647	0.278764	0.297764	0.306133	0.323998	0.351216	0.375528	0.386652	0.384427	0.376196	0.369498
x1tot(BIOPRE)	0.232219	0.45938	0.733426	0.909975	0.947783	0.892752	0.816859	0.767672	0.75272	0.752904	0.749432	0.739384	0.731533	0.734129
x1tot(KERO)	-0.622761	-0.529758	-0.530102	-0.558943	-0.592395	-0.620938	-0.634902	-0.628129	-0.60047	-0.557373	-0.508135	-0.461993	-0.424633	-0.397784
x1tot(HSDO)	-0.278759	-0.193082	-0.149429	-0.110864	-7.14E-02	-3.12E-02	1.26E-02	6.20E-02	0.116725	0.172744	0.223387	0.263172	0.290248	0.306024
x1tot(BIOSOL)	-9.45E-02	-1.99E-03	6.96E-02	0.137258	0.190828	0.223542	0.242017	0.258248	0.281121	0.310813	0.340515	0.363758	0.37902	0.388933
x1tot(NSUBBBM)	-0.337035	-0.182298	-7.03E-02	1.78E-02	8.94E-02	0.151963	0.211432	0.268033	0.31698	0.353062	0.374921	0.385607	0.390025	0.392032
x1tot(LPGSUB)	-0.621931	-0.646149	-0.776802	-0.921629	-1.0312	-1.08352	-1.07586	-1.02142	-0.94113	-0.855112	-0.778547	-0.720324	-0.683327	-0.666093
x1tot(LPGNSUB)	-0.438611	-0.427351	-0.499387	-0.58535	-0.652057	-0.684636	-0.679002	-0.641123	-0.582669	-0.516001	-0.451708	-0.397336	-0.356939	-0.331585
x1tot(LNG)	-1.12E-02	-3.44E-02	-8.37E-02	-0.153165	-0.230073	-0.298634	-0.347717	-0.374024	-0.379906	-0.368566	-0.341556	-0.300172	-0.247764	-0.190007
x1tot(LISTRIKSUB)	-0.280637	-0.116342	-1.07E-02	9.50E-02	0.199468	0.286448	0.348934	0.389807	0.416963	0.436601	0.449693	0.455186	0.454198	0.450397
x1tot(LISTRIKNSUB)	-0.662206	-0.636745	-0.677732	-0.716726	-0.729436	-0.714365	-0.67826	-0.6322	-0.586827	-0.549003	-0.52172	-0.50483	-0.49579	-0.491389
x1tot(HIDRO)	-0.230936	-0.152805	-0.102093	-1.70E-02	0.109918	0.258173	0.397801	0.503129	0.562598	0.580224	0.569588	0.546542	0.523878	0.508554
x1tot(GASKOTA)	0.953147	1.08094	1.16392	1.24055	1.30642	1.35229	1.37996	1.39893	1.41962	1.44693	1.47868	1.50995	1.53754	1.56103
x1tot(AIRBERSIH)	-0.893257	-0.688936	-0.571952	-0.474909	-0.393015	-0.336047	-0.301836	-0.279432	-0.257493	-0.231852	-0.207237	-0.190698	-0.184758	-0.186509
x1tot(CONSTRUCT)	-6.57E-02	0.291147	0.684682	0.937945	1.00113	0.935093	0.834435	0.763778	0.736687	0.731369	0.724051	0.709569	0.697721	0.698618
x1tot(TRADE)	-0.826258	-0.595794	-0.466969	-0.3341	-0.194817	-7.81E-02	8.34E-04	4.75E-02	7.85E-02	0.106102	0.12934	0.140984	0.137923	0.124453
x1tot(RESTHOT)	-1.61675	-1.36882	-1.25208	-1.14815	-1.04426	-0.964866	-0.919037	-0.896775	-0.879632	-0.855182	-0.826339	-0.805019	-0.779254	-0.807853
x1tot(TRAIN)	-1.00138	-0.852192	-0.784213	-0.706203	-0.610757	-0.519534	-0.447852	-0.397585	-0.360993	-0.330778	-0.306862	-0.292902	-0.289925	-0.294559
x1tot(LANDTRAN)	-0.638103	-0.42243	-0.290359	-0.170864	-6.60E-02	8.49E-03	5.28E-02	8.02E-02	0.10554	0.134668	0.1618	0.178614	0.182762	0.178605
x1tot(WATTRAN)	-0.876881	-0.67869	-0.563578	-0.44415	-0.316785	-0.20551	-0.124698	-7.26E-02	-3.74E-02	-9.43E-03	1.25E-02	2.45E-02	2.48E-02	1.71E-02
x1tot(SUPSERV)	-1.00381	-0.726873	-0.569122	-0.404793	-0.23155	-8.44E-02	1.68E-02	7.65E-02	0.114082	0.143865	0.165704	0.172913	0.16381	0.144708
x1tot(BANK)	-0.618667	-0.421391	-0.292845	-0.163193	-3.90E-02	5.55E-02	0.113753	0.146941	0.172273	0.199521	0.225749	0.242991	0.247939	0.244227
x1tot(RESTATE)	-0.766167	-0.58844	-0.46614	-0.343969	-0.226844	-0.133579	-6.94E-02	-2.64E-02	7.55E-03	3.93E-02	6.69E-02	8.55E-02	9.35E-02	9.42E-02
x1tot(PUBLIC)	-1.48918	-1.26231	-1.15011	-1.06854	-1.00412	-0.963263	-0.940959	-0.924717	-0.903302	-0.873388	-0.841356	-0.816765	-0.804405	-0.802617
x1tot(OTHSERV)	-1.01966	-0.79958	-0.662851	-0.55309	-0.470111	-0.420509	-0.395122	-0.377346	-0.354235	-0.323677	-0.293457	-0.27237	-0.26295	-0.261612

3. PMI Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
x1tot(FCROPS)	-1.03995	-0.523783	-0.2921	-0.142203	-3.14E-02	1.59E-02	1.38E-03	-4.85E-02	-9.96E-02	-0.126481	-0.128177	-0.121558	-0.121063
x1tot(OTHCROPS)	-3.28E-03	0.950597	1.33036	1.50196	1.6017	1.62648	1.57801	1.48674	1.3997	1.35809	1.36819	1.40293	1.4334
x1tot(LSTOCK)	-1.90659	-1.62853	-1.451	-1.27673	-1.12718	-1.04744	-1.03701	-1.06753	-1.10662	-1.13416	-1.15064	-1.16671	-1.18807
x1tot(FOREST)	-1.63768	-2.28875	-2.7379	-2.58158	-2.01511	-1.5615	-1.45168	-1.59577	-1.75393	-1.75107	-1.62591	-1.52631	-1.5309
x1tot(FISH)	-1.32872	-1.381	-1.5047	-1.42754	-1.19918	-1.01463	-0.974062	-1.05554	-1.16931	-1.23092	-1.22376	-1.19188	-1.18214
x1tot(METAL)	-7.57E-02	-0.400308	-0.8351	-1.23647	-1.5467	-1.73998	-1.82402	-1.83759	-1.82928	-1.83283	-1.85436	-1.87919	-1.89995
x1tot(COAL)	2.55E-02	-5.36E-02	-0.154	-0.246531	-0.341929	-0.440976	-0.54109	-0.648051	-0.774063	-0.927318	-1.10315	-1.28569	-1.45773
x1tot(MNAYAK)	2.03E-02	-5.30E-02	-0.1173	-0.178978	-0.263013	-0.371123	-0.495793	-0.635728	-0.797019	-0.985053	-1.19597	-1.41685	-1.63379
x1tot(GAS)	1.33E-02	-9.81E-02	-0.2237	-0.362694	-0.530565	-0.720094	-0.916977	-1.11547	-1.31907	-1.53143	-1.74708	-1.95171	-2.13146
x1tot(GEO)	-0.169771	-0.98025	-2.0235	-2.819	-3.07019	-2.74736	-2.07533	-1.37892	-0.917175	-0.793818	-0.959419	-1.27812	-1.60669
x1tot(OTHMN)	-3.22157	-4.3125	-4.3565	-3.90231	-3.37049	-2.98315	-2.75666	-2.61835	-2.51775	-2.44285	-2.40987	-2.42173	-2.46326
x1tot(FOODPROC)	-0.365068	0.244066	0.43378	0.518522	0.588458	0.613523	0.58125	0.512122	0.445145	0.415863	0.428739	0.458719	0.479974
x1tot(TEXTILE)	0.648346	1.68319	2.07078	2.19169	2.22775	2.22199	2.17945	2.10241	2.00343	1.90415	1.81935	1.7494	1.68999
x1tot(WOOD)	7.81E-02	9.11E-02	-0.5154	-0.601995	-0.101185	0.320379	0.307119	-4.78E-02	-0.40019	-0.468816	-0.294611	-0.111305	-6.85E-02
x1tot(PM)	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12
x1tot(CHEMIC)	-0.509271	7.35E-02	0.25055	0.285244	0.276554	0.221487	0.126832	1.82E-02	-7.48E-02	-0.130623	-0.150323	-0.15246	-0.152112
x1tot(BIOETHA)	-3.44882	-4.72697	-4.9576	-4.74704	-4.50195	-4.34688	-4.24104	-4.12235	-3.97854	-3.84695	-3.76997	-3.75081	-3.75869
x1tot(BIODIES)	4.96735	6.97842	7.30033	7.08153	6.88737	6.77133	6.66004	6.50979	6.35162	6.26378	6.28119	6.35905	6.43215
x1tot(OTHREF)	8.77E-04	0.18335	0.13777	1.06E-03	-0.173312	-0.362386	-0.544103	-0.702879	-0.832242	-0.931769	-1.00545	-1.0586	-1.09466
x1tot(GASOL)	-2.22596	-2.96225	-3.285	-3.447	-3.60746	-3.77515	-3.88304	-3.88238	-3.77912	-3.62177	-3.46583	-3.34086	-3.24859
x1tot(BIOPRE)	-3.44882	-4.72697	-4.9576	-4.74704	-4.50195	-4.34688	-4.24104	-4.12235	-3.97854	-3.84695	-3.76997	-3.75081	-3.75869
x1tot(KERO)	-1.72391	-1.74204	-1.8507	-1.97295	-2.10835	-2.25138	-2.37426	-2.4544	-2.48712	-2.48401	-2.46519	-2.44661	-2.43423
x1tot(HSDO)	-0.796529	-0.913296	-1.1565	-1.42441	-1.68711	-1.93242	-2.1368	-2.28077	-2.35899	-2.38059	-2.366	-2.33635	-2.30483
x1tot(BIOSOL)	-1.58052	-1.86727	-2.051	-2.12085	-2.13445	-2.14939	-2.17973	-2.21455	-2.23944	-2.24989	-2.25622	-2.27	-2.29164
x1tot(NSUBBBM)	-1.0592	-1.24842	-1.5563	-1.94234	-2.36972	-2.7598	-3.0408	-3.18464	-3.2077	-3.15264	-3.06257	-2.96357	-2.86733
x1tot(LPGSUB)	-1.1434	-1.41563	-1.9213	-2.46106	-2.91493	-3.20264	-3.29427	-3.22143	-3.05442	-2.86893	-2.72197	-2.64081	-2.62614
x1tot(LPGNSUB)	-0.927865	-1.17061	-1.6507	-2.17847	-2.64306	-2.97007	-3.12327	-3.11795	-3.00691	-2.85388	-2.7125	-2.61469	-2.57025
x1tot(LNG)	0.188844	0.165211	0.11806	4.89E-02	-5.75E-02	-0.19473	-0.350269	-0.520357	-0.710241	-0.92442	-1.1565	-1.38994	-1.60835
x1tot(LISTRKSUB)	-1.50209	-1.41688	-1.4689	-1.50448	-1.50106	-1.4848	-1.47063	-1.46329	-1.46168	-1.4638	-1.47353	-1.49502	-1.52433
x1tot(LISTRKNSUB)	-1.79097	-2.0555	-2.3563	-2.57129	-2.67353	-2.66524	-2.57082	-2.43827	-2.3196	-2.25169	-2.24714	-2.29343	-2.36353
x1tot(HIDRO)	-0.769395	-0.977973	-1.388	-1.73392	-1.89062	-1.8434	-1.65828	-1.44088	-1.28237	-1.22587	-1.26526	-1.36229	-1.46966
x1tot(GASKOTA)	-1.99286	-2.02716	-2.1544	-2.27972	-2.40069	-2.53671	-2.67889	-2.80337	-2.89115	-2.93742	-2.95334	-2.95585	-2.95601
x1tot(AIRBERSIH)	-1.87108	-1.64564	-1.5246	-1.40702	-1.30732	-1.26375	-1.27337	-1.30936	-1.3433	-1.36043	-1.36686	-1.37635	-1.39381
x1tot(CONSTRUCT)	-3.68552	-4.97781	-4.9539	-4.39143	-3.82898	-3.44814	-3.2083	-3.0245	-2.86255	-2.74653	-2.71005	-2.74505	-2.80667
x1tot(TRADE)	-0.541754	3.63E-02	0.19726	0.241034	0.267226	0.254025	0.192257	0.104678	3.07E-02	1.83E-03	1.56E-02	4.35E-02	6.16E-02
x1tot(RESTHOT)	-1.86535	-1.34771	-1.0578	-0.800895	-0.577331	-0.452571	-0.43432	-0.482877	-0.543577	-0.576433	-0.57857	-0.572553	-0.576661
x1tot(TRAIN)	-2.15025	-1.86758	-1.9053	-1.99692	-2.0436	-2.06	-2.07215	-2.09168	-2.11348	-2.1256	-2.12774	-2.13102	-2.14253
x1tot(LANDTRAN)	-1.50445	-1.2591	-1.1676	-1.08576	-1.01088	-0.990032	-1.02582	-1.08721	-1.13667	-1.15264	-1.14376	-1.13305	-1.13326
x1tot(WATTRAN)	-0.735397	-0.305305	-0.2536	-0.306927	-0.365058	-0.431781	-0.513788	-0.600424	-0.670016	-0.704957	-0.708738	-0.701444	-0.699555
x1tot(SUPSERV)	-0.52591	0.248447	0.45247	0.484055	0.499334	0.481834	0.41406	0.31459	0.226268	0.187689	0.198765	0.226995	0.244457
x1tot(BANK)	-1.34173	-1.13946	-1.1107	-1.07802	-1.02766	-1.01449	-1.05409	-1.12307	-1.18415	-1.21166	-1.21053	-1.20429	-1.20891
x1tot(RESTATE)	-1.15841	-1.04567	-1.1059	-1.17491	-1.22531	-1.28632	-1.36591	-1.44919	-1.51473	-1.5506	-1.56472	-1.57498	-1.59204
x1tot(PUBLIC)	-2.97919	-2.69794	-2.4812	-2.26032	-2.08167	-1.99158	-1.97923	-2.00764	-2.04212	-2.06606	-2.0845	-2.1084	-2.13969
x1tot(OTHSERV)	-2.57485	-2.48692	-2.3871	-2.23375	-2.09026	-2.01683	-2.01076	-2.03756	-2.06348	-2.07393	-2.07808	-2.09052	-2.11376

4. Petrochemical Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-0.595155	-0.421007	-0.344215	-0.292087	-0.24957	-0.223888	-0.217076	-0.222335	-0.228628	-0.228051	-0.22111	-0.213875	-0.211366	-0.214206
x1tot(OTHCROPS)	-0.389601	-0.119889	-5.81E-03	6.46E-02	0.123294	0.162301	0.174869	0.166446	0.152056	0.145424	0.148876	0.155094	0.156564	0.151475
x1tot(LSTOCK)	-0.80908	-0.708117	-0.653961	-0.606222	-0.565808	-0.543939	-0.540819	-0.547733	-0.55436	-0.555164	-0.551619	-0.548421	-0.548559	-0.551756
x1tot(FOREST)	-0.630574	-0.848298	-0.976394	-0.887418	-0.684664	-0.535862	-0.512967	-0.572649	-0.618692	-0.598495	-0.5388	-0.494707	-0.492105	-0.514885
x1tot(FISH)	-0.540423	-0.573035	-0.629525	-0.609451	-0.532484	-0.466147	-0.449269	-0.475633	-0.510992	-0.524473	-0.511873	-0.490811	-0.479788	-0.48434
x1tot(METAL)	-8.87E-03	-5.98E-02	-0.11856	-0.162567	-0.192248	-0.210199	-0.220608	-0.230975	-0.248811	-0.27614	-0.307372	-0.333193	-0.346703	-0.346813
x1tot(COAL)	2.11E-02	3.07E-02	5.23E-02	8.63E-02	0.12611	0.169577	0.215656	0.260101	0.296254	0.319282	0.329266	0.3302	0.326658	0.321159
x1tot(MINYAK)	7.89E-03	1.28E-02	3.50E-02	6.60E-02	9.68E-02	0.126733	0.157412	0.187705	0.21344	0.230954	0.24011	0.243853	0.245426	0.246319
x1tot(GAS)	6.66E-03	2.89E-03	1.12E-02	2.34E-02	3.17E-02	3.63E-02	3.96E-02	4.05E-02	3.50E-02	1.98E-02	-4.35E-03	-3.30E-02	-6.15E-02	-8.74E-02
x1tot(GEO)	-6.29E-02	-0.346659	-0.711153	-0.991117	-1.08756	-0.994577	-0.786481	-0.567819	-0.421096	-0.378569	-0.424109	-0.515142	-0.607718	-0.673037
x1tot(OTHMIN)	-0.895912	-1.17428	-1.12516	-0.947756	-0.779865	-0.673548	-0.616001	-0.57583	-0.534513	-0.49416	-0.466028	-0.454894	-0.454821	-0.456293
x1tot(FOODPROC)	-0.384453	-0.195948	-0.14178	-0.112715	-8.15E-02	-5.89E-02	-5.34E-02	-6.14E-02	-7.02E-02	-6.83E-02	-5.55E-02	-4.08E-02	-3.28E-02	-3.40E-02
x1tot(TEXTILE)	-0.792489	-0.570529	-0.593592	-0.709604	-0.844314	-0.972361	-1.0882	-1.1907	-1.27658	-1.3412	-1.38369	-1.40834	-1.42116	-1.42669
x1tot(WOOD)	-0.343119	-0.406822	-0.604143	-0.5782	-0.378095	-0.220497	-0.223903	-0.34495	-0.44783	-0.446698	-0.372629	-0.308064	-0.299663	-0.331079
x1tot(PMI)	-0.773102	-0.648682	-0.668692	-0.738702	-0.82028	-0.901178	-0.974018	-1.03205	-1.06994	-1.08682	-1.08768	-1.07985	-1.06878	-1.05686
x1tot(CHEMIC)	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76	-4.76
x1tot(BIOETHA)	-1.15391	-1.50823	-1.54609	-1.47758	-1.42276	-1.4049	-1.39673	-1.37067	-1.32334	-1.2724	-1.23552	-1.21552	-1.20344	-1.19034
x1tot(BIODIES)	-0.848633	-0.338484	-0.296903	-0.368178	-0.400913	-0.390323	-0.376348	-0.385607	-0.410517	-0.425185	-0.418157	-0.401682	-0.394437	-0.404349
x1tot(OTHPREF)	1.15E-02	0.100186	0.117598	0.108693	8.74E-02	5.84E-02	2.60E-02	-5.98E-03	-3.51E-02	-6.00E-02	-8.08E-02	-9.79E-02	-0.111285	-0.120889
x1tot(GASOL)	-0.736317	-0.923969	-0.991496	-1.02633	-1.07275	-1.12591	-1.15939	-1.15508	-1.1153	-1.05772	-1.00099	-0.95411	-0.91708	-0.887414
x1tot(BIOPRE)	-1.15391	-1.50823	-1.54609	-1.47758	-1.42276	-1.4049	-1.39673	-1.37067	-1.32334	-1.2724	-1.23552	-1.21552	-1.20344	-1.19034
x1tot(KERO)	-0.573148	-0.566467	-0.597291	-0.638271	-0.685358	-0.734117	-0.774798	-0.799425	-0.80624	-0.799542	-0.786352	-0.772328	-0.760056	-0.750073
x1tot(HSDO)	-0.303084	-0.325893	-0.396694	-0.479114	-0.562464	-0.641103	-0.707199	-0.75405	-0.779096	-0.785124	-0.778803	-0.766876	-0.753651	-0.741046
x1tot(BIOSOL)	-0.600513	-0.67781	-0.735872	-0.765383	-0.781566	-0.798516	-0.818277	-0.835296	-0.843669	-0.843057	-0.838608	-0.835399	-0.834589	-0.834188
x1tot(NSUBBBM)	-0.368182	-0.399655	-0.479855	-0.592241	-0.719399	-0.835868	-0.919604	-0.961724	-0.967611	-0.950487	-0.922597	-0.890918	-0.858493	-0.827543
x1tot(LPGSUB)	-0.425738	-0.512397	-0.689822	-0.883255	-1.04624	-1.15052	-1.18698	-1.16617	-1.1109	-1.04579	-0.989521	-0.951771	-0.934168	-0.933475
x1tot(LPGNSUB)	-0.341221	-0.412813	-0.574004	-0.755894	-0.91748	-1.03284	-1.09049	-1.09511	-1.06285	-1.01343	-0.963643	-0.924029	-0.898861	-0.888093
x1tot(LNG)	2.84E-02	3.74E-02	4.69E-02	5.33E-02	5.26E-02	4.73E-02	4.10E-02	3.33E-02	2.02E-02	-1.87E-03	-3.23E-02	-6.69E-02	-0.101403	-0.133727
x1tot(LISTRKSUB)	-0.566062	-0.525516	-0.547383	-0.568757	-0.577011	-0.578148	-0.577535	-0.576813	-0.57503	-0.572004	-0.57003	-0.571346	-0.575466	-0.579676
x1tot(LISTRKSUB)	-0.654527	-0.736009	-0.845995	-0.935001	-0.985457	-0.99495	-0.971083	-0.929337	-0.887078	-0.857406	-0.845534	-0.848817	-0.86015	-0.872391
x1tot(HIDRO)	-0.288925	-0.354213	-0.495964	-0.618374	-0.67768	-0.669053	-0.614776	-0.548787	-0.499661	-0.480822	-0.490357	-0.516499	-0.545126	-0.565778
x1tot(GASKOTA)	-0.372093	-0.346604	-0.367751	-0.394336	-0.42366	-0.460879	-0.503354	-0.542671	-0.570838	-0.585285	-0.589527	-0.588969	-0.58703	-0.584562
x1tot(AIRBERSH)	-0.891145	-0.797406	-0.750037	-0.70887	-0.67588	-0.659727	-0.659188	-0.665403	-0.668809	-0.665486	-0.65865	-0.653557	-0.652453	-0.653876
x1tot(CONSTRUCT)	-1.12651	-1.45424	-1.38144	-1.18008	-1.01176	-0.914839	-0.858611	-0.805953	-0.74613	-0.693562	-0.664368	-0.658416	-0.662163	-0.662491
x1tot(TRADE)	-0.277341	-7.59E-02	-1.57E-02	1.29E-02	3.80E-02	5.05E-02	4.35E-02	2.33E-02	5.03E-03	-6.17E-05	6.63E-03	1.57E-02	1.97E-02	1.81E-02
x1tot(RESTHOT)	-0.801093	-0.617718	-0.519162	-0.432116	-0.353616	-0.30332	-0.286335	-0.291219	-0.299683	-0.299115	-0.28984	-0.280272	-0.27704	-0.280556
x1tot(TRAIN)	-0.470464	-0.373546	-0.386188	-0.412295	-0.422476	-0.422329	-0.421944	-0.425041	-0.428136	-0.426919	-0.422399	-0.41906	-0.419498	-0.422416
x1tot(LANDTRAN)	-0.513181	-0.410689	-0.371104	-0.338107	-0.310155	-0.300257	-0.309455	-0.326935	-0.338764	-0.338361	-0.330077	-0.322233	-0.319205	-0.319707
x1tot(WATTRAN)	-0.225048	-7.09E-02	-3.76E-02	-3.19E-02	-2.63E-02	-2.53E-02	-3.41E-02	-4.97E-02	-6.31E-02	-6.72E-02	-6.34E-02	-5.79E-02	-5.57E-02	-5.71E-02
x1tot(SUPSERV)	-0.16061	0.104221	0.187478	0.227238	0.26326	0.28594	0.285266	0.266506	0.246825	0.240187	0.245876	0.253542	0.255291	0.251251
x1tot(BANK)	-0.497753	-0.414691	-0.395656	-0.375705	-0.351132	-0.338877	-0.345057	-0.361755	-0.375022	-0.376433	-0.368828	-0.360684	-0.357478	-0.358742
x1tot(RESTATE)	-0.43679	-0.378076	-0.380403	-0.385874	-0.386698	-0.392631	-0.407187	-0.425049	-0.437625	-0.440525	-0.436774	-0.432566	-0.431549	-0.433152
x1tot(PUBLIC)	-1.13273	-1.01978	-0.94683	-0.881502	-0.830707	-0.804982	-0.800388	-0.804825	-0.807297	-0.803913	-0.798013	-0.794639	-0.795661	-0.799498
x1tot(OTHSERV)	-0.96556	-0.9098	-0.867087	-0.81672	-0.773985	-0.753501	-0.752724	-0.7592	-0.761263	-0.755579	-0.747003	-0.741557	-0.740955	-0.742797

5. Crude Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-0.021	0.00172	0.01262	0.01957	0.02426	0.02648	0.02641	0.02499	0.02344	0.02246	0.02191	0.02125	0.02013	0.01863
x1tot(OTHCROPS)	-0.068	-0.032	-0.0175	-0.0093	-0.0032	0.00103	0.00314	0.00371	0.00422	0.00579	0.00842	0.01123	0.01339	0.01467
x1tot(LSTOCK)	-0.0779	-0.0648	-0.0583	-0.054	-0.0516	-0.0516	-0.0534	-0.0558	-0.0576	-0.0584	-0.0586	-0.0588	-0.0592	-0.0599
x1tot(FOREST)	-0.0467	-0.0697	-0.0836	-0.0817	-0.0717	-0.0651	-0.0678	-0.0767	-0.0837	-0.0844	-0.0805	-0.0766	-0.0756	-0.0768
x1tot(FISH)	-0.0517	-0.0525	-0.0564	-0.0545	-0.0489	-0.0453	-0.0465	-0.0513	-0.0562	-0.0585	-0.0583	-0.0571	-0.0568	-0.0578
x1tot(METAL)	-0.0025	-0.0055	-0.0071	-0.0057	-0.0024	0.00138	0.00468	0.00671	0.00679	0.00489	0.00177	-0.0014	-0.0037	-0.0047
x1tot(COAL)	0.00496	0.01582	0.035	0.06035	0.08933	0.12021	0.15168	0.18241	0.21092	0.23608	0.25733	0.2747	0.28847	0.29887
x1tot(MINYAK)	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4
x1tot(GAS)	-0.0319	-0.1211	-0.2625	-0.4303	-0.6047	-0.7699	-0.9132	-1.0257	-1.1019	-1.1402	-1.1422	-1.1135	-1.0624	-0.9988
x1tot(GEO)	-0.0259	-0.1357	-0.2948	-0.4499	-0.5644	-0.6241	-0.6358	-0.6166	-0.5843	-0.5515	-0.5237	-0.502	-0.4853	-0.4724
x1tot(OTHMIN)	-0.1698	-0.22	-0.2343	-0.2341	-0.2329	-0.2356	-0.2409	-0.2454	-0.2467	-0.2446	-0.2405	-0.2361	-0.2319	-0.2228
x1tot(FOODPROC)	0.02013	0.04694	0.05944	0.0683	0.0757	0.08068	0.08262	0.0821	0.08059	0.07927	0.07834	0.07722	0.07546	0.07313
x1tot(TEXTILE)	0.07449	0.12155	0.15021	0.17323	0.19457	0.21413	0.23069	0.24331	0.25183	0.2567	0.25841	0.25739	0.25416	0.24938
x1tot(WOOD)	0.06422	0.07196	0.06441	0.06983	0.08669	0.10053	0.10129	0.09119	0.08111	0.07842	0.08158	0.08451	0.08316	0.07848
x1tot(PMI)	0.03763	0.06211	0.07449	0.08228	0.08738	0.08985	0.08983	0.08793	0.08502	0.08177	0.0784	0.07498	0.07165	0.06866
x1tot(CHEMIC)	-0.5443	-0.5333	-0.5439	-0.5602	-0.5758	-0.5881	-0.5957	-0.5977	-0.5937	-0.584	-0.57	-0.5539	-0.5375	-0.522
x1tot(BIOETHA)	-0.1838	-0.2376	-0.255	-0.2609	-0.2676	-0.2771	-0.2861	-0.2912	-0.2915	-0.2885	-0.284	-0.2792	-0.2741	-0.2685
x1tot(BIODIES)	0.27582	0.35477	0.38604	0.40616	0.42755	0.4487	0.46467	0.47252	0.47342	0.47062	0.46628	0.46067	0.45353	0.44524
x1tot(OTHPREF)	-0.1255	-0.1467	-0.1947	-0.2522	-0.309	-0.3584	-0.3964	-0.4215	-0.434	-0.4356	-0.4286	-0.4156	-0.3991	-0.381
x1tot(GASOL)	-0.1999	-0.2355	-0.2614	-0.2856	-0.3102	-0.3328	-0.3493	-0.3572	-0.3568	-0.3503	-0.3404	-0.3294	-0.3182	-0.3075
x1tot(BIOPRE)	-0.1838	-0.2376	-0.255	-0.2609	-0.2676	-0.2771	-0.2861	-0.2912	-0.2915	-0.2885	-0.284	-0.2792	-0.2741	-0.2685
x1tot(KERO)	-0.212	-0.2165	-0.2304	-0.247	-0.2633	-0.2768	-0.2856	-0.2889	-0.2871	-0.2816	-0.2743	-0.2666	-0.2595	-0.2534
x1tot(HSDO)	-0.1402	-0.1505	-0.171	-0.1938	-0.2149	-0.2316	-0.2425	-0.2471	-0.246	-0.241	-0.2337	-0.2259	-0.2187	-0.2126
x1tot(BIOSOL)	-0.0994	-0.1072	-0.1132	-0.1169	-0.1198	-0.1232	-0.127	-0.1307	-0.1333	-0.1347	-0.1352	-0.1355	-0.1357	-0.1356
x1tot(NSUBBBM)	-0.1428	-0.17	-0.2162	-0.2707	-0.3243	-0.3694	-0.4008	-0.4172	-0.4201	-0.4129	-0.3994	-0.3827	-0.3649	-0.3477
x1tot(LPGSUB)	-0.2214	-0.2785	-0.3698	-0.4637	-0.5386	-0.5822	-0.5926	-0.5761	-0.5434	-0.5055	-0.4709	-0.4447	-0.428	-0.4197
x1tot(LPGNSUB)	-0.2262	-0.288	-0.3874	-0.4913	-0.577	-0.6312	-0.6503	-0.6394	-0.6085	-0.5687	-0.5293	-0.4966	-0.4732	-0.4591
x1tot(LNG)	0.02046	0.02015	0.01717	0.0083	-0.0093	-0.0368	-0.0738	-0.1185	-0.1674	-0.2159	-0.2597	-0.2955	-0.3223	-0.341
x1tot(LISTRIKSUB)	-0.0703	-0.0635	-0.0645	-0.0665	-0.0677	-0.0684	-0.0692	-0.0698	-0.0703	-0.0706	-0.0707	-0.071	-0.0714	-0.0716
x1tot(LISTRKNSUB)	-0.0919	-0.102	-0.1168	-0.1302	-0.1396	-0.1446	-0.1457	-0.1445	-0.1424	-0.1409	-0.1404	-0.1408	-0.1416	-0.1422
x1tot(HIDRO)	-0.0284	-0.0303	-0.0386	-0.0438	-0.0429	-0.0365	-0.0276	-0.02	-0.0159	-0.0163	-0.0203	-0.0261	-0.0318	-0.0363
x1tot(GASKOTA)	-0.122	-0.1254	-0.1432	-0.168	-0.1974	-0.2298	-0.2631	-0.2939	-0.3184	-0.3334	-0.3376	-0.3318	-0.3187	-0.3018
x1tot(AIRBERSIH)	-0.0903	-0.079	-0.0751	-0.0735	-0.0735	-0.0753	-0.0783	-0.0812	-0.0831	-0.0837	-0.0834	-0.0831	-0.0829	-0.0829
x1tot(CONSTRUCT)	-0.1589	-0.2166	-0.2286	-0.2263	-0.2259	-0.2306	-0.2372	-0.2412	-0.2412	-0.2384	-0.235	-0.2318	-0.2287	-0.2252
x1tot(TRADE)	0.00352	0.02986	0.03943	0.04431	0.04777	0.04958	0.04934	0.04758	0.04568	0.04462	0.04432	0.04402	0.04319	0.04187
x1tot(RESTHOT)	-0.0614	-0.0385	-0.0268	-0.0184	-0.0124	-0.0099	-0.0106	-0.013	-0.0151	-0.016	-0.016	-0.016	-0.0166	-0.0177
x1tot(TRAIN)	-0.0431	-0.0322	-0.0361	-0.0429	-0.0484	-0.0523	-0.0553	-0.0576	-0.0592	-0.0597	-0.0594	-0.0588	-0.0585	-0.0582
x1tot(LANDTRAN)	-0.0889	-0.0739	-0.0701	-0.0686	-0.0683	-0.0696	-0.072	-0.0746	-0.0759	-0.0755	-0.0741	-0.0724	-0.0712	-0.0703
x1tot(WATTTRAN)	-0.0044	0.01276	0.01386	0.01031	0.00583	0.00087	-0.0046	-0.0102	-0.0151	-0.0187	-0.0211	-0.0231	-0.0251	-0.027
x1tot(SUPSERV)	0.00988	0.04309	0.05376	0.058	0.06087	0.0624	0.06186	0.0596	0.05707	0.05548	0.05479	0.05419	0.05302	0.05136
x1tot(BANK)	-0.0535	-0.0435	-0.0425	-0.0431	-0.0443	-0.0471	-0.0514	-0.0564	-0.0606	-0.0632	-0.0646	-0.0655	-0.0666	-0.0678
x1tot(RESTATE)	-0.0277	-0.0222	-0.0255	-0.0308	-0.0369	-0.044	-0.0521	-0.0603	-0.0675	-0.0733	-0.0778	-0.0817	-0.0852	-0.0884
x1tot(PUBLIC)	-0.1189	-0.1054	-0.099	-0.0956	-0.0949	-0.0971	-0.1009	-0.1047	-0.1072	-0.1082	-0.1083	-0.1084	-0.1087	-0.1092
x1tot(OTHSERV)	-0.108	-0.1024	-0.1004	-0.0993	-0.0999	-0.1028	-0.1072	-0.1113	-0.114	-0.1149	-0.1147	-0.1144	-0.1142	-0.1141

6. Electricity Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020
x1tot(FCROPS)	0.00415	0.00242	0.00127	0.00043	-0.00005	-0.00016	0.00001	0.00028	0.00048
x1tot(OTHCROPS)	0.00527	0.00339	0.00206	0.00087	-0.00005	-0.00049	-0.00045	-0.00015	0.00017
x1tot(LSTOCK)	0.00463	0.00268	0.00133	0.00046	0.00010	0.00021	0.00058	0.00097	0.00119
x1tot(FOREST)	0.00158	-0.00014	-0.00180	-0.00315	-0.00341	-0.00243	-0.00091	0.00016	0.00022
x1tot(FISH)	0.00322	0.00243	0.00175	0.00085	0.00006	-0.00023	0.00005	0.00061	0.00105
x1tot(METAL)	0.00065	0.00190	0.00359	0.00490	0.00528	0.00465	0.00335	0.00192	0.00084
x1tot(COAL)	0.00010	0.00005	0.00003	0.00000	-0.00011	-0.00041	-0.00091	-0.00156	-0.00228
x1tot(MINYAK)	0.00004	0.00058	0.00145	0.00243	0.00328	0.00387	0.00413	0.00414	0.00403
x1tot(GAS)	0.00022	0.00172	0.00405	0.00662	0.00899	0.01093	0.01240	0.01355	0.01461
x1tot(GEO)	-0.00502	-0.02577	-0.05542	-0.08168	-0.09599	-0.09613	-0.08566	-0.07085	-0.05762
x1tot(OTHMIN)	-0.00212	-0.00564	-0.00759	-0.00744	-0.00567	-0.00340	-0.00172	-0.00117	-0.00161
x1tot(FOODPROC)	0.00474	0.00330	0.00232	0.00142	0.00068	0.00028	0.00025	0.00042	0.00061
x1tot(TEXTILE)	0.01054	0.00938	0.00865	0.00794	0.00739	0.00716	0.00725	0.00748	0.00770
x1tot(WOOD)	0.00541	0.00449	0.00275	0.00022	-0.00154	-0.00164	-0.00039	0.00097	0.00144
x1tot(PMI)	0.00656	0.00498	0.00395	0.00319	0.00276	0.00261	0.00266	0.00270	0.00266
x1tot(CHEMIC)	0.00627	0.00420	0.00271	0.00163	0.00105	0.00095	0.00118	0.00147	0.00162
x1tot(BIOETHA)	0.00110	-0.00183	-0.00362	-0.00365	-0.00226	-0.00038	0.00104	0.00158	0.00134
x1tot(BIODIES)	0.02676	0.02346	0.01890	0.01346	0.00869	0.00592	0.00550	0.00675	0.00863
x1tot(OTHREF)	0.00244	0.00244	0.00303	0.00368	0.00414	0.00431	0.00422	0.00394	0.00357
x1tot(GASOL)	0.00167	-0.00057	-0.00193	-0.00221	-0.00164	-0.00073	0.00000	0.00034	0.00031
x1tot(BIOPRE)	0.00110	-0.00183	-0.00362	-0.00365	-0.00226	-0.00038	0.00104	0.00158	0.00134
x1tot(KERO)	0.00397	0.00268	0.00197	0.00162	0.00155	0.00165	0.00177	0.00178	0.00166
x1tot(HSDO)	0.00421	0.00360	0.00335	0.00326	0.00325	0.00325	0.00320	0.00305	0.00282
x1tot(BIOSOL)	0.00673	0.00514	0.00361	0.00245	0.00193	0.00202	0.00245	0.00290	0.00313
x1tot(NSUBBBM)	-0.00776	-0.00972	-0.01127	-0.01231	-0.01284	-0.01301	-0.01294	-0.01277	-0.01258
x1tot(LPGSUB)	0.00201	0.00170	0.00193	0.00220	0.00223	0.00199	0.00158	0.00114	0.00083
x1tot(LPGNSUB)	0.00228	0.00216	0.00257	0.00296	0.00304	0.00277	0.00226	0.00169	0.00124
x1tot(LNG)	-0.00247	-0.00180	-0.00084	0.00014	0.00092	0.00134	0.00139	0.00114	0.00069
x1tot(LISTRIKSUB)	0.02318	0.01830	0.01282	0.00815	0.00535	0.00459	0.00535	0.00680	0.00814
x1tot(LISTRIKNSUB)	0.00570	0.00373	0.00182	0.00039	-0.00027	-0.00015	0.00046	0.00120	0.00173
x1tot(HDRO)	-0.02450	-0.03478	-0.04853	-0.06084	-0.06831	-0.06994	-0.06696	-0.06173	-0.05663
x1tot(GASKOTA)	-0.00325	-0.00353	-0.00306	-0.00242	-0.00191	-0.00169	-0.00185	-0.00234	-0.00303
x1tot(AIRBERSIH)	0.00636	0.00405	0.00224	0.00096	0.00037	0.00044	0.00089	0.00138	0.00168
x1tot(CONSTRUCT)	-0.00320	-0.00697	-0.00890	-0.00842	-0.00623	-0.00364	-0.00188	-0.00139	-0.00194
x1tot(TRADE)	0.00655	0.00457	0.00292	0.00148	0.00050	0.00016	0.00037	0.00082	0.00119
x1tot(RESTHOT)	0.00570	0.00316	0.00140	0.00015	-0.00047	-0.00046	-0.00001	0.00052	0.00088
x1tot(TRAIN)	0.01640	0.01301	0.00897	0.00525	0.00280	0.00201	0.00259	0.00386	0.00510
x1tot(LANDTRAN)	0.00508	0.00311	0.00169	0.00071	0.00027	0.00034	0.00070	0.00105	0.00120
x1tot(WATTRAN)	0.00581	0.00370	0.00173	0.00000	-0.00113	-0.00152	-0.00127	-0.00074	-0.00023
x1tot(SUPSERV)	0.00890	0.00632	0.00393	0.00176	0.00027	-0.00025	0.00008	0.00078	0.00144
x1tot(BANK)	0.00450	0.00259	0.00111	-0.00002	-0.00062	-0.00066	-0.00031	0.00008	0.00033
x1tot(RESTATE)	0.00340	0.00158	0.00007	-0.00110	-0.00173	-0.00181	-0.00153	-0.00116	-0.00092
x1tot(PUBLIC)	0.00545	0.00292	0.00117	0.00010	-0.00026	-0.00004	0.00048	0.00097	0.00121
x1tot(OTHSERV)	0.00481	0.00245	0.00078	-0.00020	-0.00045	-0.00013	0.00042	0.00085	0.00101

7. Gas Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-0.00772	-0.00237	0.00104	0.00364	0.00541	0.00607	0.00567	0.00455	0.00321	0.00199	0.00099	9.84588E-05	-0.00077	-0.0016
x1tot(OTHCROPS)	-0.00026	0.01207	0.01987	0.02576	0.03031	0.03326	0.03447	0.0342	0.03312	0.03188	0.03076	0.02969302	0.02854	0.02728
x1tot(LSTOCK)	-0.0258	-0.02441	-0.0229	-0.02119	-0.0199	-0.0196	-0.0202	-0.0213	-0.0225	-0.0234	-0.0241	-0.02477691	-0.02543	-0.026
x1tot(FOREST)	-0.02395	-0.03966	-0.0507	-0.05295	-0.0492	-0.04524	-0.045	-0.0482	-0.0515	-0.0522	-0.0507	-0.04877292	-0.04793	-0.0481
x1tot(FISH)	-0.01686	-0.01904	-0.021	-0.02052	-0.0186	-0.01714	-0.0174	-0.0191	-0.0213	-0.0229	-0.0236	-0.02391285	-0.02424	-0.0249
x1tot(METAL)	-0.00074	-0.00073	0.00097	0.00491	0.0104	0.01649	0.02218	0.0265	0.02877	0.02874	0.02678	0.02363792	0.02008	0.01669
x1tot(COAL)	0.002237	0.00794	0.01806	0.03123	0.04602	0.06141	0.07669	0.09116	0.10419	0.11526	0.12412	0.130813	0.13555	0.13853
x1tot(MINYAK)	-0.00063	0.00317	0.01058	0.02046	0.03169	0.04361	0.05577	0.06774	0.07899	0.08909	0.0978	0.105099	0.11105	0.11572
x1tot(GAS)	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
x1tot(GEO)	-0.02483	-0.02602	-0.0265	-0.02557	-0.0231	-0.01966	-0.0163	-0.0143	-0.0144	-0.0164	-0.0196	-0.02272906	-0.02495	-0.026
x1tot(OTHMIN)	-0.06538	-0.09436	-0.1057	-0.1079	-0.1072	-0.10689	-0.1074	-0.1079	-0.1075	-0.106	-0.1039	-0.101731	-0.09958	-0.0975
x1tot(FOODPROC)	0.004356	0.01204	0.0166	0.02011	0.02289	0.02446	0.02464	0.02362	0.02199	0.02032	0.01884	0.01748719	0.01616	0.01484
x1tot(TEXTILE)	0.018539	0.0361	0.04972	0.06178	0.07287	0.08263	0.09057	0.09629	0.09979	0.10126	0.10101	0.09927504	0.0964	0.09269
x1tot(WOOD)	0.017534	0.0158	0.00813	0.00709	0.01303	0.01928	0.02012	0.01531	0.00953	0.00687	0.00739	0.008553573	0.0082	0.0063
x1tot(PMI)	-0.02922	-0.02156	-0.0153	-0.00955	-0.0046	-0.00078	0.00166	0.00283	0.00299	0.00238	0.00116	-0.000585594	-0.0027	-0.005
x1tot(CHEMIC)	-0.06947	-0.0602	-0.0519	-0.04393	-0.0364	-0.03031	-0.0261	-0.0236	-0.0223	-0.0218	-0.0219	-0.02248234	-0.0235	-0.0248
x1tot(BIOETHA)	-0.07366	-0.10217	-0.1136	-0.11731	-0.1192	-0.1213	-0.123	-0.1233	-0.1219	-0.1193	-0.1163	-0.113383	-0.11046	-0.1075
x1tot(BIODIES)	0.087959	0.1202	0.13739	0.14885	0.15841	0.16591	0.17009	0.17029	0.16732	0.1628	0.15797	0.153202	0.14844	0.1437
x1tot(OTHREF)	0.009429	0.01673	0.02459	0.03293	0.04112	0.04851	0.05468	0.05935	0.06235	0.06368	0.06343	0.06187021	0.05934	0.0562
x1tot(GASOL)	-0.04083	-0.05783	-0.0671	-0.07343	-0.0793	-0.08511	-0.0898	-0.0925	-0.093	-0.0918	-0.0897	-0.08725358	-0.08462	-0.0819
x1tot(BIOPRE)	-0.07366	-0.10217	-0.1136	-0.11731	-0.1192	-0.1213	-0.123	-0.1233	-0.1219	-0.1193	-0.1163	-0.113383	-0.11046	-0.1075
x1tot(KERO)	-0.02383	-0.02498	-0.0255	-0.02577	-0.0263	-0.02742	-0.0288	-0.03	-0.0311	-0.0321	-0.033	-0.034106	-0.03518	-0.0362
x1tot(HSDO)	-0.01335	-0.01414	-0.0147	-0.01499	-0.0152	-0.01562	-0.0162	-0.0169	-0.0176	-0.0183	-0.0193	-0.02050822	-0.02191	-0.0234
x1tot(BIOSOL)	-0.03264	-0.03719	-0.0389	-0.03874	-0.0379	-0.03743	-0.0376	-0.0382	-0.0389	-0.0397	-0.0404	-0.04129397	-0.04226	-0.0432
x1tot(NSUBBBM)	-0.01158	-0.01488	-0.0181	-0.02197	-0.0267	-0.03145	-0.0354	-0.038	-0.0394	-0.0398	-0.0397	-0.03932297	-0.03874	-0.038
x1tot(LPGSUB)	-0.0148	-0.01835	-0.0237	-0.02933	-0.0343	-0.03781	-0.0396	-0.0399	-0.0393	-0.0387	-0.0385	-0.03879952	-0.03962	-0.0407
x1tot(LPGNSUB)	-0.01033	-0.01234	-0.0159	-0.01972	-0.0233	-0.02598	-0.0276	-0.0282	-0.0282	-0.0282	-0.0285	-0.02919391	-0.03021	-0.0314
x1tot(LNG)	-0.82995	-0.87743	-0.9549	-1.0471	-1.1439	-1.2374	-1.3227	-1.3969	-1.4591	-1.5095	-1.5488	-1.57819	-1.59898	-1.6127
x1tot(LISTRIKSUB)	-0.03539	-0.03295	-0.0304	-0.02747	-0.0248	-0.023	-0.0222	-0.0222	-0.0227	-0.0235	-0.0245	-0.02552987	-0.02665	-0.0277
x1tot(LISTRIKNSUB)	-0.0447	-0.04735	-0.0491	-0.05003	-0.0508	-0.05159	-0.0523	-0.0528	-0.0533	-0.0539	-0.0546	-0.05539303	-0.05607	-0.0565
x1tot(HDRO)	-0.0025	-0.00173	-0.0014	-0.00068	0.0002	0.00105	0.00153	0.00131	0.00027	-0.0015	-0.0038	-0.006105412	-0.00812	-0.0097
x1tot(GASKOTA)	-0.64339	-0.61731	-0.5794	-0.53641	-0.4949	-0.45895	-0.4307	-0.4106	-0.3976	-0.3906	-0.3877	-0.387725	-0.38936	-0.3916
x1tot(AIRBERSIH)	-0.02788	-0.02687	-0.0255	-0.02382	-0.0225	-0.0222	-0.0228	-0.0239	-0.0251	-0.0261	-0.0269	-0.02765616	-0.02845	-0.0292
x1tot(CONSTRUCT)	-0.07175	-0.10528	-0.1173	-0.11957	-0.1198	-0.12063	-0.1218	-0.1221	-0.121	-0.1188	-0.1163	-0.113956	-0.1116	-0.1091
x1tot(TRADE)	-0.00127	0.00667	0.01121	0.01467	0.01743	0.01906	0.01929	0.01831	0.01676	0.01522	0.01387	0.01257599	0.01119	0.00974
x1tot(RESTHOT)	-0.02208	-0.01838	-0.0154	-0.01256	-0.0104	-0.00961	-0.0103	-0.0118	-0.0134	-0.0147	-0.0156	-0.01629255	-0.01698	-0.0177
x1tot(TRAIN)	-0.01442	-0.01043	-0.009	-0.00818	-0.0075	-0.00721	-0.0077	-0.0089	-0.0104	-0.0119	-0.0132	-0.01431925	-0.01544	-0.0165
x1tot(LANDTRAN)	-0.02453	-0.02203	-0.0197	-0.01689	-0.0144	-0.01287	-0.0125	-0.0131	-0.0139	-0.0146	-0.0153	-0.01595885	-0.01683	-0.0178
x1tot(WATTRAN)	-0.0009	0.00341	0.0039	0.00304	0.00161	-0.00044	-0.0031	-0.0062	-0.0093	-0.012	-0.0142	-0.01610699	-0.01774	-0.0192
x1tot(SUPSERV)	0.004443	0.01476	0.0197	0.02282	0.02513	0.02631	0.02601	0.02436	0.02213	0.02002	0.01829	0.01673715	0.01514	0.0135
x1tot(BANK)	-0.01963	-0.01895	-0.0192	-0.01918	-0.0192	-0.01987	-0.0215	-0.0238	-0.0261	-0.0281	-0.0297	-0.03105493	-0.03235	-0.0336
x1tot(RESTATE)	-0.01294	-0.01439	-0.0175	-0.02072	-0.0241	-0.02777	-0.0319	-0.0361	-0.04	-0.0433	-0.0459	-0.04818947	-0.05011	-0.0517
x1tot(PUBLIC)	-0.03788	-0.03762	-0.0366	-0.03512	-0.0343	-0.03476	-0.0361	-0.0378	-0.0393	-0.0403	-0.0412	-0.04194693	-0.04265	-0.0432
x1tot(OTHSERV)	-0.03625	-0.03845	-0.0387	-0.03782	-0.037	-0.03718	-0.0382	-0.0397	-0.0411	-0.0421	-0.0428	-0.04355371	-0.04428	-0.0449

Appendix C Impact on Sectors Output for Scenario A2 in percentage

1. Crude Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-2.51719	1.00224	3.64275	5.97917	8.10561	9.68575	10.7443	11.3734	11.7232	11.9715	12.1445	12.2086	12.2031	12.1924
x1tot(OTHCROPS)	0.871403	5.80298	9.31386	12.3524	15.2	17.402	18.9128	19.7964	20.2372	20.5174	20.7075	20.7512	20.684	20.5936
x1tot(LSTOCK)	-18.0954	-17.4049	-17.022	-16.806	-16.724	-16.741	-16.75	-16.704	-16.6	-16.479	-16.387	-16.3281	-16.28	-16.234
x1tot(Forest)	-9.18525	-8.42031	-8.1677	-6.3489	-3.7746	-2.5758	-2.4283	-2.7949	-3.0166	-2.4508	-1.6383	-1.20204	-1.1564	-1.265
x1tot(FISH)	-7.93639	-6.7541	-6.0167	-5.0287	-3.8907	-3.1577	-2.7646	-2.5676	-2.4301	-2.2378	-2.0368	-1.91277	-1.8587	-1.8296
x1tot(METAL)	-1.00913	-2.29516	-4.1278	-5.8209	-6.9598	-7.2734	-6.7502	-5.6328	-4.2917	-3.0663	-2.143	-1.56143	-1.2855	-1.2502
x1tot(COAL)	-0.594183	-1.04213	-1.7702	-2.5718	-3.3159	-3.8554	-4.1084	-4.0818	-3.8481	-3.493	-3.0616	-2.56852	-2.0358	-1.5043
x1tot(MINYAK)	-0.256115	-0.573237	-1.0055	-1.5336	-2.1206	-2.6426	-3.0069	-3.1852	-3.2077	-3.1285	-2.9722	-2.74034	-2.4469	-2.1255
x1tot(GAS)	-0.159281	-0.466516	-0.8628	-1.3411	-1.8632	-2.2954	-2.5379	-2.5596	-2.3938	-2.1024	-1.7197	-1.25945	-0.7534	-0.2553
x1tot(GEO)	-1.71568	-5.45372	-10.484	-14.871	-16.866	-15.663	-12.327	-8.6365	-6.031	-5.127	-5.6587	-6.9208	-8.2282	-9.1281
x1tot(OTHMIN)	-6.9364	-5.99818	-3.2811	-0.3968	1.26952	1.68805	1.65423	1.70825	2.02717	2.43683	2.73827	2.95059	3.1809	3.45384
x1tot(FOODPROC)	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20
x1tot(TEXTILE)	-13.0898	-10.8917	-10.816	-11.538	-12.176	-12.53	-12.667	-12.712	-12.729	-12.677	-12.538	-12.3599	-12.185	-12.032
x1tot(WOOD)	-11.0339	-9.63126	-10.87	-9.6763	-6.2227	-4.1784	-3.6899	-4.2854	-4.9086	-4.1969	-2.9297	-2.28573	-2.4041	-2.8622
x1tot(PMI)	-10.9674	-8.78911	-8.0623	-7.8408	-7.6438	-7.3952	-7.009	-6.5162	-5.9699	-5.3864	-4.8278	-4.35808	-3.9908	-3.7175
x1tot(CHEMC)	-13.0526	-10.4545	-9.2312	-8.5091	-7.8805	-7.3417	-6.8187	-6.3235	-5.8762	-5.4534	-5.0844	-4.81792	-4.6482	-4.5446
x1tot(BIOETHA)	-2.78027	-2.90182	-0.9681	1.11378	2.00796	1.97805	1.82585	1.96603	2.44059	2.95189	3.27391	3.50112	3.78237	4.1335
x1tot(BIODIES)	-67.3719	-67.7669	-68.023	-68.198	-68.333	-68.467	-68.596	-68.727	-68.859	-68.984	-69.102	-69.2082	-69.292	-69.354
x1tot(OTHPREF)	-3.87421	-2.63418	-2.1786	-1.9686	-1.7423	-1.4513	-1.0331	-0.4911	0.1396	0.83784	1.55753	2.24305	2.85721	3.37156
x1tot(GASOL)	-6.29094	-5.77071	-4.5062	-3.3384	-2.824	-2.698	-2.4895	-2.0202	-1.3363	-0.6633	-0.1613	0.214683	0.55309	0.87
x1tot(BIOPRE)	-2.78027	-2.90182	-0.9681	1.11378	2.00796	1.97805	1.82585	1.96603	2.44059	2.95189	3.27391	3.50112	3.78237	4.1335
x1tot(KERO)	-13.4917	-13.573	-14.327	-15.416	-16.64	-17.781	-18.61	-19.044	-19.115	-18.936	-18.628	-18.2627	-17.887	-17.547
x1tot(HSDO)	-3.45774	-2.51183	-1.9562	-1.4933	-1.0509	-0.6386	-0.1616	0.38323	0.96184	1.54118	2.0562	2.47047	2.79439	3.0446
x1tot(BIOSOL)	-3.82514	-3.39205	-3.0022	-2.5395	-2.1307	-1.8689	-1.6151	-1.3261	-0.9926	-0.6256	-0.3048	-0.24E-02	0.13752	0.32824
x1tot(NSUBBBM)	-7.03959	-6.38957	-6.0106	-5.9371	-6.0998	-6.2069	-6.0914	-5.7235	-5.1882	-4.6528	-4.1992	-3.79122	-3.4004	-3.0414
x1tot(LPGSUB)	-11.8995	-13.2366	-15.516	-18.191	-20.792	-22.813	-23.895	-24.017	-23.442	-22.551	-21.667	-20.9795	-20.56	-20.404
x1tot(LPGNSUB)	-8.57434	-9.50396	-11.452	-13.737	-15.904	-17.593	-18.547	-18.746	-18.352	-17.618	-16.787	-16.0346	-15.461	-15.111
x1tot(LNG)	-7.78E-02	-9.98E-02	-0.2031	-0.4143	-0.7064	-0.9533	-1.0717	-1.041	-0.8936	-0.679	-0.4079	-0.69E-02	0.32214	0.73024
x1tot(LISTRKSUB)	-12.8488	-11.7736	-11.333	-11.028	-10.715	-10.463	-10.213	-9.9505	-9.6659	-9.3608	-9.0994	-8.91696	-8.7922	-8.6972
x1tot(LISTRKNSUB)	-15.0755	-15.6519	-16.3	-16.889	-17.412	-17.781	-17.929	-17.88	-17.691	-17.483	-17.343	-17.2474	-17.153	-17.052
x1tot(HIDRO)	-7.82026	-8.6444	-10.384	-11.988	-12.754	-12.41	-11.224	-9.8039	-8.6705	-8.0673	-7.9695	-8.17627	-8.4518	-8.6336
x1tot(GASKOTA)	-4.07395	-2.79413	-2.2237	-1.7598	-1.2955	-0.9793	-0.7079	-0.3863	3.34E-02	0.56499	1.12876	1.63674	2.05712	2.38335
x1tot(AIRBERSIH)	-13.3419	-11.9074	-10.997	-10.304	-9.7778	-9.4544	-9.1975	-8.9468	-8.6821	-8.4137	-8.2024	-8.0691	-7.9816	-7.9098
x1tot(CONSTRUCT)	-6.09869	-5.3131	-2.1906	0.96883	2.52704	2.74536	2.59434	2.66047	3.07414	3.52587	3.77347	3.9303	4.1665	4.49872
x1tot(TRADE)	-5.38641	-1.83977	0.33753	2.16101	3.96842	5.43591	6.53515	7.26688	7.72416	8.09716	8.39558	8.54816	8.58171	8.57323
x1tot(RESTHOT)	-28.3163	-27.9243	-27.902	-28.039	-28.253	-28.506	-28.693	-28.778	-28.773	-28.729	-28.703	-28.7012	-28.71	-28.723
x1tot(TRAIN)	-12.9421	-11.9102	-11.948	-12.134	-12.057	-11.745	-11.245	-10.725	-10.301	-9.977	-9.7681	-9.68615	-9.6836	-9.6966
x1tot(LANDTRAN)	-10.6475	-8.61557	-7.3882	-6.3818	-5.4845	-4.8619	-4.3979	-4.0254	-3.6873	-3.3264	-3.0104	-2.80235	-2.6791	-2.5952
x1tot(WATTRAN)	-11.9291	-10.133	-9.3632	-8.8196	-8.16	-7.5027	-6.9116	-6.4474	-6.1109	-5.8355	-5.6187	-5.49235	-5.4396	-5.4152
x1tot(SUPSERV)	-12.5384	-9.22097	-7.6391	-6.4733	-5.1668	-3.9815	-3.0034	-2.3152	-1.8822	-1.5267	-1.2434	-1.11735	-1.1302	-1.1993
x1tot(BANK)	-10.7485	-8.89332	-7.745	-6.6776	-5.6068	-4.8137	-4.2415	-3.8216	-3.4666	-3.0861	-2.7385	-2.50154	-2.359	-2.2583
x1tot(RESTATE)	-10.4485	-9.10998	-8.2985	-7.5684	-6.8358	-6.2385	-5.7535	-5.3531	-5.0002	-4.6632	-4.3753	-4.16411	-4.0066	-3.8678
x1tot(PUBLIC)	-22.7459	-22.2166	-21.97	-21.941	-22.117	-22.377	-22.538	-22.537	-22.405	-22.244	-22.132	-22.0594	-21.998	-21.941
x1tot(OTHSERV)	-15.3983	-14.1831	-13.293	-12.566	-12.076	-11.857	-11.697	-11.487	-11.198	-10.877	-10.617	-10.443	-10.314	-10.202

2. Textile Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-1.7603	-1.4242	-1.27622	-1.14934	-1.02073	-0.91812	-0.85244	-0.81434	-0.78508	-0.75057	-0.71341	-0.68688	-0.67984	-0.69035
x1tot(OTHCROPS)	-1.53695	-1.09641	-0.89361	-0.69859	-0.48311	-0.29628	-0.16951	-0.10015	-6.25E-02	-3.13E-02	-2.35E-03	1.26E-02	4.81E-03	-2.25E-02
x1tot(LSTOCK)	-1.25295	-0.91391	-0.71934	-0.55919	-0.4253	-0.33892	-0.29788	-0.28345	-0.27429	-0.2575	-0.23545	-0.21884	-0.21403	-0.21899
x1tot(FOREST)	-0.88485	-0.72364	-0.49555	-7.65E-02	0.295167	0.438164	0.370191	0.236381	0.189025	0.257589	0.355253	0.397799	0.372823	0.325992
x1tot(FISH)	-1.24791	-1.21742	-1.27533	-1.19244	-1.00315	-0.84453	-0.78578	-0.808	-0.84359	-0.83451	-0.77789	-0.71434	-0.68151	-0.68712
x1tot(METAL)	-0.12164	-0.30904	-0.57007	-0.79095	-0.89704	-0.85412	-0.67931	-0.42942	-0.17193	4.25E-02	0.191158	0.274371	0.303986	0.295007
x1tot(COAL)	-6.52E-02	-0.12277	-0.22734	-0.35006	-0.46462	-0.54577	-0.57913	-0.56501	-0.51333	-0.43509	-0.33777	-0.22675	-0.10838	9.14E-03
x1tot(MINYAK)	-2.84E-02	-6.06E-02	-0.11897	-0.1969	-0.27787	-0.33989	-0.36796	-0.3593	-0.32	-0.2577	-0.17729	-8.20E-02	2.39E-02	0.134196
x1tot(GAS)	-1.02E-02	-2.69E-02	-5.63E-02	-9.67E-02	-0.13353	-0.14575	-0.11934	-5.31E-02	4.47E-02	0.163584	0.295781	0.434795	0.572861	0.700681
x1tot(GEO)	-6.20E-02	-0.24401	-0.39708	-0.37363	-0.13183	0.260979	0.668568	0.961258	1.07432	1.02296	0.876743	0.716464	0.599827	0.548293
x1tot(OTHMIN)	-0.30482	0.231891	0.825713	1.25173	1.41454	1.37657	1.26468	1.17585	1.14329	1.14644	1.15007	1.13949	1.12411	1.11961
x1tot(FOODPROC)	-1.57308	-1.28334	-1.19928	-1.10341	-0.96741	-0.8381	-0.74467	-0.68603	-0.64135	-0.59057	-0.53518	-0.49353	-0.47994	-0.49374
x1tot(TEXTILE)	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24	-24
x1tot(WOOD)	-1.69095	-1.57746	-1.54461	-1.13836	-0.84291	-0.36543	-0.36321	-0.48454	-0.51962	-0.40679	-0.25415	-0.18114	-0.21338	-0.29027
x1tot(PMI)	-1.50316	-1.16889	-1.03415	-0.93566	-0.8368	-0.73848	-0.63989	-0.53722	-0.4275	-0.31467	-0.21136	-0.13043	-7.69E-02	-4.77E-02
x1tot(CHEMIC)	-1.18913	-0.73626	-0.47471	-0.25173	-5.01E-02	0.113088	0.234923	0.326069	0.401647	0.469474	0.524278	0.557238	0.567098	0.56106
x1tot(BIOETHA)	0.324262	0.685548	1.14507	1.45888	1.54917	1.48836	1.39224	1.33451	1.32554	1.33468	1.3329	1.31735	1.30357	1.30541
x1tot(BIODIES)	-1.08315	-0.66484	-0.67296	-0.55545	-0.22421	0.188075	0.544664	0.786314	0.935603	1.04727	1.14213	1.19998	1.1983	1.13952
x1tot(OTHEREF)	-0.10614	0.137749	0.332687	0.531282	0.734051	0.929951	1.11237	1.27813	1.4263	1.55673	1.66777	1.75718	1.82438	1.8708
x1tot(GASOL)	-0.46342	-0.12639	0.207361	0.455222	0.589465	0.647704	0.684988	0.732064	0.787939	0.833427	0.85322	0.848557	0.832593	0.818357
x1tot(BIOPRE)	0.324262	0.685548	1.14507	1.45888	1.54917	1.48836	1.39224	1.33451	1.32554	1.33468	1.3329	1.31735	1.30357	1.30541
x1tot(KERO)	-1.0484	-0.87715	-0.85436	-0.876	-0.90667	-0.93349	-0.94102	-0.91947	-0.8688	-0.79716	-0.7185	-0.64682	-0.59019	-0.55035
x1tot(HSDO)	-0.4194	-0.26638	-0.18013	-0.10224	-2.55E-02	4.86E-02	0.124652	0.206398	0.293699	0.380973	0.458644	0.518822	0.559354	0.583041
x1tot(BIOSOL)	-0.1673	-1.11E-02	0.112957	0.232213	0.327859	0.388232	0.424613	0.455728	0.495184	0.543551	0.590602	0.626728	0.650306	0.665978
x1tot(NSUBBBM)	-0.53135	-0.2681	-7.08E-02	8.93E-02	0.222223	0.339148	0.449163	0.551948	0.639355	0.702928	0.740852	0.758625	0.764806	0.766276
x1tot(LPGSUB)	-1.00765	-1.02921	-1.21989	-1.4294	-1.57942	-1.63692	-1.59972	-1.49186	-1.34925	-1.20492	-1.08244	-0.99438	-0.94303	-0.9235
x1tot(LPGNSUB)	-0.71868	-0.69018	-0.79607	-0.92119	-1.0119	-1.04557	-1.01723	-0.9388	-0.8314	-0.71614	-0.61013	-0.52473	-0.46489	-0.43035
x1tot(LNG)	1.48E-02	8.61E-03	-1.88E-02	-6.62E-02	-0.11923	-0.15747	-0.1666	-0.14367	-9.40E-02	-2.40E-02	6.32E-02	0.165545	0.278182	0.393183
x1tot(LISTRIKSUB)	-0.59913	-0.33114	-0.16814	-8.29E-03	0.149561	0.280503	0.374695	0.436502	0.477527	0.507349	0.527509	0.536267	0.535565	0.531363
x1tot(LISTRIKNSUB)	-1.12146	-1.0635	-1.11038	-1.15062	-1.1474	-1.10126	-1.02506	-0.93856	-0.85989	-0.79932	-0.75978	-0.73887	-0.73043	-0.72765
x1tot(HDRO)	-0.42536	-0.31148	-0.25288	-0.13753	5.29E-02	0.285478	0.509062	0.678343	0.771868	0.795524	0.772261	0.729273	0.688789	0.663059
x1tot(GASKOTA)	1.21659	1.41525	1.53862	1.65355	1.75526	1.82909	1.87855	1.91796	1.96197	2.01658	2.07663	2.13309	2.18058	2.21873
x1tot(ARBERSIH)	-1.45327	-1.10145	-0.89465	-0.7237	-0.58247	-0.4874	-0.43268	-0.3992	-0.368	-0.33121	-0.29543	-0.27152	-0.26316	-0.26549
x1tot(CONSTRUCT)	-0.13402	0.437806	1.09132	1.52914	1.65802	1.57492	1.43334	1.33541	1.30212	1.29909	1.28955	1.2669	1.2479	1.24885
x1tot(TRADE)	-1.26162	-0.86777	-0.65314	-0.44208	-0.22795	-5.54E-02	5.56E-02	0.116365	0.154587	0.19057	0.222922	0.239525	0.235018	0.215896
x1tot(RESTHOT)	-2.56815	-2.13066	-1.91122	-1.71876	-1.53551	-1.40307	-1.33242	-1.30393	-1.28594	-1.25613	-1.21744	-1.18848	-1.18181	-1.19529
x1tot(TRAIN)	-1.55716	-1.29488	-1.17173	-1.03701	-0.87817	-0.73011	-0.61589	-0.53776	-0.48305	-0.43911	-0.40492	-0.38583	-0.38287	-0.39019
x1tot(LANDTRAN)	-1.04127	-0.67321	-0.44734	-0.24719	-7.64E-02	4.05E-02	0.107015	0.145592	0.18085	0.222786	0.262701	0.28745	0.293471	0.287716
x1tot(WATTRAN)	-1.2995	-0.95891	-0.76384	-0.56893	-0.36649	-0.19435	-7.29E-02	2.94E-03	5.27E-02	9.33E-02	0.126606	0.145818	0.148203	0.139156
x1tot(SUPSERV)	-1.46684	-0.99391	-0.73346	-0.47546	-0.2118	4.53E-03	0.14661	0.224817	0.270951	0.309051	0.338736	0.348555	0.335245	0.30832
x1tot(BANK)	-1.02461	-0.68889	-0.47253	-0.25953	-6.00E-02	8.75E-02	0.175455	0.223611	0.260027	0.30099	0.342015	0.370089	0.379767	0.376732
x1tot(RESTATE)	-1.2015	-0.89703	-0.68758	-0.4819	-0.28827	-0.13706	-3.46E-02	3.33E-02	8.67E-02	0.13717	0.182222	0.213759	0.229345	0.234305
x1tot(PUBLIC)	-2.40485	-2.00487	-1.78943	-1.62594	-1.49744	-1.41698	-1.37441	-1.34743	-1.31645	-1.27398	-1.22828	-1.19363	-1.17689	-1.1748
x1tot(OTHSERV)	-1.67826	-1.29766	-1.05181	-0.85158	-0.70057	-0.61081	-0.56529	-0.53587	-0.50092	-0.45555	-0.41084	-0.38004	-0.36657	-0.36436

3. PMI Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-2.29365	-1.1586	-0.6732	-0.35224	-8.37E-02	3.42E-02	8.79E-03	-9.54E-02	-0.20664	-0.26655	-0.26886	-0.2548	-0.25745	-0.279
x1tot(OTHCROPS)	-5.63E-03	2.13887	3.01356	3.40686	3.66557	3.73812	3.63746	3.44276	3.25055	3.15071	3.16673	3.2382	3.29985	3.33073
x1tot(LSTOCK)	-4.21792	-3.57963	-3.2133	-2.83894	-2.48953	-2.30223	-2.27391	-2.33758	-2.42343	-2.48187	-2.51247	-2.5448	-2.59298	-2.6479
x1tot(FOREST)	-3.54694	-4.69039	-5.6445	-5.47802	-4.25497	-3.26201	-2.99887	-3.26914	-3.62887	-3.66747	-3.40759	-3.1836	-3.1781	-3.3301
x1tot(FISH)	-3.03619	-3.01665	-3.2701	-3.13154	-2.62795	-2.23033	-2.14376	-2.30758	-2.54379	-2.67406	-2.65625	-2.59	-2.5759	-2.6346
x1tot(METAL)	-0.18986	-0.91042	-1.8918	-2.80607	-3.52132	-3.97013	-4.16209	-4.18217	-4.14056	-4.11949	-4.14362	-4.1882	-4.21592	-4.2079
x1tot(COAL)	4.50E-02	-0.12796	-0.3505	-0.55343	-0.76421	-0.98242	-1.19923	-1.42514	-1.68412	-1.99424	-2.3496	-2.7201	-3.07091	-3.3812
x1tot(MINYAK)	4.33E-02	-0.10526	-0.2311	-0.34229	-0.50059	-0.70912	-0.95004	-1.21944	-1.52823	-1.88808	-2.29447	-2.7233	-3.1466	-3.5479
x1tot(GAS)	2.83E-02	-0.20171	-0.459	-0.73659	-1.07623	-1.4623	-1.86276	-2.26419	-2.67156	-3.09274	-3.52	-3.9266	-4.28486	-4.5827
x1tot(GEO)	-0.39338	-2.07866	-4.2562	-5.95771	-6.54038	-5.88404	-4.4495	-2.94331	-1.93913	-1.6718	-2.03391	-2.7263	-3.43701	-3.9548
x1tot(OTHMIN)	-6.74911	-9.01583	-9.147	-8.22614	-7.09591	-6.2579	-5.77079	-5.47556	-5.26148	-5.10064	-5.02107	-5.0403	-5.12273	-5.2057
x1tot(FOODPROC)	-0.78541	0.59733	1.01748	1.20361	1.3947	1.46923	1.40528	1.25898	1.1111	1.04212	1.06974	1.13461	1.17705	1.18167
x1tot(TEXTILE)	1.33955	3.59311	4.47677	4.76367	4.87031	4.87513	4.80025	4.65507	4.45982	4.25512	4.07652	3.92563	3.79405	3.68346
x1tot(WOOD)	0.117868	0.50075	-0.8162	-1.27886	-0.12436	0.86355	0.8872	0.164473	-0.65219	-0.88614	-0.52477	-0.1108	5.87E-04	-0.156
x1tot(PMI)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
x1tot(CHEMC)	-1.10728	0.19067	0.59476	0.66328	0.663375	0.55709	0.35972	0.134322	-6.25E-02	-0.18638	-0.2325	-0.2409	-0.24486	-0.2485
x1tot(BIOETHA)	-7.22832	-9.8168	-10.321	-9.87296	-9.34789	-9.01953	-8.80892	-8.58085	-8.30098	-8.03075	-7.8642	-7.8189	-7.83255	-7.8392
x1tot(BIODIES)	11.3454	16.0588	16.9169	16.4322	16.0578	15.8349	15.612	15.3041	14.953	14.7252	14.7322	14.88	15.0177	15.0845
x1tot(OTHREF)	-1.83E-02	0.39845	0.31758	3.78E-02	-0.31768	-0.71299	-1.0972	-1.43275	-1.70608	-1.91574	-2.06973	-2.1817	-2.2595	-2.3071
x1tot(GASOL)	-4.72628	-6.2352	-6.888	-7.16295	-7.44672	-7.78167	-8.02116	-8.04722	-7.85986	-7.5473	-7.22755	-6.9693	-6.77774	-6.6359
x1tot(BIOPRE)	-7.22832	-9.8168	-10.321	-9.87296	-9.34789	-9.01953	-8.80892	-8.58085	-8.30098	-8.03075	-7.8642	-7.8189	-7.83255	-7.8392
x1tot(KERO)	-3.82661	-3.8138	-4.0338	-4.2676	-4.5207	-4.80839	-5.06574	-5.23766	-5.31035	-5.30207	-5.25613	-5.2126	-5.18585	-5.1734
x1tot(HSDO)	-1.75248	-1.95911	-2.4605	-3.01502	-3.54724	-4.0536	-4.48347	-4.79044	-4.96228	-5.0134	-4.98427	-4.9226	-4.85755	-4.8003
x1tot(BIOSOL)	-3.42842	-3.96158	-4.3508	-4.5155	-4.54016	-4.5673	-4.62879	-4.70132	-4.75823	-4.78307	-4.79339	-4.8188	-4.86288	-4.9079
x1tot(NSUBBBM)	-2.3219	-2.69062	-3.2918	-4.0272	-4.87383	-5.67685	-6.27203	-6.59012	-6.65577	-6.55085	-6.36876	-6.1674	-5.96991	-5.7907
x1tot(LPGSUB)	-2.63117	-3.16442	-4.1861	-5.27255	-6.20073	-6.80847	-7.0098	-6.859	-6.50328	-6.10337	-5.78439	-5.6094	-5.58016	-5.662
x1tot(LPGNSUB)	-2.11808	-2.59848	-3.5837	-4.66104	-5.6169	-6.30854	-6.64349	-6.64116	-6.40907	-6.08088	-5.77346	-5.56	-5.46323	-5.4711
x1tot(LNG)	0.414789	0.37161	0.2874	0.16708	-3.33E-02	-0.30012	-0.60453	-0.93732	-1.30709	-1.72396	-2.17853	-2.6387	-3.07063	-3.4573
x1tot(LISTRISUB)	-3.38907	-3.12439	-3.1961	-3.24487	-3.2067	-3.16447	-3.14145	-3.13733	-3.14711	-3.15851	-3.17657	-3.2171	-3.27594	-3.3319
x1tot(LISTRKNSUB)	-4.07244	-4.54387	-5.1077	-5.48402	-5.64635	-5.61417	-5.42375	-5.16471	-4.93743	-4.80892	-4.80431	-4.9019	-5.04659	-5.1829
x1tot(HIDRO)	-1.74415	-2.13947	-2.9786	-3.69555	-4.02063	-3.92229	-3.52915	-3.06497	-2.72837	-2.61059	-2.6969	-2.9068	-3.13872	-3.3138
x1tot(GASKOTA)	-4.4998	-4.51085	-4.7586	-5.01583	-5.25101	-5.52901	-5.82971	-6.09434	-6.28162	-6.37768	-6.40369	-6.3996	-6.39224	-6.3895
x1tot(AIRBERSIH)	-4.11234	-3.58388	-3.3325	-3.08423	-2.84918	-2.74422	-2.76044	-2.83576	-2.91152	-2.94981	-2.96061	-2.9792	-3.01785	-3.063
x1tot(CONSTRUCT)	-7.70308	-10.4217	-10.44	-9.25047	-8.04892	-7.23349	-6.72535	-6.33973	-5.99916	-5.74199	-5.64875	-5.7132	-5.83977	-5.9343
x1tot(TRADE)	-1.2398	7.61E-02	0.45029	0.53888	0.616458	0.59772	0.46792	0.283103	0.11934	4.67E-02	7.01E-02	0.12573	0.16054	0.16655
x1tot(RESTHOT)	-4.10323	-2.91061	-2.2914	-1.73636	-1.20876	-0.91357	-0.86613	-0.97005	-1.10779	-1.18337	-1.18412	-1.1676	-1.17792	-1.2147
x1tot(TRAIN)	-4.81585	-4.19589	-4.2556	-4.43902	-4.5079	-4.52321	-4.53626	-4.56673	-4.60948	-4.6379	-4.64517	-4.6557	-4.68457	-4.7224
x1tot(LANDTRAN)	-3.3231	-2.74018	-2.5437	-2.37894	-2.19781	-2.14163	-2.2146	-2.34443	-2.45596	-2.49653	-2.47782	-2.4544	-2.45611	-2.4751
x1tot(WATTRAN)	-1.5776	-0.62145	-0.497	-0.60987	-0.71365	-0.8457	-1.01626	-1.19731	-1.34704	-1.42646	-1.43732	-1.4242	-1.42302	-1.4386
x1tot(SUPSERV)	-1.18674	0.53409	1.00391	1.06013	1.11725	1.09461	0.95742	0.752835	0.560857	0.46563	0.48056	0.5352	0.56746	0.56845
x1tot(BANK)	-2.99346	-2.49669	-2.4236	-2.35143	-2.21119	-2.16302	-2.23905	-2.3817	-2.51499	-2.57781	-2.57352	-2.5575	-2.56694	-2.5989
x1tot(RESTATE)	-2.53242	-2.25079	-2.3713	-2.51419	-2.60024	-2.71832	-2.88258	-3.05656	-3.19685	-3.27451	-3.30275	-3.323	-3.35912	-3.4067
x1tot(PUBLIC)	-6.51412	-5.88163	-5.4437	-4.97282	-4.56296	-4.35533	-4.32282	-4.38117	-4.45623	-4.50489	-4.53757	-4.5857	-4.65451	-4.7258
x1tot(OTHSERV)	-5.54213	-5.3141	-5.1207	-4.80092	-4.47253	-4.30292	-4.28501	-4.34016	-4.3982	-4.42035	-4.42372	-4.4466	-4.49629	-4.5522

4. Petrochemical Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-1.19015	-0.83626	-0.68343	-0.57924	-0.49222	-0.44048	-0.42752	-0.43868	-0.45202	-0.45135	-0.43737	-0.4228	-0.41798	-0.42393
x1tot(OTHCROPS)	-0.79372	-0.25188	-2.57E-02	0.11301	0.23087	0.308085	0.331866	0.314441	0.285112	0.2715	0.278727	0.291612	0.294777	0.284777
x1tot(LSTOCK)	-1.63301	-1.42688	-1.31936	-1.22292	-1.13938	-1.0946	-1.08849	-1.10275	-1.11664	-1.11861	-1.11153	-1.1053	-1.106	-1.11284
x1tot(FOREST)	-1.2794	-1.69314	-1.96054	-1.79448	-1.38307	-1.08435	-1.03761	-1.15563	-1.25166	-1.21419	-1.09454	-1.00618	-1.00094	-1.04668
x1tot(FISH)	-1.1032	-1.15427	-1.26789	-1.23019	-1.07439	-0.94183	-0.90906	-0.96165	-1.03241	-1.05966	-1.03435	-0.9925	-0.97132	-0.98117
x1tot(METAL)	-1.96E-02	-0.12752	-0.25339	-0.34911	-0.41428	-0.45309	-0.47406	-0.49311	-0.52637	-0.57889	-0.64024	-0.69188	-0.71972	-0.72119
x1tot(COAL)	4.28E-02	6.03E-02	0.101578	0.167797	0.245155	0.329724	0.41958	0.506268	0.576531	0.62059	0.638443	0.638171	0.629016	0.616099
x1tot(MINYAK)	1.60E-02	2.42E-02	6.69E-02	0.127266	0.186646	0.243645	0.301837	0.359029	0.407016	0.43842	0.452902	0.456417	0.455586	0.453437
x1tot(GAS)	1.36E-02	4.06E-03	1.85E-02	4.08E-02	5.45E-02	6.04E-02	6.35E-02	6.20E-02	4.79E-02	1.46E-02	-3.64E-02	-9.62E-02	-0.15536	-0.20896
x1tot(GEO)	-0.12873	-0.69625	-1.42669	-1.98933	-2.18594	-1.99925	-1.57807	-1.13492	-0.83799	-0.75313	-0.84721	-1.03317	-1.22171	-1.35446
x1tot(OTHHMIN)	-1.81396	-2.37949	-2.28965	-1.93603	-1.59704	-1.38274	-1.26757	-1.18798	-1.10657	-1.0265	-0.97016	-0.94779	-0.94767	-0.95057
x1tot(FOODPROC)	-0.76434	-0.37599	-0.2668	-0.20875	-0.14365	-9.77E-02	-8.75E-02	-0.10422	-0.12282	-0.11981	-9.40E-02	-6.41E-02	-4.83E-02	-5.09E-02
x1tot(TEXTILE)	-1.55247	-1.09815	-1.13345	-1.35556	-1.6147	-1.86234	-2.08736	-2.28681	-2.45438	-2.58087	-2.66417	-2.71275	-2.73837	-2.74963
x1tot(WOOD)	-0.6976	-0.78632	-1.19935	-1.16711	-0.75536	-0.43639	-0.44253	-0.68482	-0.89856	-0.9013	-0.75192	-0.62159	-0.60467	-0.66843
x1tot(PMI)	-1.52746	-1.27303	-1.30891	-1.44441	-1.60253	-1.7617	-1.90641	-2.02214	-2.09837	-2.13293	-2.1355	-2.12092	-2.09985	-2.07675
x1tot(CHEMIC)	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51	-9.51
x1tot(BIOETHA)	-2.32391	-3.03631	-3.11677	-2.97822	-2.86698	-2.83142	-2.81612	-2.76622	-2.67402	-2.57343	-2.50041	-2.46101	-2.43718	-2.41103
x1tot(BIODIES)	-1.7603	-0.72991	-0.6449	-0.79357	-0.86106	-0.84298	-0.8179	-0.83665	-0.88702	-0.91814	-0.90517	-0.87283	-0.85894	-0.87892
x1tot(OTHREF)	2.44E-02	0.20374	0.237272	0.217318	0.172783	0.112197	4.49E-02	-2.10E-02	-8.06E-02	-0.1314	-0.17351	-0.20803	-0.23514	-0.2546
x1tot(GASOL)	-1.48405	-1.86324	-2.00004	-2.06709	-2.15876	-2.26694	-2.33705	-2.33208	-2.25571	-2.14247	-2.02998	-1.93678	-1.86286	-1.8033
x1tot(BIOPRE)	-2.32391	-3.03631	-3.11677	-2.97822	-2.86698	-2.83142	-2.81612	-2.76622	-2.67402	-2.57343	-2.50041	-2.46101	-2.43718	-2.41103
x1tot(KERO)	-1.17061	-1.15638	-1.21994	-1.30188	-1.3955	-1.49374	-1.57631	-1.62669	-1.64116	-1.62804	-1.60159	-1.57356	-1.5492	-1.52954
x1tot(HSDO)	-0.61438	-0.6588	-0.8024	-0.96863	-1.13573	-1.29428	-1.42805	-1.52316	-1.57459	-1.58757	-1.57538	-1.55186	-1.5257	-1.50074
x1tot(BIOSOL)	-1.21728	-1.36943	-1.48761	-1.54766	-1.57918	-1.61291	-1.6525	-1.68682	-1.70444	-1.70398	-1.69556	-1.68967	-1.68861	-1.6883
x1tot(NSUBBBM)	-0.74413	-0.8078	-0.96727	-1.18961	-1.44382	-1.67877	-1.84892	-1.9359	-1.94975	-1.9167	-1.86171	-1.79891	-1.73429	-1.67236
x1tot(LPGSUB)	-0.86983	-1.04142	-1.39467	-1.77931	-2.1045	-2.31395	-2.38773	-2.34625	-2.23532	-2.10456	-1.99185	-1.91679	-1.88262	-1.88251
x1tot(LPGNSUB)	-0.69562	-0.83827	-1.16124	-1.52481	-1.84828	-2.08055	-2.19735	-2.20726	-2.14266	-2.04325	-1.94307	-1.86365	-1.81366	-1.79285
x1tot(LNG)	6.27E-02	8.08E-02	0.100223	0.113878	0.112701	0.101938	8.89E-02	7.30E-02	4.62E-02	1.41E-03	6.03E-02	-0.13049	-0.2004	-0.26605
x1tot(LISTRIKSUB)	-1.15004	-1.06209	-1.10312	-1.143	-1.15636	-1.15791	-1.15741	-1.1571	-1.15488	-1.14968	-1.14592	-1.14865	-1.15714	-1.16582
x1tot(LISTRIKNSUB)	-1.3363	-1.49413	-1.70916	-1.88103	-1.97765	-1.99533	-1.94817	-1.86632	-1.78385	-1.72628	-1.70392	-1.71158	-1.73498	-1.75971
x1tot(HIDRO)	-0.5868	-0.71443	-0.9972	-1.24164	-1.35976	-1.34192	-1.23214	-1.09882	-0.99998	-0.96261	-0.9826	-1.03618	-1.09467	-1.13682
x1tot(GASKOTA)	-0.76755	-0.71626	-0.76088	-0.8154	-0.87366	-0.94865	-1.03456	-1.11389	-1.17077	-1.1998	-1.20802	-1.20671	-1.20289	-1.19817
x1tot(AIRBERSIH)	-1.78814	-1.59749	-1.50417	-1.42187	-1.35422	-1.32156	-1.32081	-1.33375	-1.34137	-1.33529	-1.32176	-1.31177	-1.30988	-1.31303
x1tot(CONSTRUCT)	-2.26587	-2.93368	-2.79586	-2.39055	-2.05081	-1.85605	-1.74352	-1.63902	-1.52015	-1.41485	-1.3563	-1.34469	-1.35248	-1.35312
x1tot(TRADE)	-0.5581	-0.14387	-2.15E-02	3.53E-02	8.75E-02	0.112591	9.80E-02	5.73E-02	1.97E-02	8.51E-03	2.16E-02	3.94E-02	4.70E-02	4.36E-02
x1tot(RESTHOT)	-1.61255	-1.23599	-1.03871	-0.86327	-0.70176	-0.59909	-0.56507	-0.57551	-0.59369	-0.59338	-0.57474	-0.55546	-0.54931	-0.55686
x1tot(TRAIN)	-0.95029	-0.74964	-0.77654	-0.83154	-0.85196	-0.8519	-0.8512	-0.8572	-0.86386	-0.86221	-0.85372	-0.84766	-0.84926	-0.85564
x1tot(LANDTRAN)	-1.04303	-0.83318	-0.75532	-0.68981	-0.63188	-0.61178	-0.63072	-0.66626	-0.69098	-0.69096	-0.67459	-0.65914	-0.65349	-0.65485
x1tot(WATTRAN)	-0.45115	-0.13523	-6.88E-02	-5.88E-02	-4.74E-02	-4.62E-02	-6.49E-02	-9.70E-02	-0.12489	-0.1343	-0.12709	-0.11654	-0.1127	-0.11593
x1tot(SUPSERV)	-0.32954	0.21272	0.380584	0.458272	0.531779	0.577189	0.57517	0.537218	0.496586	0.48205	0.493009	0.508075	0.51112	0.502614
x1tot(BANK)	-1.0101	-0.83823	-0.801	-0.76123	-0.7096	-0.68432	-0.69709	-0.73117	-0.75888	-0.76257	-0.74755	-0.73147	-0.72552	-0.72854
x1tot(RESTATE)	-0.88151	-0.76001	-0.76563	-0.77739	-0.7784	-0.79071	-0.82087	-0.85763	-0.88401	-0.89083	-0.88394	-0.87614	-0.8748	-0.8786
x1tot(PUBLIC)	-2.2815	-2.0528	-1.9085	-1.77673	-1.6725	-1.62032	-1.6115	-1.62106	-1.62686	-1.62061	-1.60901	-1.60266	-1.60535	-1.61358
x1tot(OTHSERV)	-1.94735	-1.83377	-1.75072	-1.64979	-1.5621	-1.52056	-1.51931	-1.53283	-1.53789	-1.52711	-1.51015	-1.4996	-1.49892	-1.50305

5. Crude Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-4.20E-02	3.16E-03	2.48E-02	3.86E-02	4.80E-02	5.26E-02	5.26E-02	4.99E-02	4.69E-02	4.51E-02	4.41E-02	4.28E-02	4.05E-02	3.74E-02
x1tot(OTHCROPS)	-0.13758	-6.59E-02	-3.67E-02	-2.00E-02	-7.22E-03	1.86E-03	6.58E-03	8.19E-03	9.56E-03	1.30E-02	1.85E-02	2.42E-02	2.86E-02	3.12E-02
x1tot(LSTOCK)	-0.15483	-0.1287	-0.11612	-0.10789	-0.10343	-0.1036	-0.10736	-0.11225	-0.11592	-0.11756	-0.11793	-0.11825	-0.11919	-0.12065
x1tot(FOREST)	-9.22E-02	-0.13699	-0.16447	-0.16105	-0.14182	-0.12966	-0.13684	-0.154	-0.16828	-0.16974	-0.16212	-0.15463	-0.15278	-0.15524
x1tot(FISH)	-0.10282	-0.10428	-0.11209	-0.10844	-9.77E-02	-9.07E-02	-9.32E-02	-0.10289	-0.11275	-0.11748	-0.11696	-0.11474	-0.1142	-0.11625
x1tot(METAL)	-5.01E-03	-1.16E-02	-1.56E-02	-1.35E-02	-7.32E-03	3.12E-04	7.44E-03	1.22E-02	1.32E-02	1.02E-02	4.52E-03	-1.47E-03	-5.82E-03	-7.78E-03
x1tot(COAL)	9.82E-03	3.11E-02	6.88E-02	0.118828	0.176193	0.237588	0.300518	0.362267	0.419886	0.471001	0.514475	0.550249	0.578772	0.600471
x1tot(MNYAK)	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8
x1tot(GAS)	-6.71E-02	-0.25403	-0.55004	-0.90044	-1.26361	-1.60597	-1.90095	-2.12945	-2.28024	-2.35028	-2.34477	-2.27666	-2.16481	-2.0307
x1tot(GEO)	-5.39E-02	-0.28048	-0.60924	-0.93068	-1.1689	-1.29439	-1.32013	-1.28122	-1.2142	-1.14489	-1.08565	-1.03901	-1.00307	-0.97554
x1tot(OTHMIN)	-0.33603	-0.43479	-0.46336	-0.46432	-0.46373	-0.47088	-0.48299	-0.49316	-0.4965	-0.49279	-0.48504	-0.47639	-0.46827	-0.46072
x1tot(FOODPROC)	3.96E-02	9.30E-02	0.117963	0.135815	0.150903	0.161253	0.165533	0.164881	0.162188	0.159808	0.158072	0.155894	0.152356	0.147605
x1tot(TEXTILE)	0.146354	0.239819	0.296873	0.34305	0.386202	0.425983	0.459917	0.486086	0.504151	0.514907	0.519293	0.518119	0.512375	0.503363
x1tot(WOOD)	0.127403	0.143509	0.12911	0.140441	0.174402	0.202121	0.203725	0.183877	0.164048	0.158861	0.165188	0.170901	0.168072	0.158595
x1tot(PMJ)	7.42E-02	0.122989	0.147597	0.163126	0.173307	0.178279	0.178335	0.174694	0.169141	0.162997	0.156703	0.150294	0.14399	0.138231
x1tot(CHEMIC)	-1.0897	-1.06803	-1.08892	-1.12124	-1.15225	-1.17685	-1.19228	-1.19657	-1.18857	-1.16899	-1.14085	-1.10834	-1.07523	-1.04406
x1tot(BIOETHA)	-0.36429	-0.47042	-0.50556	-0.51882	-0.53414	-0.55486	-0.57444	-0.58601	-0.58757	-0.58208	-0.57355	-0.56413	-0.55402	-0.543
x1tot(BIODIES)	0.544339	0.701753	0.765043	0.806955	0.851987	0.896725	0.930913	0.948628	0.952073	0.94768	0.939753	0.928988	0.914931	0.898421
x1tot(OTHEREF)	-0.23847	-0.27765	-0.36828	-0.47705	-0.58442	-0.67776	-0.74963	-0.79704	-0.82061	-0.82355	-0.81045	-0.78623	-0.75541	-0.72179
x1tot(GASOL)	-0.38655	-0.45609	-0.50667	-0.55421	-0.60328	-0.64868	-0.68246	-0.69959	-0.70027	-0.68891	-0.67091	-0.65026	-0.62919	-0.60696
x1tot(BOPRE)	-0.36429	-0.47042	-0.50556	-0.51882	-0.53414	-0.55486	-0.57444	-0.58601	-0.58757	-0.58208	-0.57355	-0.56413	-0.55402	-0.543
x1tot(KERO)	-0.41223	-0.42057	-0.44763	-0.48007	-0.51207	-0.53885	-0.55664	-0.56372	-0.56082	-0.55078	-0.53713	-0.5228	-0.50955	-0.4982
x1tot(HSDO)	-0.26967	-0.28929	-0.32877	-0.3728	-0.41378	-0.44662	-0.46827	-0.47784	-0.47659	-0.46746	-0.45408	-0.43964	-0.42623	-0.41489
x1tot(BIOSOL)	-0.19864	-0.21397	-0.22607	-0.23381	-0.24022	-0.24744	-0.25553	-0.26302	-0.26834	-0.27113	-0.27224	-0.27269	-0.27293	-0.27282
x1tot(NSUBBBM)	-0.27427	-0.32588	-0.4141	-0.51839	-0.6216	-0.70872	-0.76999	-0.80247	-0.80922	-0.7968	-0.77222	-0.74122	-0.70808	-0.67595
x1tot(LPGSUB)	-0.43326	-0.54381	-0.72092	-0.90346	-1.04964	-1.13553	-1.15699	-1.12608	-1.06349	-0.99071	-0.92438	-0.87395	-0.84205	-0.82646
x1tot(LPGNSUB)	-0.4426	-0.56231	-0.75515	-0.957	-1.124	-1.23004	-1.26829	-1.2482	-1.18904	-1.11245	-1.03673	-0.97382	-0.929	-0.90224
x1tot(LNG)	4.04E-02	3.84E-02	2.97E-02	7.50E-03	-3.41E-02	-9.76E-02	-0.18153	-0.28062	-0.38626	-0.48809	-0.57699	-0.64762	-0.69911	-0.7338
x1tot(LISTRKSUB)	-0.1399	-0.12617	-0.12844	-0.13243	-0.13507	-0.13681	-0.13841	-0.13995	-0.14101	-0.14145	-0.14167	-0.1421	-0.14273	-0.1432
x1tot(LISTRKNSUB)	-0.18209	-0.20208	-0.23191	-0.25886	-0.27816	-0.28859	-0.2914	-0.28936	-0.28563	-0.28275	-0.28189	-0.28278	-0.28436	-0.28553
x1tot(HIDRO)	-5.69E-02	-6.09E-02	-7.76E-02	-8.83E-02	-8.66E-02	-7.39E-02	-5.62E-02	-4.07E-02	-3.24E-02	-3.30E-02	-4.08E-02	-5.22E-02	-6.36E-02	-7.25E-02
x1tot(GASKOTA)	-0.24454	-0.25219	-0.28941	-0.34162	-0.40405	-0.47357	-0.54504	-0.61068	-0.66151	-0.69045	-0.69518	-0.67875	-0.64791	-0.61057
x1tot(AIRBERSIH)	-0.17953	-0.15704	-0.14938	-0.14629	-0.14657	-0.1504	-0.15652	-0.16257	-0.16641	-0.16759	-0.16713	-0.16644	-0.16621	-0.16632
x1tot(CONSTRUCT)	-0.31339	-0.42701	-0.45122	-0.44816	-0.44936	-0.46087	-0.47555	-0.48492	-0.48586	-0.481	-0.47448	-0.46836	-0.46234	-0.4556
x1tot(TRADE)	6.74E-03	5.94E-02	7.88E-02	8.89E-02	9.63E-02	0.100327	0.100162	9.69E-02	9.33E-02	9.13E-02	9.08E-02	9.02E-02	8.84E-02	8.57E-02
x1tot(RESTHOT)	-0.12213	-7.65E-02	-5.33E-02	-3.66E-02	-2.49E-02	-2.00E-02	-2.15E-02	-2.62E-02	-3.04E-02	-3.21E-02	-3.21E-02	-3.20E-02	-3.33E-02	-3.57E-02
x1tot(TRAIN)	-8.49E-02	-6.30E-02	-7.05E-02	-8.37E-02	-9.42E-02	-0.10174	-0.10751	-0.11222	-0.11534	-0.11641	-0.11599	-0.11518	-0.11468	-0.11445
x1tot(LANDTRAN)	-0.17283	-0.14679	-0.13913	-0.13616	-0.13564	-0.1382	-0.14319	-0.1483	-0.15097	-0.15028	-0.14737	-0.14412	-0.14166	-0.14001
x1tot(WATTRAN)	-8.56E-03	2.59E-02	2.85E-02	2.19E-02	1.34E-02	3.91E-03	-6.83E-03	-1.79E-02	-2.77E-02	-3.50E-02	-4.02E-02	-4.45E-02	-4.87E-02	-5.28E-02
x1tot(SUPSERV)	1.89E-02	8.52E-02	0.106831	0.115859	0.122245	0.12591	0.125311	0.121148	0.116328	0.113265	0.111915	0.110646	0.108221	0.104766
x1tot(BANK)	-0.10654	-8.65E-02	-8.44E-02	-8.56E-02	-8.81E-02	-9.36E-02	-0.10243	-0.11252	-0.12101	-0.12633	-0.12911	-0.13102	-0.13321	-0.13571
x1tot(RESTATE)	-5.51E-02	-4.39E-02	-5.03E-02	-6.08E-02	-7.29E-02	-8.71E-02	-0.10339	-0.11994	-0.13465	-0.14647	-0.15583	-0.16381	-0.17108	-0.17763
x1tot(PUBLIC)	-0.23613	-0.20914	-0.19684	-0.19042	-0.18955	-0.19426	-0.20227	-0.21013	-0.21526	-0.21733	-0.21769	-0.21791	-0.21865	-0.21971
x1tot(OTHSERV)	-0.21457	-0.20317	-0.19938	-0.19763	-0.19938	-0.20561	-0.21464	-0.2232	-0.22866	-0.23058	-0.23038	-0.22975	-0.22949	-0.22944

6. Electricity Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	8.60E-03	5.00E-03	2.64E-03	9.18E-04	-9.43E-05	-3.06E-04	7.12E-05	6.50E-04	1.07E-03	1.15E-03	9.71E-04	6.96E-04	5.21E-04	4.74E-04
x1tot(OTHCROPS)	1.10E-02	7.09E-03	4.35E-03	1.91E-03	5.35E-05	-8.29E-04	-7.46E-04	-9.40E-05	5.85E-04	9.52E-04	9.43E-04	7.04E-04	4.75E-04	3.28E-04
x1tot(LSTOCK)	9.59E-03	5.51E-03	2.74E-03	9.41E-04	2.04E-04	4.44E-04	1.23E-03	2.05E-03	2.50E-03	2.50E-03	2.16E-03	1.73E-03	1.42E-03	1.29E-03
x1tot(FOREST)	3.26E-03	-3.43E-04	-3.81E-03	-6.61E-03	-7.12E-03	-5.09E-03	-1.91E-03	3.24E-04	4.44E-04	-1.04E-03	-2.76E-03	-3.68E-03	-3.68E-03	-3.23E-03
x1tot(FISH)	6.67E-03	5.00E-03	3.60E-03	1.74E-03	1.06E-04	-4.73E-04	9.70E-06	1.26E-03	2.17E-03	2.33E-03	1.86E-03	1.22E-03	8.26E-04	7.89E-04
x1tot(METAL)	1.36E-03	3.97E-03	7.51E-03	1.02E-02	1.10E-02	9.65E-03	6.93E-03	3.95E-03	1.73E-03	7.49E-04	9.23E-04	1.82E-03	2.90E-03	3.74E-03
x1tot(COAL)	2.17E-04	1.13E-04	1.13E-04	1.13E-04	-5.62E-05	-5.73E-04	-1.47E-03	-2.67E-03	-4.06E-03	-5.50E-03	-6.91E-03	-8.27E-03	-9.53E-03	-1.07E-02
x1tot(MNYAK)	7.56E-05	1.18E-03	3.00E-03	5.06E-03	6.84E-03	8.04E-03	8.59E-03	8.64E-03	8.44E-03	8.23E-03	8.10E-03	8.08E-03	8.13E-03	8.19E-03
x1tot(GAS)	3.40E-04	2.71E-03	6.39E-03	1.04E-02	1.40E-02	1.68E-02	1.87E-02	2.01E-02	2.14E-02	2.28E-02	2.46E-02	2.69E-02	2.96E-02	3.27E-02
x1tot(GEO)	-1.03E-02	-5.33E-02	-0.11466	-0.16909	-0.19878	-0.19913	-0.1775	-0.14688	-0.11953	-0.10313	-9.98E-02	-0.10722	-0.1203	-0.13366
x1tot(OTHMIN)	-4.45E-03	-1.18E-02	-1.59E-02	-1.56E-02	-1.19E-02	-7.26E-03	-3.78E-03	-2.62E-03	-3.51E-03	-5.37E-03	-7.11E-03	-8.08E-03	-8.26E-03	-7.88E-03
x1tot(FOODPROC)	9.82E-03	6.84E-03	4.83E-03	2.97E-03	1.46E-03	6.64E-04	6.00E-04	9.76E-04	1.39E-03	1.56E-03	1.47E-03	1.28E-03	1.17E-03	1.18E-03
x1tot(TEXTILE)	2.19E-02	1.95E-02	1.80E-02	1.66E-02	1.55E-02	1.51E-02	1.53E-02	1.59E-02	1.64E-02	1.65E-02	1.63E-02	1.57E-02	1.51E-02	1.46E-02
x1tot(WOOD)	1.12E-02	9.32E-03	5.71E-03	5.01E-04	-3.15E-03	-3.30E-03	-6.92E-04	2.14E-03	3.11E-03	2.20E-03	7.61E-04	-2.82E-05	5.40E-05	4.39E-04
x1tot(PMJ)	1.37E-02	1.04E-02	8.25E-03	6.71E-03	5.81E-03	5.54E-03	5.65E-03	5.79E-03	5.73E-03	5.42E-03	5.00E-03	4.58E-03	4.27E-03	4.11E-03
x1tot(CHEMIC)	1.32E-02	8.88E-03	5.78E-03	3.52E-03	2.31E-03	2.15E-03	2.64E-03	3.27E-03	3.61E-03	3.55E-03	3.23E-03	2.82E-03	2.50E-03	2.31E-03
x1tot(BIOETHA)	2.21E-03	-3.93E-03	-7.71E-03	-7.79E-03	-4.91E-03	-1.04E-03	1.93E-03	3.03E-03	2.53E-03	1.28E-03	8.40E-05	-6.21E-04	-8.23E-04	-6.58E-04
x1tot(BIODIES)	5.58E-02	4.87E-02	3.94E-02	2.82E-02	1.83E-02	1.26E-02	1.18E-02	1.45E-02	1.84E-02	2.16E-02	2.32E-02	2.32E-02	2.23E-02	2.11E-02
x1tot(OTHREF)	5.06E-03	5.07E-03	6.28E-03	7.62E-03	8.58E-03	8.95E-03	8.74E-03	8.11E-03	7.29E-03	6.48E-03	5.81E-03	5.36E-03	5.12E-03	5.02E-03
x1tot(GASOL)	3.42E-03	-1.27E-03	-4.11E-03	-4.72E-03	-3.56E-03	-1.71E-03	-1.77E-04	5.19E-04	4.72E-04	7.88E-05	-3.15E-04	-5.25E-04	-5.44E-04	-4.52E-04
x1tot(BIOPRE)	2.21E-03	-3.93E-03	-7.71E-03	-7.79E-03	-4.91E-03	-1.04E-03	1.93E-03	3.03E-03	2.53E-03	1.28E-03	8.40E-05	-6.21E-04	-8.23E-04	-6.58E-04
x1tot(KERO)	8.20E-03	5.50E-03	4.03E-03	3.34E-03	3.25E-03	3.51E-03	3.80E-03	3.88E-03	3.69E-03	3.34E-03	2.93E-03	2.62E-03	2.46E-03	2.45E-03
x1tot(HSDO)	8.72E-03	7.45E-03	6.94E-03	6.76E-03	6.75E-03	6.78E-03	6.70E-03	6.41E-03	5.96E-03	5.46E-03	5.05E-03	4.79E-03	4.69E-03	4.71E-03
x1tot(BIOSOL)	1.40E-02	1.07E-02	7.47E-03	5.05E-03	3.95E-03	4.15E-03	5.06E-03	6.00E-03	6.51E-03	6.52E-03	6.17E-03	5.69E-03	5.27E-03	4.99E-03
x1tot(NSUBBBM)	-1.61E-02	-2.02E-02	-2.34E-02	-2.56E-02	-2.67E-02	-2.70E-02	-2.69E-02	-2.66E-02	-2.62E-02	-2.60E-02	-2.59E-02	-2.60E-02	-2.62E-02	-2.64E-02
x1tot(LPGSUB)	4.15E-03	3.50E-03	4.00E-03	4.56E-03	4.64E-03	4.15E-03	3.29E-03	2.40E-03	1.76E-03	1.49E-03	1.56E-03	1.80E-03	2.09E-03	2.31E-03
x1tot(LPGNSUB)	4.73E-03	4.46E-03	5.34E-03	6.18E-03	6.41E-03	5.92E-03	4.92E-03	3.79E-03	2.89E-03	2.40E-03	2.33E-03	2.56E-03	2.92E-03	3.26E-03
x1tot(LNG)	-2.93E-03	-1.56E-03	3.92E-04	2.38E-03	3.96E-03	4.84E-03	5.01E-03	4.62E-03	3.91E-03	3.11E-03	2.32E-03	1.64E-03	1.14E-03	8.65E-04
x1tot(LISTRKSUB)	4.81E-02	3.80E-02	2.66E-02	1.70E-02	1.12E-02	9.58E-03	1.12E-02	1.42E-02	1.70E-02	1.87E-02	1.89E-02	1.81E-02	1.69E-02	1.56E-02
x1tot(LISTRKNSUB)	1.18E-02	7.75E-03	3.78E-03	8.01E-04	-5.67E-04	-3.27E-04	9.43E-04	2.45E-03	3.54E-03	3.90E-03	3.56E-03	2.79E-03	1.95E-03	1.35E-03
x1tot(HIDRO)	-5.07E-02	-7.20E-02	-0.10049	-0.126	-0.14146	-0.14485	-0.13867	-0.12784	-0.11727	-0.11028	-0.10804	-0.10985	-0.11398	-0.11849
x1tot(GASKOTA)	-5.04E-03	-5.81E-03	-5.14E-03	-4.13E-03	-3.31E-03	-3.01E-03	-3.37E-03	-4.31E-03	-5.57E-03	-6.89E-03	-7.96E-03	-8.61E-03	-8.78E-03	-8.54E-03
x1tot(AIRBERSIH)	1.32E-02	8.39E-03	4.64E-03	2.00E-03	7.89E-04	9.36E-04	1.87E-03	2.91E-03	3.54E-03	3.63E-03	3.32E-03	2.86E-03	2.47E-03	2.25E-03
x1tot(CONSTRUCT)	-6.71E-03	-1.46E-02	-1.87E-02	-1.77E-02	-1.32E-02	-7.82E-03	-4.14E-03	-3.11E-03	-4.25E-03	-6.29E-03	-8.09E-03	-9.08E-03	-9.25E-03	-8.85E-03
x1tot(TRADE)	1.36E-02	9.49E-03	6.09E-03	3.12E-03	1.12E-03	4.49E-04	9.00E-04	1.84E-03	2.63E-03	2.96E-03	2.85E-03	2.51E-03	2.17E-03	1.92E-03
x1tot(RESTHOT)	1.18E-02	6.55E-03	2.90E-03	3.46E-04	-9.35E-04	-8.80E-04	6.74E-06	1.21E-03	1.95E-03	2.08E-03	1.71E-03	1.18E-03	7.94E-04	6.38E-04
x1tot(TRAN)	3.40E-02	2.70E-02	1.86E-02	1.09E-02	5.83E-03	4.21E-03	5.44E-03	8.06E-03	1.06E-02	1.23E-02	1.28E-02	1.23E-02	1.13E-02	1.04E-02
x1tot(LANDTRAN)	1.05E-02	6.45E-03	3.51E-03	1.49E-03	5.81E-04	7.47E-04	1.50E-03	2.25E-03	2.58E-03	2.44E-03	2.04E-03	1.60E-03	1.32E-03	1.20E-03
x1tot(WATTRAN)	1.21E-02	7.69E-03	3.62E-03	6.01E-06	-2.30E-03	-3.09E-03	-2.57E-03	-1.44E-03	-4.04E-04	1.48E-04	1.58E-04	-2.01E-04	-6.51E-04	-1.05E-03
x1tot(SUPSERV)	1.85E-02	1.31E-02	8.21E-03	3.73E-03	6.76E-04	-3.66E-04	3.06E-04	1.80E-03	3.16E-03	3.89E-03	3.95E-03	3.58E-03	3.07E-03	2.62E-03
x1tot(BANK)	9.33E-03	5.37E-03	2.29E-03	-5.05E-05	-1.29E-03	-1.36E-03	-6.63E-04	1.85E-04	7.00E-04	7.09E-04	3.60E-04	-9.95E-05	-4.40E-04	-6.14E-04
x1tot(RESTATE)	7.04E-03	3.24E-03	1.05E-04	-2.30E-03	-3.61E-03	-3.77E-03	-3.17E-03	-2.38E-03	-1.87E-03	-1.82E-03	-2.11E-03	-2.54E-03	-2.91E-03	-3.15E-03
x1tot(PUBLIC)	1.13E-02	5.99E-03	2.36E-03	1.41E-04	-6.06E-04	-1.17E-04	9.78E-04	1.99E-03	2.50E-03	2.43E-03	1.99E-03	1.47E-03	1.10E-03	9.53E-04
x1tot(OTHSERV)	9.96E-03	5.03E-03	1.57E-03	-4.60E-04	-9.77E-04	-3.22E-04	8.20E-04	1.73E-03	2.05E-03	1.80E-03	1.26E-03	7.30E-04	3.99E-04	2.88E-04
x2tot(FCROPS)	5.52E-02	4.53E-02	3.94E-03	-3.18E-02	-4.10E-02	-2.35E-02	5.30E-03	2.53E-02	2.63E-02	1.28E-02	-3.42E-03	-1.18E-02	-9.81E-03	-1.60E-03

7. Gas Scenario

Sectors	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
x1tot(FCROPS)	-1.56E-02	-4.79E-03	2.08E-03	7.33E-03	1.09E-02	1.23E-02	1.15E-02	9.20E-03	6.50E-03	4.07E-03	2.06E-03	2.85E-04	-1.46E-03	-3.14E-03
x1tot(OTHCROPS)	-5.72E-04	2.43E-02	3.99E-02	5.18E-02	6.09E-02	6.68E-02	6.92E-02	6.87E-02	6.65E-02	6.40E-02	6.18E-02	5.97E-02	5.74E-02	5.49E-02
x1tot(LSTOCK)	-5.16E-02	-4.92E-02	-4.61E-02	-4.26E-02	-3.99E-02	-3.93E-02	-4.05E-02	-4.28E-02	-4.50E-02	-4.69E-02	-4.83E-02	-4.97E-02	-5.10E-02	-5.22E-02
x1tot(FOREST)	-4.83E-02	-7.98E-02	-0.101847	-0.106257	-9.86E-02	-9.05E-02	-9.00E-02	-9.65E-02	-0.103159	-0.104689	-0.101609	-9.78E-02	-9.61E-02	-9.65E-02
x1tot(FISH)	-3.40E-02	-3.84E-02	-4.22E-02	-4.13E-02	-3.73E-02	-3.44E-02	-3.48E-02	-3.84E-02	-4.28E-02	-4.60E-02	-4.75E-02	-4.80E-02	-4.86E-02	-4.99E-02
x1tot(METAL)	-1.50E-03	-1.52E-03	1.87E-03	9.72E-03	2.07E-02	3.28E-02	4.42E-02	5.29E-02	5.74E-02	5.74E-02	5.35E-02	4.72E-02	4.02E-02	3.34E-02
x1tot(COAL)	4.52E-03	1.60E-02	3.64E-02	6.29E-02	9.28E-02	0.123808	0.154607	0.183784	0.210015	0.232255	0.250065	0.263532	0.273081	0.279126
x1tot(MNYAK)	-1.24E-03	6.40E-03	2.13E-02	4.12E-02	6.37E-02	8.76E-02	0.11193	0.135861	0.158371	0.178584	0.196009	0.21059	0.222471	0.231799
x1tot(GAS)	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4
x1tot(GEO)	-4.97E-02	-5.21E-02	-5.31E-02	-5.12E-02	-4.63E-02	-3.93E-02	-3.25E-02	-2.84E-02	-2.86E-02	-3.27E-02	-3.91E-02	-4.55E-02	-5.00E-02	-5.22E-02
x1tot(OTHMIN)	-0.131755	-0.189899	-0.212498	-0.216614	-0.215081	-0.214351	-0.215363	-0.216359	-0.2156	-0.212747	-0.209637	-0.20426	-0.200019	-0.195861
x1tot(FOODPROC)	8.76E-03	2.42E-02	3.34E-02	4.05E-02	4.61E-02	4.93E-02	4.96E-02	4.76E-02	4.43E-02	4.10E-02	3.80E-02	3.53E-02	3.27E-02	3.00E-02
x1tot(TEXTILE)	3.73E-02	7.26E-02	0.100034	0.124244	0.146494	0.166096	0.182016	0.193517	0.200548	0.20354	0.203069	0.19968	0.193974	0.186599
x1tot(WOOD)	3.54E-02	3.19E-02	1.65E-02	1.44E-02	2.64E-02	3.91E-02	4.08E-02	3.11E-02	1.95E-02	1.41E-02	1.52E-02	1.76E-02	1.69E-02	1.31E-02
x1tot(PMI)	-5.90E-02	-4.36E-02	-3.10E-02	-1.94E-02	-9.46E-03	-1.85E-03	3.03E-03	5.37E-03	5.70E-03	4.52E-03	2.11E-03	-1.36E-03	-5.59E-03	-1.01E-02
x1tot(CHEMIC)	-0.140207	-0.121555	-0.104932	-8.86E-02	-7.36E-02	-6.14E-02	-5.29E-02	-4.78E-02	-4.53E-02	-4.43E-02	-4.43E-02	-4.54E-02	-4.74E-02	-5.00E-02
x1tot(BIOETHA)	-0.148449	-0.205625	-0.228298	-0.235532	-0.239235	-0.243308	-0.246758	-0.247425	-0.244603	-0.239432	-0.23348	-0.227619	-0.221855	-0.215971
x1tot(BIODIES)	0.17737	0.242203	0.27663	0.299499	0.31861	0.33365	0.34203	0.342444	0.336494	0.327459	0.317819	0.308341	0.29884	0.289346
x1tot(OTHREF)	1.90E-02	3.37E-02	4.95E-02	6.63E-02	8.28E-02	9.77E-02	0.110107	0.119473	0.125522	0.128212	0.12776	0.124673	0.119621	0.113304
x1tot(GASOL)	-8.23E-02	-0.116405	-0.134904	-0.147467	-0.159263	-0.170795	-0.180187	-0.185579	-0.186585	-0.184274	-0.180136	-0.175238	-0.170016	-0.16469
x1tot(BIOPRE)	-0.148449	-0.205625	-0.228298	-0.235532	-0.239235	-0.243308	-0.246758	-0.247425	-0.244603	-0.239432	-0.23348	-0.227619	-0.221855	-0.215971
x1tot(KERO)	-4.81E-02	-5.03E-02	-5.14E-02	-5.18E-02	-5.29E-02	-5.51E-02	-5.77E-02	-6.03E-02	-6.24E-02	-6.43E-02	-6.63E-02	-6.84E-02	-7.05E-02	-7.25E-02
x1tot(HSDO)	-2.69E-02	-2.85E-02	-2.97E-02	-3.02E-02	-3.06E-02	-3.15E-02	-3.27E-02	-3.40E-02	-3.54E-02	-3.69E-02	-3.88E-02	-4.13E-02	-4.41E-02	-4.71E-02
x1tot(BIOSOL)	-6.58E-02	-7.49E-02	-7.84E-02	-7.79E-02	-7.62E-02	-7.52E-02	-7.55E-02	-7.67E-02	-7.82E-02	-7.97E-02	-8.12E-02	-8.29E-02	-8.49E-02	-8.68E-02
x1tot(NSUBBBM)	-2.33E-02	-3.00E-02	-3.63E-02	-4.41E-02	-5.35E-02	-6.31E-02	-7.10E-02	-7.62E-02	-7.89E-02	-7.97E-02	-7.95E-02	-7.88E-02	-7.77E-02	-7.63E-02
x1tot(LPGSUB)	-2.99E-02	-3.70E-02	-4.78E-02	-5.91E-02	-6.91E-02	-7.61E-02	-7.97E-02	-8.02E-02	-7.91E-02	-7.78E-02	-7.73E-02	-7.80E-02	-7.97E-02	-8.19E-02
x1tot(LPGNSUB)	-2.09E-02	-2.49E-02	-3.20E-02	-3.98E-02	-4.69E-02	-5.23E-02	-5.55E-02	-5.67E-02	-5.67E-02	-5.66E-02	-5.71E-02	-5.85E-02	-6.05E-02	-6.29E-02
x1tot(LNG)	-1.66792	-1.76248	-1.91666	-2.10001	-2.29241	-2.47842	-2.648	-2.79568	-2.91955	-3.0199	-3.09824	-3.15678	-3.19819	-3.2254
x1tot(LISTRIKSUB)	-7.14E-02	-6.64E-02	-6.13E-02	-5.53E-02	-5.00E-02	-4.63E-02	-4.47E-02	-4.47E-02	-4.58E-02	-4.73E-02	-4.92E-02	-5.13E-02	-5.35E-02	-5.57E-02
x1tot(LISTRIKNSUB)	-9.01E-02	-9.54E-02	-9.88E-02	-0.100662	-0.102176	-0.103631	-0.104946	-0.106012	-0.106986	-0.108144	-0.109587	-0.111158	-0.112554	-0.113527
x1tot(HIDRO)	-5.05E-03	-3.48E-03	-2.73E-03	-1.38E-03	4.35E-04	2.19E-03	3.21E-03	2.87E-03	8.35E-04	-2.71E-03	-7.18E-03	-1.18E-02	-1.58E-02	-1.89E-02
x1tot(GASKOTA)	-1.29513	-1.24283	-1.16679	-1.0806	-0.997307	-0.925152	-0.868346	-0.827659	-0.801424	-0.78679	-0.780682	-0.780307	-0.783237	-0.787525
x1tot(AIRBERSIH)	-5.62E-02	-5.42E-02	-5.14E-02	-4.79E-02	-4.53E-02	-4.46E-02	-4.68E-02	-4.81E-02	-5.04E-02	-5.23E-02	-5.39E-02	-5.55E-02	-5.71E-02	-5.86E-02
x1tot(CONSTRUCT)	-0.144583	-0.21186	-0.235682	-0.240013	-0.240214	-0.241881	-0.244332	-0.244999	-0.242724	-0.238389	-0.233502	-0.228834	-0.224209	-0.219218
x1tot(TRADE)	-2.60E-03	1.34E-02	2.25E-02	2.95E-02	3.50E-02	3.83E-02	3.87E-02	3.68E-02	3.36E-02	3.06E-02	2.79E-02	2.53E-02	2.25E-02	1.96E-02
x1tot(RESTHOT)	-4.45E-02	-3.70E-02	-3.11E-02	-2.52E-02	-2.08E-02	-1.92E-02	-2.05E-02	-2.36E-02	-2.69E-02	-2.95E-02	-3.12E-02	-3.26E-02	-3.40E-02	-3.54E-02
x1tot(TRAIN)	-2.91E-02	-2.11E-02	-1.82E-02	-1.65E-02	-1.50E-02	-1.45E-02	-1.55E-02	-1.79E-02	-2.09E-02	-2.38E-02	-2.64E-02	-2.87E-02	-3.10E-02	-3.31E-02
x1tot(LANDTRAN)	-4.95E-02	-4.44E-02	-3.96E-02	-3.40E-02	-2.89E-02	-2.58E-02	-2.52E-02	-2.63E-02	-2.79E-02	-2.94E-02	-3.06E-02	-3.20E-02	-3.37E-02	-3.57E-02
x1tot(WATTRAN)	-1.84E-03	6.84E-03	7.84E-03	6.11E-03	3.22E-03	-8.72E-04	-6.26E-03	-1.25E-02	-1.87E-02	-2.41E-02	-2.86E-02	-3.23E-02	-3.56E-02	-3.85E-02
x1tot(SUPSERV)	8.92E-03	2.97E-02	3.96E-02	4.59E-02	5.05E-02	5.29E-02	5.22E-02	4.89E-02	4.44E-02	4.02E-02	3.68E-02	3.37E-02	3.05E-02	2.72E-02
x1tot(BANK)	-3.96E-02	-3.82E-02	-3.87E-02	-3.85E-02	-3.85E-02	-3.99E-02	-4.31E-02	-4.77E-02	-5.24E-02	-5.64E-02	-5.95E-02	-6.23E-02	-6.49E-02	-6.73E-02
x1tot(RESTATE)	-2.61E-02	-2.90E-02	-3.51E-02	-4.16E-02	-4.83E-02	-5.57E-02	-6.39E-02	-7.24E-02	-8.02E-02	-8.67E-02	-9.21E-02	-9.66E-02	-0.100492	-0.103718
x1tot(PUBLIC)	-7.64E-02	-7.58E-02	-7.36E-02	-7.06E-02	-6.90E-02	-6.98E-02	-7.25E-02	-7.58E-02	-7.88E-02	-8.10E-02	-8.27E-02	-8.42E-02	-8.56E-02	-8.68E-02
x1tot(OTHSERV)	-7.31E-02	-7.75E-02	-7.79E-02	-7.60E-02	-7.44E-02	-7.46E-02	-7.68E-02	-7.98E-02	-8.25E-02	-8.45E-02	-8.60E-02	-8.74E-02	-8.89E-02	-9.02E-02

Appendix D Summary of Impact on Sectors Output for Scenario A2 (author's calculation)

Summary

Natural gas is regarded as the future energy of Indonesia and the natural gas sector has a strategic role to play in national development. This role can be seen in the state revenue and multiplier effect it generates, for example, in the growth of employment levels. Its contribution to the national economy is about to 5.55% of Indonesia's total GDP (ICAS, 2010).

Since 2001, domestic gas demand has grown slowly at 2.8% per annum (IEA, 2008). Recent increases in the demand for gas have been strongly affected by the replacement of higher priced oil with gas; it was estimated that, in 2006, natural gas replaced 1.9 billion barrels of oil usage (IEA, 2008). However, this drastic change was not accompanied by sufficient preparation (for example, there was insufficient infrastructure connectivity), because natural gas had not been included in long-term planning as a significant part of the energy mix.

Prior to 2001, gas policy prioritized gas utilization for export in order to maximize state revenue, and infrastructure development went to the Trans ASEAN Gas Pipeline (TAGP) instead of domestic consumption. After the new oil and gas law was introduced in 2001, there were some crucial changes in gas policy. The producers now had a domestic market obligation (DMO) of 25%, and big gas reserves were prioritized for the domestic market.

That new policy directive could not easily be implemented because of path dependency. Some parts of the reserves were bound by long-term contracts, limited infrastructure connectivity, and lack of clarity about pricing policy. Moreover, boosting gas production was hindered by a non-conducive investment environment.

Most energy policy issues in Indonesia were approached without the benefit of a reliable, integrated energy policy model, one that takes into account the impact of various policies on economic factors (e.g., prices), technologies, environment, lifestyle, GDP, population, and so forth (Muliadireja, 2005). Natural gas policy, as an integral and coherent part of national energy policy, has a similar problem.

We argue, within the context of Indonesia's political and cultural background, that energy planning is needed based on solid scientific grounding. Successive Indonesian governments

have implemented a series of policies to mitigate domestic natural gas scarcities. However, both the nature and consequences of these policy measures lacked solid scientific grounding. Gas policy-making in Indonesia should take into account the potential benefits of natural gas, such as energy security, economic growth, household welfare, and income distribution. The important questions to be addressed are: How can decision-makers assess the policy impact on each of these dimensions? Will the policy benefit residents, or affect them negatively? Economic and social variables have complex direct and indirect linkages; therefore we need a tool for quantitative economic analysis that evaluates policy effectiveness and its impact on the economy and welfare (Qin, 2011).

The main objective of this thesis is to provide scientific grounding for natural gas policy. Based on this objective, the overarching research question in this dissertation is:

Does Indonesian gas policy contribute optimally to macroeconomic development of the nation, and, if not, what adjustments are needed?

The answer is to be found in the debate between two different perspectives on regulation which have different objectives: the neoclassical economics perspective and the political regulation perspective. The neoclassical viewpoint emphasizes the importance of economic efficiency and correcting market failures, while political regulation focuses on social goals.

These two different objectives should not be in conflict. Instead, an energy-planning perspective with a three-layered structure – macro (national economy), meso (energy sector), and micro (prices) – can theoretically integrate the economic efficiency perspective of neoclassical economics and the political regulation perspective of achieving certain social goals (equity). Energy planning requires analysis that links the energy sector to the rest of the economy, its national objectives, and the impact of policy on the economy in terms of availability, prices, taxes, and the like (Munasinghe, 1993).

This dissertation focuses on providing this type of analysis for natural gas policy. We argue that gas policy affects the macroeconomic situation of the nation.

Chapter 2 reviews the current condition of the Indonesian gas sector, its contribution to economic activity, and the policy directive implemented since the new oil and gas law in 2001. Here, we identify the fundamental problems in the Indonesian gas sector, which can

be classified into three parts: gas allocation, pricing, and infrastructure. These are the central components of our analysis in the empirical chapters (6, 7, and 8).

Our theoretical framework, which is based on the linkages between energy and development, is developed in chapter 3. Energy is a substantial component in achieving social development and economic growth. These objectives can be conflicting; therefore the role of the government is to mediate these two different paradigms and to ensure an effective balance between economic efficiency and social objectives. This concept becomes the cornerstone for the integrated energy planning (INEP), the analytical framework used in this thesis.

In chapter 4, the concept of INEP is adapted to the natural gas sector. The analytical framework leads to the formulation of counterfactual analysis using the Computable General Equilibrium (CGE) model to answer the three main research questions. The structure of the CGE model, our main methodology for the empirical chapters, is discussed in chapter 5. Model construction is described step by step, starting from processing the database through execution of simulation scenarios.

In chapter 6, we use a recursive dynamic CGE model to analyze the relationship between the economy and natural gas consumption, with natural gas as an explicit production factor. The model evaluates the effectiveness of gas allocation policies for mitigating gas scarcity issues through three different groups of scenarios, in which gas consumption for each sector is reduced. This method helps to determine the sectors with the highest impact on gas consumption, and allows reallocation of gas from low-value to relatively high-value sectors. The results indicate that gas allocation priority should be ranked: Industry, Petrochemical Sector, Crude Oil Production, and Electricity. This indicates that the current natural gas allocation by the government needs to be revised.

Chapter 7 examines the impact of natural gas price adjustments from macro and micro perspectives with the CGE model and Net Back Value methods. The results show that increasing natural gas prices up to 91% does not cause critical damage to the Indonesian economy. Micro analysis of two gas consumers, fertilizer and electricity, shows similar results, where price adjustments are still within acceptable ranges for their cost structures. This indicates that a new range of gas prices can serve as a conceptual model for the Indonesian government.

Chapter 8 investigates the impact of natural gas infrastructure development on the Indonesian economy and potential sources to finance it. Based on natural gas supply-and-demand projections and engineering design of natural gas infrastructure, we simulated three sources of financing public investment: foreign loan, removal of the gasoline subsidy, and state revenue from oil and gas. Each of these three options has a different effect on the economy. Subsidy removal is far more effective with respect to macro indicators, but reallocation of state revenue from oil and gas has a more positive impact on sectoral indicators (economic output and employment), followed by foreign loan. A trade-off should be made, and this very much depends on the policy-maker's priorities.

The answer to this central research question is expected to bring genuine change, or at least stimulate change, in relevant areas of natural gas policy that would improve both welfare and energy security. The objective of this thesis was to understand under which circumstances policy reforms in the gas sector can be improved.

Samenvatting

Indonesië beschouwt aardgas de energiebron van de toekomst. Sinds 2001 is de vraag naar aardgas jaarlijks met 2,8% toegenomen en wordt aardgas van strategisch belang geacht voor de nationale ontwikkeling van het land (IEA, 2008). Het strategisch belang van aardgas toont zich in staatsinkomsten (aardgasbaten) en in het economische multiplier effect, zoals de groei van de werkgelegenheid. Aardgas draagt circa 5,55% bij aan het nationale product van Indonesië (ICAS, 2010).

De recente toename van de vraag naar aardgas is mede een gevolg van de substitutie van het duurdere aardolie door aardgas. Schattingen geven aan dat in 2006 circa 1.9 miljard vaten olie werden vervangen door aardgas (IEA, 2008). Dit substitutie effect en de gevolgen voor de vraag naar aardgas werden niet voorzien, waardoor geen maatregelen werden genomen om aan de toenemende vraag te kunnen voldoen (bijvoorbeeld te weinig pijpleidingen). Aardgas is namelijk geen aandachtspunt in de lange termijn planning van de binnenlandse energievoorziening.

Voor 2001 werd in het Indonesische gasbeleid namelijk prioriteit gegeven aan export van aardgas en het maximaliseren van de daarmee verbonden aardgasbaten. Om die reden werd in de ontwikkeling van de gasinfrastructuur voorkeur gegeven aan de export gerichte Trans ASEAN Gas Pipeline (TAGP). Echter, na 2001 werd in het gasbeleid meer prioriteit toegekend aan de binnenlandse vraag naar aardgas, hetgeen een significante wijziging in het nationale aardgasbeleid betekende. Producenten van aardgas kregen door deze beleidswijziging een verplichting om ten minste 25% van hun productie te bestemmen voor binnenlands gebruik en enkele grote nog niet in productie genomen aardgasvelden werden gereserveerd voor binnenlands gebruik.

Het realiseren van deze beleidswijziging ten gunste van de binnenlandse gasmarkt werd gehinderd door pad afhankelijkheid. Delen van de aardgasreserves waren al gecontracteerd onder lange termijn contracten en ook de capaciteit van de binnenlandse gasinfrastructuur bleek onvoldoende. Daarnaast voerde de Indonesische regering een ondoorzichtig prijsbeleid en was het investeringsklimaat niet bevorderlijk voor investeringen in de exploitatie van nieuwe gasvelden.

Het energiebeleid van Indonesië mist een gedegen onderbouwing met behulp van een geïntegreerd energiebeleidsmodel waarmee economische effecten van beleidsmaatregelen

kunnen worden geanalyseerd, zoals effecten op prijzen, het milieu, de technologie, lifestyle, binnenlands product en dergelijke (Muliadireja, 2005). Hetzelfde geldt voor het aardgasbeleid van Indonesië.

In dit proefschrift beargumenteren wij dat binnen de politieke en culturele historie en context van het land, energie planning in Indonesië gebaseerd moet en kan worden op een gedegen wetenschappelijke analyse. De recente maatregelen van de Indonesische regering om de binnenlandse schaarste aan aardgas op te vangen, missen deze wetenschappelijke basis. Gasbeleid in Indonesië zou veel meer gebaseerd moeten worden op de potentiële economische voordelen van aardgas voor het land, zoals zekerheid van energievoorziening, economische groei, welvaart en inkomensverdeling. Een belangrijke vraag in dit verband is hoe in de besluitvorming over aardgas meer rekening gehouden kan worden met mogelijke positieve economische effecten voor Indonesië. Komt het gasbeleid ten goede aan de inwoners of worden deze juist benadeeld? Echter economische en sociale factoren zijn complex en hebben vele directe en indirecte relaties. Om die reden is een geavanceerde kwantitatieve economische analyse methodiek belangrijk om de economische effecten van het gasbeleid betrouwbaar en gedetailleerd in beeld te brengen (Qin, 2011).

De centrale doelstelling van dit proefschrift is om het gasbeleid in Indonesië te voorzien van een wetenschappelijke basis. Deze doelstelling is vertaald in de volgende probleemstelling van het onderzoek: *Draagt het Indonesische gasbeleid optimaal bij aan de macro-economische ontwikkeling van het land en zo niet, welke aanpassingen zijn nodig?*

Theoretisch hebben we ons antwoord op deze vraag uitgewerkt met behulp van twee reguleringsperspectieven: het neoklassieke economische reguleringsperspectief en het politieke reguleringsperspectief. In het neoklassieke economische perspectief dient regulering het streven naar economische efficiëntie en het corrigeren van markt falen. In het politieke perspectief dient regulering sociale doelstellingen. Beide perspectieven moeten niet conflicteren. Integendeel, ons theoretisch kader is gebaseerd op de idee dat een energie planningsperspectief met een driedelige structuur – macro (nationale economie), meso (energie sector) en micro (prijzen) – beide perspectieven (economische efficiency en sociale doelen, gelijkheid) kan integreren. Dat betekent wel dat energieplanning gebaseerd zou moeten zijn op een samenhangende analyse van de energiesector en de rest van de economie. Op deze wijze kunnen economische consequenties van energieplanning in termen van beschikbaarheid van energie, prijzen, belastingen, etc. onderbouwd in beeld worden gebracht (Munasinghe, 1993). Dit proefschrift verschaft een dergelijke onderbouwde

analyse van het aardgasbeleid in Indonesië, waarbij wij beargumenteren en laten zien dat het gasbeleid gevolgen heeft voor de macro-economische ontwikkeling van het land.

Hoofdstuk 2 analyseert de huidige aardgas sector in Indonesië, hoe het bijdraagt aan de nationale economie en welke ontwikkelingen zich hebben voorgedaan sinds de beleidswijziging ten gunste van de binnenlandse gasmarkt, in 2001. Gebleken is dat het Indonesische gasbeleid drie fundamentele problemen kent: de wijze waarop aardgas wordt geprioriteerd voor binnenlands gebruik, het prijsbeleid en de gasinfrastructuur. Deze drie problemen staan centraal in de drie empirische hoofdstukken (6, 7, 8) van dit proefschrift.

De uitwerking van het theoretische kader, gebaseerd op de relatie tussen energie en ontwikkeling, is het onderwerp in hoofdstuk 3. De analyse laat zien dat energie belangrijk is voor het realiseren van sociale ontwikkeling en economische groei. Omdat beide doelstellingen kunnen conflicteren, is het de taak van de overheid om beide doelstellingen door middel van beleid in balans te brengen. Dit in balans brengen van beide doelstellingen vormt de kern van Geïntegreerde energie planning (INEP), het analyse kader in dit onderzoek.

In hoofdstuk 4 passen we het kader (INEP) toe op de gassector in Indonesië. Het analyse kader wordt in combinatie met het *Computable General Equilibrium* (CGE) model gebruikt om drie onderzoeksvragen te beantwoorden. De opzet en structuur van het CGE model, onze methodologie voor de empirische analyse, wordt in hoofdstuk 5 besproken. Het model wordt stapsgewijs besproken van het verwerken van data tot en met de simulatie van beleidsscenario's.

In hoofdstuk 6 gebruiken we een recursief dynamisch CGE model in de analyse van de economische effecten van aardgasconsumptie waarbij aardgas is beschouwd als productiefactor. Het model vergelijkt en evalueert de effecten van aardgasprioritering door de Indonesische regering als antwoord op aardgas schaarste in drie beleidsscenario's. In de scenario's varieert de beschikbaarheid van aardgas per economische sector. Daardoor kunnen de economische effecten worden geanalyseerd van een herallocatie van aardgas van economisch laagwaardige naar economisch hoogwaardige sectoren. Onze analyse laat zien dat optimale economische effecten worden bereikt bij prioritering in binnenlandse gasconsumptie naar de sectoren Industrie, Petrochemische sector, Olieproductie en Elektriciteit. Deze resultaten geven aan dat de huidige prioritering van de binnenlandse aardgasconsumptie door de Indonesische regering aanpassing behoeft.

Hoofdstuk 7 analyseert de macro en micro economische effecten van aanpassingen in de binnenlandse aardgasprijs met behulp van het CGE model en de Net Back Value methode. De resultaten van onze analyse laten zien dat een gasprijsverhoging tot 91% niet schadelijk is voor de Indonesische economie. De analyse van de effecten op microniveau voor de kunstmestindustrie en elektriciteitsproductie geeft eenzelfde beeld. Substantiële prijsverhogingen van aardgas blijven binnen aanvaardbare grenzen van de kostenstructuur in beide sectoren. Dit geeft aan dat een nieuwe range van aardgasprijzen basis kan zijn in het aardgasbeleid in Indonesië.

Hoofdstuk 8 analyseert de invloed van de verdere ontwikkeling van de aardgasinfrastructuur op de Indonesische economie en de wijze waarop deze ontwikkeling gefinancierd zou kunnen worden. Uitgaande van bestaande verwachtingen ten aanzien van vraag en aanbod ontwikkeling en infrastructuur ontwerp, hebben we drie simulaties uitgevoerd naar financieringsvormen en economische effecten. De eerste simulatie financiert de infrastructuur ontwikkeling door middel van buitenlandse leningen, de tweede financiert door afschaffing van brandstof subsidies en de derde door middel van aardgasbaten. De drie financieringsvormen hebben elk een specifiek effect op de economie. Onze resultaten laten zien dat het afschaffen van brandstofsubsidies de meeste positieve effecten heeft op macro indicatoren, maar dat de aanwending van de baten uit aardolie en aardgas een meer positieve invloed heeft op sectorale indicatoren als economische output en werkgelegenheid. Een vergelijkbaar, maar minder positief effect treedt op bij financiering door buitenlandse leningen. Dit betekent dat een trade-off tussen de drie financieringsvormen economisch het meest gewenst is, maar het realiseren daarvan hangt af van de prioriteiten van beleidsmakers.

Het antwoord op de probleemstelling van ons onderzoek zou tot substantiële veranderingen in relevante onderdelen van het Indonesische gasbeleid moeten leiden ten gunste van welvaartsontwikkeling en zekerheid in de nationale energievoorziening. Het doel van ons onderzoek was om een beter inzicht te verschaffen in de omstandigheden waaronder dit kan worden gerealiseerd.

Author Biography

Aldi holds a Bachelor of Petroleum Engineering from Trisakti University in Indonesia. Then he enrolled in the MSc program in Chemical Engineering at The University of Indonesia. He subsequently worked for almost 4 years in the Ministry of Energy and Mineral Resources of the Republic of Indonesia before pursuing a Ph.D degree at the University of Twente in 2010.

His research is focused on the analysis of economic value of natural gas in Indonesia through three policy measures, allocation policy, pricing policy and infrastructure policy. The research was supervised by Prof. Dr. Jon Lovett and Dr. Maarten Arentsen of the Department of Governance and Technology for Sustainability (CSTM). He got a scholarship from the Netherlands Fellowship Programme (NFP) of the Dutch Government. Research findings have been presented at conferences and published in a book chapter targeting different audiences.