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Simulating Indonesian fuel subsidy reform: a social accounting matrix analysis

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Abstract The debate over phasing out fuel subsidies in Indonesia is quite intense. Recent studies pointed out an unfair distribution of subsidies. Besides this, the burden of fuel subsidies to Indonesian government is expected to increasingly continue in parallel with rising fuel consumption as well as international oil prices. However, recent experiences indicated that phasing out the fuel subsidy could potentially result in adverse effects in the economy. Then, the need for comprehensive economy-wide analyses in order to reveal diverse impacts of these subsidies, has emerged. The main objective of this study is to estimate the impacts of fuel subsidies from the economic, social, and environmental perspective, and to propose policy options for a subsidy reform. For this purpose, a social accounting matrix model is employed to simulate the impact analysis. Scenarios including reallocation of subsidy to either other sectors (sectoral subsidy) or income groups (target subsidy) are simulated and the social, economic and environmental impacts of these scenarios are presented. The results show that reallocation of fuel subsidy to other sectors will be able to positively increase the overall economic development, while compromising environmental aspects. The direct reallocation of subsidy to the low income households, on the other hand, will slow down overall economic development but show a positive result for social welfare.

Keywords Social accounting matrix · Economic modelling · Oil · Energy policy · Subsidy · Sustainable development

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1 Introduction

Since the subsidies have elemental impacts on economic development, social equity and environmental aspects, implementation of these policies need serious attention. Subsidies are generally put in place when the markets are not working efficiently for political equity issues. Energy subsidies have turned out to be useful for reinforcing economic development. However, they can also have negative long-term effects such as over-consumption of energy resources, under-investment in energy related industries or environmental degradation. Besides, subsidies which once provided positive social and economic impacts may become redundant or may play an opposite role in the long-run. Determining a road map for fossil fuel subsidies is one of the major items in G20 Leaders' agenda in recent years. In 2009, G20 Leaders committed to phase out inefficient fossil fuel subsidies without compromising those in need for essential energy services. Moreover, IEA et al. (2011) are assigned to provide analysis and suggestions for the initiative.

The introduction of fuel subsidy in Indonesia dates back to 1967 when the retail price of fuels were subsidized to keep fuel products affordable for the low income households and raise real income. Since then, the fuel subsidy policy has been one of the hot topics in Indonesian energy debate which intensified in recent years. The reason is that, Indonesia has been facing an increasing fiscal pressure for a long time and this pressure has reached its peak in the last decade, i.e., 24 % of total government expenditures were spent on energy subsidies; 90 % of which was fuel subsidies in 2005. Then, it was inevitable that some urgent policies should have been put into use. Phasing out fuel subsidies is a viable option under existing circumstances. In November 2014, only a month after the elections, the new government decided to further carry out fuel subsidy removal policy by applying adjustment on retail fuel price. Furthermore, a 70 % fuel subsidy reduction (compare to last year's budget) is planned in the Revised 2015 State Budget (Republik Indonesia 2015).

Nevertheless, the government realized that implementing this policy should be carefully planned due to adverse consequences that it may have on the society such as: rising inflation, increasing number of low income households, and increased unemployment. The main arguments of the government to phase out fuel subsidy are:

- Saving government budget from a deficit (caused by oil price hike)
- Fuel subsidy not reaching its target (low income households).

Indonesian fiscal balance is threatened by decreasing oil revenues in terms of tax and non-tax revenues and also an increase in fuel subsidies due to oil price volatility (Dartanto 2013). Fuel subsidies also affected the income distribution in Indonesia since they are enjoyed by the high income groups, quite more than they are enjoyed by low income groups. Based on National Social Economic Survey, SUSENAS 2008, more than 41 % of gasoline subsidies were benefitted by the top richest income groups.

Indonesia is very dependent on petroleum for its energy supply, i.e., in 2011, petroleum accounted for 34 % of primary energy supply which has the largest share among alternative sources (BPPT 2012). In addition, since mid-2003, Indonesia started to become an oil net-importing country and also has had a problem of decreasing oil production and increasing consumption. Crude oil production has fallen by approximately 3 % per year, while overall fuel use has increased by almost 4 % per year during the last 15 years (OPEC 2012).

In brief, high amount of energy subsidies, wasteful energy consumption, increasing greenhouse gas emissions, depreciation of national currency and high international oil prices increase the fiscal pressure on Indonesian economy. Therefore, the need for economic models, those are capable of assessing the impacts of policy options in respect of energy subsidies, can provide invaluable insight. This study aims to simulate various scenarios on fuel subsidy removal to see their impacts on the Indonesian economy–social–environment nexus. Those three criteria may be viewed as an implementation of sustainable development practice. Furthermore, the fast environmental degradation and the stark threat of climate change make it essential to take the environmental criteria into consideration in policy making.

In this respect, we introduced four different scenarios of subsidy removal where the scenario development was based on the energy profile as well as economic and environmental goals of Indonesia. The scenarios consist of 50 or 100 % subsidy removal, and reallocation of the subsidy to various sectors or to low income households. For the simulations, SAM analysis is applied. SAM is a representative of the economy where inter-institutional relationships can be identified and it is primarily a data framework which serves as a dual-entry square matrix of transactions ensued by the economic activities. It is also able to show how the economic and social sectors are related. The rest of the paper is organized as follows. Related literature is summarized in Sect. 2, and data and methodology are presented in Sect. 3. Section 4 is devoted to numerical results and discussions. The final section concludes the paper and addresses future research areas.

2 Literature review

Subsidies play a vital role in accomplishing national objectives especially for developing countries, that is why analysis of subsidy schemes always arouse interest among government bodies as well as among researchers. For the case of Indonesia, energy subsidies are of great interest since the burden of these subsidies on fiscal balances have reached critical levels in recent years. Of course Indonesia is not the only country suffering from energy subsidies and a wide range of studies have been conducted in regional, national or global level. Before going into more detail on those studies, it would be pertinent to introduce main approaches employed for revealing the impacts of energy subsidy policies. These models are generally divided into two broad groups based on their scope, i.e., partial and general equilibrium models. In partial-equilibrium models, changes in the sector of interest are regarded whereas general equilibrium models cover the whole economy, i.e., the interactions between the sectors are taken into account. Since, energy is a crucial input for most of the sectors, partial equilibrium models are poor in representing the dynamics of changes in the economy.

Input–output analysis, SAM analysis and CGE models are the general equilibrium models those are widely used in regional and global policy analysis. CGE models make use of SAMs as the database. Furthermore, prices and quantities are endogenously determined where the utility maximizing behavior of consumers and profit-maximizing behavior of producers are represented in these models, i.e., relations representing supply and demand behavior are defined for each sector. The need for defining representative relations as well as substitution possibilities due to price changes make these models highly dependent on the accuracy of assumptions and estimates. As the names suggest, IO and SAM models use IO tables and SAMs as the database. A SAM model, in fact, is an enhanced version of IO model since SAMs involve additional information especially on the flows between institutions and therefore represents the whole circular flow in an economy. Although these two models, IO and SAM, are criticized for the assumption of constant relative prices; the multipliers calculated in IO and SAM models provide substantial insight for the interactions among sectoral flows, i.e., effects of exogenous changes on endogenous accounts.

First studies that demonstrate how to utilize SAMs as a general equilibrium model were Pyatt and Roe (1977), Pyatt and Round (1979) and Pyatt (1988). This methodology was used not only for revealing impacts of energy subsidy policies, but also for a wide range of sectoral analysis. Breisinger et al. (2009) introduced a guide to SAM and multiplier analysis. It covers the basic concept of SAM analysis, and practical examples. Food sector in Ghana is used as an example to explain how an exogenous shock affects the economy. Hara (2008), in parallel with Breisinger et al. (2009), explained SAM as one of the tools to analyze tourism industry by using IO and SAM models. Parra and Wodon (2008) applied SAM model to examine the impact of food and energy price shocks to Ghana economy and Widodo et al. (2011) applied a SAM model in analyzing the impacts of fuel subsidy removal on the Indonesian economy. Jiang and Tan (2013), Lin and Jiang (2010), and Lin and Li (2012) have estimated the impact of removal of various energy subsidies on the different indicators for China. Jiang and Tan (2013) employed a price-gap approach to approximate fossil-fuel subsidies without regarding external costs and used an input–output model to assess the impacts of energy subsidies reform in China. Their results showed that the greatest impact is observed on the energy intensive industries that subsequently increase the general price level. Lin and Jiang (2010) employed a CGE model to simulate economic impacts of subsidy reform in China. They found that removing energy subsidies will result in a significant fall in energy demand and emissions, but negatively affect macroeconomic variables. Their results indicate that removing these subsidies and reallocating a certain proportion of these subsidies back into the economy could improve energy efficiency and favor the environment. Lin and Li (2012) put the removal of fossil fuel subsidies in China under the scope and examined the accompanying impacts of the removal on competitiveness not only in China but also across the world. The main results derived in Lin and Li (2012) is that China would be negatively affected in terms of macroeconomic indicators while positive externalities would happen in the rest of the world. However, the results also indicated an adverse impact on total emissions. Other notable country examples of subsidy reform impact include Ogarenko and Hubacek (2013), Birol et al. (1995), and Siddig et al. (2014). Ogarenko and Hubacek (2013) studied the impact of energy subsidy removal in Ukraina where their scope was on indirect subsidies in gas and electricity sectors. The price gap approach was employed to estimate these indirect subsidies and an IO model is proposed to assess economic and environmental impacts. The results showed that removing those subsidies would lead a decline of 2.5 and 3.6 % in energy consumption and GHG emissions, respectively. Birol et al. (1995) used an econometric approach to find out the impact of subsidy removal on energy sectors and oil revenues in Algeria, Iran, and Nigeria. They found that the policy that favors more rational energy use would ensure future oil demand fulfillment while maintaining stability in oil production. In addition, such policy will further increase the oil revenue. Siddig et al. (2014) studied the impact of imported petroleum products subsidies on poverty in Nigeria. Results of the proposed applied general equilibrium model indicate that reduction in subsidy will provide a positive impact on GDP in return of a decrease in the income of low income households.

Our study has close affinity with Clements et al. (2007), Maipita et al. (2011), Widodo et al. (2011) and Dartanto (2013) since these four studies are focusing on energy subsidies in Indonesia and employ general equilibrium models.

Clements et al. (2007) proposed a CGE model to analyze the impacts of increases in petroleum prices on several economic variables and indicators, i.e., average price level, sectoral outputs, factor incomes, real consumption and poverty. Maipita et al. (2011) proposed a CGE model in order to analyze the impact of a change in the subsidy policy, i.e., diverting subsidies to agricultural sector instead of fuel subsidies. The indicators examined in the study are the poverty level and income distribution where these indicators are examined under three levels of subsidies diverted. The results showed that the proposed diversions led to positive effects for low income households in the rural area while those in urban area are negatively affected.

Dartanto (2013) applied a CGE-micro simulation model, i.e., a CGE model for wage and price effects coupled with a microsimulation for distribution analysis. The objective of the study is to identify impacts of reducing fuel subsidies on the fiscal balance and poverty in Indonesia. It is emphasized that reducing fuel subsidies and reallocation of these subsidies for government spending could provide a positive impact on poverty incidence reduction. Also, it is illustrated that 25 % fuel subsidy removal will increase poverty by 0.259 %. However, if the removed amount were reallocated to government spending, the poverty will decrease by 0.27 %.

Widodo et al. (2011), applied SAM approach in analyzing the impacts of fuel subsidy removal on the Indonesian economy. The scenarios including complete removal of fuel subsidy and redistribution of fuel subsidy to four targeted sectors, i.e. agriculture sector; trade sector; food, beverages, and tobacco sector; and education and health sector. The study emphasized three policy recommendations, i.e., a gradual fuel subsidy removal plan rather than a complete removal in a lump sum manner: adjustable fuel subsidy in accordance with government fiscal capacity; focusing on compensation programs for the low income households instead of reallocation of subsidies to other sectors. In summary, the studies mainly agreed to the idea of inefficiency of fossil-fuel subsidies which then encourages governments to phase-out the subsidy. The studies then become more focused on the analysis of the impact on phasing-out fossil-fuel subsidies.

Analyzing the impacts of removing subsidies on either economic or societal aspects has been widely studied in the literature. Our study significantly differs from the studies in literature in several aspects. First of all, environmental impacts, as well as economic and social impacts, are taken into account and GHG emissions are calculated under each scenario. This study, then, fills the gap where researchers usually focused on either economic, or social, or environmental aspects of the impact. However, as Ellis (2010) states, “few studies to date have effectively integrated the assessment of all economic, environmental and social impacts”. Second, instead of reallocation into non-energy sectors as followed in most of the studies; reallocation of fuel subsidies into another energy sector, i.e., “electricity, gas, and drinking water sector” (utility sector), has been analyzed in addition to reallocation of those into income groups. Note that, utility sector is selected for reallocation in order to understand whether it is possible to decrease dependency to oil imports and alleviate the negative effects of being an oil net-importing country by promoting gas sector in the medium term. Although coal is also an abundant resource in Indonesia, it is disregarded due to its adverse environmental effects. Third, identifying low income groups by an objective criteria and reallocating subsidies in a way that favors increasing equity among household groups also distinguishes our work from previous research. In addition to all these, unlike the studies in the literature, the scenarios targeting more than one sector or more than one income group at a time or mixed scenarios, i.e. including targeted sectors and income groups at a time, are analyzed in this study. Finally, a SAM model has been proposed in the study since the data requirements are less severe than with CGE modelling; note that Widodo et al. (2011) has also applied a SAM model for Indonesia; however, each study analyzes different scenarios, and environmental concerns are not in the main scope of Widodo et al. (2011).

3 Data and methodology

3.1 Social accounting matrix (SAM)

In the study, a social accounting matrix model is developed to address the impacts of various scenarios on fuel subsidy. SAM is a data framework arranged in a matrix form that keeps national accounting balances. Each account in a SAM is represented by a row and a column where rows represent revenues and columns represent expenditures, i.e., each entry is a payment from the account of corresponding column to the account of corresponding row. Note that row sum for an account is equal to the column sum of the same account. It represents the economy of a country in a certain time period, i.e., snapshot of an economy in a base year, and shows interdependent relationships between social and economic variables. It is able to picture social and economic variables and indicators such as GDP, income distribution, household consumption structure, etc., and provides high level of flexibility in the degree of disaggregation as well as in the sector/sectors to be examined.

A SAM itself is a database that keeps the national accounts as explained above; but, at the same time, it can be used for describing the economic theory which drives those activities. Pyatt Pyatt (1988) explains how a SAM can be employed as "the basic framework for model presentation.", i.e., the data in SAM is used for the representation of economic theory lying behind. This can be accomplished by identifying exogenous and endogenous transactions, i.e., whether the transactions (entries in SAM) are independent on income or the scale of production, or not. SAM analyses provide substantial insight not only for energy subsidy policies, but also for a wide range of policy options in diversified sectors.

The main aim of SAM analysis is to examine social and economic performance in a territory as summarized below:

- Analyzing economic development in an area, such as GDP, sectoral contributions, sectoral economy analysis, its expenditure, income, and value added
- Factorial income distribution
- Household income distribution
- Sectoral employment distribution

In addition, Sudaryadi (2007) expressed the three advantages of SAM analysis as below:

- SAM is a complete, compact, and consistent data system that can capture sectoral interdependencies in a region.
- SAM is able to assess government policy impact related to employment, poverty, and income distribution.
- SAM is a relatively simple analysis tool that is easy to apply.

However, despite its advantages, employing SAM model may pose some drawbacks. The interpretation of the results should be treated with caution due to limitative assumptions employed in the model. The model assumed that prices are fixed and any changes in demand will change physical output rather than prices. This leads to additional assumption that the factor resources (e.g. land, labor, capital) are unlimited. Consequently, any increases in demand can be matched by increases in supply. Therefore, the results should be highlighted mainly on magnitudes, directions, and distributive patterns rather than numeric outcomes themselves. In that sense, the results should be treated as "illustrations" for policy implementation, which are suggested to be accompanied by additional analytic works.

Basic structure of a SAM is a 4 × 4 matrix which is based on consolidated balance sheets of economic actors. It describes monetary flows from variety of economic transactions. A simple representation of SAM can be seen in Table 1. As shown in the table, there are mainly four accounts, which are:

- Production activities
- Production factors
- Institutions
- Other accounts

In the accounts of production activities, industries sell and purchase goods and services which form inter-industry transactions. Industrial sectors receive input from others to produce outputs, which then will be sold as intermediate or end products for final demands. The production factors are referred to as the exchange market for labor and capital. Institution accounts can be described as several economic entities that are involved in economic activity. The institutions include households, enterprises, and governments. Furthermore, households are usually classified into groups of mutually distinct socioeconomic levels. The other accounts consist of exogenous capital account and the rest of the World (ROW), i.e., it distinguishes major types of economic activity such as savings and investment, imports and exports, and indirect tax and subsidies.

Each account holds a column and a row which represent their economic transactions. The columns represent expenditures, while the rows describe income. Cell $T_{3,2}$ for example, is an income of institutions from production factors. Or, it is an expenditure of production factors to institutions. Furthermore, the total expenditures must be equal to total income, i.e., the row sum will be equal to column sum for the same account.

In Table 1, $T_{1,1}$ represents intermediate demand of goods and services and $T_{1,3}$ is the final demand of goods and services (by institutions, i.e., households, government). The cells with a value of zero, ($T_{1,2}$, $T_{2,2}$, $T_{2,3}$ and $T_{3,1}$) mean that no economic activity take place between the corresponding accounts.

3.2 Mathematical model of SAM

In Table 1, production activities, production factors, and institutions are assumed as endogenous accounts, while other accounts being exogenous. Income distributions of endogenous accounts can be mathematically described as below:

$$Y_1 = T_{1,1} + T_{1,3} + X_1 \tag{1}$$

$$Y_2 = T_{2,1} + X_2 \tag{2}$$

$$Y_3 = T_{3,2} + T_{3,3} + X_3 \tag{3}$$

where Y and X represent total output in endogenous accounts and injections of exogenous accounts, respectively. Expenditures of endogenous accounts can be described as:

$$Y_1' = T_{1,1} + T_{2,1} + L_1 \tag{4}$$

$$Y_2' = T_{3,2} + L_2 \tag{5}$$

$$Y_3' = T_{1,3} + T_{3,3} + L_3 \tag{6}$$

Matrix T as a transactional matrix between each endogenous account can be written as:

$$T = \begin{pmatrix} T_{1,1} & 0 & T_{1,3} \\ T_{2,1} & 0 & 0 \\ 0 & T_{3,2} & T_{3,3} \end{pmatrix} \tag{7}$$

As one of sub-matrix in SAM, matrix T can also illustrate income and expenditure transactions in the smaller scale (endogenous transactions). The share of each account's expenditure is equal to the ratio of the corresponding cell over its column total. It can be written as:

$$A_{ij} = T_{ij} Y_j^{-1} \tag{8}$$

equivalently

$$T_{ij} = A_{ij} Y_j \tag{9}$$

Table 1 Basic structure of SAM

	Expenditure				
	Production activities	Production factors	Institutions	Other accounts	Total
Income					
Prod. activities	$T_{1,1}$ Intermediate demand	$T_{1,2} = 0$	$T_{1,3}$ Final demand	X_1 Exports and investments	Y_1 Total output and demand
Prod. factors	$T_{2,1}$ Value added to prod. sectors	$T_{2,2} = 0$	$T_{2,3} = 0$	X_2 Prod. factor inc. from other acc.	Y_2 Factorial Income distribution
Institutions	$T_{3,1} = 0$	$T_{3,2}$ Income allocation to institutions	$T_{3,3}$ Institutional transfers	X_3 Foreign Transfers	Y_3 Institutional Inc. distribution
Other accounts	L_1 Imports, indirect taxes	L_2 Other factor payments	L_3 Savings	L_4 Transfer and other accounts	Y_4 Other income
Total	Y'_1 Total input and supply	Y'_2 Production factors expenditure	Y'_3 Institutions' expenditure	Y'_4 Other expenditures	

where A_{ij}, ratio of expenditure in row-i , column-j\coefficient matrix; T_{ij}, entry of matrix T in row-i , column-j; Y_j, total output of row-j.

SAM framework can be represented in matrix form as below:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix} = \begin{bmatrix} T_{1,1} & 0 & T_{1,3} \\ T_{2,1} & 0 & 0 \\ 0 & T_{3,2} & T_{3,3} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} \tag{10}$$

$$Y = A \cdot Y + X \tag{11}$$

The equation is then further simplified in matrix multiplication form:

$$Y - A \cdot Y = X \tag{12}$$

$$(I - A) \cdot Y = X \tag{13}$$

$$Y = (I - A)^{-1} \cdot X \tag{14}$$

The matrix $(I - A)^{-1}$ called as the multiplier matrix, M_a, (or Leontieff Inverse Matrix) and implies the level of change in endogenous accounts due to a unit shock in an exogenous account. In other words, each unit change in exogenous account (X) will subsequently impact endogenous account (Y) by M_a units. Then Eq. 12 can be written as $Y = M_a \cdot X$ and also holds for changes in these accounts:

$$\Delta Y = M_a \cdot \Delta X \tag{15}$$

3.3 Employment, energy, and CO_2 emissions

SAM framework is basically using monetary values in its transactions matrix. However, changes in employment, energy, and CO_2 emissions will be analyzed in the study. In order to perform these analysis, some of the the monetary values should also be represented in particular physical terms by the help of relevant coefficients. In mathematical form it can be written as follows:

$$c_j = e_j / Y_j \tag{16}$$

where e_j represents the total employment/energy demand/CO_2 emissions for sector j and c_j denotes the employment/energy demand/CO_2 emissions coefficient for sector j (per billion IDR).

The employment, energy, and CO_2 emissions coefficients in Fathurrahman (2014) are used in the study, where those coefficients are derived using the data sets from World Input–Output Database (Timmer et al. 2015; Timmer 2012), see Table 13. Here, we assume that those coefficients will remain constant regardless of changes in sectoral output. The level of impact due to change in output can be determined as follows:

$$\Delta\varepsilon_j = \Delta Y_j c_j \tag{17}$$

where $\Delta\varepsilon_j$ represents the employment/energy/CO_2 emissions impact for sector j.

3.4 Indonesia SAM for 2008

The SAM framework offers a flexible tool which can be used in varying levels of analysis. Most of the countries have their own SAMs. However, the structure varies across countries based on classifications applied, the type of sectors, groups and transactions distinguished, the degree of detail, etc. The way a SAM is constructed also depends on the availability of the data and the part of the economy on which the emphasis is placed. Since 1975, Indonesian Central Agency of Statistics (BPS) periodically publishes the Indonesian SAM and these SAMs were used in many related studies, e.g., Azis and Mansury (2003), Bourguignon et al. (2005), Clements et al. (2007), Hartono and Resosudarmo (2008), and Widodo et al. (2011). The main data used in the study is Indonesia SAM for 2008 (BPS 2011). The basic framework of Indonesia SAM for 2008, in accordance with basic SAM's framework, includes four main accounts, namely: production activity accounts, production factors account, institution accounts, and exogenous accounts consisting capital and rest of the world (ROW). Those accounts bring together the structure of production, income generation by factors of production, distribution of income by institutions in return for factor services, consumption of wants (i.e. final consumption items) by households, savings and investment patterns. The accounts can be classified in 5 broad groups:

- 23 Production sectors,
- 5 Production factors,
- 8 Household groups,
- 2 other institutions,
- 5 other accounts.

The complete classification of Indonesia SAM for 2008 is defined in Table 2. The production accounts composed of 23 sectors which are derived from Indonesia IO table for 2008. Agriculture sector is becoming a guide for production factors and household groups' classification due to high labor intensity in this sector. The production factors are composed of labor and non-labor (capital). The labor accounts are classified into four major categories, i.e., "Agriculture", "Production, operators of transportation means, unskilled labor", "Administration, sales, and services", and "Leaders, military, professionals, and technicians". The other institutions account captures transactions from corporations and government. Finally, the "other accounts" consists of 5 accounts which include trade margin, transport margin, capital balance, indirect tax and subsidy, and rest of the world (ROW).

The sectors listed in Indonesia SAM for 2008 needs to be reorganized to satisfy our model objectives and due to data inconsistency. For example, since the study is about oil subsidies; in order to define scenarios related with oil sector, oil refinery were segregated from "chemical and cement industry" sectors. This segregation was performed by the help of data from Indonesia IO Table for 2008. On the other hand, in order to ensure consistency and use more accurate coefficients, crop farming, other crop farming, "livestock and livestock products", forestry, and fishery were aggregated to "agriculture, hunting, forestry, and fishing". "Coal, Metal, and Oil mining" and other mining industry aggregated into "Mining and quarrying", restaurants and hotels into "restaurants and hotels". The new reconstructed SAM has a total of 18 sectors. The summary of Indonesia SAM for 2008 is presented in Table 10 in "Appendix". In this table, current amount of subsidies related to oil can be seen in two of the entries, i.e., subsidies on imported oil products, i.e., 41,190 billion IDR, and 97,917 billion IDR directed to oil refinery sector which is a part of whole subsidies (199,702 billion IDR) directed to production sectors.

Table 2 Classification of the accounts in Indonesia SAM for 2008

SAM accounts	Classifications/sub-accounts
Production sectors (23)	Agriculture (5)
	(1) crop farming, (2) other crop farming, (3) livestock and livestock products, (4) forestry, (5) fishery
	Industry (7)
	(1) coal, metal, and oil mining, (2) other mining industry, (3) food, beverages, and tobacco industry, (4) garment, textile, clothes, and leather industry, (5) wood and wood product industry, (6) paper, printing, transportation tools, metal products, and other, (7) chemical and cement industry
	Utility and constructions (2)
	(1) electricity, gas, and drinking water , 2) constructions
	Service (9)
	(1) trade, transportation supporting services, and warehousing, (2) restaurant, (3) hotel, (4) land transport, (5) air, water transport, and communication, (6) bank and insurance, (7) real estate and services, (8) government, defense, education, health, film, and other social services, (9) individual service, household, and others
Production factors (5)	Labor (4)
	(1) agriculture, (2) production, operators of transportation means, unskilled labors, (3) administration, sales, and services, (4) leaders, military, professionals, and technicians
	Capital (1)
Households (8)	Agriculture (2)
	(1) agriculture labor, (2) agriculture entrepreneurs
	Non-agriculture rural (3)
	(1) low income, (2) non-labor force, (3) high income
	Non-agriculture urban (3)
	(1) low income, (2) non-labor force, (3) high income
Other institutions (2)	(1) corporations, (2) government
Other accounts (5)	(1) trade margin, (2) transport margin, (3) capital balance, (4) indirect taxes and subsidy, (5) rest of the world

4 Numerical results

Four scenario options are defined based on the availability of alternative energy resources, economic structure, and government priorities. These are:

- Scenario 1a (S1a): 50 % fuel subsidy removal, redistributed to utility sector
- Scenario 1b (S1b): 100 % fuel subsidy removal, redistributed to utility sector
- Scenario 2a (S2a): 50 % fuel subsidy removal, redirected to the low income households
- Scenario 2b (S2b): 100 % fuel subsidy removal, redirected to the low income households
- Scenario 3 (S3): 50 % fuel subsidy removal, equally reallocated to utility sector and low income households
- Scenario 4 (S4): 50 % fuel subsidy removal, reallocation to several key sectors (i.e. “Agriculture, hunting, forestry and fishing”, “food, beverages, and tobacco”, and “government, defense, and education”)

Table 3 Reallocation of subsidies—in million IDR

	S1a	S1b	S2a	S2b	S3	S4
Labor						
Agri.						
Labor			23,240	46,480	11,620	
Entrep.			12,182	24,363	6,091	
Non-agri.						
Rural						
Low-inc.			10,365	20,730	5,182	
Non-lab. force			9,250	18,500	4,625	
Urban						
Low-inc.			7,412	14,824	3,706	
Non-lab. force			7,105	14,210	3,552	
Prod. sec.						
Elec., gas, and drinking water	69,553	139,107			34,777	
Agri., hunting, forestry and fishing						31,114
Food, beverages, and tobacco						25,323
Government, defense, and education						13,116
Total subsidy redirected	69,553	139,107	69,553	139,107	69,553	69,553

S1a and S1b serve as sectoral subsidies, in which 50 % or all of the subsidy for oil is redirected to another sector of energy, i.e., utility sector. One of the reasons for utility sector being selected is paying attention to environmental concerns, i.e., the amount of emissions due to gas consumption is relatively lower than the other fossil fuels. Furthermore, a significant rise in the share of renewable resources is not expected in the near future. In S1a, 50 % of total oil subsidies, i.e., 50 % of 139,107 billion IDR (sum of 41,190 billion IDR and 97,917 billion IDR as highlighted at the end of Sect. 3), is directed to utility sector while whole amount is directed in S1b.

Scenarios S2a and S2b are targeted subsidies, i.e., social welfare and level of equality is tried to be raised by direct cash injection of subsidy to the low income households where low income households are identified based on per capita income of household groups. Household groups with a per capita income of less than 20k IDR are assumed to be target groups for redirecting subsidies, i.e., agricultural labor and entrepreneurs, non-agricultural (both rural and urban) low income labor and non-labor force, BPS (2008). After target income groups are identified, total subsidies in current balance (139,107 billion IDR) is distributed among these groups inversely proportional to per capita income of each group. S3 is a mix of S1 and S2, in which reallocation of fuel subsidy to utility sector and direct cash injection to low income households are considered together.

Finally, in S4, the subsidies are directed to three of the major sectors for low income households, i.e., "Agriculture, Hunting, Forestry and Fishing", "Food, Beverages, and Tobacco", and "Government, defense, and education, health, film, and other social services". The allocation in S4 is made proportional to total output in each sector which corresponds to redirecting 44.7, 36.4 and 18.9 % of half of the subsidies (69,553 billion IDR) to "Agriculture, Hunting, Forestry and Fishing", "Food, Beverages, and Tobacco", and "Government, defense, and education, health, film, and other social services", respectively. Final allocation of subsidies to income groups and other sectors are summarized in Table 3.

In order to assess the impacts under the scenarios, two economic indicators are selected: sectoral outputs and GDP. The social criterion will be analyzed based on impact to households' incomes and change in employment. Finally, environmental impact will be analyzed through two indicators: changes in energy consumption/demand and changes in CO_2 emissions.

4.1 Economic impacts

Table 4 shows the changes in the output of production sectors under each scenario. The results represent the deviations from the base year values, both in nominal and percentage terms. The degree of deviations varies among sectors due to different multipliers for each sector. Exogenous shocks result in direct and indirect effects to the whole economy. The multipliers assure, "how much a direct effect is amplified or multiplied by indirect linkage effects" (Breisinger et al. 2009). The changes in total output correspond to 0.126, 0.253, −0.014, −0.027, 0.056, and 0.545 % for S1a, S1b, S2a, S2b, S3, and S4, respectively. Note that due to the linearity nature of SAM analysis, the level of impacts for S1b & S2b is twice as much as those for S1a & S2a.

In the sectoral point of view, model results show that the highest decrease is observed in oil refineries. This is quite obvious since redirecting the subsidy given to oil sector will subsequently decrease oil demand. These changes are called as the "direct impacts". Except for S2, the highest gain occurs in the sector to which the subsidy is reallocated, i.e., utility sector gets the highest gain in S1 and S3. Under S4, on the other hand, "agriculture, hunting, forestry and fishing", "food, beverages, and tobacco", and "government, defense, and education" are the sectors those get the highest increase on their output. For S2, the higher increases happen on the sectors that got "indirect impacts" through the reallocation of subsidy to the low income households. The subsidy injection to the low income households increase their income and simultaneously increase their consumptions, especially on their primary needs (see Table 11 for households' consumption profiles in the base year). Then, the change in primary needs further increase the demand for intermediate goods used in production of those primary goods. Thus, relatively high increases are observed in the sectors those are mostly consumed by the low income households.

The deviations in value added and GDP under scenarios are shown in Table 5. The results show that S1a & S1b will increase GDP by 0.08 and 0.16 %, respectively. In S2a & S2b, on the other hand, GDP has declined by 0.29 and 0.58 %, respectively. Finally, a 0.11 % decrease has been observed in S3 while S4 results in a 0.36 % increase in GDP. These results are due to changes in sectoral outputs and the share of the sectoral value added amounts (see Table 12 for distribution of total value added among production sectors). In S1, relatively low share of value added in utility sector is compensated with the huge increase in sectoral output, resulting in a rise in GDP. In S2 and S3, on the other hand, the effect of decreases in "Oil refinery" and "Mining and quarrying" is relatively higher than the effects of increases in the rest of the sectors when the sectoral shares of value added are taken into account. Finally, in S4, the increases in outputs of the relatively big sectors to which subsidies are redirected easily compensate the decrease in oil sector. Note that, the value added shares of the three sectors, i.e., "Agriculture, Hunting, Forestry and Fishing", "Food, Beverages, and Tobacco", and "Government, defense, and education, health, film, and other social services", sum up to 27.64 % of GDP, whereas oil sectors has a share of only 6.53 %.

Table 4 Sectoral output changes: value (trillion IDR) and percentage

Production sector	Initial value	S1a	S1b	S2a	S2b	S3	S4
Agriculture, hunting, forestry and fishing	1,170.31	−0.29	−0.57	21.73	43.46	10.72	56.96
		−0.02 %	−0.05 %	1.86 %	3.71 %	0.92 %	4.87 %
Mining and quarrying	692.16	−7.93	−15.87	−15.01	−30.03	−11.47	−15.18
		−1.15 %	−2.29 %	−2.17 %	−4.34 %	−1.66 %	−2.19 %
Food, beverage, and tobacco industry	952.51	−0.24	−0.48	16.99	33.98	8.38	39.19
		−0.03 %	−0.05 %	1.78 %	3.57 %	0.88 %	4.11 %
Garment, textile, clothes, and leather industry	292.37	−0.03	−0.06	2.59	5.18	1.28	1.16
		−0.01 %	−0.02 %	0.89 %	1.77 %	0.44 %	0.4 %
Wood and wood product industry	173.15	0.01	0.02	0.74	1.48	0.37	0.39
		0 %	0.01 %	0.43 %	0.85 %	0.22 %	0.22 %
Paper, printing, transportation tools, metal products, and other industries	1,246.99	0.62	1.24	5.65	11.3	3.14	3.65
		0.05 %	0.1 %	0.45 %	0.91 %	0.25 %	0.29 %
Oil refinery	507.53	−54.54	−109.08	−59.76	−119.52	−57.15	−60.27
		−10.75 %	−21.49 %	−11.77 %	−23.55 %	−11.26 %	−11.87 %
Chemical and cement industry	655.17	0.47	0.94	4.93	9.87	2.7	5.11
		0.07 %	0.14 %	0.75 %	1.51 %	0.41 %	0.78 %
Electricity, gas, and drinking water	206.05	74.07	148.13	0.9	1.79	37.48	0.63
		35.95 %	71.89 %	0.44 %	0.87 %	18.19 %	0.31 %
Construction	1,219.99	0.29	0.57	0.2	0.41	0.25	0.46
		0.02 %	0.05 %	0.02 %	0.03 %	0.02 %	0.04 %
Trade, transportation supporting services, and warehousing	1013.88	0	0	0.25	0.5	0.13	0.19
		0 %	0 %	0.02 %	0.05 %	0.01 %	0.02 %
Hotels and restaurants	324.63	−0.06	−0.11	3.46	6.91	1.7	1.76
		−0.02 %	−0.03 %	1.06 %	2.13 %	0.52 %	0.54 %
Land transport	266.37	0	0.01	1.9	3.8	0.95	0.97
		0 %	0 %	0.71 %	1.43 %	0.36 %	0.36 %
Air, water transport and communication	326.71	0.01	0.03	1.98	3.96	1	1.42
		0 %	0.01 %	0.61 %	1.21 %	0.3 %	0.43 %
Bank and insurance	268.19	0.33	0.65	1.45	2.9	0.89	1.72
		0.12 %	0.24 %	0.54 %	1.08 %	0.33 %	0.64 %
Real estate and services	286.49	0.52	1.05	1.8	3.6	1.16	1.13
		0.18 %	0.37 %	0.63 %	1.26 %	0.41 %	0.39 %
Government, defense, education, health, film, and other social services	493.36	−0.09	−0.18	6.45	12.89	3.18	15.87
		−0.02 %	−0.04 %	1.31 %	2.61 %	0.64 %	3.22 %
Individual service, household, and others	281.5	−0.04	−0.09	2.36	4.71	1.16	1.39
		−0.02 %	−0.03 %	0.84 %	1.67 %	0.41 %	0.49 %
Total	10,377.36	13.1	26.2	−1.41	−2.82	5.85	56.55
		0.126 %	0.253 %	−0.014 %	−0.027 %	0.056 %	0.545 %

Table 5 Change in value added: value (trillion IDR) and percentage

	Initial value	S1a	S1b	S2a	S2b	S3	S4
Labor							
Agriculture	594.51	−0.15	−0.29	11.04	22.08	5.45	28.94
		−0.02 %	−0.05 %	1.86 %	3.71 %	0.92 %	4.87 %
Prod., operators of transp. means, unskilled labors	886.61	−4.2	−8.41	−3.02	−6.05	−3.61	−0.93
		−0.47 %	−0.95 %	−0.34 %	−0.68 %	−0.41 %	−0.10 %
Administration, sales, and services	904.39	0.5	1.01	2.23	4.46	1.37	3.73
		0.06 %	0.11 %	0.25 %	0.49 %	0.15 %	0.41 %
Leaders, military, profess., and technicians	308.82	0.4	0.81	1.65	3.31	1.03	5.04
		0.13 %	0.26 %	0.54 %	1.07 %	0.33 %	1.63 %
Non-labor (capital)	2,470.97	7.45	14.9	−26.77	−53.54	−9.66	−18.34
		0.30 %	0.60 %	−1.08 %	−2.17 %	−0.39 %	−0.74 %
Total	5,165.3	4.01	8.01	−14.87	−29.74	−5.43	18.44
		0.08 %	0.16 %	−0.29 %	−0.58 %	−0.11 %	0.36 %

4.2 Social impact

The direct relationship between production sectors and households cannot be observed in a SAM. Because, the production sectors pay to production factors and the amounts paid to these factors are then distributed to household groups as incomes. In other words, explicitly quantifying the amount of income for a household group coming from a specific production sector is not possible. However, it is possible to make inferences by analyzing production sectors-production factors and production factors-households matrices, i.e., $T_{2,1}$ and $T_{3,2}$ matrices in Table 1. For example, most of factor payments in agriculture is paid to production factor of labor or non-labor in agriculture and these amounts are distributed to household groups of agricultural labor and entrepreneurs as well as low income non-agricultural households in rural area. Then, an increase in agricultural output favors an increase in incomes of these households.

Deviations in household incomes can be seen in Table 6. In S1, declines in income levels of households except for high income households (both in rural and urban) have been observed. These declines are due to the fact that many sectors face a decrease in sectoral output resulting in a decline in income received by households. Agricultural households (labor and land owner) get a decrease of income through the decline in agricultural output. The low income and non-labor households are affected from the decline in output of the sectors on which their income generation is dependent. This observation would be enforced by analyzing the changes in value added values. Low income households are generally those who work as “Production, Operators of Transportation means, Unskilled Workers”. Thus, the negative value for “Production, Operators of Transportation means, Unskilled Labors” can be incorporated with the negative value of household income for low income households. The same evidence is also valid for agriculture workers. On the other hand, high income households get the most benefit from the reallocation of fuel subsidy to gas subsidy since this reallocation increases their household income level. The fact that high income households control more resources in the utility sector is the cause of this increase. In addition, high income households generally work as “Administration, Sales, and Services and/or Leaders, Military, Professional, and Technicians”. Those workers face with positive impact in S1.

Table 6 Changes in households' income: value (trillion IDR) and percentage

	Initial value	S1a	S1b	S2a	S2b	S3	S4
Agri.							
Labor	176.76	−0.06	−0.11	24.36	48.71	12.15	3.14
		−0.03 %	−0.06 %	13.78 %	27.56 %	6.87 %	1.78 %
Entrepreneurs	731.56	−0.21	−0.41	16.51	33.02	8.15	14.95
		−0.03 %	−0.06 %	2.26 %	4.51 %	1.11 %	2.04 %
Non-agri.							
Rural							
Low income	494.23	−0.32	−0.64	9.96	19.91	4.82	1.93
		−0.07 %	−0.13 %	2.01 %	4.03 %	0.97 %	0.39 %
Non labor force	173.15	−0.19	−0.37	9.64	19.28	4.73	2.17
		−0.11 %	−0.21 %	5.57 %	11.14 %	2.73 %	1.25 %
High income	468.45	0.06	0.12	0.8	1.61	0.43	5.51
		0.01 %	0.03 %	0.17 %	0.34 %	0.09 %	1.18 %
Urban							
Low income	710.5	−1.01	−2.03	5.63	11.26	2.31	0.04
		−0.14 %	−0.29 %	0.79 %	1.58 %	0.32 %	0.01 %
Non labor force	243.91	−0.11	−0.22	6.64	13.28	3.27	0.29
		−0.04 %	−0.09 %	2.72 %	5.44 %	1.34 %	0.12 %
High income	827.88	0.77	1.54	−0.24	−0.49	0.26	3.12
		0.09 %	0.19 %	−0.03 %	−0.06 %	0.03 %	0.38 %
Total	3826.44	−1.06	−2.13	73.29	146.59	36.11	31.13
		−0.03 %	−0.06 %	1.92 %	3.83 %	0.94 %	0.81 %

Furthermore, although both oil and utility sectors are capital-intensive sectors, the level of intensity is higher in utility sector. Since high income households mostly benefit from capital gains, a transfer from a sector with a relatively lower capital-intensity, i.e., oil sector, to a more capital-intensive sector, i.e., utility sector, results in a positive impact for the high income households.

The targeted subsidy simulations as depicted by S2 show a contrasting picture. All household groups except urban high income households experience increased level of incomes. Low income households get multiple benefits via increases of outputs in most of the sectors as well as redistribution of fuel subsidy directly to themselves. The households those enjoyed most in this scenario are the agriculture labor and non-labor force (both in rural and urban). The only way that high income groups could have increased their income levels would have been by the help of indirect impacts since they do not get a direct subsidy. The decrease in incomes of these household groups due to decline in oil sector has been compensated by the indirect impacts, i.e., increase in other sectors, to some extent. The compensation was able to result in a positive overall impact on high income non-agricultural households in rural area while it was not enough for those in urban area. The main determinant for the overall impact being positive in high income non-agricultural households in rural area is the significant amount of factor payments they receive from agriculture sector.

In S3 none of the households received a decrease in their incomes. This makes sense based on inferences from S1 and S2. In S1, transferring subsidies to utility sector favors incomes of high income households. In S2, on the other hand, direct impact due to allocation of subsi-

Table 7 Change in employment: number (thousand people) and percentage

Initial employment	S1a	S1b	S2a	S2b	S3	S4
40,926	42.031	84.063	372.617	745.215	207.319	792.294
	0.1 %	0.21 %	0.91 %	1.82 %	0.51 %	1.94 %

dies to low income households significantly increases incomes of these households. For low income households, the negative impact of decreases in sectoral outputs due to transferring subsidies from oil to utility sector is easily overcome by direct subsidies directed to them. For high income non-agricultural households in rural area, results obtained in S2 imply that the indirect impacts were enough to compensate income decrease due to decline in oil sector even no subsidy were directed to the utility sector. For high income non-agricultural households in urban area, on the other hand, the indirect impacts were not enough to compensate income decrease due to decline in oil sector. However, redirecting some of fuel subsidies to utility sector, i.e., as it is employed in S3, helps removing negative impacts and results in a positive overall impact.

Similar with S3, no negative effect to any of the households happens in S4. The distribution of benefit to the households in this simulation is fairer compared to other scenario options. One of the reasons leading to this result is that the target sectors for reallocations are those fulfilling basic needs of all households (e.g. agriculture, food and beverages). The relatively low increase in non-agricultural low income households in urban area is due to their relatively high dependency to oil sector.

Overall, S1 will result in a decrease of household income level. The aggregate results in S1a shows that households will experience a 0.03 % income decrease. While for S1b the decrease will be 0.06 %. S2, on the other hand, brings positive income increases. For S2a, household income level will increase by 1.92 % and for S2b the increase will be 3.83 %. Finally, S3 and S4 will result in a positive increase of household incomes by 0.94 and 0.81 %, respectively.

The employment impact indicator can show the impact of varying simulations to the availability of jobs. The most important parameters that account for employment impact are sectoral output and labor productivity (also used as employment intensity/coefficient in IO models). The negative changes of output will also result in a decrease in employment. The labor productivity then, will be an important factor to determine the magnitude of employment changes. Note that, since there is a linear relationship between sectoral outputs and employment in the corresponding sector, percentage changes of employment in each sector will be exactly the same as reported in Table 4. However, employment change in the whole economy differs from the total change in output since employment to output ratio varies among sectors, see Table 13 for sectoral employment figures. Table 7 shows the deviations in total employment availability for each scenario. It is observed that further 42,031 people (0.10 % increase) and 84,063 people (0.21 % increase) would be employed in S1a & S1b, respectively. S2a & S2b, on the other hand, would produce more employment, i.e., in S2a further 371,607 people (0.91 % increase) would be employed and in S2b further 745,215 people (1.82 % increase) would be employed. Corresponding figures for S3 and S4 are increases of 0.51 and 1.94 %, respectively.

4.3 Environmental impact

The changes in energy demand are influenced by sectoral output changes and energy intensity. The additional output will need to be fulfilled sufficiently by additional energy input. Thus, the increase of output will also increase the energy demand. And it is also valid vice versa.

Table 8 Changes in energy demand: 10^{15} J

Initial energy demand	S1a	S1b	S2a	S2b	S3	S4
10,317.253	539.156 5.23 %	1078.313 10.45 %	−170.288 −1.65 %	−340.576 −3.3 %	184.434 1.79 %	−194.524 −1.89 %

Similar to sectoral output-employment relationship, there is a linear relationship between sectoral outputs and sectoral energy demands or sectoral emissions, i.e., percentage changes in energy demands/emissions in each sector will be exactly the same as reported in Table 4. Sectoral energy demand and emission figures for the base year can be seen in Table 13.

Table 8 shows the overall changes in energy demand under each scenario. Results show distinguished pictures on how energy demand responds to different allocations of subsidy. For sectoral reallocation of subsidy to the utility sector (S1a & S1b), it is found that energy demand will increase by 5.23 % for S1a and 10.45 % for S1b. The significant increase in the energy demand is due to reallocation of subsidy to the energy intensive sectors. Utility sectors are the most energy intensive sector with the level of energy intensity of 10.4 tJ/billion IDR. In the first glance, the removal of subsidy would make the energy demand drop due to decrease in the demand for oil. However, Utility sectors' energy demand rise is able to offset the decrease.

A contrasting picture is found on the results of targeted subsidy (S2a & S2b). The reallocation of fuel subsidy to the low income households will decrease overall energy demand, i.e., S2a leads to a decrease in energy demand by 1.65 % while S2b would decrease energy demand by 3.30 %. In these scenarios, the decrease of energy demand (via direct impact of fuel removal) is able to offset the increase of energy demand from other sectors.

For the case of S3, it is found that the mix reallocation to utility and low income households will increase overall energy demand by 1.79 %. The increase of energy demand in utility sector is the main determinant in this case. S4, on the other hand, shows the greatest decrease in energy demand for the same level of subsidy removal (i.e. 50 % subsidy removal). In this scenario, energy demand would decrease by 1.89 %. There were a significant energy demand increases in the targeted sector (e.g. Food, Beverages and Tobacco). However, the decrease of energy demand from oil refinery sector compensates the increase in other sectors.

Changes in CO_2 emissions are shown in Table 9. These results are parallel to those obtained for changes in energy demand. The two main factors affecting emissions are the changes in output and sectoral emission intensities. Utility sector is the most energy intensive sector which emits 502.28 tons of CO_2 emissions/billion IDR. Overall CO_2 emissions rise by 10.06 and 20.13 % compared to the base case in S1a & S1b, respectively. The significant increase in output (due to subsidy reallocation) and high CO_2 emission intensity in the sector lead to this result.

Emissions in S2 are lower compared to S1. In these scenarios, households are the determinant factor accounting for overall increase in CO_2 emissions. The households' CO_2 emissions are able to offset the decrease that occurred in oil refinery sector. S3 shows the moderate amount of increase in CO_2 emissions. The largest contribution for the increase in this simu-

Table 9 Changes in CO_2 emissions: kilotonne and percentage

Initial emissions	S1a	S1b	S2a	S2b	S3	S4
361,930.00	36,419.89 10.06 %	72,839.79 20.13 %	1,487.34 0.41 %	2,974.69 0.82 %	18,953.62 5.24 %	1,177.58 0.33 %

lation is from partly reallocated subsidy to the utility sectors. The decrease of CO_2 emissions from the oil refinery could not compensate the increase from other sectors. Finally, S4 results in the most favorable outcome which indicates the lowest increase in CO_2 emissions. This result is because of low emission intensity in the sectors to which subsidies are reallocated.

5 Conclusions and policy implications

In this study, a SAM model is proposed to simulate different fuel subsidy removal scenarios and present their impacts on economic, social and environmental variables and indicators. The model has advantages in capturing inter-industry transactions and illustrates the impact of particular exogenous shocks to different economic agents. The scenarios employed in the study can be segregated into three main categories: sectoral reallocation, targeted reallocation, and mixed reallocation. S1 and S4 are regarded as sectoral subsidy reallocation, by-which the fuel subsidy is reallocated to other sectors. S2 is a targeted subsidy, in which reallocation of fuel subsidy to the low income households is proposed. Finally, S3 comprises a mixed reallocation scheme in which reallocation of fuel subsidy is directed to another energy sector and low income households at the same time.

S1 can be translated as reallocation of fuel subsidy to another energy sector. The result shows that for the case of S1, the overall economic development will increase with concomitant increases in energy demand and CO_2 emissions, i.e., the economic development has to be paid off by the environment. From the societal view, on the other hand, total income earned by households is decreased under S1.

Scenario S2 intends to give the full benefit of subsidy directly to its target household groups (i.e. low income households). It is found that, economic development would slow down indicated by decreases in sectoral output and GDP. However, the social development will greatly increase, with significant additions to household income, and employment. For the environment dimension, CO_2 emissions will still rise although energy demand decreases.

Scenario S3 tries to mix S1 and S2. The results as expected are linear combinations of results from S1 and S2. For the economic criteria, the overall sectoral output will increase, but GDP will decrease. For social criteria, both income and employment will rise. However, the incremental amount is in between S1 and S2. From the environmental point of view, S3 will increase both energy demand and CO_2 emissions.

Finally, S4 shows plausible results. In economic dimensions, increases in sectoral output as well as GDP have been observed. In addition, the employment rises together with households' income. Finally, there is a decrease in energy demand and a slight increase of CO_2 emissions.

Numerical results show that the sectoral subsidy (S1 and S4) are able to positively increase the overall economic development while these scenarios result in negative environmental effects. However, the degree of environmental damage can be turned down by addressing the right sectors as observed in S4. The targeted subsidy to the low income households (S2) will slow down overall economic development but showing positive impacts for social welfare with a low level of environmental damage. Then, further research is required to determine combinations of target sectors and income groups which satisfy the three features of sustainable development, i.e., economic, social and environmental dimensions, as much as possible. Links between IO models and multi-objective linear programming as reviewed in Oliveira et al. (2014) may offer new insights to the research on fuel subsidies.

Appendix

See Tables 10, 11, 12, 13.

Table 10 Summary of Indonesia SAM for 2008

		Comm.		Prod. sec.	Prod. fac.		HHs	Corp.	Gov.	TTM	Cap. Bal.	Subsidies	RoW	Total
		Dom. 1	Imp. 2	3	Lab. 4	Non-Lab. 5	6	7	8	9	10	11	12	
Comm.														
Dom.	1			4,190,140			2,973,367		277,090	1,170,980	1,314,139		1,487,238	11,412,954
Imp.	2			1,028,009			344,737		17,477		194,691	41,190		1,626,103
Prod. sec.	3	10,175,382										199,702		10,375,084
Prod. Fac.														
Lab.	4			2,692,618									1,707	2,694,325
Non-lab.	5			2,464,317									6,658	2,470,975
HHs	6				2,688,905	788,550	43,365	43,085	199,034				63,506	3,826,445
Corp.	7					1,591,198	35,164	176,470	89,692				24,177	1,916,702
Gov.	8						85,073	650,053	181,676			344,940	2,291	1,264,033
TTM	9	1,000,473	170,506											1,170,980
Cap. Bal.	10						325,444	990,597	229,473					1,545,515
Subsidies	11	237,099	107,841						240,891					585,831
RoW	12		1,347,756		5,420	91,227	19,293	56,497	28,700		36,684			1,585,576
Total		11,412,954	1,626,103	10,375,084	2,694,325	2,470,975	3,826,445	1,916,702	1,264,033	1,170,980	1,545,515	585,831	1,585,576	

Table 11 Households' expenditures on final goods: value (billion IDR) and percentage, Indonesia SAM for 2008

	Agriculture		Non-agriculture			
	Labor	Enterp.	Rural		Urban	
			Low Income	Non-labor Force	Low Income	Non-labor Force
Agri., hunting, forestry and fish.	44,724.9	150,330.7	103,071.9	29,926.9	115,199.0	38,289.5
	27.60 %	23.40 %	22.88 %	18.94 %	18.18 %	17.91 %
Mining and quarrying	27.1	156.7	191.5	52.8	262.0	53.8
	0.02 %	0.02 %	0.04 %	0.03 %	0.04 %	0.03 %
Food, bever., and tobacco ind.	52,334.8	165,653.5	101,189.2	33,389.1	140,626.0	48,963.8
	32.30 %	25.79 %	22.46 %	21.13 %	22.20 %	22.91 %
Garment, textile, clothes, and Leather Ind.	5,001.4	22,510.0	18,906.7	6,623.5	20,175.0	6,975.3
	3.09 %	3.50 %	4.20 %	4.19 %	3.18 %	3.26 %
Wood and wood product industry	1,903.3	7,020.6	7,198.1	878.2	6,871.3	940.9
	1.17 %	1.09 %	1.60 %	0.56 %	1.08 %	0.44 %
Paper, printing, transport. tools, metal prod., and other ind.	11,167.1	62,778.1	38,678.4	15,652.6	75,798.9	29,611.8
	6.89 %	9.77 %	8.59 %	9.91 %	11.97 %	13.85 %
Oil refinery	3,371.6	17,975.8	14,120.0	7,154.6	15,768.2	9,853.6
	2.08 %	2.80 %	3.13 %	4.53 %	2.49 %	4.61 %
Chemical and cement industry	6,364.5	33,932.2	26,653.7	13,505.5	29,764.9	18,600.3
	3.93 %	5.28 %	5.92 %	8.55 %	4.70 %	8.70 %
Elec., gas, and drinking water	610.5	5,972.9	4,858.2	2,020.9	7,934.9	1,982.8
	0.38 %	0.93 %	1.08 %	1.28 %	1.25 %	0.93 %
Trade, transportation supporting services, and warehousing	134.0	869.7	563.9	337.9	687.2	364.7
	0.08 %	0.14 %	0.13 %	0.21 %	0.11 %	0.17 %

Table 11 continued

	Agriculture		Non-agriculture			
	Labor	Enterp.	Rural		Urban	
			Low Income	Non-labor Force	Low Income	Non-labor Force
Hotels and restaurants	3,603.5	36,874.7	25,398.8	15,438.7	56,319.7	18,674.7
	2.22 %	5.74 %	5.64 %	9.77 %	8.89 %	8.74 %
Land transport	4,772.6	17,489.3	10,558.0	4,504.3	14,152.0	4,186.0
	2.95 %	2.72 %	2.34 %	2.85 %	2.23 %	1.96 %
Air, water transport and comm.	1,001.5	28,508.5	17,748.7	5,700.6	25,141.0	9,737.9
	0.62 %	4.44 %	3.94 %	3.61 %	3.97 %	4.56 %
Bank and insurance	345.5	9,596.7	6,697.9	1,301.2	9,741.8	1,956.0
	0.21 %	1.49 %	1.49 %	0.82 %	1.54 %	0.92 %
Real estate and services	3,610.9	13,295.7	15,971.6	2,888.1	26,526.6	5,292.2
	2.23 %	2.07 %	3.55 %	1.83 %	4.19 %	2.48 %
Govern., defence, educ., health, film, and other social serv.	19,077.0	51,995.2	42,548.9	14,888.4	61,899.1	12,197.2
	11.77 %	8.09 %	9.44 %	9.42 %	9.77 %	5.71 %
Individual service, household, and others	3,971.4	17,366.9	16,153.0	3,752.3	26,631.4	6,087.6
	2.45 %	2.70 %	3.59 %	2.37 %	4.20 %	2.85 %

Table 12 Sectoral value added, Indonesia SAM for 2008

	Billion IDR	%
Agriculture, hunting, forestry and fishing	810,210.89	15.69
Mining and quarrying	549,131.63	10.63
Food, beverage, and tobacco industry	286,707.68	5.55
Garment, textile, clothes, and leather industry	108,712.26	2.10
Wood and wood product industry	72,105.21	1.40
Paper, printing, transportation tools, metal products, and other industries	430,989.92	8.34
Oil refinery	337,111.84	6.53
Chemical and cement industry	204,262.50	3.95
Electricity, gas, and drinking water	127,592.26	2.47
Construction	427,655.06	8.28
Trade, transportation supporting services, and warehousing	526,380.52	10.19
Hotels and restaurants	139,597.79	2.70
Land transport	105,917.37	2.05
Air, water transport and communication	184,907.81	3.58
Bank and insurance	174,958.44	3.39
Real estate and services	198,080.86	3.83
Government, defence, education, health, film, and other social services	330,640.96	6.40
Individual service, household, and others	141,973.23	2.75
Net factor income from abroad	8,364.70	0.16
Toatal	5,165,300.93	100.00

Table 13 Energy demand, emission and employment figures for year 2008, Timmer (2012)

	CO_2 emissions		Energy demand		Total employment	
	(kt CO_2)	%	(tJ)	%	(10^3 people)	%
Production sectors						
Agriculture, hunting, forestry and fishing	16,157.4	4.5	224,662.9	2.2	8,726.8	21.3
Mining and quarrying	39,565.9	10.9	486,923.3	4.7	625.9	1.5
Food, beverage, and tobacco industry	7,989.2	2.2	351,451.3	3.4	1,180.7	2.9
Garment, textile, clothes, and leather ind.	13,650.5	3.8	234,992.9	2.3	1,808.2	4.4
Wood and wood product industry	2,351.3	0.6	61,425.3	0.6	1,539.0	3.8
Paper, print., transp. tools, metal prod., other ind.	61,072.8	16.9	652,175.0	6.3	2,212.3	5.4
Oil refinery	3,234.7	0.9	2,095,704.6	20.3	58.6	0.1
Chemical and cement industry	11,343.1	3.1	437,809.5	4.2	898.8	2.2

Table 13 continued

	CO_2 emissions		Energy demand		Total employment	
	(kt CO_2)	%	(tJ)	%	(10^3 people)	%
Electricity, gas, and drinking water	103,492.5	28.6	2,142,594.5	20.8	153.5	0.4
Construction	10,087.6	2.8	177,698.6	1.7	4,450.4	10.9
Trade, transp. support. serv., and w/h	5,565.3	1.5	122,521.0	1.2	3,545.9	8.7
Hotels and restaurants	2,174.2	0.6	47,469.1	0.5	1,361.1	3.3
Land transport	12,848.4	3.5	173,578.5	1.7	1,252.5	3.1
Air, water transport and communication	8,787.9	2.4	124,074.1	1.2	835.8	2.0
Bank and insurance	225.3	0.1	4,504.4	0.0	713.0	1.7
Real estate and services	1,013.5	0.3	26,899.1	0.3	708.9	1.7
Govern., def., educ., health, film,other social serv.	2,604.7	0.7	46,465.5	0.5	8,674.1	21.2
Individual serv., hh, and others	1,584.2	0.4	33,170.3	0.3	2,180.8	5.3
Households	58,181.5	16.1	2,873,132.9	27.8	–	
Total	361,930.1		10,317,252.9		40,926.1	

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