Macroeconomic Impacts of Oil Price Shocks on the Bangladesh Economy

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1. Introduction

The macroeconomic effects of oil price shocks have been extensively examined in the energy literature ever since the first oil crisis of 1973. Evidence from the literature suggests that there exist multiple channels of transmission through which oil price shocks can affect the macroeconomy (Kilian, 2009). It is expected that higher oil prices reduce discretionary income since consumers are left with less money to spend after having to pay for escalated energy bills. On the other hand, an oil price shock also affects a firm's decision regarding substitution of oil as an input to production, with capital and labour hiring. In addition, substitution of oil with capital in the production process might influence decisions on capital accumulation which may eventually lead to long run consequences. Furthermore, the dependency of many developing countries on imported oil-derived fuels in the generation of electricity makes these economies vulnerable to adverse macroeconomic effects in the face of oil price shocks.

The relationship between oil price shocks and macroeconomic variables has received considerable attention in the literature (Among others, Brown and Yücel, 2002, Hamilton, 2005 and De Miguel et al., 2005) and can broadly be classified into two categories. On one hand, the oil price shocks of the 1970s and 1980s generated extensive empirical studies which were aimed at investigating the relationship between oil price change and macroeconomic variables (Hamilton, 1983, 2003 and 2009, Mork, 1989, Killian, 2009, Gisser and Goodwin, 1986,

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Hooker, 1996, Abeysinghe, 2001, Bacon, 2005, Blanchard and Gali, 2007, Lescaroux and Mignon, 2008, Du et al., 2010, Ftiti et al., 2014, and Cuando et al., 2015). On the other hand, theoretical studies have investigated different channels through which energy or oil prices might affect macroeconomic outcomes (Kim and Loungani, 1992, Rotemberg and Woodford, 1996, Finn, 2000, De Miguel et al., 2003 and 2005, Dhawan and Jeske, 2007, Tan, 2012). In general, macroeconomists have identified changes in the price of energy and oil not only as an important source of economic fluctuations but also as a paradigm of a global shock which is likely to affect many economies simultaneously (Blanchard and Gali, 2007).

However, one common feature in most of the previous studies is the tendency to focus on developed economies such as U.S.A or European countries. Therefore, how oil price shocks impact on a mixed economy as in many developing countries has been neglected. In most of the developing countries, governments still control and keep energy prices below the full economic cost of supply. Given the cost of subsidies, government price controlling mechanism can only be justified if the overall welfare is increased. Furthermore, subsidies might be offered to protect the country from the oil price volatility if the country is exposed to oil price shocks. Thus it is essential for developing countries to carefully assess their own policy objectives, economic and market conditions before implementing any subsidy reform. Moreover, macroeconomic analysis is also required to examine the economic justification of keeping subsidies which promote development and welfare while phasing out the inefficient ones.

Hence, this paper develops a Dynamic Stochastic General Equilibrium (DSGE) model with a detailed disaggregation of the electricity sector for a mixed economy where government still controls some electricity prices when it enters both production and consumption functions and the economy burns oil to generate electricity. This specific framework of the model allows us to examine electricity price and subsidy reform adjustments as a move towards electricity price liberalisation. In addition to considering the disaggregation of energy sector, this paper asks the question of how the oil price shocks would affect the macroeconomy of a small, oil importing developing country like Bangladesh and whether oil price shocks are more effective under government price controlling mechanism or market price scenario where governments abolish all the price controls.

The link between oil and economy in Bangladesh is strong and any disruption in oil supplies is bound to have a negative impact on the economy. Hence, we simulate our model for Bangladesh to analyse the impulse response functions to oil price shocks pertinent in the economy. Our results show that higher oil price have a negative effect on the household welfare through reduction in all types of consumption and economic output. However, Bangladesh economy is found to be less vulnerable to oil price shocks if the government abolishes energy price controls through liberalisation of the energy sector and moves towards a free market economy.

The paper is organised as follows. The DSGE model is presented in section 2 which is followed by a discussion on calibration of the parameters in section 3. Section 4 reflects the analysis of the obtained results. Finally, conclusions and policy implications are presented in the last section.

2. The Model

The model considered in this paper is a DSGE model of a small economy that needs to import oil in order to generate electricity[4]. Electricity is also generated by locally produced natural gas. There are four sectors in the economy- the production sector, the household sector, the energy sector and the government sector. The economy is open and small in the sense that its behaviour does not affect the rest of the world. Considering the oil price as exogenous is the most sensible

[4] Compared with econometric models, DSGE models emphasise structural analysis based on economic theory rather than statistics, so they can provide a more theoretical framework for identifying both the diverse sources of oil price shocks and the diverse transmission paths of oil prices to economic aggregates.

hypothesis in this context. Shocks in the price of oil and technology across the sectors are main sources of fluctuation in the economy. The basic structure of the model in terms of technology is similar in its set up to Kim and Loungani (1992). Energy enters in the model as electricity consumption for households and as a productive input for firms in the form of oil and natural gas. We assume a Constant Elasticity of Substitution (CES) function to describe our utility and production functions because the CES function provides flexibility to choose the value of elasticity over unitary (Chung, 1994).

2.1 The Production Sector

There are three production sectors in the model: a service sector and an industrial sector where final goods are being produced using energy as an additional productive input which is produced in the third sector, the energy sector. Final output in each sector is produced with a CES technology, exhibiting Decreasing Returns to Scale (DRS) in the inputs; labour, capital and electricity in the industry and service sector. Since the firms face fixed prices controlled by the government, DRS is more rational in this framework. Some other studies also assume DRS in their production function (Rotemberg and Woodford, 1996; Jaaskela and Nimral, 2011).

The representative firm uses labour (l), capital (k) and electricity (j) to produce the final good of the respective sector. The production technology of the firms is described by a CES function with DRS:

$$F_i(l_{i,t}, k_{i,t}, j_{i,t}) = A_t^i . l_{i,t}^{\alpha_i}[(1-\Psi_i)k_{i,t}^{-\nu^j} + \Psi_i j_{i,t}^{-\nu^j}]^{-\frac{(\vartheta^i)}{\acute{\upsilon}^{jj}}}$$

Where, A_t^i is the stochastic productivity shock, i= respective sectors (Y or X), j= electricity used by respective sectors (g or s). Alpha, α is the labour share, Psi, Ψ represents the importance of electricity with respect to capital, $\acute{\upsilon}^{jj}$ implies the degree of homogeneity in the CES production function and $\frac{1}{1+\upsilon}$ is the elasticity of substitution between capital and electricity which determines the degree of substitutability of capital and electricity. In order to hold the DRS assumption, following two conditions need to be met:

1. v<1-α
2. $\frac{\nu}{\acute{\upsilon}}$<1

Following Kim and Loungani (1992), we specify the production function in industry and service sector as follows:

$$Y=A_t^Y l_{Y,t}^{\alpha_Y}[(1-\Psi_Y)k_{Y,t}^{-\nu^g}+\Psi_Y g_t^{-\nu^g}]^{-\frac{\vartheta^Y}{\acute{\upsilon}^{gg}}} \quad \text{[Industrial Sector]}$$

$$X=l_{X,t}^{\alpha_X}[(1-\Psi_X)k_{X,t}^{-\nu^s}+\Psi_X s_t^{-\nu^s}]^{-\frac{\vartheta^X}{\acute{\upsilon}^{ss}}} \quad \text{[Service Sector]}$$

All the firms except for the Government operate under perfect competition and maximises profits as following:

$$\text{Max}\ \pi_{i,t}=P^i.A_t^i.l_{i,t}^{\alpha_i}[(1-\Psi_i)k_{i,t}^{-\nu^j}+\Psi_i j_{i,t}^{-\nu^j}]^{-\frac{(\vartheta^i)}{\acute{\upsilon}^{jj}}}-rk_i-wl_i-v^j.j$$

Where w is the wage rate, r is the capital interest rate and v is the market price of electricity. Wage and interest rate are assumed to be equalised across all the sectors. The price of the final good is normalised to 1, thus v^j can be considered as the relative electricity price.

On the other hand, government faces the following cost minimisation function:

$$c_G=wl_G+rk_G+v^m.m_{G,t}-P^G.A_t^G l_t^{\alpha_G}[(1-\Psi_G)k_{G,t}^{-\nu^{m,G}}+\Psi_G m_{G,t}^{-\nu^{m,G}}]^{-\frac{\vartheta^G}{\nu^{m,GG}}}$$

2.2 The Energy Sector

Three different electricity generating firms have been considered in this model for the case of Bangladesh. The three electricity generating companies are i) Bangladesh Power Development Board (BPDB) which represents the government sector and mainly uses natural gas to produce electricity, ii) Independent Power Producer (IPP) which represents private sector and uses natural gas in electricity production and finally, iii) Quick Rentals (QR) which represents private sector and uses oil to produce electricity.

Similar to the production function used by Kim and Loungani (1992), we employ a CES production function for different electricity generating firms in this model. Each electricity generating firm transforms the three factor inputs-labour, capital and energy (gas, m or oil, h) into electricity according to the following specification:

BPDB: G=$A_t^G l_t^{\alpha_G}[(1-\Psi_G)k_{G,t}^{-v^{m,G}} + \Psi_G m_{G,t}^{-v^{m,G}}]^{-\frac{\vartheta^G}{v^{m,GG}}}$

IPP: I=$A_t^I l_{I,t}^{\alpha_I}[(1-\Psi_I)k_{I,t}^{-v^{m,I}} + \Psi_I m_{I,t}^{-v^{m,I}}]^{-\frac{\vartheta^I}{v^{m,II}}}$

QR: H= $A_t^H l_{H,t}^{\alpha_H}[(1-\Psi_H)k_{H,t}^{-v^h} + \Psi_H h_t^{-v^h}]^{-\frac{\vartheta^H}{v^{mh,h}}}$

The parameter v^i (i=m, h) depends on the elasticity of substitution between capital and energy. Labour's distributive share is given by the parameter α_i(i=G, I, H) and Ψ_i(i=G, I, H) is the share of energy in production aggregation where $\Psi \in$ (0, 1). A certain amount of electricity (x) is lost while transmitting by the distribution companies to the end consumers. So, equilibrium in electricity market:

$e + s + g = H + I + G - x(H + I + G)$

2.3 The Household

The household gets utility from consuming three types of consumption goods: electricity oriented goods (e), non-electricity oriented goods (c) and service goods (x) and all three types of goods are imperfect substitutes in the consumption basket. Electricity oriented goods, e, can be considered as the consumption of electricity which enhances other consumptions in a non-perfect substitutable manner. Another way of thinking behind the rationality of introducing electricity oriented goods is to assume implicitly the presence of durable goods as household requires electricity to operate many durable goods. The household uses the following aggregator function to combine these three types of consumption into Consumption Aggregator:

$$c_t^A = X_t^{\gamma}\left(\theta c_t^{\rho} + (1-\theta)e_t^{\rho}\right)^{\frac{1-\gamma}{\rho}}$$

Where $\theta \in (0,\ 1)$ and $\rho \leq 1$. With this aggregation function, the elasticity of substitution between c and e is $\frac{1}{1-\rho}$ and θ is the share of non-electricity oriented consumption in the household aggregator. The elasticity of substitution between services and the composite of electricity and non-electricity consumption is 1 in our model. The parameter γ represents the share of service consumption in the consumption aggregator. This is similar to the aggregator function used by Dhawan and Jeske (2007), who include consumption of nondurables and services excluding energy, the flow of services from the stock of durable goods and energy goods. So, we write the period t utility function as follows:

$$U\left(c_t^A, l_t\right) = \varphi \log c_t^A + (1-\varphi)\log(1-l_t)$$

Where $\varphi \in (0,\ 1)$. This log-utility specification is the same as in Kim and Loungani (1992). Notice that household's endowment of time is normalised to 1 so that leisure is equal to 1-l.

The momentary utility function is assumed to have the usual properties of monotonicity and quasi concavity. The household has four primary sources of income: 1) Capital income derived from selling capital stock, 2) Labour income, 3) The lump sum transfer payment ъ, it receives from the government and 4) Dividends. Capital and labour income are taxed at the rates τ^k *and* τ^l respectively. The price of service goods and electricity are n and q^e respectively.

So, the household resource constraint is defined as follows:

$$k_{t+1} + c_t + n.X_t + q_t^e.e_t = (1-\tau^l)wl_t + ъ + (1-\tau^k)rk_t + (1-\delta)k_t + \pi$$

Where δ is the depreciation rate.

Thus, the representative household maximises expected utility subject to the following resource constraint:

$$\text{Max } E \sum_{t=0}^{\infty} \beta^t \varphi \log\left[X_t^{\gamma}\left(\theta c_t^{\rho} + (1-\theta) e_t^{\rho}\right)^{\frac{1-\gamma}{\rho}}\right] + (1-\varphi)\log(1-l_t)$$

Subject to

$$k_{t+1} + c_t + nX_t + q_t^e . e_t = \left(1-\tau^l\right) w l_t + ъ + \left(1-\tau^k\right) r k_t + (1-\delta) k_t$$

Where β is the discount factor.

The Lagrangian constrained for the household can be defined as follows:

$$L = \sum_{t=0}^{\infty} \beta^t [(\varphi \log\left[X_t^{\gamma}\left(\theta c_t^{\rho} + (1-\theta) e_t^{\rho}\right)^{\frac{1-\gamma}{\rho}}\right]) + (1-\varphi)\log(1-l_t)] - \lambda_t [k_{t+1} + c_t + nX_t + q_t^e . e_t - \left(1-\tau^l\right) w l_t - ъ - \left(1-\tau^k\right) r k_t - (1-\delta) k_t]$$

Where λ_t is the Lagrange multiplier and the function is maximised with respect to c_t, k_{t+1}, e_t, l_t, X_t and λ_t.

2.4 The Government

The government earns revenue from taxing labour income, capital income, selling natural gas to other electricity generating firms and selling electricity to the national grid. On the expenditure sides, the government purchases labour, capital and gas for its own electricity production and makes a lump sum transfer to households. Government provides subsidy to the electricity producer to fill the gap between the world oil price (v^e) and domestic oil price(v^h) faced by the producer. Additionally, there is also an extraction cost of natural gas (δ^C) which is the actual cost of true gas price to control the use of free resource. The government, like any other entity in the economy, must satisfy a budget constraint.

$$\tau^l . w . l + \tau^k . r . k + (v^m - \delta^C)(m^I + m^G) + (v^h - v^e) h + P^G . G - r k_G - w l_G - v^m . m^G - ъ = b$$

In this paper, we assume that government has to provide subsidy as it purchases electricity from the electricity producers at a high price and distributes it at a low price among the consumers. So, the negative of total subsidy is:

$$-b = q^{e}.e + q^{s}.s + q^{g}.g - P^{H}.H - P^{I}.I - P^{G}.G$$

Finally, combining household resource constraint, government resource constraint and the subsidy equation, the economy wide resource constraint can also be derived.

$$k_{t+1} = Y - c_t - v^{e}.h + (1-\delta)k_t - \delta^{C}(m^{I} + m^{G})$$

2.5 Model Shocks

The basic model is driven by five different shocks: oil price shocks and productivity shocks affect the industrial and electricity output in three electricity generating firms.

Just as Cooley and Prescott (1995), the stochastic productivity shock A^{i} across sectors is assumed to be:

$$\ln A_t^{Y} = \Omega^{Y} + \mu^{Y} \ln A_{t-1}^{Y} + \eta_t^{y} \quad \text{(Technology shocks in industrial sector)}$$

$$\ln A_t^{G} = \Omega^{G} + \mu^{G} \ln A_{t-1}^{G} + \eta_t^{G} \quad \text{(Technology shocks in BPDB)}$$

$$\ln A_t^{I} = \Omega^{I} + \mu^{I} \ln A_{t-1}^{I} + \eta_t^{I} \quad \text{(Technology shocks in IPP)}$$

$$\ln A_t^{H} = \Omega^{H} + \mu^{H} \ln A_{t-1}^{G} + \eta_t^{H} \quad \text{(Technology shocks in QR)}$$

In all the cases, the residuals are normally distributed with standard deviation of one and zero mean. The world price of oil imported in the economy, v^{e}, is exogenously given and follows AR (1) process:

$\ln v_t^{e} = \Omega^{v} + \omega \ln v_{t-1}^{e} + \kappa_t$; Where κ_t is normally distributed with standard deviation one and zero mean.

3. Dataset, Parameter Specification and Calibration

In order to obtain a numerical solution, model calibration is necessary. Hence, the model is calibrated following Kydland and Prescott (1982). The model is implemented numerically using detailed data and parameter sets. The dataset is reported in **Table 1 (Page 26)** and reflects the variable values for 2011-2012. Parameter values are specified in different ways. Wherever possible, parameter values are taken from the available data sources. In some cases, the parameters are chosen freely from the literature and thus are not implied by the steady state restrictions. Although free, these parameters have to be carefully chosen since their values could affect the values of the remaining calibration parameters. The remaining parameters are obtained by calibration using the first order equations and different variable ratios in a way that the real picture of the economy is extrapolated as the steady state trajectory. There are 58 parameters in total with 32 structural parameters, 15 shock related parameters and 11 policy related parameters in our model. Structural parameters can be categorised into utility and production function related parameters. It is important to have a good understanding of rationale behind picking different parameter values in order to properly evaluate the fit of the model.

First of all, we discuss parameters related to production. Alpha (α), Psi (ψ), nu (ν) and depreciation rate (δ) are the main parameters related to production. Since the model has two different sectors namely industry and service sector and three different electricity generating firms, we need to calculate different alpha for each sector. Following Roberts and Fagernas (2004) we set the labour distributive share of industrial sector, α_Y equals to 0.2 using the following first order condition: $w = \alpha_Y . \frac{Y}{l_{Y,t}}$. The labour distributive share in the service sector, α_X can be calculated using the first order conditions; considering share of labour in service sector from data and calculating the ratios of $\frac{wl}{Y}$ and $\frac{nX}{Y}$ as follows:

$\frac{\omega_1^X}{\omega l} = \frac{nX}{Y} . \alpha_X . \frac{1}{\frac{\omega 1}{y}}$

Given $\frac{\omega_1^X}{\omega l} = 0.7194$; $\frac{nX}{Y} = 1.6588$ and $\frac{\omega 1}{y} = 0.7228$, we can estimate α_X equals to 0.3135.

Given the value of total labour cost (wl_i) and total revenue in the IPP and QR, the labour distributive share of different electricity generating sector can be calculated as follows:

$\alpha_I = \frac{wl_{I,t}}{p^I I} = 0.0361$

$\alpha_H = \frac{wl_{H,t}}{p^H H} = 0.0041$

We estimate ν^h, $\nu^{m.i}$, $\nu^{m,g}$, ν^Y and ν^X equals to 0.1 from Thompson and Taylor (1995). Here, ν^i= (1-1/η) where η is the elasticity of substitution between capital and electricity in the production function. Additionally, we also assume that $\acute{\upsilon}^{hh}$, $\acute{\upsilon}^{m.i}i$, $\acute{\upsilon}^{m,gg}$, $\acute{\upsilon}^{YY}$ and $\acute{\upsilon}^{XX}$ equals to 0.2 to fulfill DRS assumptions .$\acute{\upsilon}^{jj}$ implies the degree of homogeneity in the CES production function. Thus if $\acute{\upsilon}^{jj}<1$, we have DRS.

Calculation of Psi (ψ) involves two different approaches for production sectors and the energy (electricity) sectors. The main variance of the approaches is due to differences in data in the calculation process. For example, the share of electricity used in industrial production, Ψ_Y, can be calculated by employing the first order conditions and DRS assumptions.

Given the value of $\frac{wl^Y}{Y}$ and $\frac{q^g.g}{Y}$, we can estimate $\frac{rk^Y}{Y}$. Now, from the first order conditions, we obtain:

$$\frac{rk^Y}{Y} = \frac{(v^Y \frac{v^g}{\acute{\upsilon}^{gg}})(1-\Psi_Y)}{(1-\Psi_Y) + \Psi_Y (\frac{k_{y,t}}{g_t})^{v^g}} \text{ where, } \frac{k_{y,t}}{g_t} = \frac{q^g}{r} . \frac{rk^Y}{Y} . \frac{Y}{q^g.g}$$

Now, given the value of q^g, r, $\frac{rk^Y}{Y}$, $\frac{Y}{q^g.g}$, α_Y, ν^g and $\acute{\upsilon}^{gg}$, we can calculate the value of Ψ_Y equals to 0.0733. In the similar fashion we can also find $\Psi_X = 0.0790$.

Then, let us move on to the calculation of energy used in the electricity generating sector which consists of three different energy generating firms. Here, we require the value of total revenue, total labour cost and total cost of sales to estimate $\Psi_{I,}$ Ψ_H and $\Psi_{G.}$ Using the first order condition and holding DRS assumptions, we obtain:

$$\frac{r\,K^I}{P^I.I} = \frac{(v^I \frac{v^{m,I}}{\acute{\upsilon}^{m,II}})(1-\Psi_I)}{(1-\Psi_I) + (\frac{K_I}{m_I})^{v^{m,I}}} \quad \text{where}$$

$$\frac{K_I}{m_I} = \frac{r\,K^I/P^I.I}{P^I.I/v^m.m} \cdot \frac{v^m}{r};$$

Given the value of $\frac{rK^I}{P^I.I}$, $\frac{P^I.I}{v^m.m}$, v^m, r, α_I, and $v^{m,I}$, $\acute{\upsilon}^{m,II}$ we can calculate Ψ_I equals to 0.3093. Similarly we can also find $\Psi_H = 0.5964$.

Finally, given the value of different ratios and using the following two first order conditions, we can estimate Ψ_G equals to 0.3020 and α_G equals to 0.0420.

$$v^m.\alpha_G[(1-\Psi_G)k_{G,t}^{-v^m} + \Psi_G.m_{G,t}^{-v^m}] = (\vartheta^G \frac{v^{m,G}}{\acute{\upsilon}^{m,GG}}).\Psi_G.m_{G,t}^{-v^m-1}.l_G.w$$

$$r.\Psi_G..m_{G,t}^{-v^m-1} = (1-\Psi_G)k_{G,t}^{-v^m-1}.v^m$$

Depreciation rate is usually very low in the developing countries. So, depreciation rate delta (δ) has been set at 0.025 implying that the overall depreciation rate in Bangladesh is 2.5% annually. This value is equally realistic from the perspective of the developing countries since Prescott (1986) and Kydland and Prescott (1991) also measure the value of δ to be 0.025.

Now, we discuss parameters related to household utility. Given the parameter values, variables ratios and using the Euler equations, we can obtain the share of non-electricity consumption in household aggregator, θ=0.9110; the share of service aggregator, γ=0.8110; the share of electricity consumption and non-electricity consumption goods in the household's utility function, φ=0.6076.

Certain standard parameters are calibrated following standard literature. To begin with, since the length of a period in the model is taken to be one year, β, the discount factor, is set to 0.96 which is quite standard in DSGE literature (Heer and Mausser, 2009). The capital and labour income tax rates τ^k and τ^l are set as 0.15 and 0.10 as mentioned in Bangladesh Tax Hand Book 2012. Next, the household consumer price of electricity, q^e; the industry consumer price of electricity, q^g and the service consumer price of electricity, q^s are taken as 4.93 Taka/Kwh, 6.95 Taka/Kwh and 9.00 Taka/Kwh respectively from BPDB for the year 2012. The selling prices of electricity by QR (P^H), and IPP (P^I) are set as 7.79 Taka/Kwh and 3.20 Taka/Kwh respectively, obtained from Dutch Bangla Power and Associates and Summit Power Limited Company. However, the selling price of electricity by BPDB (P^G) is calibrated using the country data which equals to the value of 2.3075.

Finally, the world market price of oil (v^e) and domestic market price of oil (v^h) are taken as 8.19 Taka/Kwh and 5.72 Taka/Kwh respectively from Bangladesh Petroleum Corporation (BPC) which is also consistent with the data obtained from the Dutch Bangla Power and Associates. The market price of natural gas (v^m) is considered as 0.7755 Taka/Kwh which is taken from Summit Power Limited Company. The extraction cost of gas (δ^C) is set equal to the world gas price which is 1.1 Taka/Kwh.

Due to unavailability of the data of working hours, we set l=0.33 with an assumption that people work about one-third of their time endowment which is a widely accepted value for RBC/DSGE analysis. In this paper, the household's utility function follows a general CES form, meaning that it cannot be used to model an elasticity of substitution of exactly 1. Following Tan (2012) here, it is set at 0.9 for the main analyses, and the CES parameter of the household's utility function, ρ, is therefore -0.11(1-(1/0.90)), which is negative and indicates that electricity and non-electricity consumption are somewhat complementary.

Owing to the unavailability of data, following King, Plosser and Rebelo (1988), we set the persistence of our two exogenous shocks equals to 0.95 and standard deviation of the shocks equal to 0.01. Using different series, empirical literature get a range of estimates for persistence 0.85-0.95 and standard deviation 0.0095-0.01. We assume that technology and oil price shocks follow a mean zero AR (1) process in its natural log, with an i.i.d. disturbance. This is standard in DSGE literature.

4. Results and Discussions

In this section, we first analyse the impacts of the oil price shocks on the model variables through the impulse response functions when the government controls prices[5]. The impulse responses show deviations of key model variables from their steady state upon the positive exogenous shocks of one standard deviation. We run the program Dynare version 4.4.3, which is a pre-processor and a collection of Matlab routines to solve and simulate the model and to approximate the dynamics of our model economy (See Schimitt-Grohe and Uribe, 2004, for the methodological details). These routines linearise the system around its deterministic steady state and perform a second order Taylor approximation.

Firstly, we describe the dynamic mechanism in which oil price shock is propagated. The shock is equal in size to the standard deviation of the actual price. **Figure 1** plots the impulse responses to an oil price shock. A rise in world oil price (v_e) implies higher import price which makes the country worse off with respect to Terms of Trade (TOT). So, higher oil price makes consumption

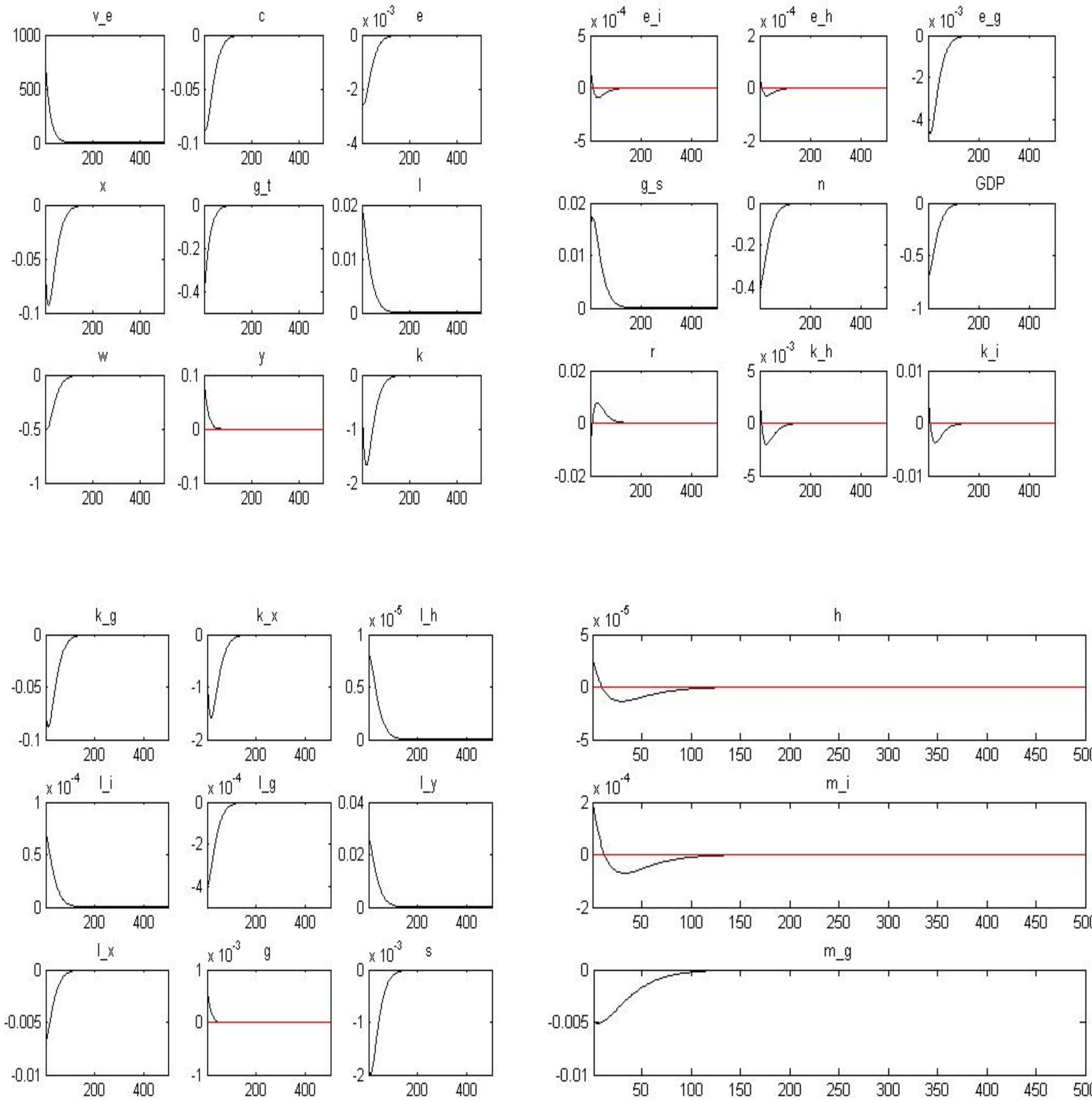
[5] Although we have considered productivity shocks in our model, we do not report the Impulse Response Functions (IRF) from the productivity shocks since our main focus is to analyse the impact of the oil price shocks on economy. IRF from productivity shocks in different model variables shows the standard results out of a productivity shocks. For example, positive technological shock makes the factors of production more productive and accordingly output, household welfare increases due to income effect.

more expensive and thus reduces consumption (c), electricity consumption (e) and service consumption (X) through income effect. Since taxes and other prices are fixed, higher world oil price makes the government worse off and reduces government transfer (g_t). Lower government transfer (g_t) increases labour supply (l) through income effect which in turn lowers the household wages (w). Industrial production (y) increases because oil imports are now more expensive and industrial sector needs to produce more exportable goods to keep the trade balance unchanged. For every level oil import, the country needs to produce more goods for export. Higher oil price also acts as a negative technological shock which causes aggregate capital (k) to reduce initially to prevent household consumption to fall by a large extent. Lower wages coupled with fixed domestic prices allow the private electricity generating firms to produce at a cheaper cost. As a result, more resources are devoted towards IPP (e_i) and QR (e_h) sectors through factor markets which expands both IPP (e_i) and QR (e_h) electricity production. Since QR power plants are facing domestic oil price (v_h) which is fixed and controlled by government, QR sector is not affected by the negative consequences of higher oil prices. The cost of energy becomes high and the other prices are not adjusted. Thereby, government intervention is required and accordingly, government subsidy increases (g_s). Additionally, private sectors tend to expand with wrong prices as the government ends up paying for the differences. Since the industrial sector expands, higher currency inflows make the other sectors, especially the service sector, less competitive and the relative price between the industry and the service sector also declines (n). Apparently, this can be referred to the “Dutch Disease” in the economy as the service sector becomes less competitive.[6] Finally, government electricity supply (e_g) needs to

[6] **Dutch disease** is the negative impact on an economy of anything that gives rise to a sharp inflow of foreign currency, such as the discovery of large oil reserves. The currency inflows lead to currency appreciation, making the country's other products less price competitive on the export market.

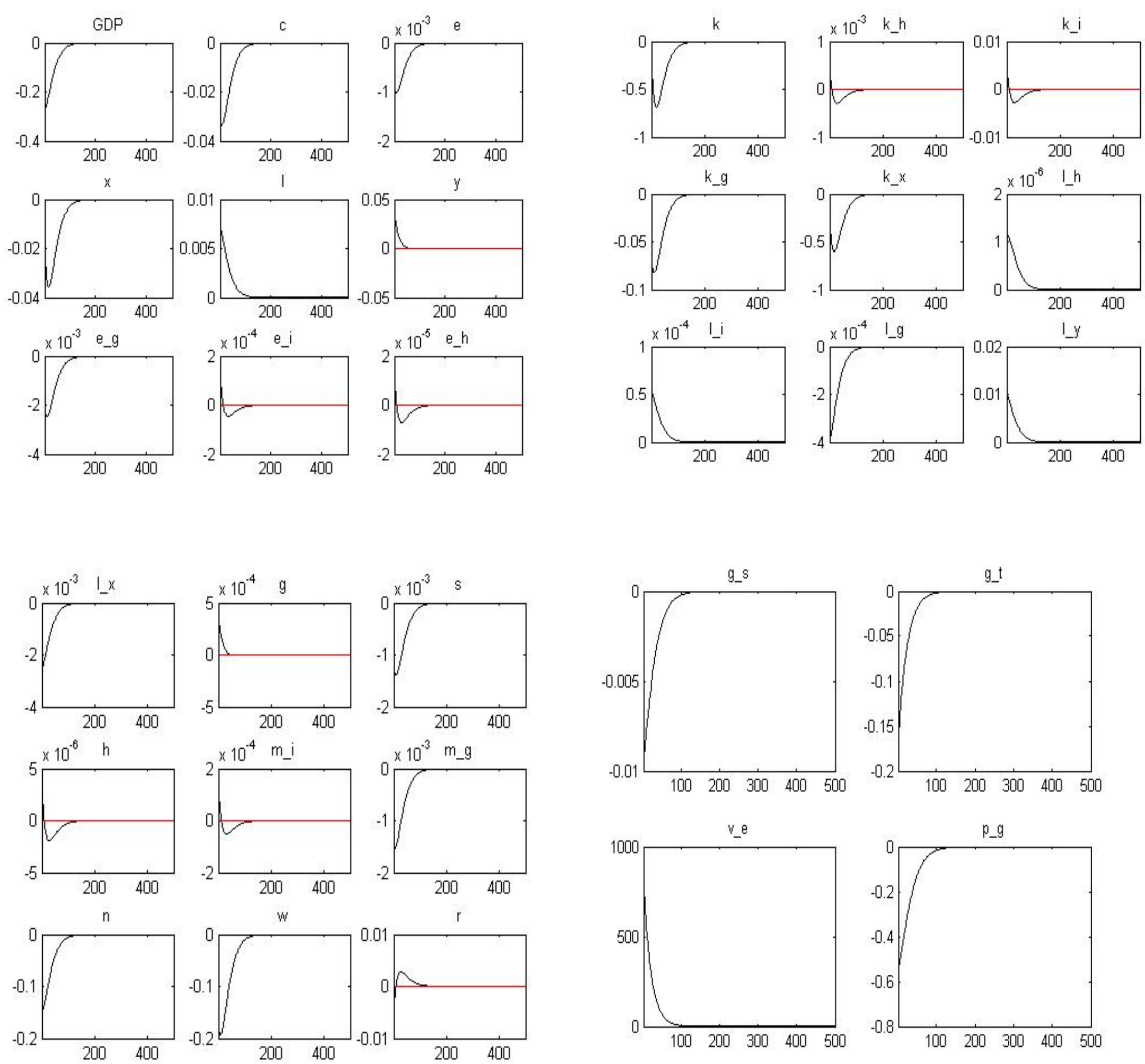
be reduced to equate total supply and demand of electricity since electricity prices are fixed. Higher oil price in the world market also reduces GDP.

Figure 1: Impulse Responses to an Oil Price shocks



Now, we examine whether the flexible price regime (when government abolish all price control and allow market to adjust prices) is better than the fixed price regime to protect the economy from adverse effects of oil price shocks. To do so, we consider a weighted average of electricity price for all the electricity consumers and producers. We also propose there is no difference in world and domestic energy (gas and oil) prices.

Figure 2: Impulse Responses to an Oil Price Shock in Flexible Price Regime



The behaviour of impulse response functions for the endogenous variables under two different scenarios (Government price control regime and flexible price regime) are very similar to their response to an oil price shock. The only difference is their smaller magnitude of effect which is clearly evident from the diagram. The magnitude is smaller under the flexible price regime which implies that if the government abolishes price controls, the country is prone to experience less deviations from the steady state situation.

We then analyse the percentage changes across steady state for the different variables and also calculate the household welfare under the two scenarios. The welfare gain/loss of different policies can be estimated comparing two different states of the economy: an economy where government controls price and where government abolish price controls. If c_1, e_1, X_1 and l_1 are the steady state values with controlled prices, one can estimate the value of the utility, U_1 for the first economy using the following equation:

$$U_1 = X_1^{\gamma}\left(\theta c_1^{\rho} + (1-\theta)e_1^{\rho}\right)^{\frac{1-\gamma}{\rho}}]^{\varphi}[1-l_1]^{1-\varphi}$$

Similarly, U_2, the level of utility, can be obtained with a new set of steady state values (c_2, e_2, X_2 and l_2) from the flexible prices. Then the utility changes under two different states of economy can be observed. However, this value is not meaningful as utility is an ordinal measure.

The actual gain in welfare can be calculated considering the percentage change of consumption which is required to reach the new level of utility, U_2, according to the following equation:

$$\hat{c}^{\rho}=(c_2^{\rho}+\frac{1-\theta}{\theta}e_2^{\rho})(\frac{X_2}{X_1})^{\gamma\frac{\rho}{1-\gamma}}\ (\frac{1-l_2}{1-l_1})^{\frac{1-\varphi}{\varphi}\cdot\frac{\rho}{1-\gamma}} - \frac{1-\theta}{\theta}e_1^{\rho}$$

The results are listed in Table 2. Price liberalisation leads to an increase of overall household consumption as the relative price of electricity faced by the household has declined. Industry enjoys lower input price since electricity prices go down under this experiment which expands the industrial production by 2.85%. There is a reallocation of the usage of fuel needed to generate electricity because of the changes of the relative prices faced by the producer. The overall electricity supply is also increased by 43.44% in this experiment. Government has no control over prices in this scenario and increase the electricity generation to match the overall electricity supply. Since all the price distortion has been removed, this is a welfare enhancing policy as observed in the results. There is a 20.87% increase in household welfare in this policy experiment. GDP has also increased by 2.15% here.

Table 2: Percentage Change in Steady State Values in Flexible Price Regime

Variables	Percentage Change in Steady State Values as a result of Flexible Prices
GDP	2.15%
Consumption	2.49%
Industrial Output	2.85%
Total Electricity Supply	43.44%
Government Transfer	-5.97%
Implicit Subsidy	-101.18%
Use of Oil	-60.66%
Total use of Natural Gas	9.47%

5. Conclusion and Policy Suggestions

Energy subsidies are very crucial for many developing countries as they are very costly. Since government controls energy prices, cost reflective electricity tariffs are also absent in many developing countries. Anand et al., (2012) conduct a research using world data to find the increasing fuel subsidies in a number of countries and confirm that the best solution is liberalising the market. In addition, they propose in favour of changing the price setting system from fixed prices to one with the provision of regular adjustments. Electricity price reform is considered as the foundation of long anticipated changes that are aimed at liberalising the electricity sector (Jamasb, 2006). Price controls and subsequent energy subsidies can only be justified if it can increase the overall welfare of the country or help to mitigate any external shocks like oil price shocks. Otherwise the policy of controlling prices might stunt the potential of the country's economics.

Therefore, this paper develops an energy augmented DSGE model for a mixed economy, with detailed disaggregation of the energy sector (where the government controls energy prices) in an effort to examine the macroeconomic impacts of oil price shocks and whether such shocks are more effective under government price controlling mechanism or flexible price scenario with no government intervention.

At first we simulate our model under government price controlling mechanisms and the simulation results highlight several important dimensions to the relationship between oil prices and economic performances in Bangladesh. For example, oil price shocks have a negative welfare effect on the economy through reducing overall consumption and GDP. Relative factor prices also play a substantial role in shaping the energy sector as more resources are devoted towards the IPP sector through factor markets which expands private electricity production. Moreover, higher oil price acts as a negative technological shock which causes aggregate capital to reduce initially in order to prevent household consumptions to fall by a large extent. Industrial production also increases because oil imports are now more expensive and industrial sector needs to produce more exportable goods to keep the trade balance unchanged. We then simulate our model for a scenario where there is no government control on electricity prices. This simulation reveals that Bangladesh economy performs better in free market economy as discussed in the previous section. Our results also portray that electricity reform policies (restructuring of prices and subsidy arrangements) increase household welfare and GDP in Bangladesh mainly by reducing the dependency on oil, increasing household consumption and electricity generation. Therefore, price controlling is not justified for the Bangladesh economy.

Given our results, it is worthwhile that the government could use the revenue earned from the subsidy removal and offer monetary and non-monetary incentives to the electricity producers for the use of renewable inputs or the introduction of renewable technology. For example, incentives could include tax rebates, long term subsidised loans for purchasing equipment, access to foreign exchange at preferred rates, Research and Development (R&D) etc. This would reduce the dependency on natural gas in electricity generation. Moreover, policymakers could carefully assess the overall welfare effect of oil price shocks and when appropriate, take some measures to redistribute welfare from the industrial sector to the household sector. Since household heterogeneity is a crucial element in the determination of how the energy market reform and energy (oil) price shocks affects the household's behaviour and welfare, the model developed in this paper can be extended with heterogeneous households in their income to examine the distributional effects of government intervention. In general terms, it refers to identifying more precisely, those households which are mainly benefitted from the welfare retribution with their overall impact for accurate welfare comparisons and ensuring equity. This field however, is left for future research.

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Appendix

Table 1: The Dynamic Stochastic General Equilibrium Model-The Basic Data Set

c, Consumption by Household	As % of GDP	0.806
$q^e.e$, Electricity consumption by household	Sectoral Share of GDP (%)	1.45
Y, Industry, value added	(% of GDP)	29.81%
GDP	Value	9,147,840,000,000 Taka
$v^h.h$	Value	30,803,363,910 Taka
$v^h.h$/ GDP	Ratio	0.003367282759
c/Y	Ratio	0.337915857
nX, Service, value added	(% of GDP)	49.45%
nX/Y	Ratio	1.658839316
c/nX	Ratio	0.203706202
e/GDP	Ratio	0.002941176471
e/Y	Ratio	0.009866408825
e/c	Ratio	0.029197827
e, Domestic Electricity Consumption	Million Kilowatt Hours(Mkwh)	11627
g, Industrial Electricity Consumption	Million Kilowatt Hours(Mkwh)	6719
s, Service Electricity Consumption	Million Kilowatt Hours(Mkwh)	5612
l^Y, Labour Share of Industry	In %	27.66859345%
l^X, Labour Share of Service	In %	71.9460501%
l^e, Labour Share of Electricity	In %	0.385356454%
q^e, consumer price of electricity faced by residential household	Taka/Kwh	4.93
q^S, consumer price of electricity faced by service sector	Taka/Kwh	9.00
q^Z, consumer price of electricity faced by industry	Taka/Kwh	6.95
p^H, selling price of electricity produced by Quick Rentals	Taka/Kwh	7.79
P^I, selling price of electricity produced by IPP	Taka/Kwh	3.20
v^m, market price of gas	Taka/Kwh	0.7755
v^h, market price of Oil (Domestic)	Taka/Kwh	5.72
v^e, market price of gas(World)	Taka/Kwh	8.19
δ^C, extraction Cost of Gas	Taka/Kwh	1.1

Sources: Annual Reports (2014-2015) of Bangladesh Bureau of Statistics (BBS), Bangladesh Economic Review (BER), Bangladesh Power Development Board (BPDB), Bangladesh Petroleum Corporation (BPC), Summit Power Limited, Dutch Bangla Power and Associates Limited and Bangladesh Tax Handbook