Covid and Energy Sector in DSGE Model

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ABSTRACT

COVID affects various sectors of the economy, including energy. Measuring these effects on the energy sector can help policymakers adopt appropriate protectionist policies. In this paper, the effect of COVID shock on energy and non-energy sectors has been investigated using the DSGE model. For this purpose, two shocks of preferences and shocks of labor supply have been used. This article adds COVID to the model as well as adding energy to the New Keynesian model. The effect of COVID on the energy and non-energy sectors of the two channels of labor supply and consumer preferences has been investigated. The results of the study indicate that consumption, investment, and production in the energy sector have increased under the influence of both shocks. But consumption, investment and production in non-energy sector have declined. Prices and production costs have increased in both sectors. Also, the negative effects of the preferences shock were greater than the negative effects of the labor supply shock.

1. Introduction

The COVID-19 pandemic has unleashed unprecedented shocks across all facets of society, from strained healthcare systems to the closure of schools and economies. The energy sector is of no exception with several connoisseurs already raising concerns about the ramifications that will arise for the clean energy transition and the fight against climate change [Goodrich (2020), Shah (2020), Akrofi and Antwi (2020)]. With travel and transport restricted across several countries in the world, global oil demand has dropped to its lowest since 1995, and lockdown measures have drastically reduced electricity demand. According to the International Energy Agency (IEA), global electricity demand decreased by 2.5% in the first quarter of 2020 with full lockdown measures causing a daily reduction of at least 15% in Italy, Spain, the United Kingdom, France, India, and the United States [Akrofi and Antwi (2020), IEA (2020)].

Governments around the world are taking measures to support the energy sector and to mitigate the adverse effects of the pandemic. These measures vary across countries and their implication is something that will be understood over time. The whole range of consequences of the COVID-19 for the energy sector is still evolving and is difficult to predict. In some countries such as Ghana, the government has decided to absorb the cost of electricity during the lockdown periods while in many other countries, customers have been advised to delay the payment of their utility bills. Some countries have also waived interest rates and placed bans on disconnections,

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restricted regular maintenance activities, and postponed or suspended planned power interruptions to ensure reliable power supply during the pandemic [Akrofi and Antwi (2020), Mylenka (2020)]. But in Iran Energy prices have risen during COVID epidemi. There is also no support program for energy consumers.

Thus far, very few studies exist on effect of COVID-19 on energy industry. Some studies review government action plans to minimize energy consumptions during the pandemic (Qarnain, Muthuvel, and Bathrinath(2020),Akrofi and Antwi (2020)).Some studies identified short term, medium-term and long term energy policy challenges of COVI-19 for policymakers(Steffen, Egli, Pahle, and Schmidt(2020)). Other studies review price, product and consume of energy industry and indicate price and product of energy industry reduce after COVID-19(Figueroa et al. (2020)). This group of studies has not modeled the effect of COVID on the energy sector. On the other hand, there are few studies on energy sector modeling in DSGE that have examined the effect of energy price shock on macro variables. LikeAlege et al (2019), Aminu (2018), Balke and Brown (2018). In Iran, few articles have modeled the energy sector in the DSGE framework. Like Abounoori et al (2014), Farazmand et al (2016). They design a DSGE model to consider the effects of energy price reform on macroeconomic. But these articles have not examined the effect of an epidemic on the energy sector.

This paper seeks to fill this gap by modeling COVID and the energy sector within the DSGE framework. The DSGE model provides a framework that can simultaneously measure the effect of COVID on the energy sector and thus on other sectors. In this paper, using the studies of Balke and Brown (2018), Amin and Marsillani (2015), and Tan Huynh (2017), the energy sector has been modeled in the DSGE framework. Also, like Ireland (2002), Money is included in the utility function. The contribution of this model is:

We use shock of labor distribution to modeling the impact of COVID on the supply labor force for different types of goods.

We use shock of preference for energy and non-energy goods in modeling the impact of the pandemic on demand for different type of goods.

The reminder of this paper is organized as follow: In section 2, we review literature about effect of COVID on energy sector. Structure of the model, has described in section 3. In section 4, we describe methodology and stylized facts and the end, we describe conclusions.

2. Literature Review

In the field of energy, there are two groups of studies, one group of studies, review effect of Covid on energy sector without modeling the effect of COVID on the energy sector (such as Akrofi and Antwi (2020), Figueroa et al (2020), zhong et al (2020), shafiullah et al (2020), Eroglu (2020)). The second group of studies have also modeled the energy sector in the framework of DSGE models but have not seen the effect of any epidemic on the energy sector (such as Alege e al (2019), Aminu (2018), Argentiero et al (2018), Balke and Brown (2018), Tan Hugnh (2017), Amin and marsiliani (2015), Abounoori (2014), Millard (2011)).

Akrofi and Antwi (2020) using an internet search to gather information from government policy statements/briefs, and websites of international organizations such as the IMF, WHO, KPMG, and the World Bank, review how governments in Africa have responded to challenges in the energy sector. Their review revealed that the majority of preliminary responses were short-term and include the provision of free electricity, waiver/suspension of bill payments, and VAT exemptions on electricity bills. These measures were more pronounced in sub-Sahara Africa while oil-rich countries of the North mostly have broad economic measures that target their oil and gas sectors. Economic stimulus packages prepared by most countries do not explicitly mention energy sector companies/ institutions, especially the Renewable Energies (RE) sector. Only three countries (Nigeria, Kenya, and Burkina Faso) had specific interventions for renewables. Overall, interventions were mostly fiscal/financial and short term, with medium to long term measures often broad without being specific to the energy sector. As governments take measures to bolster their economies, they must pay particular attention to the challenges posed by the pandemic in the energy sector and capitalize on the opportunities that it presents to drive the clean energy transition.

Figueroa, et al. (2020) report abroad compilation and assessment of the implications of COVID-19 for electric and natural gas utilities. It reflects an expedited review of many sources of information, with public health, economic, and industry data changing considerably day by day. The goal is to make abroad overview of energy industry implications available in one document, rather than to offer a detailed forecast or opinion. They summarize recent developments in energy commodity spot and forward pricing, electricity demand, and financial markets, and They consider select implications for utilities as and if the pandemic persists in time.

Zhong et al. (2020) provide a comprehensive review of the impacts that the pandemic has caused on the electricity sector. Electricity demand has dropped sharply as governments around the world executed lockdown restrictions, while the load composition and daily load profile have also changed. The share of renewable generation has increased against the decline of the total electricity generation. Changed power balance situation and increased uncertainty of demand have posed higher pressure on system operators, along with voltage violation issue and challenges for system maintenance and management. The electricity market is also substantially influenced, while long term investment in clean energy is expected to be stable.

Shafiullah, et al (2020) investigate the global scenarios of power systems during COVID-19 along with the socio-economic and technical issues faced by the utilities. Then this study further scrutinized the Indian power system as a case study and explored scenarios, issues and challenges currently being faced to manage the consumer load demand, including the actions taken by the utilities/power sector for the smooth operation of the power system. Finally, a set of recommendations are presented that will not only help government/policy makers/utilities around the world to overcome the current crisis but also helps to overcome future unforeseeable pandemic alike scenarios.

Eroglu, (2020) examined the effects of Covid-19 outbreak in terms of the environment and renewable energy sector in the literature. Eroglu presented that Covid-19 outbreak has serious environmental impacts such as increased environmental waste. Covid-19 outbreak provides a reduction in greenhouse gas emissions, but more efforts are needed to prevent air pollution. The capacity increase estimates for 2020 for wind energy are projected to decrease by 4.9 GW and 28% in solar energy due to the outbreak. There are serious dismissals and discontinuities in the energy sector. In order to reduce the negative impact of the outbreak on the renewable energy sector, governments should urgently make the necessary interventions.

Alege et al. (2019) seeks to investigate the consequences of technology, and energy shocks on key macroeconomic variables including output and consumption using an energy augmented small open economy dynamic stochastic general equilibrium model. The model is estimated using Bayesian techniques under different scenarios in order to show the various ramifications of the shocks to the Nigerian economy. The findings show that shocks to the renewable energy sector have more impact of the Nigerian economy compared to shocks to the fossil fuel sector.

Aminu (2018) examine the impact of energy price shock (oil prices shock and gas prices shock) on the economic activities in the United Kingdom using a dynamic stochastic general equilibrium model with a New Keynesian Philips Curve. He decomposed the changes in output caused by all of the stationary structural shocks. He found that the fall in output during the financial crisis period is driven by domestic demand shock, energy prices shock and world demand shock. He found the energy prices shock's contribution to fall in output is temporary. Such that, the UK can borrow against such a temporary fall. This estimated model can create additional input to the policymaker's choice of models.

Argentiero, et al (2018) assess the effectiveness of a comprehensive strategy for renewable energy sources in a dynamic stochastic general equilibrium model estimated for the Euro area using Bayesian estimation techniques, which includes carbon tax and subsidy measures. To this end, they compare the cost-effectiveness of technology-push measures and demand-pull measures. Their findings show that the environmental policy based on technology-push measures may produce better dynamic effects than demand-pull measures based on a subsidy policy of equal monetary amount. In fact, RES price parity is estimated to occur sooner by implementing technology-push measures than demand-pull measures.

Balke and Brown, (2018) develop and use a medium-sized DSGE model of the U.S. economy to evaluate how U.S. real GDP responds to oil price movements that originate from global oil supply shocks. The core of the model is a standard macroeconomic DSGE framework that includes nominal and real frictions. The model includes oil as an input in multiple domestic sectors (consumption, intermediate goods, and transportation services). They include a domestic oil production sector for the United States to reflect the recent development in shale oil technology. The model also captures international trade in goods and oil. The model parameters are set through a combination of calibration and Bayesian estimation using quarterly data for 1991 through 2015. Baseline estimation of the model finds the elasticity of U.S. real GDP with respect to an oil price shock of -0.015, which is among the less elastic estimates in the literature. Using the model to conduct counterfactual analysis, they find that decreasing steady state U.S. oil consumption substantially reduces the response of real GDP to oil prices. Increasing U.S. domestic oil production only modestly reduces the response of real GDP to oil prices.

Argentiero et al (2017) examine the role of energy policy in RES promotion, based on a carbon tax and RES price subsidy, at a time of technological and demand shocks in the European Union (E.U.) 15 countries, the United States (U.S.) and China, focusing on the macroeconomic implications. Using a dynamic stochastic general equilibrium model for RES and fossil fuels, their results suggest that, in the presence of a total factor productivity shock in the fossil fuel sector, such an energy policy can also be a driving force for smoothing the reduction of RES in the energy market (and vice versa). Additionally, they show that the E.U.15 grouping has a comparative advantage in terms of reaching grid parity compared with the other countries we considered which are more fossil fuel dependent.

Tan Huynh, (2017) prescribe the desirable monetary responses to four types of energy price shocks, highlighting the distinct characteristics of each shock. They also found several points of divergence in relation to previous studies on addressing energy supply shocks. In addition, they shed light on the role of sectoral price rigidities in the shocks' propagation.

Farazmand et al (2016) design a dynamic stochastic general equilibrium model to consider the effects of energy price reform on macroeconomic and optimal reaction of central bank in Iran. In this regard, they design a dynamic stochastic general equilibrium model for economy of Iran, so that energy is included in the household bundle as a separate commodity and in the production function as an input. To investigate the role of monetary Authority, first, they used a reaction function for the central bank, so that indicating the discretionary behavior of central bank. Using calibration and solving the model, the effects of energy price shock on macroeconomic variables were investigated. To evaluate the optimal response of the central bank to the energy price shock, optimal monetary rule is obtained using stochastic optimal control. Finally, by substituting the optimal rule rather than the central bank reaction function, the impact of energy price shock is investigated. The results indicate that the central bank can use the optimal monetary policy rule have better responses to energy price shock and reduce the effect of its stagflation.

Amin and Marsiliani (2015) investigate the role of energy price shocks on business cycle fl uctuations in Bangladesh. In doing so, they calibrate a Dynamic Stochastic General Equilibrium (DSGE) model, allowing for both energy consumption by households and as an input in production. They find that qualitatively temporary energy price shocks and technology shocks produce similar impulse response functions, as well as similar (quantitatively) autocorrelations in aggregate quantities. The variance in aggregate quantities is better explained by technology shocks than by energy price shocks, suggesting that technology stocks are more important source of fluctuations in Bangladesh.

Abounoori et al. (2014) introduce a DSGE model to evaluate the effects of an energy price shock on macroeconomic variables in Iran. The results indicate deviation in production, labor supply, and inflation from their steady state due to an energy price shock. The most important deviation from optimal levels relates to an 11% deviance in relation to long term investment growth rates. The results further indicate that the lower the share of energy and the higher the share of labor in the production function, the more quickly investment returns to its steady state rate and the less GDP will deviate from optimal levels. In addition, the more energy revenues are neutralized in the national budget, the less production and government expenditure will deviate from their steady state.

Millard (2011) produces a macroeconomic model that can be used to analyse quantitatively the effects on inflation of many temporary shocks, including but not limited to energy prices as well as how monetary policy can respond to such shocks. The estimates suggest, not surprisingly, that petrol prices are highly flexible, utility prices are quite flexible, while non-energy prices, on the other hand, are very sticky. The relative stickiness of prices in the three sectors are in line with survey and other evidence for the United Kingdom. In terms of the shocks, the estimates suggest that the productivity shock is fairly persistent but the others much less so; the model is able to explain persistence in the data without having to resort to extremely persistent shocks. The estimated standard deviation of monetary policy shocks is very low, not altogether surprising given that the model was estimated over the inflation-targeting period. But, the domestic demand and investment-specific technology stocks are highly volatile over this period. Finally, the estimates suggest that the model including energy prices is better able to explain UK macroeconomic data than an otherwise identical model that does not include energy prices.

3. Structure of the Model

In this article the model is based on New Keynesian models. We Such as Alege et al (2019), Aminu (2018), Balke and Brown (2018),Abounoori et al (2014), Farazmand et al (2016) we modeled energy sector in the DSGE framework. The Martin and Okolo (2020) study were also used to model the COVID in the DSGE framework.

We develop these models taking into account:

We use shock of labor distribution to modeling the impact of COVID on the supply labor force for different types of goods.

We use shock of preference for energy and non-energy goods in modeling the impact of the pandemic on demand for different type of goods.

3.1. Households

Households are based on the New Keynesian model. Such as Dunacan (2002) and Ireland (2002), we assume households collectively drive utility from consumption, labour and Money. We develop the utility function with adding COVID shock.The household utility function is:

$$\sum_{s=0}^{\infty}(\beta^h)^s E_t\left[\frac{(c_t)^{1-\sigma_c}}{1-\sigma_c}-\frac{(N_t)^{1+\sigma_n}}{1+\sigma_n}+\frac{1}{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{1-\vartheta}\right] \quad (1)$$

Where β is the inter-temporal discount factor, c_t is real consumption, N_t is supply of labor in goods sector, M_t is money, σ_c is inverse of elasticity of inter-temporal substitution of consumption, σ_n is inverse of elasticity of inter-temporal substitution of labor and ϑ is elasticity of money.

We such as Medina and Soto (2005) and Farazmand et al (2016) assume, households consume energy and non-energy goods that these goods are substitutable, according CES, consumption function, c_t is:

$$c_t=\left[\sigma_{tcenshare}^{\frac{1}{\theta_{en}}}c_{ten}^{\frac{\theta_{en}-1}{\theta_{en}}}+\left(1-\sigma_{tcenshare}^{\frac{1}{\theta_{en}}}\right)^{\frac{1}{\theta_{en}}}c_{tnonen}^{\frac{\theta_{en}-1}{\theta_{en}}}\right]^{\frac{\theta_{en}}{\theta_{en}-1}} \quad (2)$$

Where c_{ten} is Consume of energy and c_{tnonen} is consume of non-energy. θ_{en} is elasticity of substitution of energy and $\sigma_{tcenshare}$ is share of energy in consumption basket. Such as Martin and Okolo (2020) we add $\sigma_{tenshare}$, preference shock, that:

$$\sigma_{tcenshare}=\sigma_{ecnshare}e_{tcenshare} \quad (3)$$

Where $e_{tcenshare}$ is a shock to the preference for energy and non-energy goods? We use this shock in modeling the impact of the COVID on the demand for types of goods. We model this shock as autoregressive processes:

$$etcenshare=\rho censhareet-1censhare+\varepsilon censhare$$
$$\rho_{censhare}\epsilon(0,1) \quad (4)$$
$$\varepsilon_{censhare}\sim(0,\sigma_{\varepsilon_{censhare}})$$

The implied price index is P_t:

$$P_t=P_t^{en}+P_t^{nonen} \quad (5)$$

Where P_t^{en} is price of index for energy goods and P_t^{nonen} is price of index for non-energy goods.

Demand for energy sector is:

$$c_{ten}=\sigma_{tcenshare}\left(\frac{P_t^{en}}{P_t}\right)^{-\theta_{en}}c_t \quad (6)$$

Demand for Non-energy is:

$$c_{tnonen}=(1-\sigma_{tcenshare})\left(\frac{P_t^{nonen}}{P_t}\right)^{-\theta_{en}}c_t \quad (7)$$

In order to be able to see the effect of COVID on the labor force in the non-energy and energy sector as well as the fossil fuel and renewable, we assume that the labor supply function has the CES. N_t is:

$$N_t=\left[\sigma_{tnenshare}N_{ten}^{\frac{-1-\sigma_{nen}}{\sigma_{ne}}}+(1-\sigma_{tnenshare})N_{tnonen}^{\frac{-1-\sigma_{nen}}{\sigma_{ne}}}\right]^{\frac{\sigma_{ne}}{-1-\sigma_{ne}}} \quad (8)$$

Where N_{ten} is labor force in energy sector and N_{tnonen} is labor force in non-energy sector. σ_{nen} is it elasticity of substitution of labor force in energy and non-energy sector and $\sigma_{tenshare}$ is share of labor force in energy sector that:

$$\sigma_{tenshare} = \sigma_{nenshare} e_{tenshare} \qquad (9)$$

Where $e_{tenshare}$ is a shock of labor distribution to modeling the impact of COVID on the supply labor force for different types of goods? we model this shock as autoregressive processes:

$$e_{tenshare} = \rho_{nenshare} e_{t-1nenshare} + \varepsilon_{nenshare} \qquad (10)$$

$$\rho_{nenshare} \epsilon (0,1) \quad \varepsilon_{nenshare} \sim (0, \sigma_{\varepsilon_{nenshare}})$$

The sectoral capital formation is:

$$k_{t+1}^i = (1 - \delta^i) k_t^i + i_t^i \qquad (11)$$

Where k_t^i is capital inventory in t with (i=en, nonen) and δ^i is capital depreciation.

The representative household maximizes the utility function subject to budget constraint. Budget constraint is:

$$m_t + c_t^{nonen} + c_t^{en} + b_t + i_t^{en} + i_t^{nonen} = w_t^{en} N_t^{en} + w_t^{nonen} N_t^{nonen} + (1 + r_{t-1}^b) \frac{b_{t-1}}{\pi_t} + r_t^k (k_t^{en} + k_t^{nonen}) + \frac{m_{t-1}}{\pi_t} + \frac{\pi_t^f}{\pi_t} \qquad (12)$$

Where b_t is bond and r_{t-1}^b is interest rate of bond. r_t^k is payment to capital. π_t^f is profit of firms.

Let obtain first order conditions with respect to $c_t^{nonen}, c_t^{en}, N_t^{en}, N_t^{nonen}, k_t^{en}, k_t^{nonen}, b_t$.

3.2. Firms

The production sector comprises of three types of firms. There is a final good firm and there are two intermediate goods firms producing non-energy, energy.

a. Final goods firms

Final good producer buys intermediate goods that are shown with j in sector i, and produce final good by using Dxit- Stieglitz (1997).

$$\left[\omega_{nonen} (Y_t^{nonen})^{\frac{\theta-1}{\theta}} + (1 - \omega_{nonen}) (Y_t^{en})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \geq Y_t \qquad (13)$$

$$\theta > 1$$

Where Y_t^{nonen} is intermediate good in non-energy sector, Y_t^{en} *is* intermediate good in energy sector θ is constant elasticity of substitution between intermediate goods. ω_{nonen} is weight of non-energy goods. Final good producer trying to determine their purchases of intermediate goods according to differ prices so determine the maximum profit. Demand function for differentiated product by any intermediate producer can be obtained:

$$Y_{jt}^i = \left(\frac{P_{jt}^i}{P_t}\right)^{-\theta} Y_t \qquad (14)$$

Price for final good is:

$$P_t = \left(\int_0^1 (P_{jt}^i)^{1-\theta} d_j\right)^{\frac{1}{1-\theta}} \qquad (15)$$

b. Intermediate good firms

Producers combine labor N_t^i and capital k_t^i to produce intermediate goods Y_t^i . The Non-energy producing firms combine capital k_t^{nonen}, labor N_t^{nonen} and energy y_t^{en} as an input, subject to productivity shocks.

$$y_t^{nonen} = A_t^{nonen} (N_t^{nonen})^{\alpha_{ynonen}} (k_t^{nonen})^{\beta_{ynonen}} (y_t^{en})^{1-\alpha_{ynonen}-\beta_{ynonen}} \qquad (16)$$

Where $\alpha_{ynonen} \epsilon (0,1)$ is share of labor, $\beta_{ynonen} \epsilon (0,1)$ is share of capital, $1 - \alpha_{ynonen} - \beta_{ynonen} \epsilon (0,1)$ is share of energy. A_t^{nonen} is technology shock.

$$A_t^{nonen} = \rho_{Anonen} A_{t-1}^{nonen} + \varepsilon_{tanon} \qquad (17)$$

$$\rho_{Anonen} \epsilon (0,1)$$

$$\varepsilon_{tanonen} \sim (0, \sigma_{\varepsilon_{tanonen}})$$

The energy producing firms combines capital k_t^{en}, labor N_t^{en} subject to productivity shocks.

$$y_t^{en} = A_t^{en} (N_t^{en})^{1-\alpha_{yen}} (k_t^{en})^{\alpha_{yen}} \qquad (18)$$

Where $\alpha_y \epsilon(0,1)$ is share of capital. A_t^{en} is technology shock in energy.

$$A_t^{en} = \rho_{Aen} A_t^{en} + \varepsilon_{taen}$$
$$\rho_{Ae} \epsilon(0,1)\ \varepsilon_{taen} \sim (0, \sigma_{\varepsilon_{taen}}) \quad (19)$$

Adjustment costs in non-energy is:

$$PAC_t^{nonen} = \frac{\varphi_f}{2}\left(\frac{P_{jt}}{\bar{\pi} P_{jt-1}} - 1\right)^2 Y_t \quad (20)$$

Where $\varphi_f \geq 0$ is adjusted cost parameter. $\bar{\pi}$ is inflation rate in steady state. Because pricing in the energy sector in Iran is set by the government and firms have no role in pricing, Therefore, energy firms do not have adjustment cost. So $PAC_t^{en} = 0$

Marginal cost in non-energy firms is:

$$mc_t^{nonen} = \frac{w_t^{\alpha_{ynonen}} r_t^{k\beta_{ynonen}} P_t^{en\,1-\alpha_{ynonen}-\beta_{ynonen}}}{\alpha_{ynonen}^{\alpha_{ynonen}} \beta_{ynonen}^{\beta_{ynonen}} (1-\alpha_{ynonen}-\beta_{ynonen})^{1-\alpha_{ynonen}-\beta_{ynonen}} A_t^{nonen}} \quad (21)$$

We assume P_t^{en} is:

$$P_t^{en} = (mc_t^{en})^{\omega_{mc}} (P_{t-1}^{en})^{\omega_{pen}} \quad (22)$$

Where mc_t^{en} is Marginal cost energy firms, ω_{mc} weight of mc_t^{en} in P_t^{en} and ω_{mc} is weight of P_{t-1}^{en} in P_t^{en}.

Marginal cost energy firms are:

$$mc_t^{en} = \frac{w_t^{1-\alpha_{yen}} r_t^{k\alpha_{yen}}}{\alpha_{yen}^{\alpha_{yen}} (1-\alpha_{yen})^{1-\alpha_{yen}} A_t^{en}} \quad (23)$$

Firms maximize profit:

$$\pi_t^{fi} = P_t Y_t^i - mc_t^i Y_t^i - PAC_t^i \quad (24)$$

Then obtain first order conditions with respect to, k_t, N_t and P_t.

3.3. Central Bank, Government and Oil Sector

The monetary growth rate is used for monetary policy tools. The behavior of the central bank is considered as discretion to reduce the output gap and the deviation of inflation from the inflation target.

$$1 + \dot{m}_t = \left(\frac{1+\dot{m}_{t-1}}{1+\bar{m}}\right)^{\rho_{mm}} \left(\frac{1+\pi_t}{1+\bar{\pi}}\right)^{\rho_{\pi m}} \left(\frac{y_t}{\bar{y}}\right)^{\rho_{ym}} \varepsilon_{tm} \quad (25)$$

Where $\dot{m}_t$ is monetary growth rate, which it is?

$$\dot{m}_t = \frac{m_t}{m_{t-1}} \quad (26)$$

π_t is inflation rate. ρ_{mm} is weight of monetary growth rate, $\rho_{\pi m}$ is weight of inflation and ρ_{ym} is weight of output in monetary growth rate policy. ε_{tm} is monetary growth rate shock.

In addition to controlling the growth rate of money, the Central Bank of Iran also uses the determination of interest rates of bonds as a monetary policy tool. In modeling the behavior of the central bank, it is assumed that the monetary authority follows Taylor's rule in setting the bond interest rate: Interest rate of bond is:

$$1 + r_t^b = \left(\frac{1+r_{t-1}^b}{1+\bar{r}_b}\right)^{\rho_{rr}} \left(\frac{1+\pi_t}{1+\bar{\pi}}\right)^{\rho_{\pi r}} \left(\frac{y_t}{\bar{y}}\right)^{\rho_{yr}} \varepsilon_{tr} \quad (27)$$

ρ_{rr} is weight of monetary growth rate, $\rho_{\pi r}$ is weight of inflation and ρ_{yr} is weight of output in bond interest rate policy. ε_{tr} is bond interest rate shock.

Government in financed with tax t_t , oil revenue or_t and money m_t. government expenditure is:

$$g_t = t_t + or_t + b_t + m_t - \frac{m_{t-1}}{\pi_t} \quad (28)$$

Bond is:

$$b_t = (r_t^b)^{\varphi_b^{rb}} \quad (29)$$

φ_b^{rk} is weights of r_t^b.Tax is:

$$t_t = y_t^{\varphi_t^y} \quad (30)$$

Where φ_t^y is weights of output. Oil revenue shock is:

$$or_t = \rho_{or} or_{t-1} \varepsilon_{tor}$$
$$\varepsilon_{tor} \sim N(0, \sigma_{\varepsilon_{tor}}) \quad (31)$$

3.4. Market Clearing

In equilibrium the output must be clear.

$$y_t = c_t + i_t + g_t + AC_t \quad (32)$$

$$c_t = c_t^{nonen} + c_t^{en} \quad (32)$$

$$i_t = i_t^{nonen} + i_t^{en} \quad (34)$$

$$N_t = \int_0^1 N_{tj}^i \, d_j \quad (35)$$

$$k_t = \int_0^1 k_{tj}^i \, d_j \quad (36)$$

4. Methodology and Stylized Facts

This paper use Calibration to Calibrated the structural parameters of this model. First, obtain the first order condition and linear them. Then solve the model. The Sample runs for the data in 1981-2018. We use central bank and Statistical center of Iran data base, such as national account and energy sector of Iran.

4.1. Calibrated Parameters

To analyze the model, the parameters of the model are initialized. To initialize the parameters, both the findings of the previous studies and actual data are used. In this way, the parameters of the model are rewritten according to the model's intrinsic variables, and then using the annual time series data, the values are obtained in a steady state and then, the values of the parameters are calculated. In order to calculate the steady state values, initially the time series data are DE trended. The following formula has been used for DE trending:

$$\log(x_t) = \acute{c} + \acute{r}.trend \quad (37)$$

Which c' is intercept and r' is coefficient of trend component. Anti-log of estimated intercept, calculates the value of this series in steady state. As for estimated coefficient for trend component, detrended time series are calculated with:

$$x_t^s = \frac{x_t}{(1+\acute{r})^t} \quad (38)$$

After rewriting the parameters according to the endogenous variables, the steady state values of the variables are embedded and thus the numerical value of the parameters is calculated using actual data.

Some parameters such as discount rate and depreciation rate are identified by solving the model. The weights assigned to the output, inflation stabilization, growth of money in previous period, and weights assigned to output, inflation stabilization and interest of bond in previous period, φ_b^{rb} , φ_b^{rb} are estimated according their functions. Parameters of shocks are estimated by Eviews according the following equation:

$$\log(x_t) = c + \rho \log(x_{t-1}) + \epsilon_{x_t} \quad (39)$$

Where ρ is Autoregressive Coefficient and its standard deviation of ϵ_{x_t} is the standard deviation of variable. Productivity shock is selected appropriately to the structure of the model. Distribution of parameters are selected based on the characteristics of parameters and features of the distribution.

Table1. Calibrated parameters.

Parameter	Value	Calibrated From	Description
Household			
β	0.96	Solving model	Discount factor
θ_{cen}	0.63	Author calculations	Elasticity of energy consumption
σc	0.73	Author calculations	Elasticity of nonenergy consumption

Parameter	Value	Calibrated From	Description
σ_{nen}	0.53	Author calculations	Relative preference for leisure of energy
σ_{n}	0.63	Author calculations	Relative preference for leisure of nonenergy
ϑ	0.67	Author calculations	Share parameter in index of money holdings
$\sigma_{censhare}$	0.40	Martin and Okolo (2020)	Preference parametre
Production			
δ_{en}	0.34	Solving model	Depreciation rate of physical capital in energy
δ_{nonen}	0.24	Solving model	Depreciation rate of physical capital in nonenergy
θ	4.33	Mark-up 30%	Elasticity of demand, intermediate goods
α_{ynonen}	0.48	Author calculations	Share of labor in output, non-energy intermediate good
β_{ynonen}	0.28	Author calculations	Share of capital in output, non-energy intermediate good
α_{yen}	0.83	Author calculations	Share of capital in output, energy intermediate good
Φ_{f}	4.26	Atta-Mensa and Dib (2010)	Adjusted cost parameter, prices
ω_{mc}	0.50	Appropriate structure of model	Weight of mc in P_t^{en}

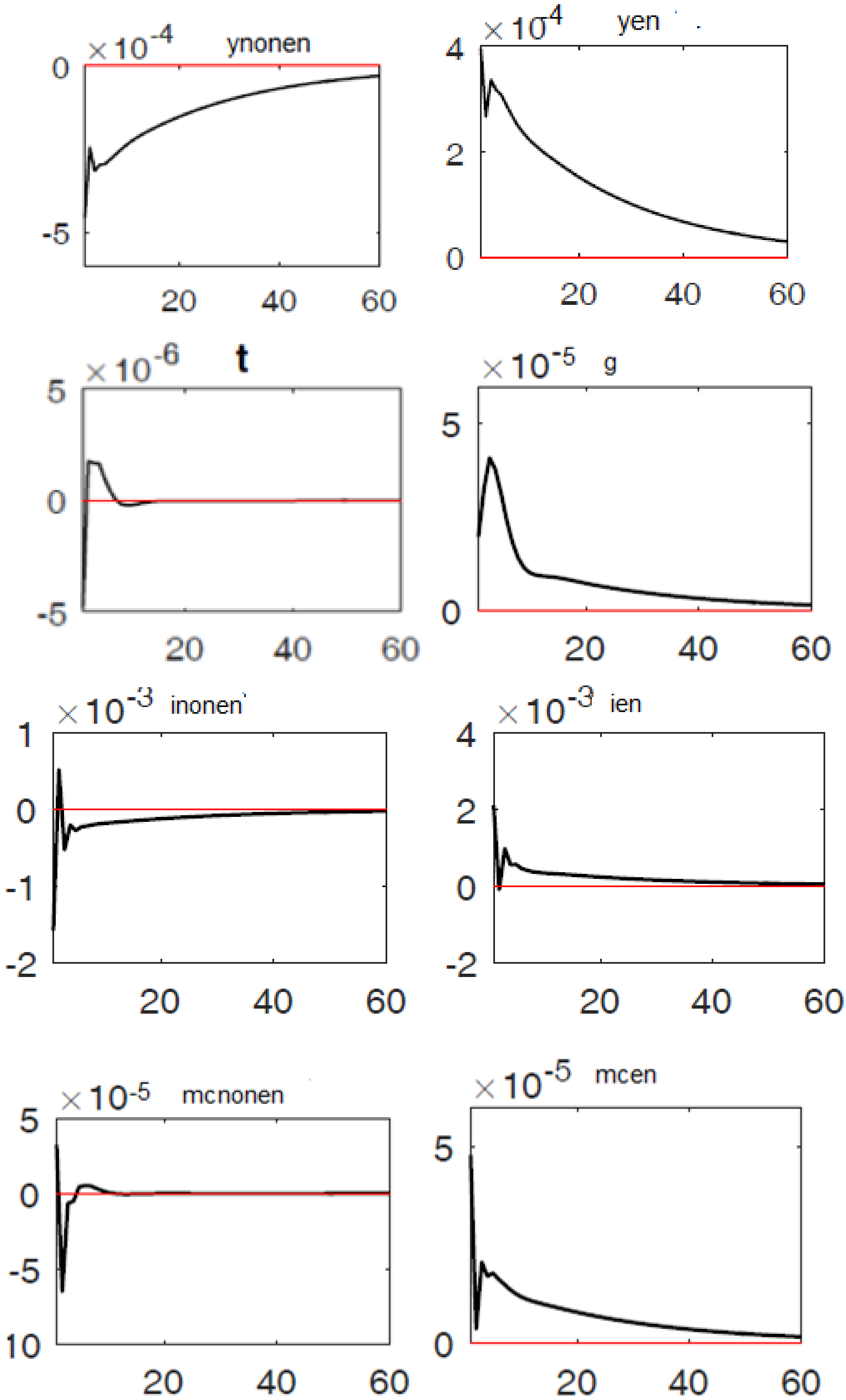
Parameter	Value	Calibrated From	Description
ω_{pen}	0.50	Appropriate structure of model	Weight of P_{t-1}^{en} in P_t^{en}
Central Bank			
ρ_{ym}	-0.8567	Author calculations	Weights assigned to the output in monetary policy
$\rho_{\pi m}$	-0.4476	Author calculations	Weights assigned to inflation in monetary policy
ρ_{mm}	0.7	Author calculations	Weights assigned to growth of money in monetary policy
ρ_{rr}	0.80	Author calculations	Weights assigned to bond interest rate of previous period in bond interest rate
$\rho_{\pi r}$	0.89	Author calculations	Weights assigned to inflation in bond interest rate
ρ_{yr}	0.36	Author calculations	Weights assigned to output in bond interest rate
Government			
φ_B^{rb}	0.25	Author calculations	Weight of output in bond
φ_t^{y}	2.08	Author calculations	Weight of output in tax
Shock			
$\rho_{covid}, \sigma_{covid}$	0.30, 0.001	Appropriate structural of model	Persistence/standard dev., COVID shock of labor
$\rho_{censhare}, \sigma_{censhare}$	0.30, 0.001	Appropriate structural of model	Persistence/standard dev., COVID shock

Parameter	Value	Calibrated From	Description
			on demand for types of goods
ρ_{Aen}, σ_{Aen}	0.40, 0.01	Appropriate structural of model	Persistence/standard dev., productivity shock in energy
$\rho_{Anonen}, \sigma_{Anonen}$	0.40, 0.01	Appropriate structural of model	Persistence/standard dev., productivity shock in non-energy
ρ_{or}, σ_{or}	0.36,0.001	Author calculations	Persistence/standard dev., oil revenue

4.2. Impulse Responses

In this section we consider tow shocks. The first is shock of labor distribution (figure 1), and the second is shock to the preference for energy and non-energy goods (figure 2).

Impulse response Figures 1 and 2 show that COVID shock has reduced labor supply in both energy and non-energy sectors. Mortality and illness, on the one hand, and job closures, on the other, have reduced labor supply. But as can be seen, the reduction in labor supply in the energy sector is less than in the non-energy sector. One of the reasons is the need for minimum presence of labor in the energy sector. Consumption, investment, production in the energy sector have increased. But consumption, investment and production in the non-energy sector have declined. Tax revenues have declined and government spending has increased. This exacerbates the government's budget deficit. Given the decline in investment and production, tax cuts are not unexpected. Government policies to support the household sector by providing commodity or payment packages, as well as policies to support the health sector, have increased government spending. The price and marginal cost of production has increased in both sectors. Also, the price increase in the energy sector is less than in the non-energy sector.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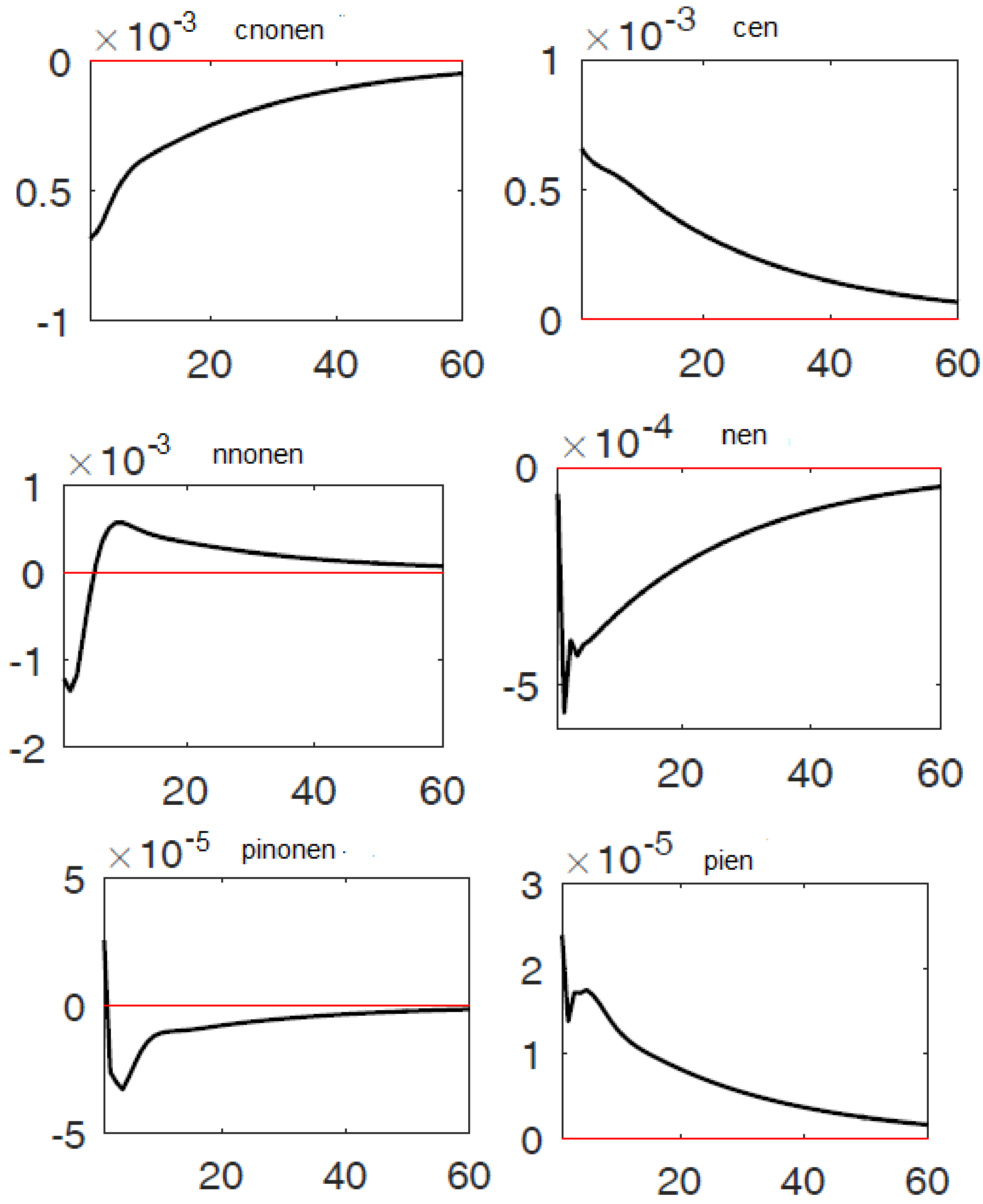
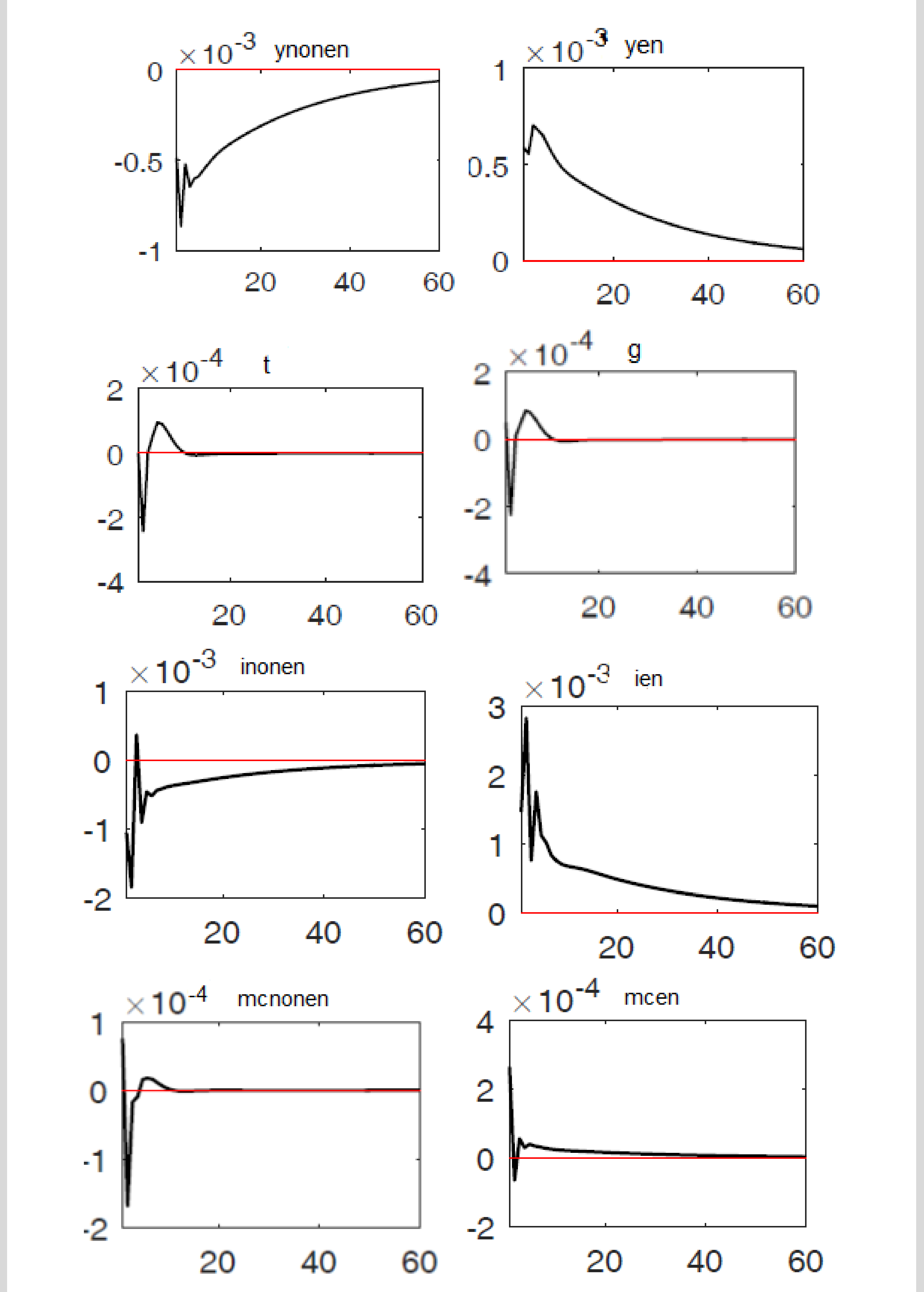


Figure 1. Shock of labor distribution.

A comparison of the two Figures shows that the decrease in production in the non-energy sector due to the shock of preferences is greater than the negative shock of labor supply. The increase in production in the energy sector due to the preference shock is more than the shock of labor supply. Government spending due to the preference shock increases more than the labor supply shock. Tax revenue is also further reduced by the shock of preferences compared to the shock of labor supply. The increase in investment in the energy sector is due to the shock of labor supply more than the shock of consumer preferences. Increased energy consumption due to preference shock is more than labor supply shock. The reduction in non-energy consumption due to the labor supply shock is greater than the preference shock. The marginal cost increasing due to the labor supply shock is greater than the preferences shock.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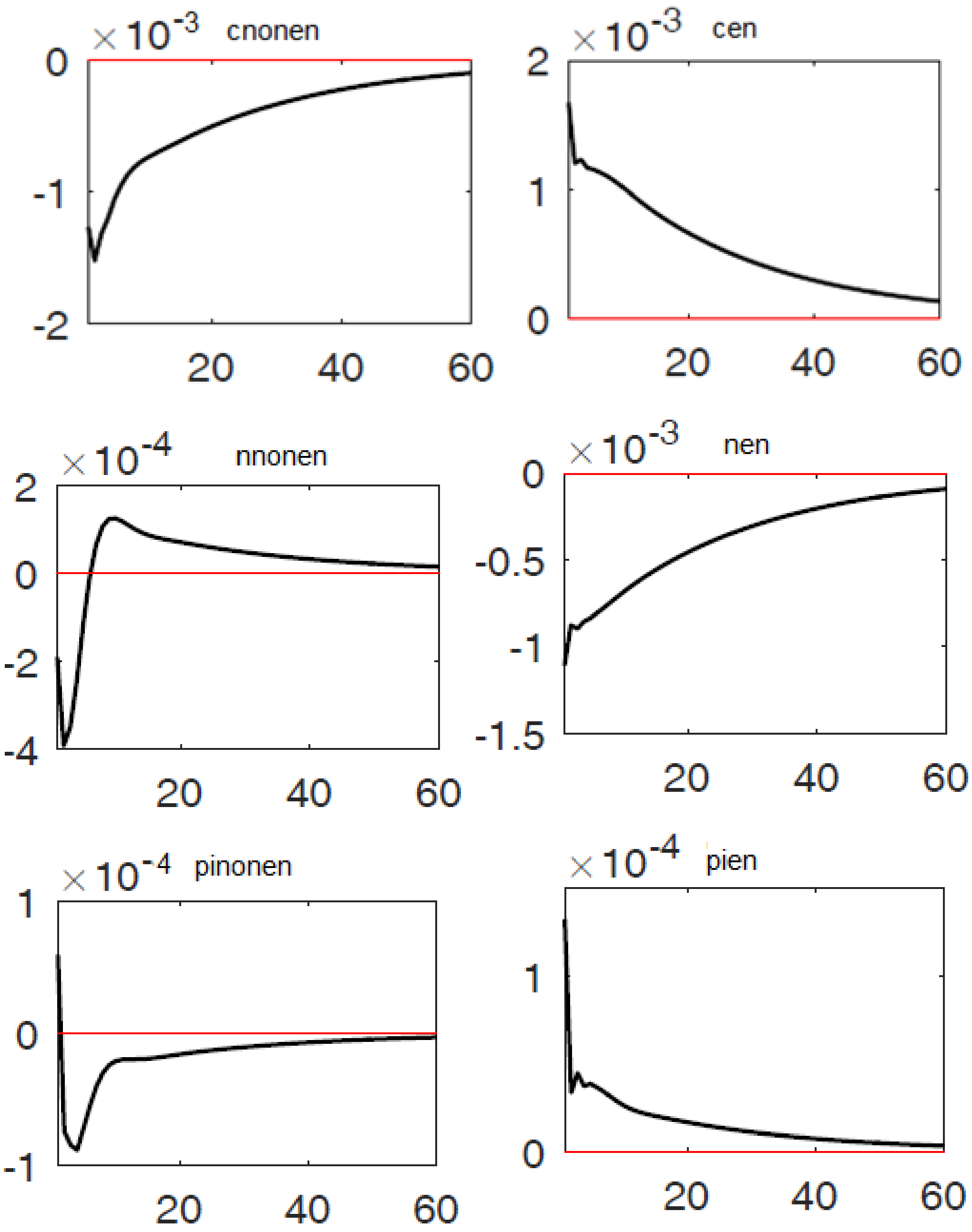

Figure 2. Shock to the preference for energy and non-energy goods.

5. Conclusion

The COVID 19 started in China in 2019 and spread to other countries. Different countries have adopted different policies to reduce the negative effects of this disease. Such as closing high-risk jobs or reducing employees' working days. In the energy sector, different governments have adopted different policies, such as reducing energy prices.

According to the International Energy Agency, in European and American countries, energy consumption has decreased. But in other countries there have been different effects. In Iran, the government has not considered any supportive policy for the energy sector. Energy prices have also risen. COVID has different effects on different sectors of the economy, including the energy sector. Measuring these effects can influence policymakers in adopting policies to support this sector. In this paper, the effect of COVID in the energy sector compared to the non-energy sector has been investigated using DSGE. This article addresses points that set it apart from other studies:

- We use shock of labor distribution to modeling the impact of COVID on the supply labor force for different types of goods.
- We use shock of preference for energy and non-energy goods in modeling the impact of the pandemic on demand for different type of goods.

To evaluate the effect of COVID, two shocks of preference and labor supply have been used. The results show that prices and costs have increased in both energy and non-energy sectors. But the increase in prices and the final cost of the labor supply shock has been greater than the preferences shock.

Consumption, investment and production have increased in the energy sector and decreased in the non-energy sector. Increased consumption, investment and production in the energy sector due to the labor supply shock is greater than the shock of preferences. The reduction in consumption, investment and production in the non-energy sector caused by the preference shock is greater than the supply of labor shock. Decreased production and investment have reduced government tax revenues. But the reduction in tax revenue from the preference shock was greater than the labor supply shock. Government spending has also increased despite the impact of both shocks. But the increase in government spending due to the shock of preferences has been greater than the shock of labor supply. These results indicate that the shock intensifies the preferences of the negative effects of COVID compared to the labor supply shock. This underscored the importance of maintaining consumers' purchasing power and enforcing consumer support packages. It is suggested that, while reviewing the support systems of other countries, apply support packages appropriate to the structure of the country's economy for consumers. At the same time, consider various restrictions on the supply of labor, such as teleworking in jobs that can be teleworked.

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