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Development and Study of a New Keynesian Small Open Economy Model for Policy Analysis in Sudan, Evidence from DSGE Model

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ABSTRACT

The purpose of this paper is to create a small open economy model for monetary policy discussion and analysis. A new Keynesian model for the Sudanese economy is developed using the DSGE technique. The paper made use of annual data from the period (1998 - 2021). The paper demonstrates that, in the case of a fully-fledged Islamic monetary system, the exchange rate can be used as a proxy for the policy rate and yield results that are consistent with what was expected. The main findings are that when monetary policy shocks occur, an increase in the exchange rate directly leads to a contraction in aggregate demand, the fluctuations in output in the short run are primarily driven by output, inflation, and exchange rate shocks, that the response of the variables to policy shocks is consistent with economic theory and what is expected from the variables, and that the empirical findings of the model demonstrate how models can help in policy discussion and analysis. The policy implications were that Sudanese authorities can use the exchange rate to track the dynamics in monetary policy DSGE models that can be used for discussion and policy analysis, and Sudanese monetary authorities must pay close attention to output fluctuations based on variance decomposition analysis.

Key Words: Business Cycle, DSGE Model, Phillips Curve, Monetary Policy, New Keynesian.

1. INTRODUCTION AND BACKGROUND

There are two main schools of thought that explain the economic fluctuations phenomenon. Mankiw, (1989), has made an effort to find an answer to the debate of the sources of economic fluctuations, explaining there are two schools of thought, the classical emphasis of optimization of the private economic actors, the adjustment of the relative price to equate the supply and the demand. The Keynesian school believes that understanding economic fluctuations requires not studying the intricacies of the general equilibrium, but also appreciating the possibility of market failure on a grand scale. While, the classical school believes that the economy always returns to full employment in the long run through the automatic forces of competitive markets. They don't have a business cycle response that is caused by endogenous or exogenous factors, Vaish, (1974). In this regard,

The fluctuation in the economy comes from changes in aggregate supply or aggregate demand. Economists call exogenous events that shift these curves shocks to the economy. Shocks that shift the aggregate demand curve called demand shocks, and shocks that shift the aggregate supply curve are called the supply shock. These shocks disrupt the economy by pushing output and employment away from their natural level. The goal of the aggregate supply and aggregate demand model is to show how the shocks cause economic fluctuations. In addition to evaluating how macroeconomic policy can respond to these shocks. The output and employment fluctuate around their long-run natural levels, the stabilization policies dampen the business cycle by keeping output and employment as close to their natural levels as possible. There are many definitions of the business cycle, for instance; Prescott, (1986) has defined the business cycle phenomena as the recurrent fluctuations of output about the trend, and the co-movements among other aggregate time series. While, Mkrtchyan, Dabla-Norris, and Stepanyan, (2009), have stated that the medium-term fluctuations in the data are related to the monetary policy transmission mechanism and its importance in controlling inflation over the business cycle.

Christiano, Eichenbaum, & Evans, (2005), have developed a model based on the imperfect market, sticky prices, and monopolistic competition in the spirit of New Keynesian macroeconomics. The Dynamic Stochastic General Equilibrium (DSGEs), integrate aggregate supply and aggregate demand responses, these models are structural, meaning they have an economic interpretation, micro-founded because they are derived from the optimization behavior of economic agents in the economy, and they explicitly discuss how random shocks (monetary and fiscal shocks) affect the economy, monopolistic competition, and sticky prices and wages, and are forward-looking, these models are useful tools for forecasting and quantitative analysis in macroeconomic, these kinds of models are gaining the credibility in many institutions, especially the central banks.

In principle, The DSGE models were extensively used by many central banks, especially after the emergence of the Inflation targeting (IT) as a central bank monetary policy regime. It focuses primarily on maintaining price stability and believing its proponents to support economic growth. The targeting of stability can be contrasted with other potential central banking policy goals, including the exchange rate, unemployment, or national income. More recently, many countries adopted inflation-targeting monetary policy, New Zealand was the pioneer in adopting the framework in 1990, followed by Canada in 1991, and some developing and emerging economies have moved to the new framework. Because the practical experiences of countries that adopted such a framework showed that it contributed positively to achieve prices and macroeconomic stability.

The performance of the Sudanese economy throughout the period (1980 – 2021), has witnessed fluctuating and oscillating economic growth. The oscillation of economic growth is the result of many factors; the prolonged twin deficit; social unrest; regional instability; and the lengthy US sanction. The wide fluctuations in production, trade, and economic activity are labeled business cycles. It is a downward and upward fluctuation in real GDP around its long-term trend (Madhani 2010). The authorities responded to the fluctuations by adopting various policies and programs, such as; the engagement with the IMF in many programs, restructuring the banking and financial sector and adjusting the exchange rate. The monetary policy was among the reform areas, enhancing the monetary policy requires building robust models for policy analysis and discussion, especially after the emergence of inflation targeting as monetary policy regime, because the IT monetary policy regime is more efficient in achieving the designated monetary policy objectives and prices stability.

Building on that, the ongoing paper seeks to build a small open economy New Keynesian model for the Sudanese economy utilizing the DSGE technique because the New Keynesian model has become in recent years the workhorse for the monetary policy analysis, inflation, real exchange rate, and output fluctuations, that is based on the process of macroeconomic policy modeling, describing the evolution of inflation dynamics, called a hydride New Keynesian Phillips Curve (NKPC), that exhibit the short-run modeling of inflation dynamics starting from optimization principle. This ultimately leads to the best management of the monetary authority's objectives and an effective monitoring of the monetary policy and inflation afterward.

The rest of the paper is organized in the following way. Section One introduces, and Section Two will provide a brief review of the theoretical underpinning of the monetary policy DSGE modeling. Section three will concentrate on the model specification. Section Four concentrates on the empirical works, and section Five concludes the paper and presents the policy implications.

2. The Theoretical Underpinning of the Monetary Policy DSGE Model

i. The New Classical and the New Keynesian Macroeconomic Models

The new classical models developed by Robert Lucas and Thomas Sargent represent the main implication of rational expectations for aggregate demand and supply analyses. In the new classical model, all wages and prices are completely flexible concerning expected changes in the price level; that is a rise in the expected price level results in an immediate and equal rise in wages and prices. The new classical macroeconomic model demonstrates that aggregate output does not increase as a result of anticipated expansionary policy and that the economy immediately moves to a point of long-run equilibrium where aggregate output is at the natural rate level. The new classical model assumes that when the policy is anticipated, aggregate output remains at the natural rate level. According to the new classical model, the unanticipated movement in the aggregate demand curve causes the aggregate output to fluctuate away from the natural rate level. The conclusion is that anticipated policy does not affect the business cycle; only unanticipated policy matters.

Many economists who accepted rational expectations as a working hypothesis do not accept the characterization of wages and price flexibility in the new classical model. The economists who criticize the new classical model, called the new Keynesian model, object to complete wage and price flexibility and identify factors in the economy that prevent some wages and prices from rising fully with a rise in the expected price level. The long-term labor contracts are one source of the rigidity that prevents wages and prices from responding fully to changes in the expected price level (wage-price stickiness), the three-year worker's wage contracts may not do anything at the end of the first year if new information is available that would make them raise their expectations of inflation and future price level because they are locked into a wage agreement. Even when there are no explicit wage contracts, the firms may be reluctant to change the wages frequently. Price stickiness may occur because firms engage in

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fixed prices contracts with their suppliers or because it is costly for the firm to change prices frequently. All these rigidities in all wage and price arrangements suggest that an increase in the expected price level might not translate into an immediate and complete adjustment of wages and prices.

Gordon, (1990), has stated that the main task of New Keynesian economics is to explain why changes in the aggregate price level are sticky (that is why price changes do not mimic changes in nominal GNP), the term sticky prices imply that the real GNP is not an object of choice by individual workers and firms. The new Keynesian economics is concerned with the choice of monopolistic competitive firms that set their prices and accept the real sales as constraint, while the new-classical economics is in which the competitive price-taking firms choose output. The New Keynesian economics seeks an answer to the question of why do changes in aggregate prices level fails to mimic changes in nominal GNP? This was due to the absence of nominal GNP indexation of individual prices. New-Keynesian macroeconomics is concerned with finding an answer to the question of why does money affect output? if prices are sticky and any changes in nominal GNP will affect the real output.

The new Keynesian model assumes that expectations are rational, but does not assume complete wages and price flexibility; instead, it assumes that the wages and prices are sticky, and the unanticipated policy has a larger effect on aggregate output than the anticipated policy. More importantly, unlike the new classical model, the new Keynesian model anticipated policy does affect aggregate output, and like the new classical model, the new Keynesian model distinguishes between the effect of anticipated versus unanticipated policy, with unanticipated policy having a greater effect. The new Keynesian model indicates that the anticipated policy affects aggregate output, in contrast to the new classical model. It does warn the policymakers that designing such policies will not be easy, because the effect of the anticipated and unanticipated policy is quite different.

The essential feature of Keynesian macroeconomics is the absence of continuous market clearing. This means that the Keynesian model is a non-market clearing model. All Keynesian models predict that in response to a decline in nominal demand, the aggregate price level will decline less than proportionately over a substantial period, during which the actual price level is above the equilibrium price level consistent with the maintenance of the initial equilibrium level of the real output. The decline in the nominal demand together with the absence of full-price adjustment cause the economic system to impose a constraint on each agent which faces a constraint that is an indirect result of its failure to reduce sufficiently its price, this point of coordination failure a central ingredient in the description of Keynesian prices stickiness.

ii. The DSGE Models:

The DSGE models are powerful that provides a coherent framework for policy discussion and analysis, through identifying the sources of fluctuations and answering counterfactual changes, forecast and predicting the effect of policy changes, and performing counterfactual experiments. (Berg, Karam, and Laxton (2006)). They are large-scale models that attempt to describe the behavior of the economy as a whole by analyzing the interaction of many microeconomic decisions. The DSGE models provide a coherent framework for policy analysis and perform counterfactual simulations. They establish a link between structural features of the economy and reduced form parameters, which are not possible with traditional macroeconomic models, these models are good for simulation and policy analyses. More importantly, these models provide a framework for identifying different types of shocks and show how these shocks are transmitted throughout the economy, these models introduce a way to evaluate alternative policies, and understand the impact of certain policies or shocks on the economy. The DSGE models overcome the Lucas critique and allow the estimation of deep structural parameters which are not likely to change when policies change, the DSGE models provide a fully integrated and coherent framework for policy analysis and assessment of alternative policy decisions.

The DSGE models offer to the traditional models the capacity for understanding, the structure is required to uncover the underline driving forces of economic development. The effect of monetary policy works in a complex way, the interdependences of economic variables must be acknowledged, and these models are a natural tool for policy experiments, the framework is free from Lucas's critique and is therefore more stable for alternative policy experiments. These kinds of models are Dynamics because they analyze the evolution of the economy over time, Stochastic because they consider exogenous random stochastic shocks, General because they describe the behavior of the economy as a whole, not partial markets, Equilibrium because market mechanisms create a balance between demand and supply in different markets of the economy.

The central banks are interested in their usefulness for policy analysis and forecasting, these kinds of models provide a framework for structuring policy, help define the causes and volatility and answer questions about structural changes, anticipate and interpret the consequences of policy changes, and carry out counterfactual studies. Galí, and Gertler, (2007), pointed out that the existing models failed to predict the stagflation of the 1970s, leading macroeconomists to criticize these models, Lucas (1976), and Sargent (1981), argued that the lack of an optimization-based approach to structural equations development, this means that the estimated model coefficients are likely not invariant to shift in policy regime or other types of structural changes. In the same context, Sims (1980), has argued that the lack of a convincing hypothesis to determine the vast simultaneity among macroeconomic variables

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raises the issue of the stability of parameters across different regimes. Following the work of Christiano et al (2005), the evidence was put together showing that an optimization-based model with nominal and real rigidities could account successfully for the effects of a monetary policy shock.

Similarly, Christiano (2005), Smet and Wouter (2003), have shown that the new Keynesian model can track and forecast time series as, if not better than estimated with the Bayesian technique (BVAR), but the complex nature of the DSGE models can limit their acceptance among policymakers, particularly in developing countries. Moreover, understanding the works of these models required well-trained macroeconomists with a modeling culture and strong statistical and programming skills, in addition to the fact that the central banks need to invest additional resources to develop such models. It is well known that Smets, et al., (2005), have explained that the DSGE models are not theoretically attractive, but they are also emerging as a useful tool in macroeconomic forecasting and quantitative policy analysis, the model is gaining credibility in policymaking institutions such as central banks. The common feature of these models is that decision rules of economic agents are derived from assumptions about preferences, technologies, and the prevailing fiscal and monetary policy regime by solving intertemporal optimization problems.

Adolfson, et al., (2008), portrayed that there are typically some restrictions on the DSGE models, especially when taking into account its inability to account for the persistence, volatility, and availability of real exchange rates in the case of open economy models, and the failure to account for the international business cycles transmission. The key problems in open economy DSGE models are, of course, the exposed Uncovered Interest Rate Parity (UIP) situation, which in its simplest definition means that the difference between domestic and international nominal interest rates is equal to the predicted future adjustments in nominal exchange rates, but for many macroeconomic variables, there is a lot of propagation of exchange rate movements that function, one shortcoming of standard DSGE open economy models is that the DSGE models with a standard (UIP) condition cannot account for the forward-premium puzzle recorded in data.

According to Tovar Mora, (2008), the specification and the estimation of dynamic stochastic general equilibrium (DSGE) models are making remarkable progress. The DSGE models are not only models used by CBs, but are very suitable for understanding and communicating the impact of shocks and monetary policy changes on the economy, these kinds of models are Dynamics because they analyze the evolution of the economy over time, Stochastic because they have random shocks meaning the shocks push the economic system away from equilibrium. Endogenous dynamics bring it back towards equilibrium, General Equilibrium because the main variables of interest are endogenous and depend on each other, Structural because each equation has an economic interpretation, and it depends on rational expectations assumption because the model is consistent expectations and has no symmetric errors.

iii. The Previous Works on Macroeconomic Performance in Sudan:

There are bulk of works that tackle the Sudanese macroeconomic performance issue; for instances, Arabi, (2020), has examined the possibility of Sudan to build small open economy DSGE model. The model consists of 14 equations, using the data for the period (1960 - 2017). The result indicates that the central bank of Sudan is practicing less radical change in the conduct of monetary policy, and attainment a limited progress in achieving the prices stability and the designated economic growth. He concluded to the findings that the nominal interest rate and the general price level have the same effect on monetary policy. He extracted that the position of interest rate in the monetary policy is weak compared to the exchange rate, and the shock of inflation has the greatest effect on the endogenous variables.

Elbadawi, and Suliman, (2018), have postulated a simple game-theoretic model, where the CBOS uses the money supply and gold purchase price to maximize the foreign exchange proceeds from gold dealership and combat gold smuggling, and minimizing economic fluctuations. The Central Bank of Sudan (CBOS) restrain domestic credit creation for financing gold purchases and budget deficit to avoid high inflation, to track the consequences of the policy on inflation, the nominal exchange rate devaluation and overall competitiveness of the economy. The findings showed that the CBOS monetary policy is largely determined by international gold prices in domestic currency, the social tolerance for high inflation and public sector borrowing requirements. The result suggests that the CBOS gold dealership has not only caused short-term macroeconomic instability but serious negative consequences for the competitiveness of the economy in the medium-term. Also the analyses confirmed that the CBOS's direct dealership in gold has caused the real exchange rate to misalign. Thus, the Ministry of Finance and Economic Planning should assign the management of gold, and for that matter oil, to an independent public institution with the aim of isolating the economy from volatility of prices of these resources, and should focus more on tax-and transfer programs geared towards poverty reduction, diversification and stabilization of the economy.

Abdalla, (2016), has modelled the sources and the impact of macroeconomic fluctuations in Sudan, he investigated the impact of different shocks on the performance of Sudanese economy, using the SVAR and the VAR(1)-GARCH(1,1), to track the Sudanese stock market responds to changes in economic forces. He concluded to the findings that the shocks in the crude oil prices and the

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output for Arab countries are less likely to explain the movements in macroeconomic variables than to the shocks in domestic variables. He recommended that the policy makers have to pay serious attention to domestic forces fluctuations such as the higher exchange rate volatility that contributes to higher exchange rate pass-through to inflation and the major driving forces of the real output and the Khartoum Stock Exchange fluctuations. Moreover, the macroeconomic policies should have emphasized on the domestic sources mobilization through enhancing the performance of the financial institutions. While, Arabi, (2019), has assessed the impact of macroeconomic policies on the performance of the Sudanese real GDP. He used simple switching regression and Markov switching regression. He concluded to the positive effect of development expenses coincided with the negative impact of current expenditure on the growth, which reveals the efficacy of monetary policy over the fiscal.

To illustrate the exchange rate behavior in Sudan, Arabi, (2020), has explored out the Sudanese pound’s optimum exchange rate, using the threshold regression throughout the period 1960 – 2017, for the variables the real GDP, the exchange rate as threshold variables, the labor force and the investment as non-threshold variables. The result indicates a positive sign of the threshold variables, which means that the exchange rate has an impact on the economic growth. The authorities have to make efforts to lift the value of the Sudanese pound the (SDG) to the threshold, that can be fostered by the accumulation of gold reserves.

iv. The Monetary Policy DSGE Modelling:

It is not possible to cover in this survey all the publications which have appeared on the New Keynesian and the DSGE modeling. However, the macroeconomic paradigm for monetary policy assessment has developed as a result of two separate types of modeling literature. The Keynesian paradigm originated in the 1980s, which seeks to provide micro-foundations for key Keynesian concepts, such as inefficiency of aggregate volatility, nominal price stickiness, and non-neutrality of money. While, real business cycle theory shows that the model can be constructed from the bottom-up level, from explicit optimization behavior at the individual level but these models abstracted from monetary and financial factors and could not address the issue. In general, the structural macroeconomic models have more hope of capturing real-world data, but the framework was developed as well as reduced form models of an earlier period, Christiano, Eichemboum, and Evans (2005), Smets and Wouters (2003), these models have a good theoretical basis and can be used for policy experiments.

The monetary policy can influence money balances by changing the nominal interest rate. The changes in money balances influence demand for goods and services and hence prices. Therefore, monetary policy can control prices by regulating the desire to hold money balances McCallum, (1999). The effectiveness of monetary policy depends on the flexibility of prices, and the responsiveness of aggregate demand and supply to monetary policy-induced price changes. For instance, a decline in commodity prices on the international market reduces income and households and firms' profit, respectively. A new equilibrium can be established if domestic prices and wages are reduced. However, price and wage contracts akin to price hedges and collective bargaining agreements undermine the efforts of firms to reduce prices and wages. The rigidity in prices can also be due to the existence of firms and labor unions with the power to set and influence prices. The New Keynesian DSGE model incorporating rigidities in wages and prices may describe the economies fairly well. The fluctuations in output, consumption, and labor supply were due to technology and labor, natural factors such as floods, and diseases that impair labor supply may induce fluctuations in output. These shocks can be incorporated into the model. The nominal variables may influence other intermediate real variables, thereby inducing fluctuations in output.

Söderström, Söderlind, and Vredin, (2005), have stated that there is a tendency towards the hypothesis that the behavior of the private sector can be approximated by aggregate supply and demand relations derived from the new Keynesian model, this framework is popular in both theoretical and practical terms because it is simple to understand, similar to the traditional model used for policy analysis, such as the IS/LM, can be derived from microeconomic theory with optimizing agents under certain assumptions, promoting contacts between policymakers and more theoretical oriented researchers.

There are several DSGE models used in macroeconomic analysis, and the majority of the models have based on two setups: a competitive structure where allocations are in general Pareto optimal, and a monopolistic competitive structure where one type of agent can set the prices of goods she supplies and allocation are sub-optimal. The Euler equation methods approximate the first condition, using the expectation equations or the policy function. There are many DSGE models, some of such models only used real variables and others consider nominal variables. Some models with both representative and heterogeneous agents with both optimal and distorted setups. If the economy is subject to other exogenous stochastic shocks, the DSGE model generates a probability distribution for time series such as aggregate output, inflation, and the interest rate.

This new modeling technique adds a new perspective to inflation and wage dynamics and explores the relative importance of prices and wage rigidity. And these models are not only purely forward-looking, but add backward-looking components in the prices and inflation, and these models allow real consumption and investment rigidities through habit-forming, information consumption, and adjustment costs in investment. Several authors have contributed to the creation of the DSGE forms such as

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Christiano, Eichenbaum, and Evan (2005) and Smets and Wouters (2007), who introduced DSGE models based on the wages stickiness, and the wage indexation plays important role in matching the model with data. Smets and Wouters demonstrate that the shock process is a very important determinant of inflation dynamics in the short run.

The New Keynesian Phillips curve NKPC, states that the wage and the price-setting decision can be derived from a problem of optimization with forward-looking agents that set their prices optimally, subject to a constraint on price adjustment frequency (Taylor 1980, Calvo 1983). Aggregating over individual behavior leads to a comparable relationship to the traditional Phillips curve. The New Keynesian Phillips curve which explains the inflation dynamics has expanded to incorporate lags of inflation to account for backward-looking behavior, establishing what is known as Gali and Gertler's hybrid New Keynesian Phillips curve. Baxa, Plašil, and Vašíček, (2015), have outlined that understanding the short-term inflation dynamics poses major challenges for monetary policy, sound knowledge of inflation properties is crucial, particularly for economies that have undergone structural changes, also for countries where monetary policy institutional arrangements have significantly changed to engine management of inflation process.

Accordingly, Schorfheide, (2008), has stated that the price-setting equation is a major building block in the modern dynamics stochastic general equilibrium DSGE model, in which the adjustment of nominal prices is expensive, the equation links inflation to current and future expected real marginal costs and referred to as the new Keynesian Phillips curve (NKPC). Rotemberg, (1982), has stated that the most popular assumptions are that the firms face quadratic nominal adjustment cost, and the firms are unable to re-optimize their prices with a certain likelihood in each period (Calvo, 1983), the Calvo model has a particular appeal because it generates predictions about the frequency of prices changes. The NKPC's slope is important for the propagation of shocks and for determining the output-inflation trade-off faced by policymakers.

The DSGE model provides a more disaggregated representation of the demand side of the economy. The Phillips curve relationship depends on real marginal costs as its deriving process, acknowledging that there are different versions of inflation dynamics. In this context, Correa-López, Pacce, and Schlepper, (2019), have explained that several approaches were used empirically to explore and model inflation dynamics, which are due to the reduced form specifications. Inflation is thus explained by expectations of inflation (both backward-looking, forward-looking, or hybrid), a proxy of cyclical position or excess demand (the output or unemployment gap), and evolution of production costs, or cost shocks (import price, inflation, tax changes, etc.). The structural underpinning of such specification is found in extended price-setting and wage-setting rules that configure a variant of the Phillips curve.

The DSGE models have some shortcomings such as; they provide only an approximate representation of the data-generating process. The Bayesian models are well suited to deal with these kinds of shortcomings. The log-linearized DSGE models are state space models with nonlinear restrictions on the mapping between the reduced form and structural parameters, posterior parameters of the structural parameters can be obtained using the posterior simulator. Once the posterior distribution of the structural parameters is obtained, it becomes trivial to conduct any inferential exercises.

3. THE SPECIFICATION OF THE MODEL

Monetary policy decisions involve analysis of the real economy, fiscal policy, and monetary condition. The monetary policy decisions or actions are intended to minimize the deviation of inflation and real GDP growth from their designated targets. The constraints to achieving monetary policy objectives are rigidities in price adjustment and structural rigidities that impede adjustment of output such as inefficiencies, market power, barriers to trade, and fiscal policy. The existence of monetary policy constraints and the practical experiences of other countries have motivated central banks' monetary authorities to shift from money targeting to inflation targeting. The adoption of inflation targeting is informed by greater responsiveness of the financial and non-financial activities to interest rate changes. In addition, inflation targeting utilizes market-based monetary policy instruments which are effective in controlling aggregate demand and supply.

The specification of the model is based on the advanced work of Smets, & Wouters, (2003), Christiano, Eichenbaum, & Evans, (2005), the guide provided by Laxton, Berg & Karam (2006), and the work of Ahmad, and Pasha, (2015, in addition, to some special features of the Sudanese economy. Papageorgiou, (2014) has postulated that the work of Smets and Wouters (2003, 2007) postulated that the DSGE models offer a suitable and credible tool for forecasting. This kind of model is in line with models that are used in many Central Banks, this model is a useful tool for forecasting and policy analysis. The model shares many standard characteristics of the models used by most Central Banks and policy institutions, moreover, it includes some important features and the stylized facts of the Sudanese economy.

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The Building Blocks of the Model:

The response of monetary policy to output and inflation shocks is based on the analysis of the economy, assuming that the domestic economy consists of a large number of households, firms, and government, using the following equations.

1. Aggregate Demand Equation
2. Aggregate Supply Equation
3. The Uncovered Interest Parity Condition.
4. Monetary policy rule, policy framework.

First, to cover the demand side, the model utilizes the well-known IS curve that describes the equilibrium in the goods market.

IS Curve:

$$\mathbf{\hat{Y}_t = \alpha_1 E\hat{Y}_{t+1} + \alpha_2 \hat{Y}_{t-1} + \alpha_3\, mci_t + \alpha_4\, \hat{Y}_t^{*} + \Sigma_t^{y}} \ldots\ldots\ldots\ldots\ldots(1)$$

This equation describes demand conditions in the goods market of the economy where, $\boldsymbol{\alpha_1}$ reflects the extent of expectation on aggregate demand, $\boldsymbol{\alpha_2}$ reflects the extent of persistence of aggregate demand, $\boldsymbol{\alpha_3}$ reflects the extent of pass-through from monetary conditions to the real economy and $\boldsymbol{\alpha_4}$ reflects the importance of foreign demand on the domestic economy, the mci_t is the monetary condition index, y_t^* external output and $\boldsymbol{\Sigma_t^y}$ is the aggregate demand shock. The mci_t is the monetary condition index derived from aggregating the deviation of the exchange rate from the trend and the deviation of the interest rate from the monetary policy rate. An increase in mci_t associated with monetary tightening and vice versa, Ahmad, and Pasha, (2015). The IS equation describes the demand conditions for monetary policy to regulate.

$$\boldsymbol{mci_t = \rho(r_t - \bar{r}_t) + (1-\rho)(\bar{z}_t - z_t)} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The supply side (Philips curve):

$$\boldsymbol{\pi_t = b_1\pi_{t-1} + (1-b_1)E\pi_{t+1} + b_2 rmc_t + \Sigma_t^{\pi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The Phillips curve describes the evolution of inflation or the inflation dynamics. Such that inflation π_t in the current period depends on the past inflation π_{t-1}, inflation expectation, and real marginal cost rmc_t, the inflation shocks are captured in ϵ_t. The parameters b_1 represents inertia in the inflation process or inflation persistence, (1-b_1) is the weight of the forward-looking component in the determination of inflation. The term rmc_t represents real marginal costs.

The Real Marginal Cost:

In an economy with a strong exchange rate pass-through to domestic production costs, a real effective depreciation leads to an increase in real marginal cost rmc_t . Real marginal cost consists of a fraction of output and the deviation of the real exchange rate Z_t from its equilibrium $\bar{Z}_t$. The changes in Z affect rmc_t in economies with strong foreign prices pass through to the domestic market. The increase in Z indicates a real effective exchange rate depreciation. A real effective exchange rate depreciation can be caused by nominal exchange rate depreciation or an increase in domestic inflation relative to foreign inflation. Hence, a real effective depreciation occasioned by a nominal depreciation or domestic inflation can be induced by expansionary monetary policy.

$$\boldsymbol{rmc_t = b_3\hat{Y}_t + (1-b_3)\hat{Z}_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

b_3 is share of the domestic component output gap, while (1-b_3) is the share of a foreign component or the real exchange rate gap. The $\boldsymbol{rmc_t}$ shows the pass-through of foreign marginal costs to inflation.

The Uncovered Interest rate:

In open economies without capital controls, the domestic interest rate is equal to the foreign interest rate in domestic currency, which is the covered interest parity condition. However, there are barriers to the capital flows, such as capital controls and transaction costs. As a result, domestic and foreign interest rate differential consists of premium and real effective exchange rates. In such cases, the monetary condition index mci_t decline. Hence, the uncovered interest parity condition is given by:

$$\mathbf{S_t = E_t\, S_{t+1} + (i_t^* - i_t + prem_t) + \varepsilon_t^s} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

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The Monetary Policy in Money Targeting Monetary Policy:

The model is closed with a monetary policy rule (Taylor Rule), which describes the Central Bank's behavior. Sudan uses a money-targeting monetary policy, so the model is extended to include money demand and supply. Money demand and supply interactions determine nominal interest rates.

Nominal money demand:

$$(MD) = md * CPI \quad \ldots\ldots (6)$$

Money Supply Target:

$$\Delta MDtar = \Delta mdT + \text{inflation target} \quad \ldots\ldots (7)$$

Money supply can deviate from the money target depending on the implementation policy of the central bank CB.

Under strict money targeting, the CB strictly adheres to the money target:

$$\Delta MD_t = q_1 \Delta MD_{t-1} + (1 - q_1)\Delta MD_t^{tar} + \varepsilon_t^{MD} \quad \ldots\ldots (8)$$

The interest rate is determined by the interaction between money supply and money demand.

A monetary policy rule

A monetary policy rule (Taylor Rule) is the monetary policy rate the, $\bar{r}$ is the equilibrium real interest rate. We assume that monetary policy in Sudan can be modeled as a Taylor-type rule with a simple nominal interest rate feedback rule:

$$i_t = \vartheta i_{t-1} + (1 - \vartheta)[\bar{r} + \pi_t + \eta y_t + \lambda(\pi_t - \bar{\pi})] + e_i \quad \ldots\ldots (9)$$

The term ϑ is the weight assigned to lag interest rate or interest rate persistency, while (1- ϑ) is the weight assigned to the usual central bank business of interest rate setting in the context of the Taylor rule.

I. The Exchange Rate as a New Monetary Policy Instrument

The exchange rate affects both inflation and the output gap through its effect on net exports, on domestic prices through imports prices pass-through, and on interest rate through interest parity. Celasun and Goswami, (2002), have found a strong impact of money and the exchange rate in the short-run inflation in Iran. Feizi, (2008), has utilized the exchange rate as a new monetary instrument, raising an argument that the vast literature for the conduct of monetary policy concentrates on the interest rate, however, in Islamic framework and developing countries, where the characteristics of the economy and the monetary policy setting are quite different, besides the conceptual problem of the interest prohibition in most of the Islamic countries, there is an institutional problem that related to the financial market, the modeling and the researches on monetary policy concentrated on the developed countries in where the debt and the foreign exchange markets are developed. Then he raises the question of what modifications need to be made for the effectiveness of monetary policy in emerging and Islamic frameworks.

The interest rate is used commonly for the conduct of monetary policy in industrial countries, but its use is not universal, and the interest rate could not play the role of reliable monetary policy instruments in countries that adopt full-fledged Islamic financial systems. The designated new instrument should have the potential that the monetary signals can be transmitted efficiently through the market. Many empirical studies have investigated the role of exchange rates on monetary policy implementation. Feizi (2008), has selected the exchange rate as a monetary policy instrument. Building on this fact, the ongoing study will implement the exchange rate as a monetary policy instrument and investigate how the exchange rate channel the Central Bank of Sudan's actions to affect the overall performance of monetary policy in Sudan. Moreover, Arabi, (2020), has indicates that the exchange rate has an impact on the economic growth in Sudan.

To bring the above-mentioned facts to reality. First, the paper investigates the descriptive power of the model by examining the sample moments produced by the model. Then we report the impulse response functions to several shocks and analyze the main transmission mechanism through which the shocks influence the macroeconomy. Finally, we perform variance decomposition analysis to quantify the relative importance of each of the shocks in the variation of the key macroeconomic variables. The result shows that the model performs quite well.

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II. The Specification of the Model in Dynare:

```
gap=alpha*gap(+1)+beta*gap(-1)+gamma*mci+ delta*fgap + e_gap;
mci = eps*( exr -pi(+1))+(1-eps)*z;
pi = zeta*pi(-1)+(1-zeta)*pi(+1)+eta*gap + e_pi;
rmc = theta*gap+ (1-theta)*z;
s = iota*s(+1)+kappa*(r- exr +prem) +e_s;
xx = chi*xx(-1) + (1-chi)*pi + e_MD;
md = lambda*md(-1) + mu*pi + e_md;
tar = omega*md(-1)+(1-omega)*pi_tar + e_tar;
exr= xi* exr (-1)+(1-xi)*(r_e+pi_tar+ups*(pi-pi_tar)+tau*gap)+e_ exr;
```

4. The Empirical Works:

The output of the DSGE Estimation:

The output of the DSGE model estimated in Dynare consists of estimated parameters, policy and transition functions, theoretical moments, impulse responses and variance decomposition and correlation matrix, and point and interval forecast. The obtained result of the model performs quite well.

Results from Posterior Estimation:

To proceed to the analysis, the parameters are interpreted depending on the functional relationship that exists on the variable to which it is attached. For example, alpha is the discount factor, measuring the value attached to current consumption relative to future consumption. A higher value of alpha reduces future value relative to current consumption.

Table 1. Parameter Estimates

Coefficient	Associated Variable	Prior Mean	Posterior Mode
Output Gap Equation; gap=alpha*gap(+1)+beta*gap(-1)+gamma*mci+ delta*fgap + e_gap;			
Alpha α	Measure the impact of expectations of the output gap on the gap	0.6000	0.5868
Beta β	Measure the impact of the Lagged output gap on the gap	0.7700	0.7104
Gamma γ	Measure the impact of Real monetary policy conditions on the output	0.5500	0.4422
Delta δ	Measure the impact of the Foreign output gap on the output	0.6000	0.6374
e_gap	Shock to the output gap	0.01	
Monetary Policy Condition Equation, mci = eps*(i-pi(+1))+(1-eps)*z;			
Epsilon ε	Represents the weight of the real interest rate gap on mci	0.6000	0.5853
(1-Epsilon ε)	Represents the weight of the Real exchange rate gap on mci	0.4000	0.4147
Inflation Rage Equation; pi = zeta*pi(-1)+(1-zeta)*pi(+1)+eta*gap + e_pi;			
Zeta ζ	Reflects the impact of lag inflation on the current level of inflation (the inertia or persistency in the inflation process) V.I for the conduct of MP, If =0 then prices are flexible.	0.8500	0.6137
(1- Zeta ζ)	Reflects the impact of lead inflation on the current level of inflation	0.1500	0.3863
Eta η	Measure the impact of the output gap on current inflation	0.8500	0.9156
e_pi	Shock to the inflation rate (Persistence of inflation shock).	0.01	
Real Marginal Cost Equation; rmc = theta*gap+ (1-theta)*z;			
Theta θ	Measures the weight of the domestic output gap on real marginal cost.	0.5000	0.4933
(1- Theta θ)	Measures the weight of real exchange rate misalignment on real marginal cost.	0.5000	0.5067
Uncovered interest rate; s = iota*s(+1)+kappa*(r-i+prem)/12+e_s;			
Iota ι	Measures the weight of the expected uncovered interest rate on the current uncovered interest rate.	0.6000	0.5688
Lambda		0.5000	0.6643
Kappa κ	Measures the weight of the domestic sovereignty component on the current uncovered interest rate	0.7000	0.5912
e_s	Shock to uncovered interest rate	0.01	
Nominal Demand for Money Growth Rate Equation; xx = chi*xx(-1) + (1-chi)*pi + e_MD;			
Chi χ	Measures the impact of lagged money supply on money demand	0.9500	0.9895

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(1- Chi χ)	Measures the impact of inflation on the current money supply	0.0500	0.0105
e_MD	Shock to demand for money	0.01	
Real Money Demand Growth Rate Equation; md = lambda*md(-1) + mu*pi + e_md;			
Lambda λ	Measures the impact of lagged reserve money on reserve money	0.5000	0.7390
Mu μ	Measures the impact of inflation on current reserve money	0.3000	0.1897
e_md	Shock to the growth rate of money demand	0.01	
Target Money Demand Growth Rate; tar = omega*md(-1)+(1-omega)*pi_tar + e_tar;			
Omega ω	Measures the impact of lagged real money demand on target money	0.6000	0.5755
(1- Omega ω)	Measures the impact of inflation targeting on the target	0.4000	0.4245
e_tar	The shock on money targeted demand	0.01	
Taylor Rule Equation; i= xi*i(-1)+(1-xi)*(r_e+pi_tar)+ups*(pi-pi_tar)+tau*gap)+e_i;			
Xi xi	Policy rate persistency in Taylor rule, Persistence of the monetary policy shock.	0.5400	0.7104
(1-xi)	Weight of inflation in the Taylor rule, Sensitivity of the central bank for inflation.	0.4600	0.2896
Ups ups	Sensitivity of the central bank concerning the deviation of inflation from its target.	0.5000	0.3572
Tau tau	Weight of output in the Taylor rule, Sensitivity of the central bank to the output gap.	0.3000	0.3762
e_exr	Shock to the interest rate (Persistence of monetary policy shock).	0.01	

Source: researcher calculation

The parameters of interest for monetary policy formulation are zeta, gamma, eps, and ups. zeta is the persistence of inflation, gamma impact of the monetary condition index on output, eps impact of real exchange rate on real monetary condition, and ups the Sensitivity of the central bank to the deviation of inflation from its target. The central bank will adjust ups because of inflation deviating from the target to influence monetary condition, inflation, and output, considering the sensitivity and persistence of zeta, eps, and ups. In this model zeta is 0.6137, implying that inflation is quite persistent. The monetary authorities adjust monetary conditions, not too tight but not too loose due to the persistence of inflation, to enhance growth. Results of the Taylor rule show that the estimated value of the coefficient attached to the lagged exchange rate xi is 0.7104 %, indicating a less radical change in the exchange rate formulation of the Central Bank of Sudan.

Initial and Steady-state:

The shocks simultaneously act on shifting components of aggregate demand and aggregate supply through the expectation channel. In the case of monetary policy shocks, in the period of the shocks, the increase in the exchange rate directly leads to a contraction in aggregate demand as agents adjust consumption. Simultaneously, the agent expects the output gap to be negative in the next period and inflation to be below the steady state, through the Euler condition, contracts the aggregate demand further. For the supply side, a fall in inflation expectations acts to expand supply: because it is costly for firms to adjust prices, they have incentives, for a given level of output to reduce prices today.

Table 2. Prior Mean and Posterior Mode:

Particular	Initial	Prior	S. State Result	STD. Dev	Variance
Gap	- 0.016	-0.019	- 0.01	0.0096	0.0001
Mci	0.092	- 0.002	- 0.004	0.0098	0.0001
pi	0.9	1.533	1.61	0.042	0.0018
Rmc	0.6	0.17	0.19	0.0054	0.0000
s	0.30	- 0.66	- 0.34	0.018	0.0003
xx	1.53	1.63	1.81	0.034	0.0012
md	1.54	0.72	1.57	0.021	0.0005
Tar	0.11	0.53	1.05	0.012	0.0002
exr	0.20	1.27	0.997	0.031	0.001

The estimate indicates that when output deviates from the steady state of one percent, the monetary condition index is changed by – 0.004%. The nominal exchange rate increases by 0.997% when inflation deviates from the steady state by 1%. Steady-state output is the potential growth, while steady-state inflation is inflation at full employment.

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Policy and Transition Variables:

The transition function indicates how the period t values of the state variables depend on t-1 values of the state variables, and the shock e_gap, e_epi…., While the policy functions: the columns: indicate period t values of the variables the raw indicate period t − 1 values of the state variables and the shocks e_gap, e_epi. The term constant is the steady state (of log transformation) of the control variables.

Table 3, Policy and Transition Functions:

Particular	gap	Mci	Pi	Rmc	S	xx	Md	Tar	Exr
Constant	-0.011	-0.0009	0.818	0.197	-0.413	1.77	0.463	0.401	0.533
xx(-1)	0.0	0.0	0.0	0.0	0.0	0.989	0.0	0.0	0.0
md(-1)	0.0	0.0	0.0	0.0	0.0	0.0	0.664	0.665	0.0
i(-1)	0.122	0.117	0.327	0.060	-0.836	0.0034	0.062	0.0	0.757
gap(-1)	0.574	-0.600	0.986	0.283	-0.294	0.010	0.187	0.0	0.165
pi(-1)	-0.130	-0.103	0.579	-0.065	-0.040	0.006	0.109	0.0	0.046
Fgap	0.515	-0.539	0.884	0.254	-0.264	0.009	0.168	0.0	0.148
z	0.148	0.259	0.255	0.579	-0.076	0.003	0.048	0.0	0.042
e_gap	0.808	-0.846	1.39	0.399	-0.414	0.015	0.263	0.0	0.232
e_pi	-0.213	-0.168	0.944	-0.105	-0.065	0.009	0.179	0.0	0.074
R	0.0	0.0	0.0	0.0	0.591	0.0	0.0	0.0	0.0
Prem	0.0	0.0	0.0	0.0	0.591	0.0	0.0	0.0	0.0
e_s	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0
e_MD	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0
e_md	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0
pi_tar	0.032	0.030	0.086	0.016	-0.219	0.0009	0.016	0.335	0.198
e_tar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
r_e	0.050	0.048	0.133	0.025	-0.341	0.001	0.025	0.0	0.309
e_exr	0.172	0.165	0.460	0.085	-1.176	0.005	0.087	0.0	1.066

Source: researcher's calculation

The Variance Decomposition (in percent):

In this Section, we quantify the contribution of each structural shock to fluctuations in the endogenous variables at different time horizons. More specifically, the total variances of the endogenous variables are decomposed into fractions explained by innovations in the exogenous variables. The variance decomposition of endogenous variables answers the question of which structural shocks have the largest importance for the dynamics of given variables. Thus, it is possible to determine which shocks and to what extent determine the dynamics of the particular variables. The Forecast Error Variance Decomposition (FEVD) can be used to analyze which variable has the most dominant influence on the value of the variables, and to see the strengths and strengths of one variable in influencing other variables over a long period. The following is the data processing output from the Forecast Error Variance Decomposition analysis.

Table 4 The Forecast Error Variance Decomposition Analysis (in percent) :

Particular	fgap	Z	e_gap	e_pi	R	prem	e_s	e_MD	e_md	pi_tar	e_tar	r_e	e_exr
Gap	0.0	0.0	78.61	13.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.45
Mci	0.0	0.0	92.01	4.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.28
Pi	0.0	0.0	63.10	8.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.99
Rmc	0.0	0.0	78.61	13.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.45
s	0.0	0.0	16.22	0.22	0.0	0.0	16.16	0.0	0.0	0.0	0.0	0.0	67.41
Xx	0.0	0.0	0.48	0.00	0.0	0.0	0.0	99.15	0.0	0.0	0.0	0.0	0.37
Md	0.0	0.0	35.63	2.14	0.0	0.0	0.0	0.0	42.22	0.0	0.0	0.0	20.00
Tar	0.0	0.0	35.63	2.14	0.0	0.0	0.0	0.0	42.22	0.0	0.0	0.0	20.00
Exr	0.0	0.0	17.08	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.53

Source: researcher's calculation

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Table (4) illustrates that the fluctuations in output in the short run are primarily driven by output shocks, inflation shocks, and exchange rate shocks. In the very short run, shocks to output and inflation explain respectively about 78.61% and 13.94% of the variance in output. It is worth noting that shocks in output become more important. Hence, the result shows that output shock e_gap is the largest among estimated shocks, implying that volatility in output has the largest impact on other endogenous variables.

Matrix of Correlations: (HP filter, lambda = 1600)

Table 5 The Matrix of Correlation Analysis:

Variables	gap	Mci	Pi	rmc	S	xx	md	tar	Exr
Gap	1.0000	-0.753	377	1.000	-0.278	-0.004	0.027	-0.146	0.226
Mci	-0.753	1.000	-0.720	-0.753	0.258	-0.004	-0.307	-0.106	-0.209
Pi	0.377	-0.721	1.000	0.377	-0.716	0.019	0.656	0.494	0.753
Rmc	1.000	-0.753	0.377	1.000	-0.278	-0.004	0.026	-0.146	0.226
S	-0.278	0.258	-0.716	-0.278	1.000	-0.019	-0.520	-0.430	-0.912
Xx	-0.004	-0.004	0.019	-0.004	-0.019	1.000	0.024	0.026	0.021
Md	0.027	-0.306	0.656	0.026	-0.520	0.0236	1.000	0.826	0.570
Tar	-0.146	-0.106	0.494	-0.146	-0.430	0.026	0.826	1.000	0.486
Exr	0.226	-0.209	0.753	0.226	-0.913	0.021	0.570	0.486	1.000

Source: researcher's calculation

Table (5), shows the matrix of correlation of the endogenous variables. This depicts that the relationship between the output and inflation is positive and amounted to 0.377%, while the relationship between the output and the monetary condition index is negative and amounted -0.753%.

Coefficients of Autocorrelations

Table 6 coefficients of autocorrelations:

Order	1	2	3	4	5
Gap	0.4568	0.0830	-0.1074	-0.1634	-0.1453
Mci	0.5897	0.2384	0.0167	-0.0847	-0.1054
pi	0.8267	0.5903	0.3810	0.2315	0.1405
Rmc	0.4568	0.0830	-0.1074	-0.1634	-0.1453
S	0.6982	0.5718	0.4597	0.3639	0.2851
Xx	0.9896	0.9793	0.9690	0.9589	0.9488
Md	0.8264	0.6592	0.5084	0.3822	0.2833
Tar	0.8264	0.6592	0.5084	0.3822	0.2833
Exr	0.8362	0.6907	0.5604	0.4470	0.3519

Source: researcher's calculation

Table (6) shows that the autocorrelations between the endogenous variables and their lags are stronger for the first lags and become weaker for the more order lags.

The Impulse Responses Analysis:

The graphs are impulse response functions simulated using the model. They indicate a response of the variable to a 1% shock. The figure displays the effect of identified output gap shocks estimated using data covering the period (1998 - 2021), all variables are expressed in deviations from what would have happened in the absence of shocks.

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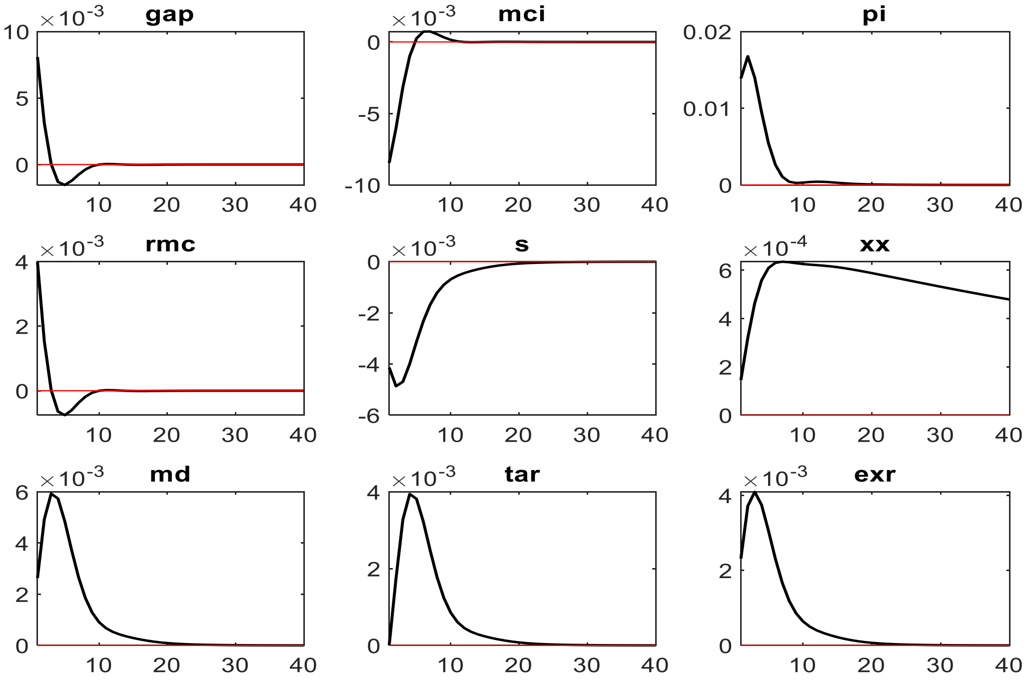

Figure 1, Shocks to Output e-gap

The figure shows a response of the variables to a 1% shock increase in output. A 1% shock increase in output leads to an immediate contract in the monetary condition index (mci) by 1% points in the next period. The response returns to its steady state after 3 periods of time horizons. The inflation rate pi increased immediately and continue increasing to reach the peak after 2 periods of time horizon, the same story can be said for the exchange rate immediate increase to 2%, which continue its increase to reach the peak at 4% in 2-time horizons, and return to its steady state after 20-time horizons. The money supply xx increase immediately and continue increasing to reach its peak after a 5-time horizon, and it will take a longer time to return to its steady state. Similarly, the reserve money md will increase immediately, and it will take about a time horizon to reach its peak, but it will return to its steady state quickly compared to the money supply.

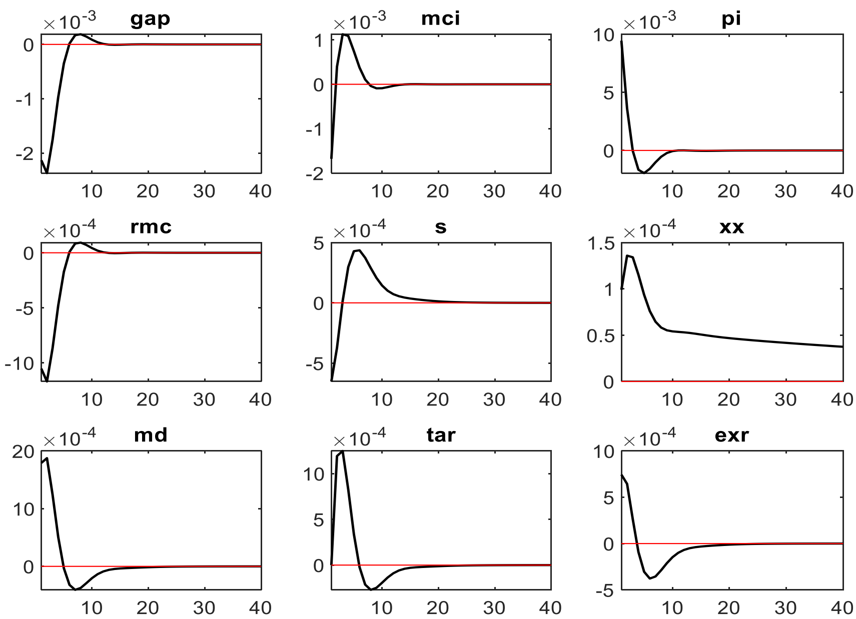

Figure (2), Shocks to Inflation e_pi:

The figure shows a response of the variables to a 1% shock increase in inflation pi. A 1% shock increase in inflation leads to an immediate contract in output by 2% basis points in the next period. The response returns to its steady state after 3 periods of time

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horizons and becomes insignificant. The monetary condition index that the monetary policy performance decreases by 1% basis points immediately, but returns quickly to its steady state and becomes insignificant. The nominal exchange rate increased immediately by 0.05%, and return to its steady state after 2 periods of time horizon. The same story can be said for the money supply xx and the reserve money md, immediate increase, but the money supply xx takes a longer period to return to its steady state.

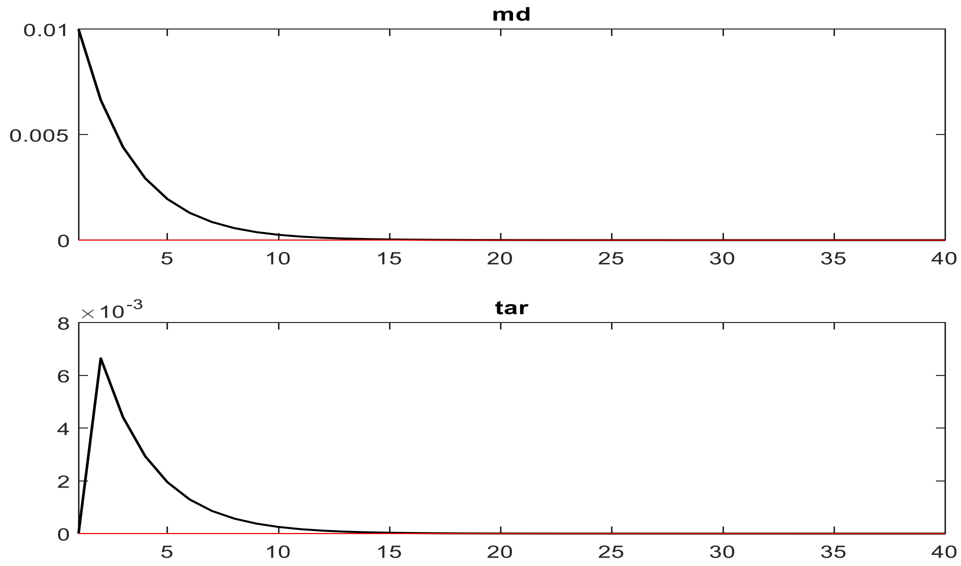

Figure (3), Shocks to Reserve Money e_md:

The figure shows a response of the variables to a 1% shock increase in the reserve money. A 1% shock increase in reserves money leads to an increase in the tar by 0.6% basis points in the next period. The response returns to its steady state after 12 periods of time horizons.

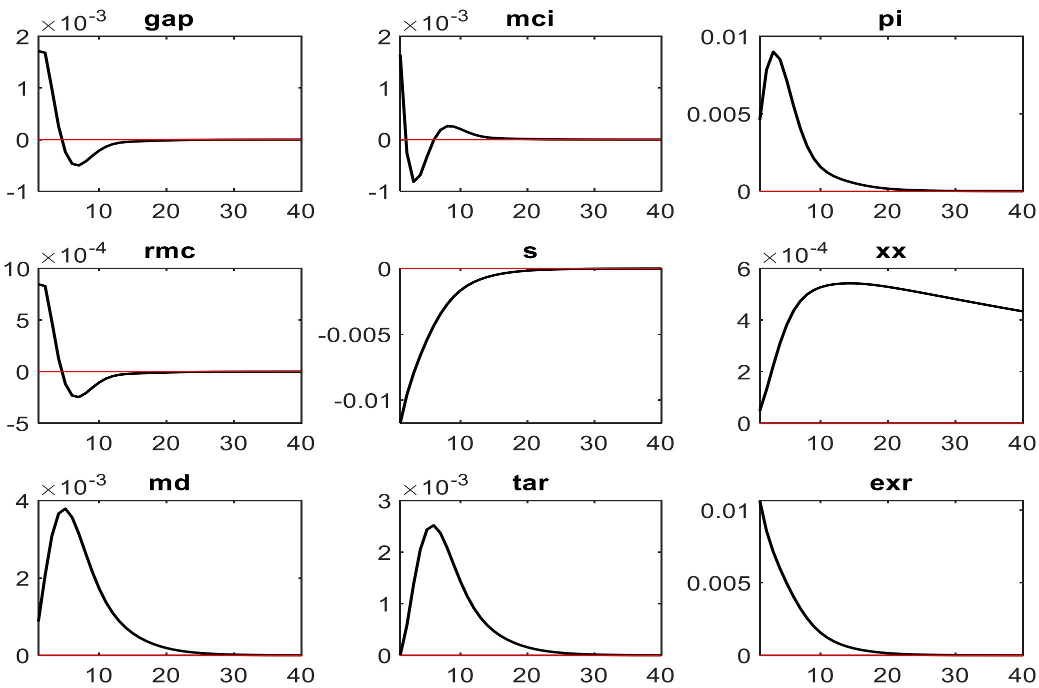

Figure (4) Shocks to Exchange Rate e_exr:

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The figure shows a response of the variables to a 1% shock increase in the nominal exchange rate. A 1% shock increase in the nominal exchange rate leads to an immediate increase in inflation by 0.005% basis points in the next period. The response continues increasing to reach the peak after the 1-time horizon, then returns gradually to its steady state after 20-time horizons. The output gap increases immediately to 0.2%, then dropped quickly to return to its steady state and becomes insignificant after 3 period time horizons. The monetary condition index increase for a while but returns quickly to its steady state and becomes insignificant. The money supply xx increased gradually and reach the peak after the 10-time horizon and takes a longer time to return to the steady state, the same story is true for the reserve money md but return faster to the steady state compared to the money supply.

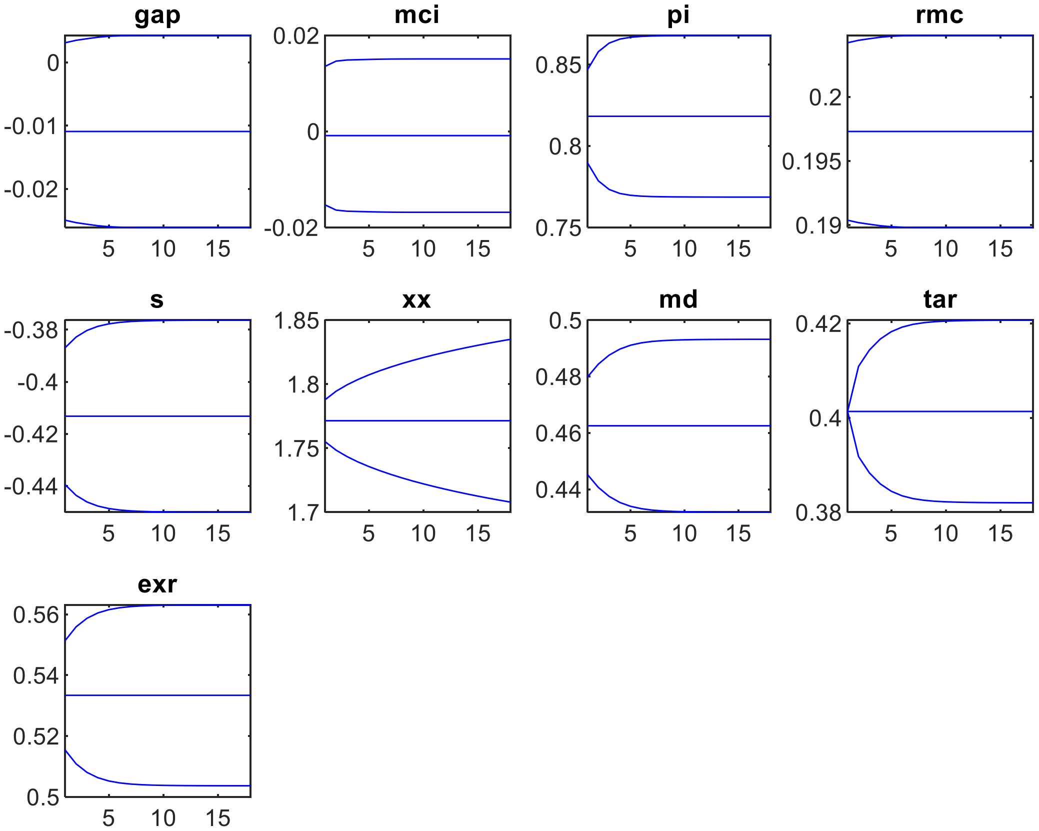

Figure (5), Forecast (18 periods a head forecast horizon):

5. The Conclusion and Policy Implication

The paper aims to build a small open economy New Keynesian model for the Sudanese economy utilizing the DSGE technique for the monetary policy discussion and analysis. There are many proxies for the policy rate in the case of a full-fledged Islamic monetary policy regime where the policy rate is prohibited, such as the Murabaha rate, the rate of return on the housing industry. The ongoing paper demonstrates that the nominal exchange rate can be used as a proxy for the policy rate and obtain a result that is consistent with what is expected based on economic theory in the case of a full-fledged Islamic monetary system. Hence the main contribution of this paper is introducing the difference of nominal exchange rate as an alternative monetary policy instrument for a full-fledged Islamic economy.

The main findings that we extract from the empirical investigation of the research are; the estimation shows that in case of monetary policy shocks the increase in the exchange rate directly leads to a contraction in aggregate demand. The estimate indicates that when output deviates from the steady state of one percent, the monetary condition index is changed by – 0.004%. The nominal exchange rate increases by 0.997% when inflation deviates from the steady state by 1%. The estimation shows that the fluctuations in output in the short run are primarily driven by output shocks, inflation shocks, and exchange rate shocks. In the very short run, shocks to output and inflation explain respectively about 78.61% and 13.94% of the variance in output. It is worth noting that shocks in output become more important. Hence, the variance decomposition analysis shows that the lags of output, exchange rate, and inflation contribute significantly to their contemporaneous values.

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Moreover, it can be extracted from the estimation that the response of the variables to policy shocks is in line with the economic theory, and what has been expected from the variables. The empirical findings of the model demonstrate how models could help in structuring policy discussions and provide a framework for assessing the policy-making process. The estimation of the structural parameters falls within plausible ranges, and simulation results suggest that output volatility is the most important part of determining the fluctuation in the Sudanese economy. The reporting impulse response functions to several shocks, and performing variance decomposition analysis indicates that the model performs quite well in these contexts. The shocks to most of the variables cause disequilibrium in the economy, which will last for about 2 – 3 years.

To conclude, the Sudanese monetary authorities can rely on the nominal exchange rate for purpose of tracking the dynamics in monetary policy DSGE models that can be used for discussion and policy analysis. To great extent, the Sudanese authorities have to give great concern to the output fluctuations based on the variance decomposition analysis. Toward that end, deeper investigations and research should be conducted to find out suitable monetary policy instruments that should be characterized by the needed dynamics to stimulate the monetary policy performance in Sudan.

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Appendixes:

Figure (1), the Priors:

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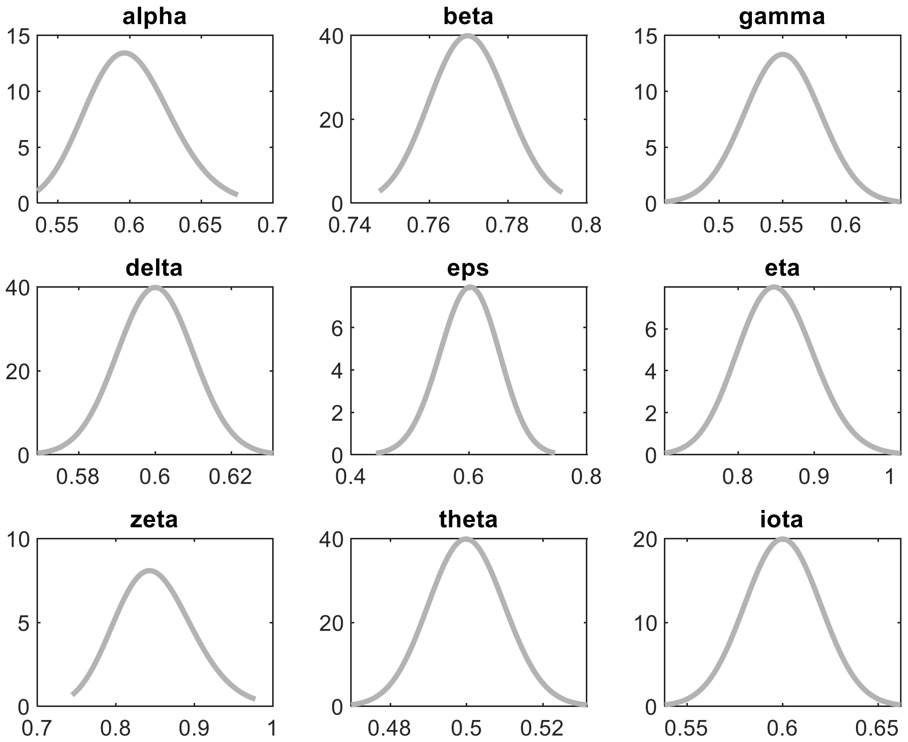

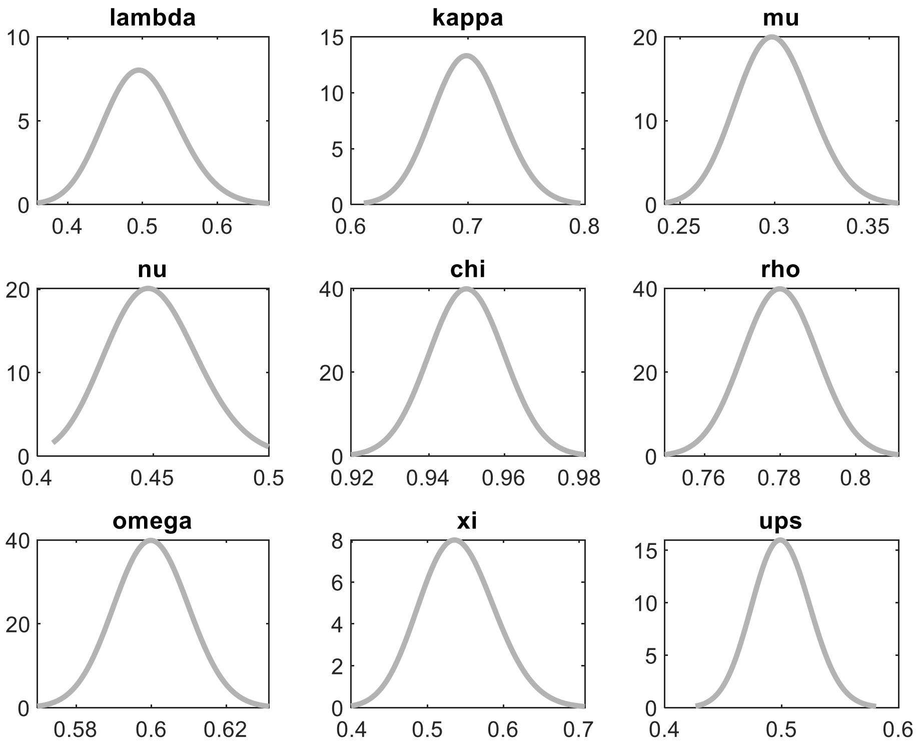

Figure (2), the Prior and the Posterior:

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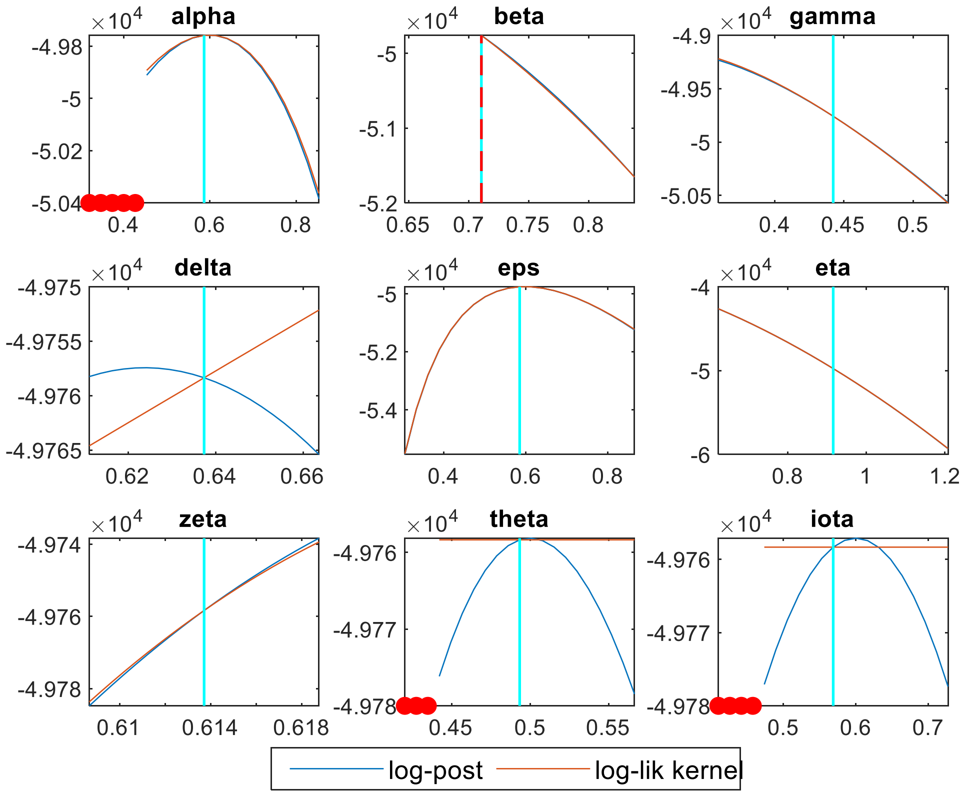

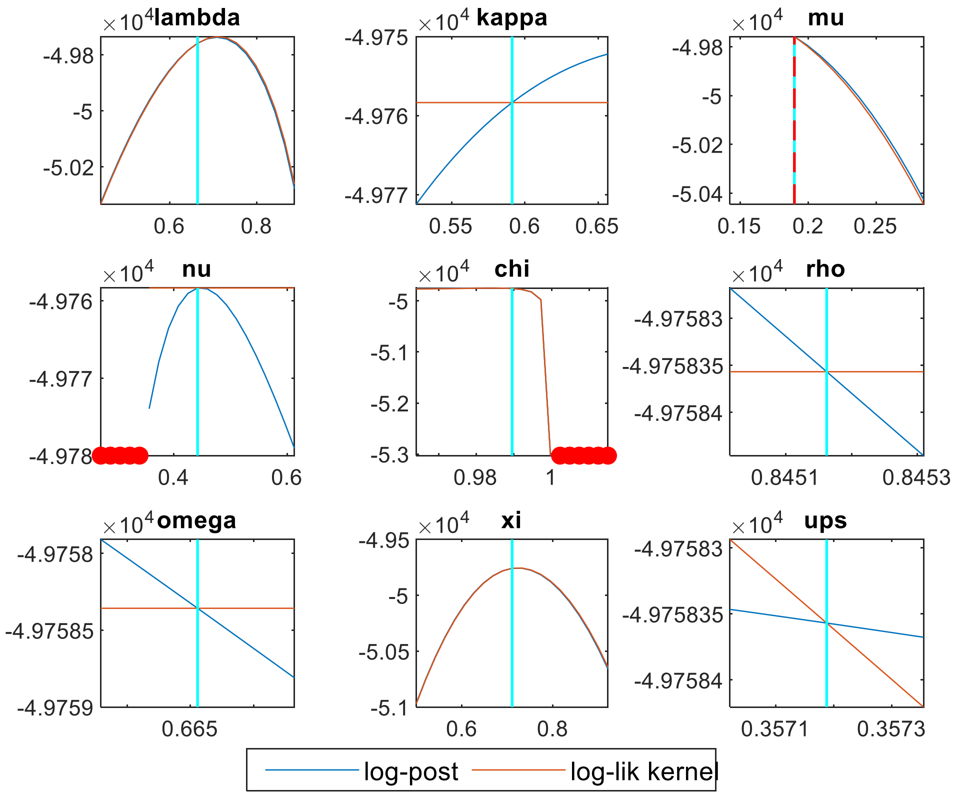

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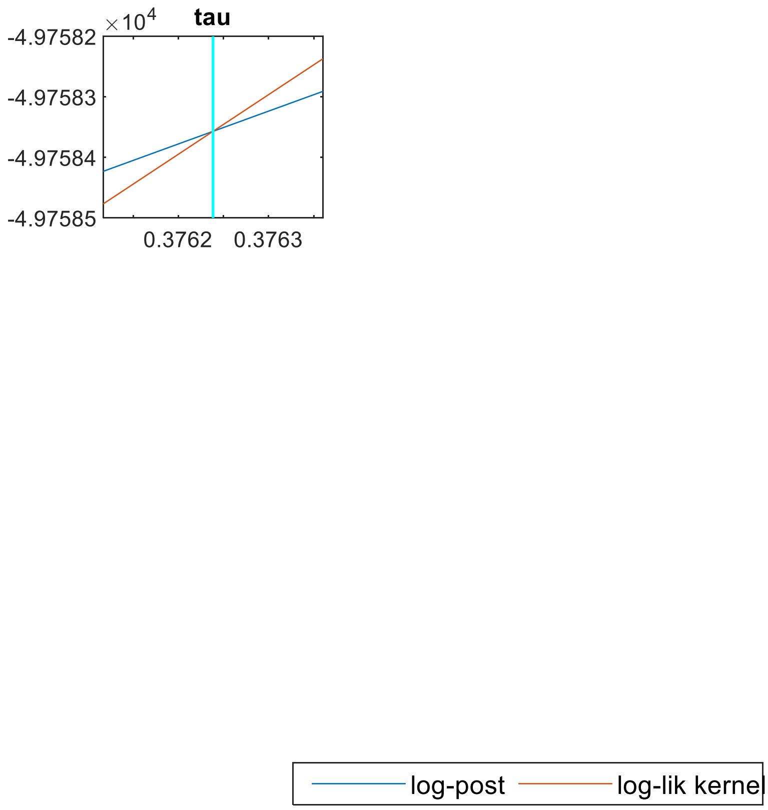
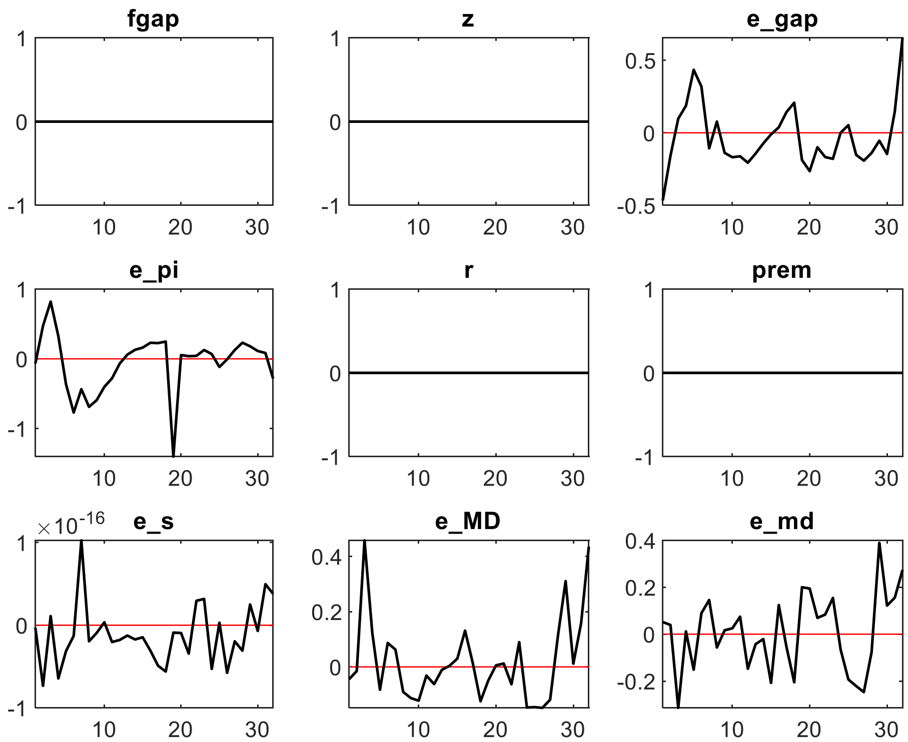


Figure (3) Smoothed Shocks:



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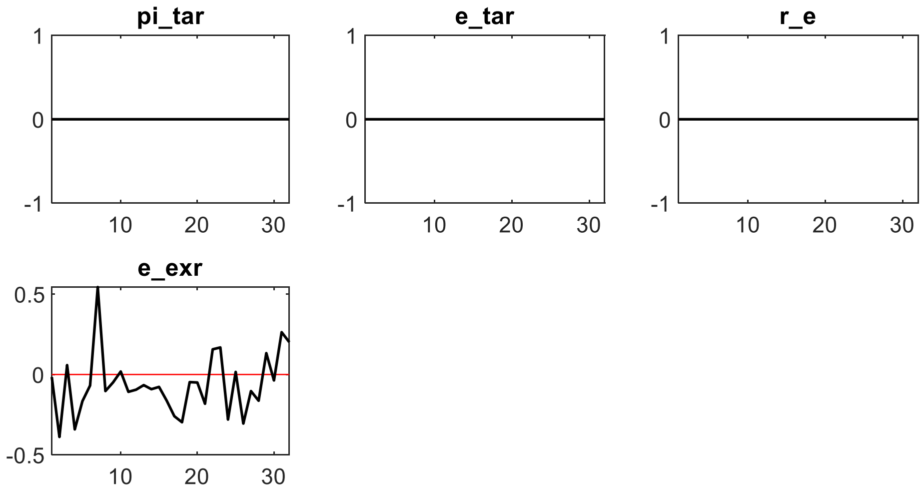

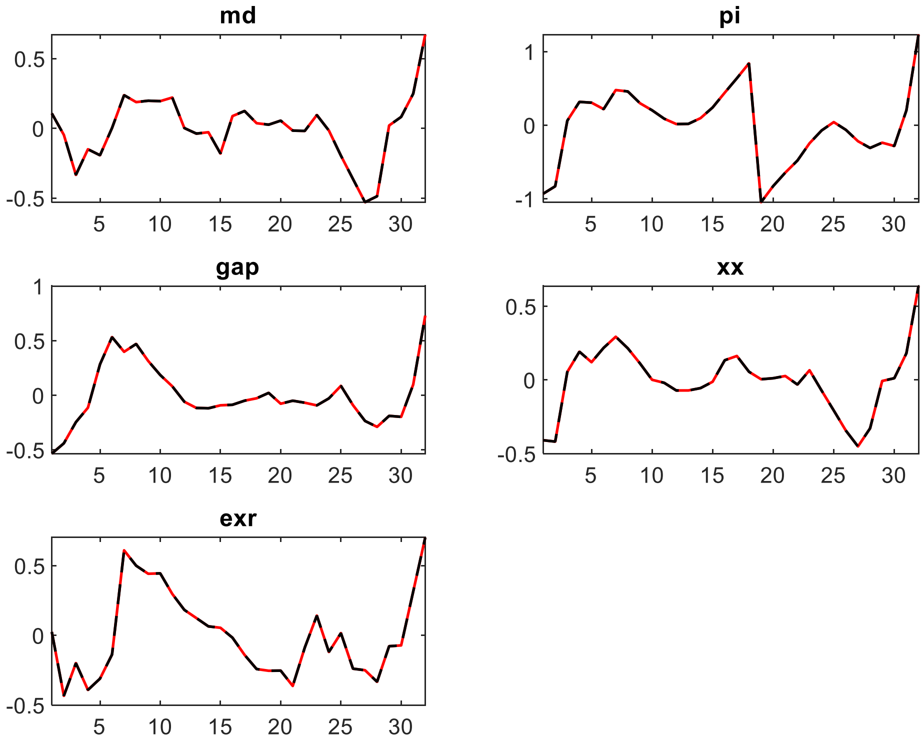

Figure (4), Historical and Smoothed Variables:

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