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Economic and environmental impacts of energy subsidy reform and oil price shock on the Malaysian transport sector

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ABSTRACT

This study employs a multi-sector computable general equilibrium model to investigate the long-run impacts of three scenarios, namely high prices of petroleum products, energy subsidy reform and the combine of both, on the Malaysian transport sector. The long-run simulation results suggest that all shocks are beneficial for the entire economy because of the increase in real GDP and investment. The shocks encourage the reallocation of resources and therefore induce disparities in sectoral adjustments. All transport sectors, except water transport, gain from high petroleum prices due to the increase in their domestic output, domestic sales and exports, while they lose from the energy subsidy reform and the combined scenario. The shocks lead to significant changes in travel behaviour of all household types through a change in their use of transport sub-sectors. The combined scenario followed by the high petroleum price shock greatly reduces energy consumption and emissions of all air pollutants in the transport sectors. These findings enhance our understanding of the transport impact of oil price shocks and energy subsidy reform and should be of much interest to scholars, corporate executives, travel agencies, regulators, and policy makers.

1. Introduction

In Malaysia, although the exports of crude oil in compare to the last two decades have decreased significantly, this country still is a net exporter of crude oil (Fig. 1). In this country, the share of exports of crude oil to real GDP in recent years has increased by more than 5%. For example, in 2010, the shares of imports and exports of crude oil to real GDP were 3.3% and 5.5%. It means that a rise in global prices of oil, which increase the value of Malaysian crude oil exports, will increase its GDP as well. Therefore, Malaysia as a net oil exporter country will influence from an increase in world oil prices. With an increase in world oil prices the prices of other fuels such as petroleum products, motor petrol, diesel, and fuel will increase as well. This rise influences the production sector by an increase in the costs of production which leads to a decline in the overall demand for goods and services in the economy.

The Malaysian transportation is the greatest consumer of petroleum products that significantly influences by an increase in the fuel market. This sector approximately consumed over 60% of petroleum products since 1995 (Fig. 2). According to this, the Malaysian transportation sector is a key area of economic growth and development and requires a high level of fuels for future sustainability (Al-Mofleh et al., 2010; Ong et al., 2012). The impact of high oil prices on transport increases transport costs, which changes distribution systems and the ability of existing logistics chains to serve markets.

On the other hand, high oil prices increase government expenditure, especially in those countries that pay subsidies on the consumption of energy carriers. One of these countries is Malaysia that its subsidies began in 1957. Fig. 3 shows that by an increase in international fuel prices the government subsidies will increase. Therefore, the relationship between international energy prices and the amount of subsidy paid to energy consumers is positive and it is not depend on economic growth in this country (Solaymani and Kari, 2014). In 2011, the government subsidies, in compare to the year 2000, have increased dramatically by 541%, while fuel prices have increased by 290%. Increase of 34% in fuel prices in 2008 relative to the previous year led to a

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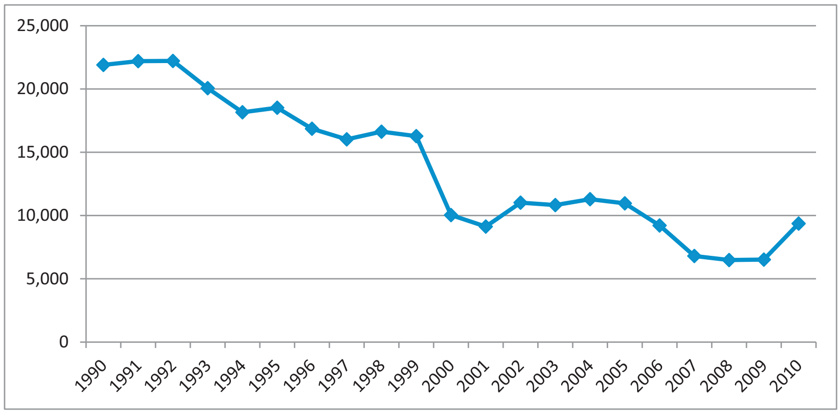

Fig. 1. Trend of net exports of crude oil in Malaysia. *Source:* National Energy Balance (2011).

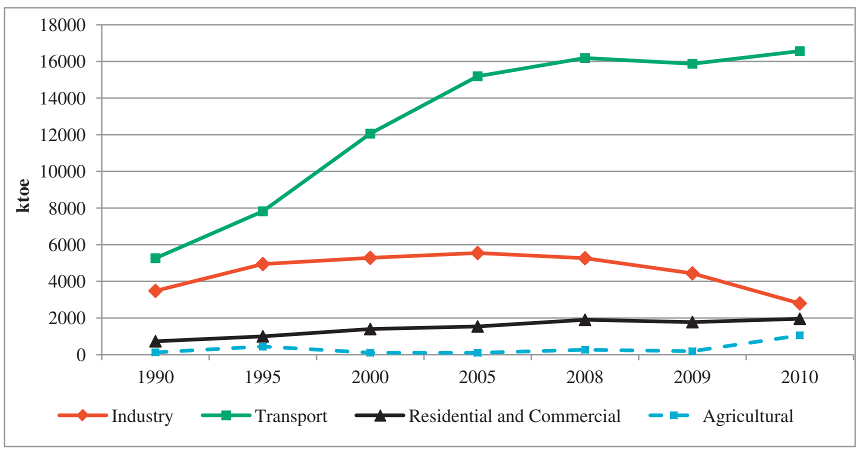

Fig. 2. Total consumption of petroleum products by economic sectors. *Source:* National Energy Balance (NEB) (2011).

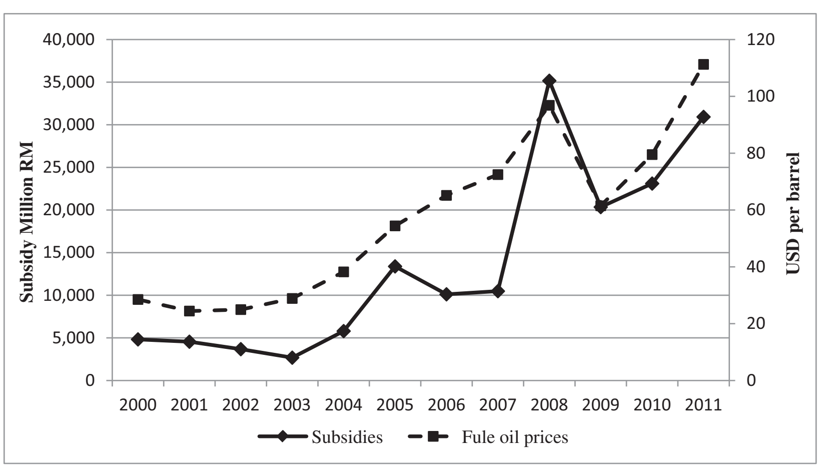

Fig. 3. Relationship between Malaysia's subsidies and international fuel oil prices. *Source:* EPU.

substantial increase in subsidies of about 235.5%. In the following year, the amount of government subsidies fell significantly by 42% following the dramatic fall (about −41%) in fuel prices. Moreover, in 2011 in compare to 2010, the price of oil increased by about 40% while the government in order to eliminate the negative impacts of this shock on the economy increased the subsidies by more than 57%. Therefore, a fluctuation in energy prices due to the above shocks would influence the fuel intensive sectors such as transport and industries. Moreover, these changes will influence behaviour of consumers for using transport. Watcharasukarn et al. (2012) showed that high oil prices leads to a change in consumer behaviour resulting a shift on the modes of transport from energy intensive modes to less-energy intensive modes. Sreenivas and Sant (2008) also indicated that rational pricing of urban transport through subsidy reform not only moves people away from private modes to more desirable public modes in Indian cities, but also helps improve the access and mobility of the poorer sections of society and provides more funds for other social expenses.

In addition to the above discussion, since Malaysian government has planned to reduce energy subsidies, this study investigate the impact of energy subsidy reforms on the Malaysian economy. Furthermore, due to high price fluctuation in oil market in recent years due to the great changes in Middle East countries, especially in oil exporting countries, analysing the effect of a rise in global fuel prices with and without energy subsidy reform on Malaysian economy will give the policy makers a significant insight for their future planning. Malaysia is an interesting case study, because as a net exporter of oil, an increase in prices might be beneficial for the country while, at the same time, the government pays a high level of energy subsidies for the consumption of energy which may also increase economic volatility due to energy subsidy reforms.

This study by focusing on the investigation of a 40% rise in international prices of petroleum products (a rise in international prices of crude oil during 2010–2011), a complete cut in energy subsidies and the combined of these scenarios on four major transport sectors (namely road, water, air and other transport services) provides a significant view point for the policy makers of the transportation sector to plan the future of this sector. Moreover, the paper seeks to contribute to the existing literature by applying a computable general equilibrium (CGE) model to analyse the impact of these shocks. These models are able to provide a very good framework for the analysis of the potential impacts of government policies and a rise in oil prices.

We analyse the impacts of these shocks on various main indicators such as output, employment, investment, imports and exports, energy consumption and emissions of 4 air pollutants, namely particulate matter (PM), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO). We also analyse the impact of these shocks on the travel behaviour of households in Malaysia through estimating the changes in household use of all kinds of transport sub-sectors. Since Malaysia pays high levels of subsidy on the consumption of energy, an alternative simulation for high prices of petroleum products is energy subsidy reform. For this purpose, the study uses a CGE model adapted from Solaymani and Kari (2013). The advantage of employing CGE models as opposed to other methods is that they are powerful methods for analysing different scenarios in fuel prices and to evaluate the impact of different policy measures and shocks on a specific sector such as transport.

The paper is organized as follows: Section 2 provides a summary of previous studies. Section 3 explains the model, data and simulations. Section 4 describes the simulation results. Section 5 shows the sensitivity analysis for the robustness of the model, and Section 6 concludes the study.

2. Review of the literature

In this section, we investigate those studies that identified the effects of oil price shock on the entire economy or on the transport sector in other countries because of the high limitation in related literature in Malaysian transport sector. The only study in this area for Malaysia was conducted by Solaymani and Kari (2013) by applying a CGE approach. They showed that, in the short-run, a rise in world oil prices would decrease transport demand and output while, in the long-run, it led to an increase in transport demand and output. The impact of high oil prices on entire economy of net oil exporting countries such as Malaysia and Indonesia by applying a structural VARX[2] model, provided benefits in terms of higher export revenues, while on the GDP growth of an oil importer like Singapore is slightly negative (Abeysinghe, 2001). Similarly, Chang and Wong (2003) pointed out that an oil price shock has an insignificant adverse effect on Singapore's GDP, inflation and unemployment rates during 1978Q1–2000Q3. Moreover, by applying a general equilibrium Yeah et al. (1994) showed that high oil prices has a little short-run impact on real GDP of Malaysia; however, it causes substantial long-run changes in sectoral production, income distribution and government financing. Therefore, the impact of higher oil prices depends on whether the country is an oil importer or exporter.

A potential increase in oil prices could increase transport costs two-to eight-fold and leads to a fall in transport profits (TEMS, 2008; Luft, 2006; Yilmazkuday, 2011). Similarly, changes in oil prices have a significant impact on the Travel and Leisure sector returns (Mohanty et al., 2014). Haldenbilen (2006) also showed that if the fuel price increases exponentially, the marginal costs of energy and transport will increase based on linear time series, polynomial time series, transport demand model and polynomial form of the transport demand model. However, Aggarwal et al. (2012) showed that oil price changes have asymmetric effects on transport sub sectors while Ajanovic and Haas (2012) could not identify asymmetric patterns. Ajanovic and Haas (2012) found that the impact of changes in fuel prices led to energy savings of about 3%, while the fuel intensity effect reduced energy consumption by about 5%. Therefore, an increase in global oil prices leads to significant increases in the cost of transport which results in a significant negative impact on the domestic output of countries.

Furthermore, by applying a TREMOVE model (a partial equilibrium model for the transport sector). Delsalle (2002) argued that as fuel prices only constitute a fraction (about 23%) of total transport costs, the effects of an oil price shock are small. However, decreasing the value of price volatility in the economy, the cost-benefits of the transport sector will increase by only 2–5% (Jensen and Møller, 2010). Therefore, an oil price shock has an initial negative impact on the transport sector and its energy consumption.

A fuel price rise also leads to a change in the market areas of some transport sub-sectors. Macharis et al. (2010), based on the different fuel price scenarios, revealed that a rise in fuel prices increases the market areas of both intermodal barge and rail terminals, but the result differs depending on the size of the increase.

Studies on energy subsidies in the transport sector are varied. Pucher et al. (1983), by applying an econometric method, suggested that an increase in the subsidies results in a decline in productivity and that costs grow most rapidly. Similarly, Sakai and Shoji (2010) showed that government subsidies to public bus sector negatively affect the cost structure and increase the demand for labour, capital, and maintenance. In contrast, Serebrisky et al. (2009) indicated that current public urban transport subsidy policies do not make the poorest better off, while Tscharaktschiew and Hirte (2012) argued that subsidizing public transport is welfare enhancing and subsidies to urban road traffic reduce aggregate urban welfare. However, energy subsidy reform in the economy leads to a decrease in the output and exports of transport sector and decreases use of transport services by households (Solaymani and Kari, 2014).

Other studies estimated the amount of energy subsidy on the transport sector. For example, the European Environment Agency calculated that transport subsidies in the 15 member countries of the European Union (EU-15) amounted to about €240 billion in 2005 of which the road, rail, air and water energy subsidies are approximately 128, 72, 26 and 14 billion Euros, respectively (EEA, 2007). Moreover, Riedy (2007) estimated the total energy and transport subsidies in Australia for 2005–06 as being between $9.3 billion and $10.1 billion. Ichinohe and Endo (2006) clarified the most cost-effective vehicle mix for reducing CO_2 emissions to estimate the subsidy necessary to achieve this vehicle mix using the MARKAL model. Based on the results of this study, hybrid

[2] Vector Autoregressive model with exogenous variables.

vehicles are the only type of clean-energy vehicle, and will have a high share of the passenger car sector (about 62%) by 2030.

In general, most of the above studies focused on estimating the amount of subsidies and its efficiency in the transport sector. Since this sector is the major energy consumer and air pollutant in many countries, energy subsidy reform has a significant effect on energy demand and emissions of air pollutants of this sector and the investigation of the effects of this policy is necessary. Therefore, in order to fill this gap, the current study attempts to investigate the impact of an energy subsidy reform policy on the Malaysian transport sector.

The review of the above literature shows that the majority of the studies have used econometric or other analytical methods to investigate the impacts of high oil prices and energy subsidy on the transport sector. Furthermore, they have analysed these effects on a specific mode or sector of transport. Therefore, accessing all transport sectors by applying a comprehensive model such as a computable general equilibrium (CGE) model provides policymakers with potential insights regarding the impacts of such shocks on the economy.

3. Materials and methods

3.1. Model specification

This study uses a computable general equilibrium (CGE) framework to investigate the impacts of three scenarios on the Malaysian transportation sector. The basic model of this study was adapted from Solaymani and Kari (2013) with some extensions in the production function and value added function that they have changed from *Leontief* and *Cobb–Douglas* functions into the constant elasticity of substitute (CES) functions, respectively. The model includes 22 sectors, namely Agriculture, Forestry and logging, Crude oil, Natural gas, Mining, Food processing, Textiles, Petroleum refinery, Chemical products, Cement, Iron and Steel products, Manufacturing, Electricity, Gas, Trade works, Four transport sectors, Communications, Financial institutions, and Other services. The transport sector includes Land, Water, Air, and Other transport sub-sectors. The nested structure of the production sector of the CGE model is presented in Fig. 4.

Production function takes a Constant Elasticity of Substitution (CES) form of value added, *VA*, and intermediate inputs, *IN*. The value added also takes a *CES* form and is a function of four primary inputs, namely rural, urban and noncitizen workers and capital.

$$X_i = \alpha_i^x \cdot \left[\beta_i^x \cdot IN_i^{-\rho_i^x} + (1-\beta_i^x) \cdot VA_i^{-\rho_i^x}\right]^{-\frac{1}{\rho_i^x}} \tag{1}$$

$$VA_i = \alpha_i^v \cdot \left[\sum_f \beta_{i,f}^v \cdot FDSC_{if}^{-\rho_i^v}\right]^{-\frac{1}{\rho_i^v}} \tag{2}$$

where $\propto_i^x$ and $\propto_i^v$ are shift parameters of the production function and the value added function, respectively. $FDSC_{if}$ denotes the employment of factor *f* (capital, rural, urban and noncitizen worker) in sector *i*, and β_i^x and β_{if}^v denote the share parameters of the production function and the value added function, respectively. The first order condition for profit maximization is as follows:

$$\frac{IN_i}{VA_i} = \left(\frac{PV_i}{PN_i} \cdot \frac{\beta_i^x}{(1-\beta_i^x)}\right)^{\frac{1}{\rho_i^x}} \tag{3}$$

PN and *PV* denote prices of intermediate inputs and value added, respectively. The factors' demand function shows the marginal cost of each factor (defined on the left-hand side), which is equal to the marginal revenue product (net of intermediate input costs) of the factor:

$$\frac{FDSC_{i,f}}{VA_i} = \left(\frac{\beta_{if}^v \cdot PV_i}{(\alpha_i^v)^{\rho_i^v} \cdot WF_i \cdot wfdist_{i,f}}\right)^{\frac{1}{\rho_i^v}} \tag{4}$$

where WF_i is the price of factor *f*. $wfdist_{if}$ is the wage distortion factor for factor *f* in sector *i*. The material aggregate, *MTAG*, is a

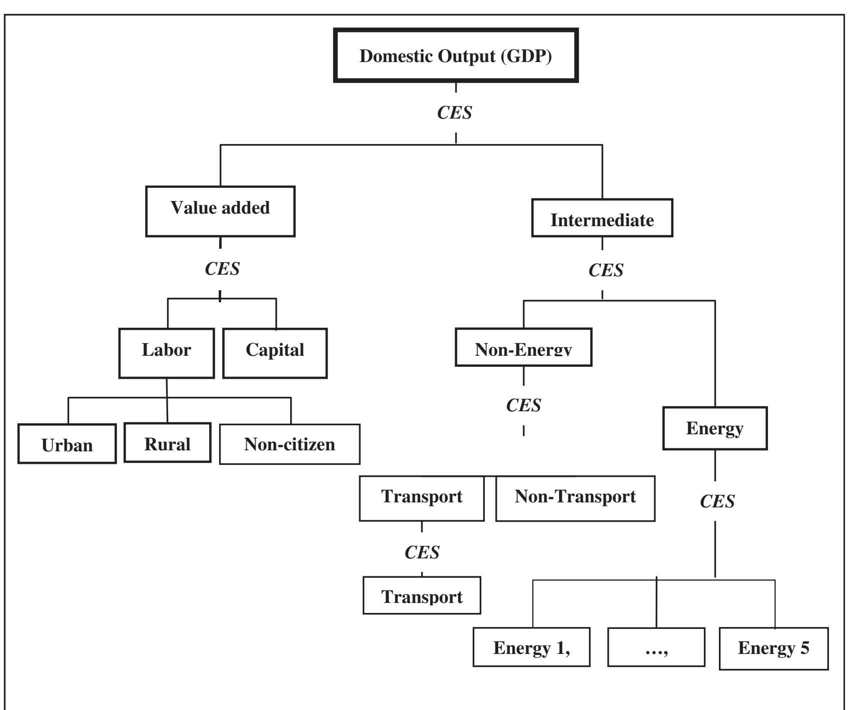

Fig. 4. A schematic representation of CGE models.

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Constant Elasticity of Substitution (*CES*) function of energy, *EN*, and non-energy, *NEN*, aggregates.

$$MTAG_j = \propto_j^{mt} \cdot \left[\delta_j^{mt} \cdot NEN_j^{-\rho_j^{mt}} + \left(1-\delta_j^{mt}\right) \cdot EN_j^{-\rho_j^{mt}}\right]^{-\frac{1}{\rho_j^{mt}}} \quad (5)$$

The production function of energy is a *CES* function of all energy inputs as follows:

$$EN_j = \propto_j^{en} \cdot \left[\sum_{e1} \delta_{e1,j}^{en} \cdot EDEM_{e1,j}^{-\rho_j^{en}}\right]^{-\frac{1}{\rho_j^{en}}}, \quad e1 \subset i \quad (6)$$

where $EDEM_{e1,j}$ is demand for energy carrier *e1* in sector *j*; ρ_i^{en} denotes the substitution parameter in the energy mix function; $\propto_i^{en}$ denotes the transforming coefficient in sector *i*; and $\delta_{e1,i}^{en}$ denotes the share of energy type *e1* in sector *i*; $\sum_{e1}\delta_{e1,j}^{en} = 1$.

Meanwhile, the production of non-energy is a function of transport, *TRANS*, and non-transport, *NTRANS*, intermediate inputs.

$$NEN_j = \propto_j^{nen} \cdot \left[\delta_j^{nen} \cdot TRANS_j^{-\rho_j^{nen}} + \left(1-\delta_j^{nen}\right) \cdot NTRANS_j^{-\rho_j^{nen}}\right]^{-\frac{1}{\rho_j^{nen}}} \quad (7)$$

where α_j^{nen} and δ_j^{nen} denote the shift and share parameters of the energy function, respectively. ρ_j^{nen} denotes the elasticity of substitution between transport and non-transport intermediate inputs in the energy function. The demand for transport is derived from minimizing the costs of using non-intermediate inputs subject to the *CES* function of Eq. (5), i.e.,

$$TRANS_j = NEN_j \cdot \left[\left(\propto_j^{nen}\right)^{-\rho_j^{nen}} \cdot \delta_j^{nen} \cdot \left(\frac{P_j^{nen}}{P_j^{trans}}\right)\right]^{\frac{1}{\left(1+\rho_j^{nen}\right)}} \quad (8)$$

As in many *CGE* models, the model is consistent with the *Armington* function (Eq. (9)), which shows the substitution of imported products and domestically produced products, and the Constant Elasticity of Transformation (*CET*) function (Eq. (11)), which is used to allocate domestic products between domestic consumption and exports:

$$Q_{im} = \propto_{im}^{c} \cdot \left[\beta_{im}^{c} \cdot M_{im}^{-\rho_{im}^{c}} + (1-\beta_{im}^{c}) \cdot D_{im}^{\rho_{im}^{c}}\right]^{-\frac{1}{\rho_{im}^{c}}}, \quad im \subset i \quad (9)$$

where Q_{im} denotes the aggregate demand for imported commodities in sector *im*; M_{im} denotes the total of imported commodities by importer sector *im*; D_{im} denotes the domestic sales of the imported commodities by sector *im*; α_{im}^{c} denotes the transforming coefficient; β_{im}^{c} denotes the share coefficient; and ρ_{im}^{c} denotes the substitution parameter. Import demand (Eq. (10)) is a function of the domestic good's price to import price ratio, the elasticity of substitution, and the *CES* share parameter.

$$M_{im} = D_{im} \cdot \left[\frac{PD_{im}}{PM_{im}} \cdot \frac{\beta_{im}^{c}}{(1-\beta_{im}^{c})}\right]^{\frac{1}{(1+\rho_{im}^{c})}} \quad (10)$$

$$X_{ie} = \propto_{ie}^{t} \cdot \left[\beta_{ie}^{t} \cdot E_{ie}^{\rho_{ie}^{t}} + (1-\beta_{ie}^{t}) \cdot D_{ie}^{\rho_{ie}^{t}}\right]^{\frac{1}{\rho_{ie}^{t}}}, \quad ie \subset i \quad (11)$$

where E_{ie} denotes the total exported commodity by exporter sector *ie*. The export supply is a function of the export to domestic price ratio, the elasticity of transformation, and the share parameters in the *CET* function.

$$E_{ie} = D_{ie} \cdot \left[\frac{PE_{ie}}{PD_{ie}} \cdot \frac{(1-\propto_{ie}^{t})}{\propto_{ie}^{t}}\right]^{\frac{1}{(\propto_{ie}^{t}-1)}} \quad (12)$$

In the income block, the production factors, the rural, urban and noncitizen workers, and capital receive their income, YF_f, from the employment and wage rate of the production factors:

$$YF_f = \sum_i WF_f \cdot wfdist_{i,f} \cdot FDSC_{i,f} \quad (13)$$

However, as mentioned in Eq. (14), households receive their income from labour and capital employment, and their wages. Government transfers and factor income from abroad are other sources of household income. Labour income allocates the income of labour to the corresponding household. For example, rural households receive their labour income from supplying rural labour. The capital income is corporate income after reducing corporate income tax (*ctax*) and savings (*csav*):

$$YH_h = \sum_f hhdis_{h,f} \cdot YF_f + ctrn_h \cdot YCORP \cdot (1-ctax) \cdot (1-csav) + gtrn_h \cdot GOVTRN + FACTIN \cdot sfin_h \cdot EXR \quad (14)$$

where $hhdis_{hf}$ denotes the share of income of factor *f* received by household *h*. $gtrn_h$denotes the share of household *h* from government transfers. $ctrn_h$ denotes the share of household *h* from corporate income. $sfin_h$ denotes the share of household *h* from factor income from abroad. *EXR* denotes the foreign exchange rate. In addition, in the income block, corporate income is a function of capital income and net receipts from the government and abroad.

$$YCOMP = YF_{cap} - EXR \cdot REPAT + INTERS_{corp} \quad (15)$$

INTERS denotes the interest rate paid by the government to corporations, *corp*. Government income is the sum of revenue collected from tariffs, indirect taxes, export taxes, and household and corporate income taxes.[3]

$$GR = TARIFF + INDTAX + HHTAX + EXPTAX + COMTAX \quad (16)$$

The government uses this income to purchase commodities for its consumption and transfers a share of it to households and enterprises. Government saving is a flexible residual. Household saving is derived from the marginal propensity to save (*mps*) out of the after-tax income.

$$HHSAV = \sum_h YH_h \cdot (1-th_h) \cdot mps_h \quad (17)$$

Enterprise saving is a function of the enterprise saving rate out of the after-tax income minus the transfer to households.

$$COMSAV = YCOMP \cdot (1-ctax) \cdot csav \quad (18)$$

Total savings is a function of household, government, and company's savings minus the current account.

$$SAVING = HHSAV + GOVSAV + COMSAV - CURACT \cdot EXR \quad (19)$$

On the demand side, the demand for commodities can be divided into household consumption demand, government consumption demand, intermediate inputs, investment demand, and inventory. Total household consumption is a function of household income deducted from household savings, mps_h, and taxes, τ_h:

$$THCON_i = \sum_h \left[\beta_{i,h} \cdot YH_h \cdot (1-mps_h) \cdot (1-\tau_h)\right]/PQ_i \quad (20)$$

This function is derived from a Linear Expenditure System (*LES*). However, it is simplified by setting all subsistence minima to zero; thus reducing the *LES* to fixed expenditure shares ($\beta_{i,h}$) and a *Cobb–Douglas* utility function as follows:

[3] The government revenue component equations are as follows: The tariff is a function of world prices of imports (pwm), imports (M), rate of tariffs (τ_i^m), and exchange rate (EXR). $TARIFF = \sum_i pwm_i \cdot M_i \cdot \tau_i^m .EXR$. Indirect tax is a function of nominal total domestic output ($PX_i \cdot X_i$) and rate of indirect tax (τ_i^x). $INTAX = \sum_i PX_i \cdot X_i \cdot \tau_i^x$. Household tax is a function of household income and the rate of household income tax (τ_h^h). $HHTAX = \sum_h YH_h \cdot \tau_h^h$. Company/Corporate tax is a function of a share of corporate income (ctax). $COMTAX = ctax \cdot YCOMP$. Export tax is a function of world prices of exports (pwe), exports (E), export tax rate (τ_i^e), and exchange rate. $EXPTAX = \sum_{ie} pwe_{ie} \cdot E_{ie} \cdot (1-\tau_{ie}^e).EXR$.

$$U_h = \prod_i THCON_i^{\beta_{i,h}} \tag{21}$$

Demand for intermediate inputs is assumed to have a *Leontief* technology with fixed coefficients, $io_{i,f}$.

$$INTM_i = \sum_j io_{i,j} \cdot X_j \tag{22}$$

Government demand for goods i (GD_i) is determined in Eq. (23) assuming a fixed share ($shgc_i$) of total government spending ($GOVCON$).

$$GD_i = shgc_i \cdot GOVCON \tag{23}$$

Eqs. (24)–(27) depict the flows of inventory investment, STK, and aggregated nominal fixed investment, $FXDINV$, to the investment by sector of origin (DK_i), and ultimately, to the investment by sector of destination (ID_i).

$$STK_i = inv_i \cdot X_i \tag{24}$$

$$FXDINV = INVEST - \sum_i PQ_i \cdot STK_i \tag{25}$$

$$DK_i = \frac{zz_i \cdot FXDINV}{\sum_j ccmat_{ij} \cdot PQ_j} \tag{26}$$

$$ID_i = \sum_j ccmat_{ij} \cdot DK_j \tag{27}$$

where inv denotes the ratio of inventory investment to gross output; $INVEST$ is the total investment; PQ_i is the price of composite commodities; zz is the share of investment by sector of destination, and $ccmat_{ij}$ denotes the capital composition coefficients.

Nominal GDP, $GDPVA$, is a function of value added, VA, indirect tax, $INDTAX$, tariff, $TARIFF$, and export tax, $EXPTAX$.

$$GDPVA = \sum_i PV_i \cdot VA_i + INDTAX + TARIFF + EXPTAX \tag{28}$$

Real GDP is a function of all demands, namely consumer demand, $THCON$, government demand, GD, investment by sector of destination, ID, fixed investment, STK, and net foreign demand (exports (E)–imports(M)).

$$REGDP = \sum_i (THCON_i + GD_i + ID_i + STK_i) + \sum_{ie} E_{ie} - \sum_{im} [(1 - \tau_{im}^m) \cdot M_{im}] \tag{29}$$

In the price block, the Domestic prices of imports are influenced by the world prices of imports, PWM, tariff rates, τ_i^m, and exchange rate, EXR. Domestic prices of exports are also influenced by the world prices of exports, PWE, export tax rates, τ_i^e, and exchange rate.

$$PM_i = PWM_i \cdot (1 + \tau_i^m) \cdot EXR \tag{30}$$

$$PE_i = PWM_i \cdot (1 + \tau_i^e) \cdot EXR \tag{31}$$

The producer price of the composite commodity is a function of the price of domestic products, PD_i, the price of imports, PM_i, and the composite commodity, Q_i.

$$PQ_i = (PD_i \cdot D_i + PM_i \cdot M_i)/Q_i \tag{32}$$

Total expenditure on the domestic output of a sector is equal to the sum of the expenditure on the domestically supplied domestic output and exports of the sector. This provides the price of the aggregate domestic output, PX_i, of the sector:

$$PX_i = (PD_i \cdot D_i + PE_i \cdot E_i)/X_i \tag{33}$$

The value added price (PV_i) is defined as the output price less indirect and export taxes (tva) and intermediate costs (computed from the fixed input–output coefficients)

$$PV_i = PX_i \cdot (1 - tva_i - \sum_j io_{ji} \cdot PQ_j) \tag{34}$$

The price of capital goods (PK_i) is the weighted sum of the cost of capital goods used in each sector:

$$PK_i = \sum_j ccmat_{ji} \cdot PQ_j \tag{35}$$

The price of energy is a function of demand for energy sources $e1$ in sector j,$io_{e1,j}$, and composite price of energy commodities.

$$P_j^{en} = \frac{\sum_{e1} io_{e1,j} \cdot X_j \cdot PQ_{e1}}{EN_j} \tag{36}$$

The price of non-energy commodities is also as follows (Joglekar, 2009):

$$P_j^{nen} = \frac{\sum_{e2} io_{e2,j} \cdot X_j \cdot PQ_{e2}}{EN_j} \tag{37}$$

The price of aggregate material, P_i^{mt}, can be formulated as a function of energy and non-energy prices as follows:

$$P_i^{mt} = \frac{P_i^{en} \cdot EN_i + P_i^{nen} \cdot NEN_i}{MTAG_i} \tag{38}$$

The price of transport services is a function of demand for transport services $t1$ in sector j, $io_{e1,j}$, and the composite price of transport services.

$$P_j^{trans} = \frac{\sum_{t1} IO_{t1,j} \cdot X_j \cdot PQ_{t1}}{TRANS_j} \tag{39}$$

The price of non-transport services is as follows:

$$P_j^{trans} = \frac{\sum_{t1} IO_{t1,j} \cdot X_j \cdot PQ_{t1}}{TRANS_j} \tag{40}$$

According to the *Walras law*, the market equilibrium module consists of good market equilibrium (Eq. (41)), factor market equilibrium (Eq. (42)), current account balance (Eq. (43)), and equilibrium within the government budget (Eq. (44)).

$$Q_i = INTM_i + THCON_i + GD_i + ID_i + STK_i \tag{41}$$

$$\sum_i FDSC_{if} = FS_f \tag{42}$$

$$CURACT = \sum_{im} pwm_{im} \cdot M_{im} \cdot EXR + \sum_{ie} PWE_{ie} \cdot (1 - te_{ie}) \cdot E_{ie} \cdot EXR \tag{43}$$

$$GOVSAV = GR - \sum_i PQ_i \cdot GD_i - EXR.INTERS^{world} - INTERS^{crop} - GOVTRN \tag{44}$$

where GD is the government demand for commodities produced by sector i, EXR denotes the exchange rate; $INTERS$ denotes the interest rate paid by the government to foreign countries, *world*, and corporations, *crop; GOVTRN* denotes government transfer to households.

3.2. Implications of emissions

The CO_2 emission by sector, $CO2E_j$, in the economy can be formulated as follows:

$$CO2E_j = \sum_{ful} \omega_{ful} \cdot EDEM_{ful,j} \tag{45}$$

Table 1
Model elasticities.

Sectors	Elasticity of substitution between	
	Imports and domestic sales	Exports and domestic sales
Agricultural	0.9	0.7
Forestry and logging	0.9	0.9
Crude oil	0.9	0.9
Natural gas	0.9	0.9
Mining	0.9	0.9
Food processing, beverage and tobacco products	1.2	1.2
Textiles, wood and paper products	0.7	0.7
Petroleum refinery	0.6	0.6
Chemical products, rubber and plastic	0.7	0.7
Cement and non-metallic mineral products	0.7	0.7
Iron and steel products	0.7	0.7
Manufacturing	0.7	0.5
Electricity	0.9	0.5
Gas	0.9	0.5
Trade works, wholesale & retail trade, hotel & restaurant	0.5	0.5
Land transport	0.5	0.5
Water transport	0.5	0.5
Air transport	0.5	0.5
Other transport services	0.5	0.5
Communication	0.5	0.5
Financial institutions	0.5	0.5
Services	0.5	0.5
Substitution elasticities between		
Intermediate inputs and value added in the production function		0.6–0.9
Factors of production in the value added equation		0.5–0.6
Aggregate materials: energy and non-energy inputs		0.62
Non-transport inputs and transport inputs		0.65
Energy inputs		0.50
Transport inputs		0.62

Source: Various studies.

where ω_{ful} denotes emission factors of fossil fuel *ful*. $EDEM_{ful,j}$ denotes demand for fuel *ful* in sector *j*.

The relative changes in CO_2 emissions (*CEM*) from subsidy reform policy can be formulated as the following:

$$CEM = \frac{\sum_j CO2E_j^1 - \sum_j CO2E_j^0}{\sum_j CO2E_j^0} \tag{46}$$

where $CO2E_j^0$ and $CO2E_i^1$ are the values of CO_2 emissions before and after simulation, respectively. Therefore, the relative changes in sectoral emissions, EMI_j, are calculated as:

$$EMI_j = \frac{CO2E_j^1 - CO2E_j^0}{CO2E_j^0} \tag{47}$$

3.3. Closure, welfare measurement and data

The choice of exogenous variables is the closure rule of the model. In the model, the general price index is fixed exogenously. All prices in the model are fixed at unity. Therefore, a change in total utility before and after the simulation equates to a welfare change; as measured by the Hicksian Equivalent Variation (EV).

$$EV_h = \frac{(U_h^1 - U_h^0)}{U_h^0} \cdot Y_h \tag{48}$$

where *EV* denotes the Hicksian equivalent valuation. U^0 and U^1 denote utility level before and after policy shock, and Y_h denotes total income of household *h*.

Government consumption, as well as its transfer to households, is fixed exogenously. The foreign exchange rate market is cleared by fluctuations in the exchange rate, whereas the current account is fixed. Three labour types and capital supply are exogenously fixed; but both are sectorally mobile. Markets for three labour categories and capital are cleared by endogenous factor prices. Since the model is static, with a fixed total factor supply, the results of the model must be interpreted as long-run results and outcomes, which shows what the new equilibrium would reach after the economy has had time to adjust.

The experiment was carried out within a long-run macro closure. In the long-run closure, both capital and labour are sectorally mobile with fixed total supplies. Furthermore, sectoral rates of interest, nominal exchange rate, government savings, and real investment expenditure are also considered endogenous. The CGE model was solved using General Algebraic Modelling System (GAMS) software.

The parameters of the functions in the model were adapted from literature on other CGE models. The extraneous parameters required for the model calibration are presented in Table 1. The assumed elasticities are deemed conservative and were based on a literature search on elasticities in the Malaysian economy, such as Solaymani and Kari (2013), and Solaymani et al. (2014).

The main data source for the present study comes from the latest Malaysian input-output table and Social Accounting Matrix (SAM) for 2005. The 2005 input–output table consists of 120 sectors that are aggregated into 22 sectors. These industries can also be sorted into two broad categories, namely transport sectors (i.e., land, water, air, and other transport services), and non-transport sectors.

3.4. Simulation scenarios

The baseline simulation is a situation that there is no any shock or scenario in the model. The base calibration year is 2005, the most recent year for which data (SAM) are available, that all simulations are evaluated in compare with this year. Since petroleum products derive from crude oil, an increase in its price would increase the prices of petroleum products. According to the Malaysian Economic Planning Unit (EPU), if there is a substantial increase in oil prices on the world market, it affects the price of petroleum products such as diesel, petrol and cooking gas (LPG) in Malaysia (EPU, 2005). Hence, this study evaluates the environmental and economic impacts of three scenarios on the Malaysian transportation sector. Scenario 1 considers a situation in which the international prices of petroleum products (import and export) increase 40% higher than the base year situation. It is consistence with the recent increase in the international prices of crude oil according to the OPEC yearly basket price (from US$77.45 per barrel in 2010 to US$107.46 per barrel in 2011). Scenario 2 considers complete removal of Malaysia's energy subsidies and Scenario 3 combines both approaches.

4. Simulation results

Since Malaysia, as a developing country, is a net exporter of crude oil and refined petroleum products, this may initially seem to be only a negative terms-of-trade shock, which would in general lead to depreciation in the economy. This is contrary to developed countries in which this kind of shock leads to an expansion of the economy.[4] Because the effects of high oil prices on developing countries is great and leads to "Dutch disease" while its effects on developed countries is small and if a "Dutch disease" happen its impacts is weak.

4.1. Macroeconomic impacts

Table 2 shows the impacts of three scenarios, high petroleum products prices, reform of energy subsidies and both scenarios combined on macroeconomic variables. Since these shocks directly influence the energy market and lead to an increase in the prices of energy carriers, especially petroleum products, they increase the cost of production resulting in a decrease in demand for primary and intermediate inputs in economic sectors, especially in non-oil producing sectors. Therefore, the output, employment and domestic sales of non-oil producing sectors decrease significantly. However, an increase in the prices of energy carriers encourages the investment in oil-producing sectors that consequently increases the total investment in the economy. This process is a normal response of the economy and its sectors to an increase in energy prices by the introduced shocks.

A 40% rise in international prices of petroleum products increases real GDP by 1.9% due to significant increases in investment by 26.4%. It also leads to an increase in aggregate household consumption by 0.5%. If the government completely cuts energy subsidies, this policy increases real GDP by 0.6% which is smaller than GDP growth in the case of an oil price shock. This increase occurs because of a 13.2% increase in investment. Furthermore, when these shocks occur at the same time (combined scenario), the economy is influenced more significantly than individual shocks (oil price rise or energy subsidy reform). In this situation, real GDP increases by 2.9% and total imports and exports decrease by 3.5% and 4%, respectively, which are greater than individual shocks.

Although the long-run impact of an oil price rise on the welfare of rural households is negative (−0.2%), it influences the welfare of urban and noncitizen households positively (0.7% and 10% respectively). Since the oil price shock leads to significant decreases in the output, export and consequently the employment of those sectors that have a high share of employment of rural workers, the income of rural households decreases by 0.18%, which leads to a decrease in their welfare by 0.2%. For example, the oil price shock leads to significant decreases in the output, export and the employment of rural workers in the Forestry and Logging sector by 13.6%, 14.1% and 13%, respectively. However, the output, exports and employment of other sectors (such as crude oil, natural gas and petroleum refinery sectors) that have a high shares of the employment of urban and noncitizen workers increase and lead to an increase in the income and consequently the welfare of urban and noncitizen households.

On the other hand, the removal of energy subsidies in the long-run leads to significant decreases in the welfare of all household groups. The welfare of rural, urban and noncitizen household decreases by 2%, 2% and 28.3%, respectively. In the combined scenario, since the negative effects of energy subsidy reform on the welfare of all households are greater than the oil price rise effects, the impact of the combined scenario on the welfare of all household groups are also negative, which shows significant decreases in the welfare of all household groups.

In terms of the magnitude of the effects on the welfare of households, we can conclude that, across different scenario, the urban and noncitizen households experienced the highest impact under the second scenario because of the great negative impact of energy subsidy reform on the sources of income and consumption of these households which come from energy intensive sectors such as Iron and steel, Cement industry, Manufacturing and Electricity. However, the rural households experienced the highest magnitude in their welfare in the third scenario because it includes the negative impacts of the first and the second scenarios.

While, in the long-run, oil price shock would decrease the level of all air pollutants, the removal of energy subsidies initially would increase their emissions level (Fig. 5). The latest is because of the increase in the consumption of fossil fuels in the Wholesale and retail trade (which includes residential and non-residential and special trade works), government services, Chemistry and Petroleum refinery sectors, which their energy demand increase in the long-run due to more use of their products, while the fuel consumption of all other economic sectors decrease. In contrast, a 40% rise in petroleum products leads to a decrease in the consumption of fossil fuels in the majority of sectors resulting in a decrease in the emission level of all air pollutants. The combined scenario would also decrease the emissions level of all air pollutants. Therefore, an oil price rise can help the energy subsidy reform to improve the quality of Malaysian environment.

It can be concluded that the results of the impacts of the shocks on whole of the economy are in line with the results of other similar studies and are not significantly different from them. For example, using a general equilibrium model, Solaymani and Kari (2013) found that in the long-run oil price rises lead to an increase in real GDP and a decrease in the emissions level of GHGs. Yeah et al. (1994), using a general equilibrium model, also found that a 30% increase in oil prices would have a positive impact (about 0.3%) on Malaysian GDP in the short-run. The magnitude of the aggregate impacts of the current study compared to similar studies may be due to differences in shock type, magnitude of shocks and differences in sectoral adjustments. Contrary to other CGE studies, all shocks, the increase in world prices of energy carriers, the energy subsidy reform and these issues combined, do not affect all sectors equally.

4.2. Impact on transport sector

The reaction of each of the transport sectors to a 40% rise in global prices of petroleum products, energy subsidy reform and these issues combined are varied. Since the model shows the long-run responses of all variables in the model to the shocks, the three labour categories and capital are mobile among the sectors. In fact,

[4] For details see Dissou (2010).

Table 2
Impacts of different scenarios on selected macroeconomic variables.

Variables	Baseline values	Percentage changes from base-run value		
		Scenario 1	Scenario 2	Scenario 3
Real GDP	521,432.123	1.94	0.63	2.90
Total investment	48,308.231	26.36	13.15	43.13
Total real imports	114,833.129	−3.64	−0.24	−4.51
Total real exports	536,541.539	−3.31	−0.14	−3.99
Household consumption	192,404.716	0.51	−1.87	−1.47
Exchange rate	1.00	−1.49	0.28	−1.49
EV-rural	487,846.541	−0.19	−2.02	−2.38
EV-urban	2,073,774.09	0.73	−1.98	−1.36
EV-noncitizen	3787.126	10.01	−28.29	−16.88

Note: The baseline values are in million Ringgit Malaysia.
Source: Simulation results.

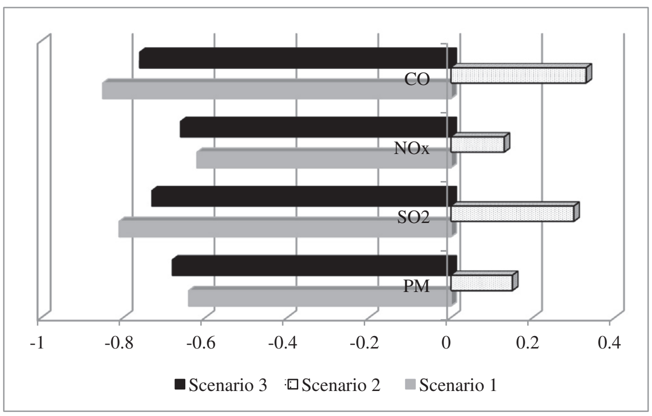

Fig. 5. Aggregate impacts of different scenarios on emissions of air pollutants. *Source:* Simulation results.

an increase in the exports and investment of booming (oil-producing) sectors due to the shocks increases the employment of primary inputs in these sectors. The higher energy prices due to the shocks lead to a reallocation of resources in the economy from non-oil producing sectors to oil-producing sectors. Therefore, primary inputs move from activities, which are in crises due to the shocks, i.e. non-oil producing sectors, to other sectors, which are not in depreciation or slightly influenced from the shock, i.e. oil-producing sectors.

According to the simulation results, in the oil-producing sectors (crude oil, natural gas and petroleum products) the numbers of workers increased significantly rather than most of the non-oil producing sectors. For example, the number of workers due to the high petroleum products prices for crude oil, natural gas and petroleum products sectors increase by 35.9%, 35.9% and 41.4%, respectively, whereas, on food processing, textiles, chemical, iron and steel, and manufacturing sectors decrease by 0.3%, 3.3%, 2.1%, 8.1%, 9.25% and 17.3%, respectively. In the transport sectors, while the 40% rise in global prices of petroleum products would decrease the aggregate demand for labour in water transport by 3%, it increased the demand for labour in land, air and other transport sectors by 2.4%, 1.3%, and 1.9%, respectively. Since the majority of water transport in Malaysia includes river transport and fishing, which are common in rural village areas of East Malaysia, high oil prices due to high poverty level in these areas lead to an increase in the production cost of this sector resulting in a decrease in their employment. Another reason is high limitation in using substitute fuels that might cause producer to substitute capital for labour. Therefore, the majority of workers migrate to other transport sectors or other economic sectors resulting in a decrease in the output and exports of this sector.

Energy subsidy reform and the combined scenario decreased demand for labour in all transport sectors. The changes in the output of all transport sectors are similar to the change in the employment of these sectors (Table 3). Although high petroleum prices increased domestic output of land, air and other transport sectors by 2.3%, 1.2% and 1.9%, respectively, it decreased domestic output of water transport by 3.1%. While energy subsidy reform decreased the output of all transport sectors, the combined scenario increased only the output of other transport sector. The latest is due to this reason that the magnitude of the high oil price is greater than the magnitude of energy subsidy reform, which leads to a positive impact in the combined scenario.

As discussed by Dissou (2010), an oil price shock stimulates investment in oil producing sectors due to the rise in the ratio of the shadow price of capital to its purchasing price, and decrease on other sectors because of the increase in energy cost. However, due to adjustment of capital during the time, investment has also increased in the non-oil producing sectors. Another reason for an increase in investment is that by an increase in government revenues and savings due to the oil price shock, the government can invest more in economic sectors. Therefore, high petroleum products prices lead to an increase in the investment in land, water,

Table 3
Impacts on selected variables in transport sector.

Sectors	Percentage change from base-run value											
	Domestic output				Employment				Investment			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	8168.13	2.31	−4.46	−1.93	974.513	2.42	−4.56	−1.93	302.676	27.24	13.90	45.56
Water	13,904.68	−3.06	−1.50	−5.17	2746.35	−2.99	−1.87	−5.44	804.34	27.22	13.91	45.55
Air	12,536.64	1.21	−2.49	−1.24	2303.39	1.33	−2.53	−1.15	206.861	27.10	13.82	45.30
Other	17,463.04	1.87	−0.17	2.05	2834.95	1.93	−0.52	1.75	490.86	27.13	13.85	45.38

Note: The baseline values are in million Ringgit Malaysia.
Source: Simulation results.

air and other transport sector by 27.2%, 27.2%, 27.1%, and 27.1%, respectively. In this period, energy subsidy reform increased the investment in all transport sectors but less than the oil price shock. However, the combination of oil price rise and energy subsidy reform increased investment more than each shock separately.

Since the oil price shock increased the output of land, air and other transport sectors, they experienced an increase in their exports (Table 4). Because, as mentioned above, the water transport is more sensitive to a rise in international prices of fuels rather than domestic prices of fuels, for instance, due to the energy subsidy reform. The imports of all transport sectors would increase due to a 1.5% decrease in the foreign exchange rate. The removal of energy subsidies would decrease the exports of all transport sectors significantly because of a fall in their outputs and a 0.3% raise in the foreign exchange rate, while their imports would increase. In the combined scenario, as the output of land, water, and air transport decreased, their exports are also decreased. However, a 1.5% rise in the exchange rate leads to an increase in the imports of all transport sectors, except water transport.

As mentioned above, transport sectors, as non-oil producing sectors, are influenced from both the shift of resources towards oil sectors and an increase in their production costs due to the rise in fuel prices. Another factor that affects the exports of the transport sectors as well as other economic sectors due to high petroleum prices is an appreciation in the domestic currency against foreign currencies.

In all transport sectors, except water transport, high petroleum prices lead to an increase in aggregate labour income since its employment decreased significantly (Table 5). On the other hand, this shock increased the aggregate household use of the transport sectors by 1.6%, 2.5%, 3.8% and 1.4%, respectively for the land, water, air and other transport sector. Since Malaysian government by an increase in world oil prices support the economy by increasing energy subsidies, the oil price shock not only would not decrease the use of transport but only it increased the use of it. The aggregate household consumption significantly decreased in the second and third scenarios because there is no any government support for energy subsidy reform policy in the economy. A

Table 4
Impacts on selected variables in transport sector.

Sectors	Percentage change from base-run value											
	Domestic sales				Export				Import			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	7527.51	2.32	−3.54	−0.98	640.62	2.11	−16.92	−14.79	422.25	2.54	12.00	15.07
Water	12,164.12	−3.10	−1.15	−4.85	1740.56	−2.84	−4.03	−7.43	1763.75	−3.36	1.81	−2.20
Air	11,518.21	1.13	−2.14	−0.96	1018.43	2.10	−6.65	−4.56	1311.66	0.16	2.59	2.78
Other	15,272.42	1.92	0.00	2.25	2190.63	1.57	−1.37	0.60	1317.87	2.27	1.39	3.94

Note: The baseline values are in million Ringgit Malaysia.
Source: Simulation results.

Table 5
Impacts on labor and household variables in transport sector.

Sectors	Percentage change from base-run value											
	Intermediate inputs				Labor income				Household consumption			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	6866.41	1.31	−0.88	0.53	8046.61	1.75	−6.01	−4.37	780.68	1.63	−26.35	−24.82
Water	11,786.2	−5.84	−1.08	−7.92	3720.80	−3.62	−3.35	−7.79	1337.34	2.52	−7.09	−4.68
Air	11,473.22	0.28	−1.11	−0.83	2344.77	0.67	−4.00	−3.61	1149.79	3.82	−10.14	−6.42
Other	14,188.17	1.15	0.27	1.61	5979.17	1.27	−2.03	−0.78	1911.26	1.40	−4.62	−2.94

Note: The baseline values are in million Ringgit Malaysia
Source: Simulation results.

Table 6
Impacts on energy demand in transport sector.

Sectors	Percentage change from base-run value							
	Aggregate energy				Petroleum products			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	1288.067	−0.23	−0.05	−0.36	1328.933	−0.002	0.00	−0.003
Water	1330.229	−0.06	−0.02	−0.10	1327.532	−0.014	−0.003	−0.022
Air	4048.801	−0.04	−0.01	−0.07	4033.332	−0.011	−0.003	−0.017
Other	667.69	−0.26	−0.06	−0.41	661.639	0.565	0.131	0.893
Sectors	Electricity				City gas			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	82.843	−2.49	−0.59	−3.85	7.857	−2.49	−0.59	−3.85
Water	11.933	−2.53	−0.60	−3.93	1.132	−2.53	−0.60	−3.93
Air	23.101	−2.53	−0.60	−3.92	2.191	−2.53	−0.60	−3.92
Other	276.382	−1.81	−0.43	−2.81	26.212	−1.81	−0.43	−2.81

Note: The baseline values are in million Ringgit Malaysia.
Source: Simulation results.

Table 7
Impacts on emissions of different air pollutant in transport sector.

Sectors	Percentage change from base-run value							
	PM emissions				SO_2 emissions			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	1338.184	−0.44	−0.11	−0.68	1375.869	−0.42	−0.10	−0.66
Water	1314.069	−0.12	−0.03	−0.18	1365.856	−0.11	−0.03	−0.17
Air	4010.286	−0.08	−0.02	−0.13	4172.648	−0.08	−0.02	−0.12
Other	943.353	−0.66	−0.16	−1.02	950.196	−0.64	−0.15	−0.98
Sectors	NO_x emissions				CO emissions			
	Baseline values	Scen.1	Scen.2	Scen.3	Baseline values	Scen.1	Scen.2	Scen.3
Land	2284.376	−0.43	−0.10	−0.67	29.386	−0.48	−0.11	−0.74
Water	2256.68	−0.11	−0.03	−0.18	28.376	−0.13	−0.03	−0.20
Air	6891.022	−0.08	−0.02	−0.12	86.464	−0.09	−0.02	−0.14
Other	1596.318	−0.66	−0.16	−1.01	21.523	−0.72	−0.17	−1.10

Note: The baseline values are in ton.
Source: Simulation results.

decrease in the output of all transport sectors due to the removal of energy subsidies would decrease the income of production factors, especially labour income, resulting in significant decreases in the consumption of all household types.

Table 6 reports the impacts of all scenarios on the demand for energy. As observed, a 40% rise in world prices of petroleum products leads to greater decreases in the consumption of aggregate energy, petroleum products, electricity and city gas in all transport sectors compared to the energy subsidy reform policy. However, the combined scenario is more effective than each separate scenario in reducing energy demand in all transport sectors.

The impact of high petroleum prices, energy subsidy reform and a combination of both on emissions of all air pollutants are presented in Table 7. Although all shocks decrease the emission of all kinds of air pollutants in Malaysia, the magnitude of the impacts is varied. For example, the combined scenario leads to the greatest decrease in the emissions of particulate matter (PM), sulphur dioxides (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO) followed by high petroleum prices. Therefore, in the long-run, the impact of high prices of petroleum products is greater in order to decrease the consumption of energy and emissions of air pollutions and the combined of a rise in international oil prices and energy subsidy reform are more effective to reduce greater reductions in energy demand and GHG emission in Malaysian economy. On the other hand, the other transport sector experienced the greatest declines in all air pollutants followed by the land transport sector, while air transport experienced the lowest decline.

5. Sensitivity analysis

Similar to other studies in CGE modelling, in order to assess the robustness of the qualitative results discussed above, it is necessary to perform some sensitivity analyses by running two additional simulations. First, we consider 80% and 20% increases in world prices of petroleum products instead of the base shock (40% increase) and a 20% and 50% decrease in energy subsidies instead of the base shock (100% cut in energy subsidies). Table 8 reports the aggregate impacts of these simulations on aggregate variables. In general, for the first scenario, the aggregate variables move in the same direction, though with smaller and greater magnitudes. For instance, for 20% and 80% increase in petroleum prices real GDP increases by 0.9% and 3.8% versus the earlier 1.94%. For the 80% petroleum price rise, the decline in the aggregate exchange rate is more severe than the base run value resulting in a greater fall in the total real exports.

The sensitivity results for the energy subsidy reform also shows that a greater decline in energy subsidies leads to greater increases in real GDP and investment, and more decreases in household income and consumption, exports and imports in Malaysia.

In the second sensitivity analysis, along with a 40% rise in world prices of petroleum products the substitution elasticities of aggregate energy is decreased and increased by 30% lower and upper than the benchmark values, respectively. With these modifications, the simulations were obtained using a 40% increase in world prices of petroleum products. Fig. 6 reports the impacts of these simulations on the emissions of all air pollutants on all transport sectors.

Table 8
Sensitivity analysis: impacts of 20% and 80% increase in world prices of petroleum products on selected aggregate variables.

Variable	Baseline values	Percentage deviation from base-run					
		20%	20%	Base shock		80%	50%
		Scen. 1	Scen. 2	Scen. 1	Scen. 2	Scen. 1	Scen. 2
Real GDP	521,432.123	0.90	0.14	1.94	0.63	3.80	0.33
Household consumption	192,404.716	0.26	−0.40	0.51	−1.87	−4.32	−0.97
Household income	220,506.235	0.26	−0.41	0.52	−1.90	−4.28	−0.99
Investment	48,308.231	10.14	2.93	26.36	13.15	79.33	6.97
Exports	536,541.539	−1.18	−0.02	−3.31	−0.14	−12.42	−0.05
Imports	114,833.129	−1.60	−0.03	−3.64	−0.24	−8.63	−0.10
Exchange rate	1.00	−0.39	0.06	−1.49	0.28	−13.12	0.15
Government revenue	84,141.749	5.83	0.10	14.29	0.56	37.18	0.27

Note: The baseline values are in million Ringgit Malaysia.
Source: Simulation results.

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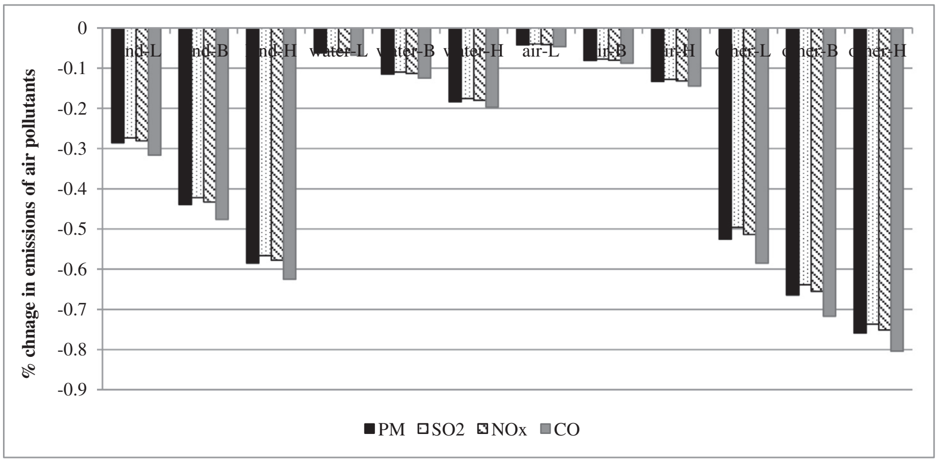

Fig. 6. Sensitivity analysis on energy substitution elasticity: impacts of 40% increase in world prices of petroleum products on emission of all air pollutants on all transport sectors. *Source:* Simulation results. *Note:* -L, -B and -H denote low, base and high elasticity for aggregate energy function, respectively.

The simulation results show that for all transport sectors, a greater increase in the energy elasticity leads to a greater decrease in the emissions level of all air pollutants. Therefore, the qualitative results obtained for the impact of a rise in prices of petroleum products on the Malaysian economy are still valid.

6. Conclusion

This paper investigated the potential effects of a sustained increase in the world prices of petroleum products, energy subsidy reform and a combination of both on the Malaysian transportation sectors. It used a multi-sector computable general equilibrium model that makes it possible to trace the impacts of these shocks on the transport sector.

The long-run simulation results suggest that the Malaysian economy would gain from high energy prices due to high prices of petroleum product, energy subsidy reform and both approaches combined. This is because all shocks lead to an increase in real GDP, terms of trade, and investment. Although the high petroleum prices increased the income, consumption and the welfare of all household groups, except in rural households, the energy subsidy reform and the combined scenario decreased household income, consumption, and welfare. Since all scenarios lead to a reallocation of resources from non-oil producing sectors to oil-producing sectors, the oil-producing sectors gain from the shocks.

All transport sectors, except water transport, experienced an increase in their outputs, employment, domestic sales, exports, and imports due to a rise in international prices of petroleum products, while the removal of energy subsidies led to a decrease in these indicators. The combined scenario decreases the outputs, employment, domestic sales, exports, and imports of all transport sectors, except for the other transport sector.

These shocks also would change the travel behaviour of households in Malaysia. High petroleum products prices would increase the use of all kinds of transport sub-sectors by all household types while energy subsidy reform and the combined scenario would decrease the use of these sectors.

The impacts of these shocks on the consumption of energy carriers show that the combined scenario is more effective than other shocks in reducing demand for aggregate energy, petroleum products, electricity and city gas in all transport sectors. This shock is also more effective than other shocks in reducing the emissions of particulate matter (PM), sulphur dioxides (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO) in all transport sectors.

Therefore, the high petroleum prices and removal of subsidies is beneficial for the economy and the environment. However, policymakers should be concerned with their negative impacts on households and provide some offsetting policy to cover these negative impacts.

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