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Macroeconomic Impacts of Fiscal Policy in Ghana: Analysis of an Estimated DSGE Model with Financial Exclusion

Paul Owusu Takyi
Roberto Leon-Gonzalez

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Macroeconomic impacts of Fiscal Policy in Ghana: Analysis of an Estimated DSGE Model with Financial Exclusion

Paul Owusu Takyi[1] and Roberto Leon-Gonzalez[2]

Abstract

This study develops and estimates a standard New-Keynesian DSGE model for the Ghanaian economy, for the analysis of the impacts of government spending, consumption tax, and labor income tax shocks on household consumption and working hours. It also applies the model to examination of the effects of fiscal policy shocks on key macroeconomic variables in the Ghanaian economy. The model features heterogeneous households of two types, financially excluded and financially included, and considers two labor markets: perfectly and monopolistically competitive labor markets. We use quarterly time series data from 1985Q1-2017Q4 to estimate the model's parameters using a Bayesian approach. The results show that a positive government spending shock has an expansionary effect on the consumption of financially excluded households but has a decreased effect on that of fully financially included ones. We find that positive consumption and labor income tax shocks decrease the consumption of financially excluded households more than that of financially included ones. From a policy perspective, government spending is effective for increasing output, employment, and the consumption of financially excluded households, although it reduces that of financially included ones.

Keywords: Fiscal policy, Financial exclusion, DSGE modeling, Bayesian Estimation
JEL Classification: E32, E62, H20

[1] National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan. Email:potakyi2005@gmail.com, phd15104@grips.ac.jp
[2] National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan. Email: rlg@grips.ac.jp

1. Introduction

Fiscal policy, as a macroeconomic policy, is one of the main policy tools available to fiscal and public authorities to intervene in and influence the level and the direction of real economic activities in an economy. Fiscal policy largely consists of alteration of government spending and taxes, and so in fact it is countercyclical demand management or macroeconomic policy. That is, during economic downturns (recession), an increase in government spending and/or a tax cut are used to boost aggregate demand and thus induce economic growth, whereas during economic upturns (boom), where the economy overheats, a decrease in government spending and/or a hike in taxes are adhered to in order to stabilize the economy. Fiscal policy long been discussed in the economics literature as a stabilization tool. For instance, in the 1920s and 1930s, fiscal policy was at the center stage in tax discussion by Ramsey (1927) and the macroeconomic analysis of Keynes (1936).

The 2007-2009 financial crisis has brought about a renewal of emphasis on fiscal policy as a stabilization policy instrument. The aftermath of the crisis, i.e. recession, has forced many governments, in both developed and developing countries, to utilize fiscal policy as a stabilization policy tool to stimulate macroeconomic economic variables. One argument in favor of the use of fiscal policy as a stabilization tool has been the limited financial market participation in many economies. As argued by Furlanetto (2011), if a section of the population cannot participate in the financial market, and therefore, consumption cannot be smoothed, fiscal policy becomes relevant. In that environment, a fiscal stimulus (e.g. increased government spending) can induce an expansionary effect in an economy by increasing the current income of households who are excluded from the financial market. According to that argument, financially included ("optimizing") households who anticipate an increase in taxes, intended to finance the increase in government spending, reduce their consumption and tend to work more to smooth consumption; this may result in a reduction in aggregate demand. However, households who cannot smooth consumption ("hand-to-mouth" or financially excluded households) simply consume their income to increase aggregate demand without changing their employment decisions. Such a behavior by the "hand-to-mouth" households may help to prompt an expansionary effect of government spending on key macroeconomic variables, especially on consumption and output. In favor of this argument, Spilimbergo et al. (2008), IMF staff, as cited in Furlanetto (2011), recommend increased public spending, and reduced taxes, or transfers towards households who cannot smooth consumption as a fiscal package for many countries.

In light of the above, many researchers have attempted to analyze, both theoretically and empirically, the macroeconomic effects of fiscal policy in various economies. Most such studies applied variants of macroeconomic models such as Vector Autoregressive (VAR), Structural VAR (SVAR) and Markov Switching. However, because of the limited capacity of those macroeconomic models to account for the presence of households who cannot participate in the financial market, consideration has been given to the use of dynamic stochastic general equilibrium (DSGE) models. The standard New Keynesian DSGE model, which only incorporates infinitely lived representative agents, who are assumed to enjoy full financial inclusion and, therefore, optimize their choices inter-temporally to smooth consumption, has been augmented to include those households who are financially constrained[3]. Despite this development, theoretical and empirical accounts DSGE models on the expansionary effects of fiscal policy on key macroeconomic variables, especially on consumption and output, is still widely debated. In particular, findings regarding the effects of government spending on aggregate consumption have been mixed and hence inconclusive.

Following suggestion by Mankiw (2000), Gali, et al. (2004) were the first to introduce "hand-to-mouth" households into their DSGE model. In a related study, Gali, et al. (2007) analyze the effect of government spending on consumption using a similar model with lump-sum taxes. They find that an increase in government spending has an expansionary effect on real economic variables including aggregate consumption and output. Following these seminal studies many studies have included various market frictions and nominal rigidities to critically examine the effects of various fiscal policies. While some of those studies find contradictory evidence to that of Gali, et al. (2007), others find supportive evidence. The strand of the literature finds a positive response of consumption following a positive government spending shock (Conenen and Straub (2005), López-Salido and Rabanal (2006), Jakab and Világi (2008), Furlanetto and Seneca (2009), Iwata (2009), Colciago (2011), Furlanetto (2011) Céspedes et al. (2013), González et al. (2014), and Babecký et al. (2018)). On the other hand , some find a negative consumption multiplier of government spending shock (Jakab and Világi (2008), Ratto et al. (2009), Forni et al. (2009), Stähler and Thomas (2012), Malik (2013), Bhattarai and Trzeciakiewicz (2017)).

The differences among those findings have been attributed to the presence (or absence) of various market frictions and rigidities that are featured in DSGE models, including size of financially excluded households, price and wage stickiness, and habit persistency. For instance, whereas Conenen and Straub (2005) document that a large share of financially excluded households (above 35%) is required to generate a positive consumption and output multipliers of government spending shock for the Euro Area, Iwata (2009) finds a positive consumption multiplier with a relatively small share of such households (25%) in the Japanese economy. Also, Ratto et al. (2009) introduce sticky wage into their model and find that government spending shock crowds-out consumption. However, Furlanetto (2011) and Colciago (2011) finds that the crowding-in effect of consumption observed in Gali et al. (2007) is preserved even when wages are sticky.

Furthermore, as noted by Iwata (2009), the dynamic responses of macroeconomic variables to a government spending shock in DSGE models largely depend on the financing behavior of fiscal authorities. Thus, a set of realistic tax rules that are practiced and used by fiscal authorities in the real world is of utmost importance. For example, the importance of including distortionary taxes in DSGE model analysis of fiscal policy effectiveness has been ossified by Bilbiie and Straub (2004). They show that distortionary taxes decrease after-tax wages and make it more difficult to generate a positive consumption multiplier of government spending shock. However, Linnemann (2004) shows that government spending shock can crowd-in consumption even when

[3] In the literature, they are referred to as "non-Ricardian", "hand-to-mouth, or "rule-of-thumb" consumers. In this paper, we call them "financially excluded" households.

distortionary taxes are present, explaining that this is possible when labor supply is elastic given that the tax base is widened by unemployment benefits (Iwata, 2009)[4]. These insights suggest that fiscal policy analysis ought to be carried out in models that feature distortionary taxes, which are major fiscal instruments on the revenue side of government budget[5] in lieu of the lump-sum taxes that are considered in most of the models mentioned above.

A number of studies have used DSGE framework to model the Ghanaian economy (e.g. Ahortor & Olopoenia, 2010; Houssa et al., 2010; Dagher et al., 2012; Bondzie et al., 2013; and Bondzie et al., 2014). Among these studies very few, if ever existed, analyze the macroeconomic impact of fiscal policy shocks in Ghana. Moreover, most of those studies consider only a representative household with full access to the financial and the capital markets[6]. However, a common characteristic of a developing country like Ghana is the predominance of financially excluded households; therefore, any macroeconomic policy modelling for this economy ought to consider the excluded group of households[7]. Further, most of those studies use calibration rather than estimation to undertake their goals.

This study addresses the above shortcomings, and thus contributes to the debate on effectiveness of fiscal policy by developing and estimating a closed economy DSGE model, which is rich in frictions and nominal rigidities and considers distortionary taxation, for the Ghanaian economy[8]. In particular, the model considers heterogeneous households: financially included and financially excluded households. As well, it introduces price stickiness, flexible and sticky wage dynamics, and two distortionary taxes: consumption and labor income taxes. We estimate this model using Bayesian techniques to examine the macroeconomic impacts of fiscal policy shocks in the Ghanaian economy. Specifically, we: [1] analyze the impacts of government spending shock on key macroeconomic variables; [2] examine the effects of consumption tax and labor income tax shocks on the consumption and employment decisions of both financially excluded and included households by considering those shocks as income shocks[9]; and [3] explore the interaction between fiscal and monetary policies in the economy.

As reported in detail later, we find that, among the three fiscal policy instruments considered in the model, the response of income tax rate to debt-to-output ratio is the

[4] Some of the papers that consider distortionary taxation in their DSGE models with financial exclusion include Forni et al. (2009), Iwata (2009), Dagher et al. (2012), Stähler and Thomas (2012), Drautzburg and Uhlig (2015), González et al. (2014), and Babecký et al. (2018).

[5] Indeed, many developing countries, including Ghana, use distortionary taxation rather than lump-sum taxation. For instance, prior to use of Value-Added Tax (VAT) system in Ghana, there was a sales tax which was replaced by the government in 1995 as a policy change to remedy the deficiencies in the sales tax to generate much revenue for the government.

[6] The only exception is the paper by Dagher et al. (2012).

[7] See Takyi and Leon-Gonzalez (2019).

[8] One paper that our paper shares many features with is the paper by Dagher et al. (2012). Even in their paper, they use calibration rather than estimation to undertake their goals. This put our paper first as we estimate our model in lieu of calibration.

[9] For justification of why analyzing the effect of income shocks on financially included and excluded households is desirable, see our previous paper: Takyi and Leon-Gonzalez (2019).

largest, followed by government spending and consumption tax rate. This suggests that fiscal authorities in Ghana use income tax as one of their major tools for the generation revenue to finance government debts and expenditures.

We also find that a positive government spending shock has an expansionary effect on consumption, output, employment, and inflation but turns to crowd-out consumption when wages are sticky. Also, the response of output and inflation to an expansionary fiscal policy is somewhat stronger in a market where wages are flexible than one where wages are sticky. At the disaggregated level, we find that an increase in government spending has a negative effect on the consumption of households who enjoy full financial inclusion but has an expansionary effect on that of financially excluded ones. Financially included households decrease their consumption in reaction to an upward adjustment in the nominal interest rate by the monetary authorities as a way of moderating the inflationary pressures caused by the positive government spending shock.

Furthermore, we find that hikes in consumption and labor income taxes discourage working and, thus, lead to a fall in labor supply, output, and consumption. At the disaggregated level, our results signal that lack of access to the financial sector and savings leave financially excluded households with no alternative to increasing their labor supply in order to mitigate the negative effect of those shocks on their consumption. Nevertheless, households that are financially included use the financial sector as a mechanism for tapping into their savings to insulate themselves from shocks, and rather reduce their working hours. Sadly, despite these inter-temporal optimal decisions by both households, we find that both type of shock decrease the consumption of the former more than that of the latter.

In addition, a contractionary monetary policy significantly leads to a fall in inflation, and in other real variables including output, employment, and consumption. The impulse response analysis shows that the response of these variables to a positive monetary positive shock is stronger under flexible wage dynamics than under sticky wage dynamics.

Finally, the results of our variance decomposition analysis show that, from the non-policy shocks side, technology and price mark-up shocks are important in driving the key macroeconomic variables of the Ghanaian economy. From the policy shocks side, consumption tax shock emerges as the main driver of those variables in the economy, with monetary policy shock playing a smaller role.

The rest of this paper is organized as follows. Section 2 describes the model. Section 3 explains the Bayesian estimation procedure and the data used. Section 4 discusses the results, and Section 5 presents conclusions and implications.

2. The Model

The model adopted here closely follows a standard New-Keynesian DSGE model featuring the so-called 'hand-to-mouth' households developed by Furlanetto and Seneca (2012). We, however, deviate from lump-sum tax considered in their model and introduce distortionary taxes including consumption and labor income taxes. Also, we introduce a fiscal authority (government) who collect those taxes from the households and issues debt to finance its expenditures. As a result, we introduce three fiscal rules: consumption tax rule, labor income tax rule, and government spending rule. In addition, we depart from labor union who negotiates wages in the labor market on behalf of the households and introduce a perfectly competitive and a monopolistically competitive labor markets[10].

2.1 Households

There are two kinds of households: a fraction λ of the households are financially excluded. These households do not have access to the financial market (and are indexed by 'm', for following 'hand-to-mouth' behavior). They neither save nor borrow and therefore, simply spend their disposable income in each period. The remaining fraction $(1-\lambda)$ of the households are financially included: that is, they have full access to the financial market (indexed by o, for 'optimizing'). This group of households chooses plans for consumption, saving, investment, and bond holdings to maximize their lifetime utility. Each household maximizes a lifetime identical inter-temporal utility function given by:

$$E_t \sum_{k=0}^{\infty} \beta^k U_{k+t}$$

where $\beta \in (0,1)$ is the subjective discount factor, and the identical instantaneous utility function is given by:

$$U_t^i = \left(\log(C_t^i - hC_{t-1}^i) - \frac{1}{1+\phi}(N_t^i)^{1+\phi} \right)$$

where $i \in (o,m)$ denotes the type of households. Here, C_t^i represents the household's real consumption at time t, C_{t-1}^i is aggregates consumption, N_t^i is the hours worked at time t, and $\phi > 0$ denotes the inverse of the Frisch labor elasticity. The level of consumption habit is represented by the parameter h and it is external to the households.

2.1.1. Financially included household utility maximization

Financially included households maximize the following utility:

$$U_t^o = \left(\log(C_t^o - hC_{t-1}^o) - \frac{1}{1+\phi}(N_t^o)^{1+\phi} \right)$$

subject to a budget constraint:

$$(1+\iota_t^c)C_t^o + I_t^o + \frac{B_t^o}{R_t P_t} = (1-\iota_t^n)\frac{W_t N_t^o}{P_t} + \frac{R_t^k K_t^o}{P_t} + \frac{B_{t-1}^o}{P_t} + \frac{D_t^o}{P_t}$$

as well as capital accumulation, expressed as:

$$K_{t+1}^o = (1-\delta)K_t^o + \Phi\left(\frac{I_t^o}{K_t^o}\right)K_t^o \qquad (1)$$

Here, P_t denotes the price level, I_t^o is real investment, B_t^o is holdings of one-period

[10] The perfectly competitive labor wage setting is as in Gali et al. (2007), whereas the monopolistically competitive wage setting is as in Junior (2016).

bonds that yield a gross risk-free interest rate R_t, W_t is nominal wage, K_t^o is capital holdings, R_t^k is the nominal rental rate on the stock of capital rented by the households, D_t^o is the dividend stream from firms, τ_t^c and τ_t^n are consumption and labor income taxes, respectively, paid by the households. Also, δ is the depreciation rate and $\Phi(.)$ is capital adjustment cost function, which has the following properties: $\Phi(\delta)=\delta$, $\Phi'>0$, $\Phi'(\delta)=1$, and $\Phi''\leq 0$.

The first order conditions for the financially included household's problem can be written as:

$$\lambda_t^o = \frac{1}{(1+\tau_t^c)(C_t^o - hC_{t-1}^o)} \tag{2}$$

$$Q_t = E_t\left\{\Lambda_{t,t+1}\left[\frac{R_{t+1}^k}{P_{t+1}} + Q_{t+1}\left((1-\delta)+\phi_{t+1} - \left(\frac{I_{t+1}^o}{K_{t+1}^o}\right)\phi'_{t+1}\right)\right]\right\} \tag{3}$$

$$Q_t = \frac{1}{\Phi'(I_t^o / K_t^o)} \tag{4}$$

$$E_t(\Lambda_{t,t+1}) = \beta E_t\left\{\frac{\lambda_{t+1}^o}{\lambda_t^o}\right\} = \frac{E_t(P_{t+1})}{R_t P_t} \tag{5}$$

$\phi_{t+1} \equiv \Phi(I_{t+1}^o / K_{t+1}^o)$, $\phi'_{t+1} \equiv \Phi'(I_{t+1}^o / K_{t+1}^o)$, $\Lambda_{t,t+1}$ is the stochastic discount factor, λ_t^o is the Lagrange multiplier, and Q_t is the (real) shadow value of capital (Tobin's Q). Here, the elasticity of investment-capital ratio with respect to Q is given by $-(1/(\Phi''(\delta)\delta)) = \eta$.

2.1.2. Financially excluded household utility maximization

Financially excluded households are unable to smooth consumption in the face of fluctuations in their labor income. Thus, at each period they solve a static problem and therefore maximize their period utility, given by:

$$U_t^m = \left(\log(C_t^m - hC_{t-1}^m) - \frac{1}{1+\phi}(N_t^m)^{1+\phi}\right),$$

subject to the following budget constraint:

$$(1+\iota_t^c)C_t^m = (1-\iota_t^n)\frac{W_t N_t^m}{P_t}$$

The first order conditions for the financially excluded households yield:

$$\lambda_t^m = \frac{1}{(1+\tau_t^c)(C_t^m - hC_{t-1}^m)} \tag{6}$$

$$C_t^m = \frac{(1-\tau_t^n)}{(1+\tau_t^c)}\frac{W_t N_t^m}{P_t} \tag{7}$$

2.2. Aggregation

Aggregate consumption and hours worked are given as a weighted average of the corresponding variables for each type of households, as follows:

$$C_t = \lambda C_t^m + (1-\lambda) C_t^o \tag{8}$$

$$N_t = \lambda N_t^m + (1-\lambda) N_t^o \tag{9}$$

Also, aggregate capital stock, investment, bonds, and dividends are given respectively as $K_t = (1-\lambda) K_t^o$, $I_t = (1-\lambda) I_t^o$, $B_t = (1-\lambda) B_t^o$, and $D_t = (1-\lambda) D_t^o$.

2.3. Firms

Firms are divided into two groups of producers: final goods producer firms and intermediate goods producer firms. The goods from the intermediate firms are used as inputs by the perfectly competitive final goods producers firms.

2.3.1. Final goods producer firms

Final goods producer firms produce a final good Y_t and sell it in a perfectly competitive market. The final good is a composite of a continuum of differentiated intermediate goods $X_t(j)$, $j \in [0,1]$ with a constant returns technology given by:

$$Y_t = \left(\int_0^1 X_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where $X_t(j)$ denotes the quantity of the intermediate good j, and $\varepsilon > 1$ represents the elasticity of substitution between differentiated intermediate goods. The final goods producer firms choose the optimal amount of each intermediate good to maximize their profit, which is the difference between revenues and costs, taken as given price of the final good P_t given by:

$$\Pi_t = P_t Y_t - \int_0^1 P_t(j) X_t(j) dj$$

where $P_t(j)$ is the price of j^{th} intermediate good. The solution of the firm's profit maximization yields the set of demand function:

$$X_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon} Y_t$$

and a zero-profit condition expressed as:

$$P_t = \left(\int_0^1 P_t(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}$$

2.3.2. Intermediate goods producer firms

All intermediate goods producer firms use the same production function. The production function for producing an intermediate good j is given by:

$$Y_t(j) = K_t(j)^{\alpha}(A_t N_t(j))^{1-\alpha} \tag{10}$$

where A_t is labor-augmenting technology shock, $K_t(j)$ and $N_t(j)$ respectively represent capital and labor services hired by firm j, and $0 \le \alpha \le 1$ is the share of capital to output. The technology shock is assumed to follow an AR (1) process with an i.i.d normal error term given by $a_t = \rho_a a_{t-1} + u_t^a$. Firm's cost minimization problem implies an optimality condition written as:

$$\frac{K_t(j)}{N_t(j)} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{W_t}{R_t^k}\right) \tag{11}$$

Thus, real marginal cost, which is common to all firms, can be written as:

$$MC_t = \frac{1}{\Theta}\left(\frac{R_t^k}{P_t}\right)^{\alpha}\left(\frac{W_t}{P_t A_t}\right)^{1-\alpha} \tag{12}$$

where $\Theta = (1-\alpha)^{1-\alpha}\alpha^{\alpha}$

2.4. Price Setting

In each period, the intermediate goods producer firms in the economy set nominal prices according to a stochastic time dependent rule proposed by Calvo (1983). A fraction of the firms are able to set a new price P_t^* with probability $1-\theta$ in each period. Thus, only a fraction $1-\theta$ of the firms are able to reset their prices while the prices of the remaining fraction θ are unchanged. The maximization problem of a j^{th} firm is given by:

$$\max_{P_t^*} E_t \sum_{k=0}^{\infty} \theta^k \left\{ \Lambda_{t,t+k} Y_t(j) \left[P_t^* - \varepsilon_{t+k}^p P_{t+k} MC_{t+k} \right] \right\},$$

subject to:

$$Y_{t+k}(j) = X_{t+k}(j) = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\varepsilon} Y_{t+k}$$

The first order condition for the firm's problem can be written as:

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ \Lambda_{t,t+k} Y_{t+k}(j) \left[P_t^* - \frac{\varepsilon}{\varepsilon - 1} \varepsilon_{t+k}^p P_{t+k} MC_{t+k} \right] \right\} = 0 \tag{13}$$

where ε_{t+k}^p is price mark-up shock common to all firms; it is assumed to follow an AR (1) process with an i.i.d normal error term given by $\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + u_t^p$. Finally, aggregate price level equation is described by:

$$P_t = \left[\theta P_{t-1}^{1-\varepsilon} + (1-\theta)(P_t^*)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{14}$$

2.5. Labor Market

For wage dynamics in the economy, we consider two labor markets: a perfectly competitive and a monopolistically competitive labor markets. Under both markets, there is no difference between the wages among the households[11].

2.5.1. Perfectly competitive market

Each household chooses the number of hours worked, taken as given the market wage rate. Thus, the real wage is equated to the marginal rate of substitution between consumption and hours worked. From the households' utility maximization problem the wage setting for financially included and excluded households can, respectively, be written as:

$$\frac{W_t}{P_t} = \frac{(N_t^o)^{\phi}(C_t^o - hC_{t-1}^o)(1+\tau_t^c)}{(1-\tau_t^n)} \tag{15a}$$

$$\frac{W_t}{P_t} = \frac{(N_t^m)^{\phi}(C_t^m - hC_{t-1}^m)(1+\tau_t^c)}{(1-\tau_t^n)} \tag{16a}$$

2.5.2. Monopolistically competitive market

The wage setting under this market directly follows the one in Junior (2016). Households supply a differentiated labor services, ($N_{t,j}$), in a monopolistically competitive market structure, and these labor services are sold to a representative firm. The representative firm then aggregates these different types of labor service into a single type of labor input, N_t, given by:

$$N_t = \left(\int_0^1 N_{j,t}^{\frac{\varepsilon_w - 1}{\varepsilon_w}} dj \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}$$

where ε_w denotes the elasticity of substitution between different types of labor. The representative firm then chooses the optimal amount of each labor service to maximize its profit taken as given the wage rate, W_t, written as:

$$\prod_t = W_t N_t - \int_0^1 W_{j,t} N_{j,t} dj$$

where $W_{j,t}$ is the wage of j^{th} labor service and $\prod_t$ is the profit. The solution of the firm's profit maximization yields the set of demand function:

$$N_{j,t} = \left(\frac{W_t}{W_{j,t}} \right)^{\varepsilon} N_t$$

and aggregate wage level equation expressed as:

$$W_t = \left(\int_0^1 W_{j,t}^{1-\varepsilon_w} dj \right)^{\frac{1}{1-\varepsilon_w}}$$

[11] That is, both financially included and excluded households receive the same wage rates.

Additionally, in each period a fraction, $1-\theta$, of the households, chosen randomly and independently, optimally define their wage by choosing $W_{j,t}^{*}$. This fraction of the households know that by optimally choosing $W_{j,t}^{*}$ for period t, they face a probability of θ_w^N which leads to those wages remaining the same for N periods. On the other hand, the remaining fraction, θ, of the households follow a wage stickiness rule proposed by Calvo (1983), which maintains the same wage by equating current period wage to the previous one ($W_{j,t} = W_{j,t-1}$). Therefore, considering the taxes on their labor income, the maximization problem of household i can be expressed as:

$$\max_{W_{j,t}^{*}} E_t \sum_{k=0}^{\infty} (\beta\theta_w)^k \left\{ -\frac{(N_{j,t+k}^{i})^{1+\phi}}{1+\phi} - \lambda_{t+k}^{i} \left[-W_{j,t}^{*} N_{j,t+k}^{i} (1-\iota_t^{n}) \right] \right\}$$

subject to :

$$N_{j,t}^{i} = \left(\frac{W_t}{W_{j,t}} \right)^{\varepsilon} N_t^{i}$$

This can be written as:

$$\max_{W_{j,t}^{*}} E_t \sum_{k=0}^{\infty} (\beta\theta_w)^k \left\{ -\frac{1}{1+\phi} \left[N_{t+k}^{i} \left(\frac{W_{t+k}}{W_{j,t}^{*}} \right)^{\varepsilon_w} \right]^{1+\phi} + \lambda_{t+k}^{i} \left[W_{j,t}^{*} N_{t+k}^{i} \left(\frac{W_{t+k}}{W_{j,t}^{*}} \right)^{\varepsilon_w} (1-\iota_t^{n}) \right] \right\}$$

The first order condition of the above problem yields:

$$W_{j,t}^{*} = \left(\frac{\varepsilon_w}{\varepsilon_w - 1} \right) E_t \sum_{k=0}^{\infty} (\beta\theta_w)^k \left[\frac{(N_{j,t+k}^{i})^{\phi}}{\lambda_{t+k}^{i} (1-\iota_t^{n})} \right] \qquad (15b)$$

Finally, the aggregate wage level equation is described by:

$$W_t = \left[\theta_w W_{t-1}^{1-\varepsilon_w} + (1-\theta_w)(W_t^{*})^{1-\varepsilon_w} \right]^{\frac{1}{1-\varepsilon_w}} \qquad (16b)$$

2.6. The Central Bank (Monetary Policy)

There is a monetary authority who controls monetary policy by setting the nominal interest rate r_t according to a Taylor (1993) rule expressed as:

$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}} \right)^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi_{ss}} \right)^{\phi_\pi} \left(\left(\frac{Y_t}{Y_{ss}} \right) \Big/ \left(\frac{Y_{t-1}}{Y_{ss}} \right) \right)^{\phi_y} \right]^{(1-\rho_r)} \exp(\varepsilon_t^{r}) \qquad (17)$$

where, ρ_r denotes the degree of interest-rate smoothing, ϕ_π and ϕ_y are the weights the central bank places on inflation and output growth, respectively, and ε_t^{r} represents a monetary policy shock which is assumed to be exogenous with an i.i.d normal error term written as $\varepsilon_t^r = u_t^r$.

2.7. Fiscal Authority (Fiscal Policy)

There is a fiscal authority (government) who collects taxes from households and issues debt to finance his spending. The government budget constraint is written as:

$$\frac{B_t}{P_t R_t} + \iota_t^c C_t + \frac{\iota_t^n W_t N_t}{P_t} = \frac{B_{t-1}}{P_t} + G_t \tag{18}$$

The government possesses one fiscal policy instrument on the expenditure side (G_t) and two fiscal policy instruments on the revenue side: ι_t^c and $_t^n$. These instruments follow the same fiscal policy rules as in Junior (2016) and Forni, et al. (2009). They are respectively written as:

$$\frac{G_t}{G_{ss}} = \left(\frac{G_{t-1}}{G_{ss}}\right)^{\rho_g} \left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} \frac{Y_{ss}P_{ss}}{B_{ss}}\right)^{\phi_g(1-\gamma_g)} \exp(\varepsilon_t^g) \tag{19}$$

$$\frac{\tau_t^c}{\tau_{ss}^c} = \left(\frac{\tau_{t-1}^c}{\tau_{ss}^c}\right)^{\rho_{\tau c}} \left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} \frac{Y_{ss}P_{ss}}{B_{ss}}\right)^{\phi_{\tau c}(1-\gamma_{\tau c})} \exp(\varepsilon_t^{\tau c}) \tag{20}$$

$$\frac{\tau_t^n}{\tau_{ss}^n} = \left(\frac{\tau_{t-1}^n}{\tau_{ss}^n}\right)^{\rho_{\tau n}} \left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} \frac{Y_{ss}P_{ss}}{B_{ss}}\right)^{\phi_{\tau n}(1-\gamma_{\tau n})} \exp(\varepsilon_t^{\tau n}) \tag{21}$$

Here, G_t is government spending, B_t is government debt, ε_t^g , $\varepsilon_t^{\tau c}$, and $\varepsilon_t^{\tau n}$ are government spending shock, consumption tax shock, and labor income tax shock, respectively. All those shocks are assumed to be exogenous with an i.i.d normal error term.

2.8. Equilibrium

Goods market clearing condition requires aggregate output to be equal to aggregate demand (the sum of aggregate consumption, investment, government spending) expressed as:

$$Y_t = C_t + I_t + G_t \tag{22}$$

2.9. Log-linearized equilibrium conditions

Here, the log-linearized versions of the equilibrium conditions and the first order conditions are presented. The first-order Taylor approximation around a zero-inflation steady state is used for some conditions whereas other conditions precisely hold. Note that lower case letters or variables with "^" represent log-deviation with respect to the corresponding steady state values. The following log-linearized equations summarize the equilibrium dynamics of the model.

2.9.1. Households

The financially included households' consumption optimality conditions with equations (2) and (5) combined yields:

$$c_t^o = \frac{h}{1+h} c_{t-1}^o + \frac{1}{1+h} E_t(c_{t+1}^o) - \frac{1-h}{1+h}(r_t - E_t(\pi_{t+1})) + \left[\frac{1-h}{1+h}\right]\left[\frac{\iota_{ss}^c}{1+\iota_{ss}^c}\right](E(\hat{\iota}_{t+1}^c) - \hat{\iota}_t^c) \tag{23}$$

$$\hat{\lambda}_t^o = -\frac{\iota_{ss}^c}{1+\iota_{ss}^c}\hat{\iota}_t^c - \frac{1-h}{1+h} c_t^o + \frac{h}{1+h} c_{t-1}^o \tag{24}$$

The investment equation (equation 4) and it relationship with the equation which describes the dynamics of Tobin's Q (equation 3) can respectively be written as:

$$i_t - k_t = \eta q_t \tag{25}$$

$$q_t = -[r_t - E_t(\pi_{t+1})] + [1-\beta(1-\delta)]E_t(r_{t+1}^k) + \beta E_t(q_{t+1}) \tag{26}$$

The log-linearized version of the capital accumulation equation (equation (1) can be written as:

$$k_{t+1} = (1-\delta)k_t + \delta i_t \tag{27}$$

The financially excluded households' consumption optimality condition (equation 6 and 7) can respectively be written as:

$$\hat{\lambda}_t^m = -\frac{\iota_{ss}^c}{1+\iota_{ss}^c}\hat{\iota}_t^c - \frac{1-h}{1+h} c_t^m + \frac{h}{1+h} c_{t-1}^m \tag{28}$$

$$c_t^m = w_t + n_t^m - \frac{\iota_{ss}^c}{1+\iota_{ss}^c}\hat{\iota}_t^c - \frac{\iota_{ss}^n}{1-\iota_{ss}^n}\hat{\iota}_t^n \tag{29}$$

The log-linearization of aggregate variables (real consumption and labor hours) implies that:

$$c_t = \lambda c_t^m + (1-\lambda)c_t^o \tag{30}$$

$$n_t = \lambda n_t^m + (1-\lambda)n_t^o \tag{31}$$

Here, it is assumed that the steady consumption and labor supply is the same for all households i.e. $C_{ss} = C_{ss}^o = C_{ss}^m$ and $N_{ss} = N_{ss}^o = N_{ss}^m$.

2.9.2. Firms

The familiar equation (New Keynesian Phillips Curve) describing the dynamics of price inflation as a function of the deviations of the average logarithm of mark-up from its steady state level can be obtained from equation 13 and 14 written as:

$$\pi_t = \beta E_t(\pi_{t+1}) + \kappa_p(mc_t + \hat{\varepsilon}_t^p) \tag{32}$$

where, $\kappa_p = \frac{(1-\beta\theta)(1-\theta)}{\theta}$, $\pi_t = p_t - p_{t-1}$ is price inflation and mc_t is real marginal cost and using equation 12, we obtain:

$$mc_t = w_t - y_t + n_t \tag{33}$$

Additionally, cost minimization implies that the ratio of inputs (capital to labor ratio) given by equation 11 can be written as:

$$r_t^k = w_t - k_t + n_t \tag{34}$$

Also, log-linearization of the production function (equation 10) yields:

$$y_t = \alpha k_t + (1-\alpha)(a_t + n_t) \tag{35}$$

2.9.3. Labor Market

The log-linearization of the wage equation under perfectly competitive market (equations 15a and 16a) gives:

$$w_t = \phi n_t^o + \frac{1}{1-h} c_t^o - \frac{h}{1-h} c_{t-1}^o + \frac{\iota_{ss}^c}{1+\iota_{ss}^c} \hat{\iota}_t^c + \frac{\iota_{ss}^n}{1-\iota_{ss}^n} \hat{\iota}_t^n \tag{36a}$$

$$w_t = \phi n_t^m + \frac{1}{1-h} c_t^m - \frac{h}{1-h} c_{t-1}^m + \frac{\iota_{ss}^c}{1+\iota_{ss}^c} \hat{\iota}_t^c + \frac{\iota_{ss}^n}{1-\iota_{ss}^n} \hat{\iota}_t^n \tag{37a}$$

where ι_{ss}^n and ι_{ss}^c are steady state labor income tax and consumption tax rates, respectively.

Also, the optimality condition following the household's wage setting problem under monopolistically competitive market structure (combining equations 15b and 16b) yields the familiar New Keynesian Phillips Curve for wage inflation for each type of households as given below:

$$\pi_t^w = \beta E_t(\pi_{t+1}^w) + \kappa_w[\phi n_t^o + \frac{\iota_{ss}^n}{1-\iota_{ss}^n} \hat{\iota}_t^n - \hat{\lambda}_t^o] \tag{36b}$$

$$\pi_t^w = \beta E_t(\pi_{t+1}^w) + \kappa_w[\phi n_t^m + \frac{\iota_{ss}^n}{1-\iota_{ss}^n} \hat{\iota}_t^n - \hat{\lambda}_t^m] \tag{37b}$$

where, $\kappa_w = \dfrac{(1-\beta\theta_w)(1-\theta_w)}{\theta_w}$, $\pi_t^w = w_t - w_{t-1}$ is wage inflation.

2.9.4. Monetary Authority

The log-linearization of the monetary policy rule (equation 17) gives:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)[\phi_\pi \pi_t + \phi_y (y_t - y_{t-1})] + \varepsilon_t^r \tag{38}$$

2.9.5. Fiscal Authority

The log-linearization of the government budget constraint (equations 18) leads to:

$$\frac{B_{ss}}{Y_{ss}} \beta(b_t - r_t) = \frac{B_{ss}}{Y_{ss}} (b_{t-1} - \pi_t) + \gamma_G g_t - \iota_{ss}^c \gamma_C (c_t + \hat{\iota}_t^c) - \iota_{ss}^n \frac{W_{ss} N_{ss}}{Y_{ss}} (\hat{\iota}_t^n + w_t + n_t) \tag{39}$$

Also, log-linearization of the three fiscal policy rules, equations 19, 20, and 21, respectively gives:

$$g_t = \rho_g g_{t-1} + (1-\rho_g)\phi_g (b_{t-1} - y_{t-1}) + \varepsilon_t^g \quad (40)$$

$$\hat{\iota}_t^c = \rho_{\iota c}\, \hat{\iota}_{t-1}^c + (1-\rho_{\iota c})\phi_{\iota c} (b_{t-1} - y_{t-1}) + \varepsilon_t^{\iota c} \quad (41)$$

$$\hat{\iota}_t^n = \rho_{\iota n}\, \hat{\iota}_{t-1}^n + (1-\rho_{\iota n})\phi_{\iota n} (b_{t-1} - y_{t-1}) + \varepsilon_t^{\iota n} \quad (42)$$

2.9.6. Equilibrium

Log-linearizing the market clearing condition (equation 22) yields:

$$y_t = \gamma_C c_t + \gamma_I i_t + \gamma_G g_t \quad (43)$$

where $\gamma_C = \frac{C_{ss}}{Y_{ss}}$, $\gamma_I = \frac{I_{ss}}{Y_{ss}}$, $\gamma_G = \frac{G_{ss}}{Y_{ss}}$ are the ratio of steady states of real consumption, investment, and government expenditure to output, respectively.

2.1.1. Shock processes

All shock processes in the set-up are given in a log-linearized form and are assumed to follow an AR (1) process (except for the four policy shocks which are assumed to be exogenous) with an i.i.d normal distribution error term and with zero mean and its own variance, δ_e^2 (i.e. $u_t^e \sim N(0, \delta_e^2)$, where e is the shock type) written below:

Price mark-up shock:

$$\hat{\varepsilon}_t^p = \rho_p\, \hat{\varepsilon}_{t-1}^p + u_t^p \quad (44)$$

Productivity shock

$$a_t = \rho_a a_{t-1} + u_t^a \quad (45)$$

Monetary policy shock

$$\varepsilon_t^r = u_t^r \quad (46)$$

Government spending shock

$$\varepsilon_t^g = u_t^g \quad (47)$$

Consumption tax shock

$$\varepsilon_t^{\iota c} = u_t^{\iota c} \quad (48)$$

Labor income tax shock

$$\varepsilon_t^{\iota n} = u_t^{\iota n} \quad (49)$$

It, therefore, follows from the above that equations 23 to 43, and the shock processes (equations 44 to 49) summarize the equilibrium in the economy. We consider two models here: Model 1 is the case where we consider flexible wage dynamics, whereas Model 2 considers sticky wage dynamics.

2.2. Steady states

The main steady state equations as implied by the model are summarized below:

$$\frac{W_{ss}N_{ss}}{Y_{ss}} = \frac{(1-\alpha)}{u^p}, \text{ where, } u^p = \frac{\varepsilon}{\varepsilon - 1},$$

$$\gamma_C = \frac{C_{ss}}{Y_{ss}} = (1-\gamma_G) - \frac{\delta\alpha}{(\rho+\delta)u^p}, \text{ where, } \rho = \frac{1}{\beta} - 1$$

$$\gamma_I = \frac{I_{ss}}{Y_{ss}} = 1 - \gamma_G - \gamma_C$$

$$\frac{B_{ss}}{Y_{ss}} = (\gamma_G - \iota_{ss}^c \gamma_C - \iota_{ss}^n \frac{W_{ss}N_{ss}}{Y_{ss}}) \frac{1}{\beta - 1}$$

3. Bayesian Estimation of the Model

The Bayesian inference method combines information from observed data and initial beliefs (priors) regarding the model's parameters to perform an estimation, resulting in a posterior distribution (estimates). That is, the posterior distribution of the parameters of the model (based on its log-linear state-space representation) are obtained by means of this method. Below, we briefly describe the procedure of this method, the data, the prior distribution used, and calibration.

3.1. Bayesian Inference Method

For a formal set up of the Bayesian method, let $p(\theta_{\mathrm{M}} \mid \mathrm{M})$ denote the prior distribution of the parameter vector θ_{M} for some model. Let the likelihood function of the observed data conditional on the model and its parameters be represented by $L(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) \equiv p(Y_T \mid \theta_{\mathrm{M}}, \mathrm{M})$. Here, $p(Y_T \mid \theta_{\mathrm{M}}, \mathrm{M})$ is the density of the data, Y are observations until period T, and $p(\bullet)$ stands for probability density function (pdf), e.g. gamma, beta, generalized beta, normal, inverse gamma, shifted gamma, and uniform function (Griffoli, 2013). Also, let the marginal density function of the data conditional on the model be written as:

$$p(Y_T \mid \mathrm{M}) = \int_{\theta_{\mathrm{M}}} p(\theta_{\mathrm{M}}; Y_T \mid \mathrm{M}) d\theta_{\mathrm{M}} = \int_{\theta_{\mathrm{M}}} p(Y_T \mid \theta_{\mathrm{M}}, \mathrm{M}) p(\theta_{\mathrm{M}} \mid \mathrm{M}) d\theta_{\mathrm{M}}$$

Then, using Bayes theorem, the posterior density $p(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M})$ can be expressed as the product of the likelihood function and the prior density, written as:

$$p(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) = \frac{p(Y_T \mid \theta_{\mathrm{M}}, \mathrm{M}) p(\theta_{\mathrm{M}} \mid \mathrm{M})}{p(Y_T \mid \mathrm{M})}$$

$$p(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) = \frac{L(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) p(\theta_{\mathrm{M}} \mid \mathrm{M})}{\int_{\theta_{\mathrm{M}}} p(Y_T \mid \theta_{\mathrm{M}}, \mathrm{M}) p(\theta_{\mathrm{M}} \mid \mathrm{M}) d\theta_{\mathrm{M}}}$$

From the above, the posterior kernel corresponds to the numerator of the posterior density, given as $\kappa(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) \equiv L(Y_T \mid \theta_{\mathrm{M}}, \mathrm{M}) p(\theta_{\mathrm{M}} \mid \mathrm{M})$. Also, the posterior distribution of the parameter vector θ_{M} for model M is directly proportional to the posterior density. This can be written as:

$$p(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) \propto L(\theta_{\mathrm{M}} \mid Y_T, \mathrm{M}) p(\theta_{\mathrm{M}} \mid \mathrm{M})$$

The above distribution is characterized by: standard measures of central tendency, such as the mean, mode, or median; and measures of dispersion, such as the standard deviation, or some selected percentiles. When the model and data of observables are given; the likelihood function can be calculated using the Kalman filter or other particle filters for non-linear models. By relying on the Metropolis-Hastings (MH) algorithm, and this what we use in the paper, the parameter values are drawn and used to plot a histogram of the posterior distribution.

3.2. Data

Estimation of the parameters of the DSGE model presented above uses quarterly time series data spanning 1985Q1 to 2017Q4 on real Gross Domestic Product (GDP), real household consumption expenditure, Consumer Price Index (CPI), real government expenditure, and nominal interest rate (monetary policy rate/discount rate) for Ghana.

Following Smets and Wouters (2007), log first difference of real GDP, real consumption, real government expenditure, and CPI multiplied by 100 are taken to represent output growth, consumption growth, government expenditure growth and inflation, respectively. Thus, our observed variables include: output growth, consumption growth, government expenditure growth, inflation, and interest rate. It is to be noted that quarterly series for real GDP, real consumption, and real government expenditure were interpolated from their annual counterparts using CPI as an indicator variable.[12]

All series are seasonally adjusted except nominal interest rate. Series on CPI and nominal interest rate were obtained from IMF's International Financial Statistics database, whereas series on real GDP, real consumption, and real government expenditure were sourced from the World Bank's World Development Indicators database (2019).

3.3. Calibration

Three of the model's parameters and three steady state variables were calibrated; the remaining parameters were estimated. We calibrated some parameters (because the data points were insufficient) and chose these three parameters (ε, η, and ε_w). We found that estimating them together with the other parameters distorted the convergence diagnostics of the MH algorithm, so, we set $\varepsilon = 6$, $\eta = 1$, $\varepsilon_w = 4$ using the calibrated values from Furlanetto and Seneca (2012). Also, γ_G, which is the steady ratio of real government expenditure to real GDP, was calibrated using our observed data and was set at 0.14. Also, the steady state values for consumption tax rate (ι_{ss}^c) and labor income tax rate (ι_{ss}^n) were set at 0.14 and 0.25, respectively.

3.4. Priors

The third, fourth, and fifth columns of Table 1 give a synopsis of our assumptions on the prior distribution of 25 parameters. In choosing the priors, in some cases, we used the calibrated values of the parameters from Furlanetto and Seneca (2012) and Gali et al., (2007) as prior means with an assumed standard deviation, while in other cases we followed the standard literature.

[12] This interpolation was performed following Chow and Lin (1971).

Particularly, the discount factor and the depreciation rate are assumed to follow a Beta distribution with means 0.99 and 0.025, and standard deviations 0.002 and 0.003, respectively. The parameters governing the share of financially excluded households and consumption habit also follow a Beta distribution with means 0.5 and 0.7, respectively and standard deviation of 0.025 for both.

A Gamma distribution is assumed for the coefficient of Frisch labor elasticity, with a mean value of 0.5 and a standard deviation equal to 0.01. The parameters governing the share of capital to output and Calvo price and wage stickiness are all assumed to follow a Beta distribution and fluctuate around 0.33 and 0.75, respectively. The standard deviation for the share of capital to output is 0.015, while both Calvo price and wage stickiness have a standard deviation of 0.01. The standard errors of all the innovations are assumed to follow inverse gamma distribution with mean 0.1 and standard deviation 10. Further, a Beta distribution is assumed for the price mark-up shock process with mean 0.5 and standard deviation 0.1, and that of the technology shock having a mean of 0.95 and a standard deviation value of 0.002.

Moreover, as in Iwata (2009), the degree of government spending, consumption tax, and labor income tax smoothing parameters all follow Beta distribution with mean 0.5 and standard deviation 0.075. Also, the parameter weight of government spending, consumption tax, and labor income tax on debt-to-output ratio are assumed to follow a normal distribution with mean 0.1 and standard deviation 0.05.

Finally, the degree of interest-rate smoothing parameter is assumed to follow a Beta distribution with mean 0.69 and standard deviation 0.1. As in Smets and Wouters (2003), the parameters governing the weight placed by the central bank on inflation and output growth are both normally distributed with means 1.7 and 0.26, and standard deviations 0.25 and 0.015, respectively.

4. Results and Discussion

The results of the posterior estimation of the model's parameters and the six exogenous shocks are reported in Table 1 for Model 1 (flexible wage dynamics) and Model 2 (sticky wage dynamics). Given our priors, we estimate the posterior distributions of the parameters using the Metropolis-Hastings algorithm. We run two independent Markov chains with five hundred thousand (500,000) draws and perform Brooks and Gelman (1998) convergence diagnostics. These results together with the trace plots suggest that the two chains have converged for both the univariate and multivariate convergence. Appendix A displays the trace plots of some selected parameters. We report the Bayesian posterior mean estimates of the parameters in the sixth and seventh columns of Table 1 for models 1 and 2, respectively. It can be seen that the posterior estimates of some of the parameters are close to the prior means (similar for both models), indicating consistency between the priors (our initial guess) and the information contained in the data. However, other parameters saw the posterior estimates moving far from their prior means indicating an additional gain from employing the data in our Bayesian technique. Below, we discuss the estimates of some selected parameters for models 1 and 2.

4.1. Posterior Estimates

The estimates of the fraction of the financially excluded household's parameter is found to be 35% in model 1 and 52% in model 2. The parameter governing habit persistence formation is estimated to be around 0.81 and 0.83 for models 1 and 2, respectively. Further, the estimate of the contribution of capital to output is modest, approximately 0.29 and 0.32 for models 1 and 2, respectively. The degree of price and wage stickiness are also found to be modest (0.75). Also, the inverse of the Frisch labor elasticity parameter estimate is found to be similar (about 0.47 and 0.50) in the two models.

Concerning the monetary policy rule, the parameter representing the degree of interest-rate smoothing (ρ_r) had estimated values of 0.68 and 0.72. Also, the response of interest rate to inflation is closer to unity in the long-term in both models. We find that the Central Bank of Ghana (BOG) pursues strict anti-inflationary policies with an inflation coefficient (ϕ_π) value of about 3.2 for both models. That is, for every one percentage point increase in inflation, BOG responds by raising the nominal interest rate by about 0.96 percentage points[13]. This finding is not surprising as BOG operates under inflation targeting monetary policy. Also, the parameter governing the weight BOG places on output growth (ϕ_y) is estimated to be around 0.26. This suggests that for every one percentage point increase in output growth, BOG increases the nominal interest rate by approximately 0.078 percentage points. This finding suggests that BOG has been somewhat been modest in achieving greater output growth in the Ghanaian economy.

In addition, the estimated values of the parameters characterizing all three fiscal policy rules indicate that the fiscal authorities react modestly to debt-to-output ratio. Specifically, the parameter characterizing the response of government spending to debt-to-output ratio (ϕ_g) had estimated values of 0.039 and 0.173, respectively for models 1 and 2. Using the estimates from model 2, it can be seen that a one percentage point increase in debt-to-output ratio induces an increase of about 0.02 percentage points in government spending. That is, as output decreases or debt increases the fiscal authorities adjust their budget accordingly to increase their expenditure.

Finally, the parameter governing the response of consumption tax to debt-to-output ratio ($\phi_{\iota c}$) registered estimated values of 0.24 and 0.14, respectively for models 1 and 2. Thus, from the estimation results in model 2, for every one percentage point increase in debt-to-output ratio, consumption tax rate increases by about 0.018 percentage points[14]. Similarly, the parameter governing the response of labor income tax to debt-to-output ratio ($\sigma_{\iota n}$) registered an estimated value of about 0.1. This suggests that a one percentage point increase in debt-to-output induces about 0.05 percentage points increase in labor income tax rate. These results suggest that the government finances its debt-to-output ratio through an increase in consumption and labor income tax rates. Overall, the response of income tax rate to debt-to-output ratio is found to be the largest among those of the three fiscal policy instruments considered in the model.

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[13] Note that the coefficient of the inflation in the Taylor rule is multiplied by (1- ρ_r) as shown in equation 38.

[14] Note that the coefficients of debt-to-output ratio in the fiscal policy rules is multiplied by one minus the smoothing parameters as shown in equations 40 to 42.

Table 1: Bayesian Estimation results

Parameters		Prior			Posterior	
		Distribution	Mean	S. D.	Mean	
					Model 1	Model 2
Households						
Financially excluded	λ	Beta	0.5	0.025	0.350	0.521
Consumption habit	h	Beta	0.7	0.025	0.8112	0.830
Discount factor	β	Beta	0.99	0.002	0.994	0.994
Depreciation rate	δ	Beta	0.025	0.003	0.012	0.012
Firms						
Share of capital	α	Beta	0.33	0.015	0.286	0.323
Degree price stickiness	θ	Beta	0.75	0.01	0.750	0.750
Frisch labor elasticity	ϕ	Gamma	0.5	0.01	0.473	0.504
Degree wage stickiness	θ_w	Beta	0.75	0.01	-	0.750
Monetary Policy (Taylor Rule)						
Interest-rate smoothing	ρ_r	Beta	0.69	0.1	0.658	0.715
Inflation	ϕ_π	Normal	1.7	0.25	3.261	3.263
Output growth	ϕ_y	Normal	0.26	0.015	0.255	0.258
Fiscal Policy Rules						
Gov. spend. smoothing	ρ_g	Beta	0.5	0.075	0.878	0.881
Cons. tax smoothing	$\rho_{\iota c}$	Beta	0.5	0.075	0.850	0.865
Inc. tax smoothing	$\rho_{\iota n}$	Beta	0.5	0.075	0.488	0.486
Gov. spending debt	ϕ_g	Normal	0.1	0.05	0.039	0.173
Consumption tax debt	$\phi_{\iota c}$	Normal	0.1	0.05	0.235	0.135
Labor income tax debt	$\phi_{\iota n}$	Normal	0.1	0.05	0.103	0.096
Shocks						
		Persistence				
Technology	ρ_a	Beta	0.95	0.002	0.956	0.955
Price mark-up	ρ_p	Beta	0.5	0.1	0.537	0.780
		St. Dev of shocks				
Technology	σ_a	inv_gamma	0.1	10	23.147	51.259
Price mark-up	σ_p	inv_gamma	0.1	10	54.942	99.170
Monetary policy	σ_m	inv_gamma	0.1	10	4.483	3.809
Government spending	σ_g	inv_gamma	0.1	10	7.057	7.680
Consumption tax	$\sigma_{\iota c}$	inv_gamma	0.1	10	114.62	68.820
Labor income tax	$\sigma_{\iota n}$	inv_gamma	0.1	10	0.086	0.094
Log data density					**-2047.4**	**-2021.3**

4.2. Bayesian impulse response analysis

In this section, we examine the impact of government spending, consumption tax, labor income tax, and monetary policy shocks on key macroeconomic variables. We also examine how each of the fiscal shocks affect the consumption and working hours by financially included and excluded households. Finally, monetary policy response to an expansionary fiscal policy is also analyzed. It is to be noted that all dynamic responses of the variables depict a one standard deviation shock to all innovations and percentage-point deviations from their steady state. The blue lines represent mean impulse responses, while the gray areas indicate the 90% posterior probability band. Also, note that we discuss the results from our two models for government spending and monetary policy shocks. However, for the remaining shocks, we only discuss the results from model 2, using the log data densities of both models as the criteria, but report that from model 1 in Appendix B.

4.2.1. Government spending shock

The impulse response functions of key macroeconomic variables to a positive government spending shock are displayed in figures 1 and 2 for models 1 and 2, respectively. In figure 1, it is observed that an exogenous increase in government spending immediately leads to an increase in output, consumption (crowd-in consumption), and employment, and hence, aggregate demand increases. The fiscal authorities finance the increase in government spending through borrowing, as one of the means, and as a result public debt immediately balloons. The increase in aggregate demand exerts upward pressure on the prices of inputs, and goods and services. Thus, inflation increases by approximately 0.16 percentage points. However, because nominal wage setting is flexible, the wage rate immediately adjusts upwards by about 0.6 percentage point following the rise in demand for labor. As a result, although inflation increases, real wage increases on impact (about 0.6 percentage points increase). Even though the increase in real wage is counterfactual, the increase in not substantial. The increase in real wage and employment raise the (real) disposable income of both households.

It can also be seen that although aggregate consumption increases, the consumption of financially included households drops by about 0.19 percentage points at maximum but that of financially excluded households increases by about 0.88 percentage points. This is because monetary authorities respond actively to rises in inflation caused by increased in government spending through an increase in the nominal interest rate (by about 0.27 percentage points). Thus, financially included households take advantage of the rise in interest rate to save and to accumulate more capital and, therefore, reduce their consumption or substitute saving for consumption. This explanation supplements what has been documented in the literature. It is argued that financially included households anticipate government spending increase, financed by increased taxes and, therefore, reduce their consumption and rather increase their working hours. On the other hand, finically excluded households simply spend all of the increase in their (real) disposable income as they lack access to the financial market, which prevents them from saving to accumulate wealth.

Moreover, from figure 2, the analysis and the transmission mechanism following expansionary fiscal policy are similar to the ones described above for model 1. However, several differences between the two results should be pointed out. In particular, exogenous increase in government spending leads to increase in output, inflation, and employment but crowds-out consumption in the second model. Also, because nominal wage setting is sticky, the rise in inflation outweighs the slow increase in nominal wage. As a result, real wage decreases by about 0.05 percentage points on impact. As before, BOG through the Taylor rule moderates the inflationary pressures by increasing the nominal interest rate. The combined effect of these (a rise in nominal interest rate and a fall in real wage) led to a fall in aggregate consumption. However, although aggregate consumption falls, the consumption of financially excluded household increases by about 0.054 percentage points, whereas that of financially included households decreases by 0.18 percentage points on impact. Surprisingly, the estimated share of financially excluded households increased considerably, from 3.5% in model 1 to 5.2% in model 2; therefore, one would expect that the weighted average of consumption of the two households would have generated a rise in aggregated consumption in the second model. However, the opposite is found. Arguably, this negative consumption multiplier of government spending shock could be explained by two factors: [1] the active response of BOG to the rise in inflation through an increase in the nominal interest rate, and [2] the sticky wage dynamics that induces a fall in real wage and (real) disposable income.

By comparing the consumption of financially included and excluded households across the two models, the rise in consumption of the later is larger under flexible wage dynamics than under sticky wage dynamics. Specifically, expansionary fiscal policy (increased government spending) increased the consumption of financially excluded households by about 0.9 percentage points and 0.05 percentage points, respectively, under flexible and sticky wage dynamics. However, the fall in the consumption of financially included household is approximately the same on impact across the two models. On the effect of government spending on output and inflation, a slightly larger increase in both variables is found under flexible wage dynamics than under sticky wage dynamics. However, the output multiplier under both models are almost less than one. Thus, fiscal policy is more effective when the labor market is perfectly competitive and when wage setting is flexible.

4.2.2. Monetary policy shock

In this session, we analyze the effectiveness of monetary policy under both sticky wage and flexible wage settings. The responses of output, inflation, consumption, and employment to a positive monetary policy shock are displayed in Figure 3 for models 1 and 2. It can be seen that, a contractionary monetary policy induces a fall in inflation, output, consumption, and employment. Although monetary policy is seen to be effective under both models, the magnitude and the impacts of the shock on the four macroeconomic variables are somewhat different. Evidently, the response of all the four variables to a rise in nominal interest are seen to be greater in a situation where wages are flexible than when wages are sticky. For example, whereas a contractionary monetary policy induces a fall in inflation and output by about 1.1 and 2.15 percentage points, respectively under flexible wage setting environment, it leads to a fall in the far variables by approximately 0.77 and 1.75 percentage points, respectively. Thus, it can be concluded that monetary policy is more effective in an economy where wages are flexible than where wages are sticky.

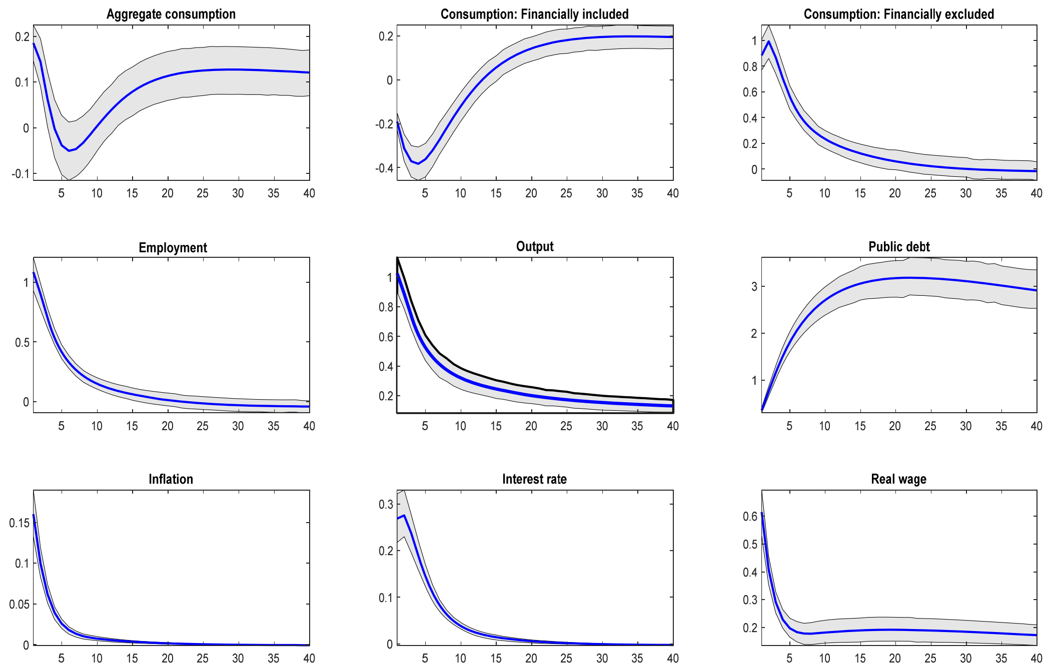

Figure 1: Response of macroeconomic variables to government spending shock (Model 1: Flexible wage dynamics).

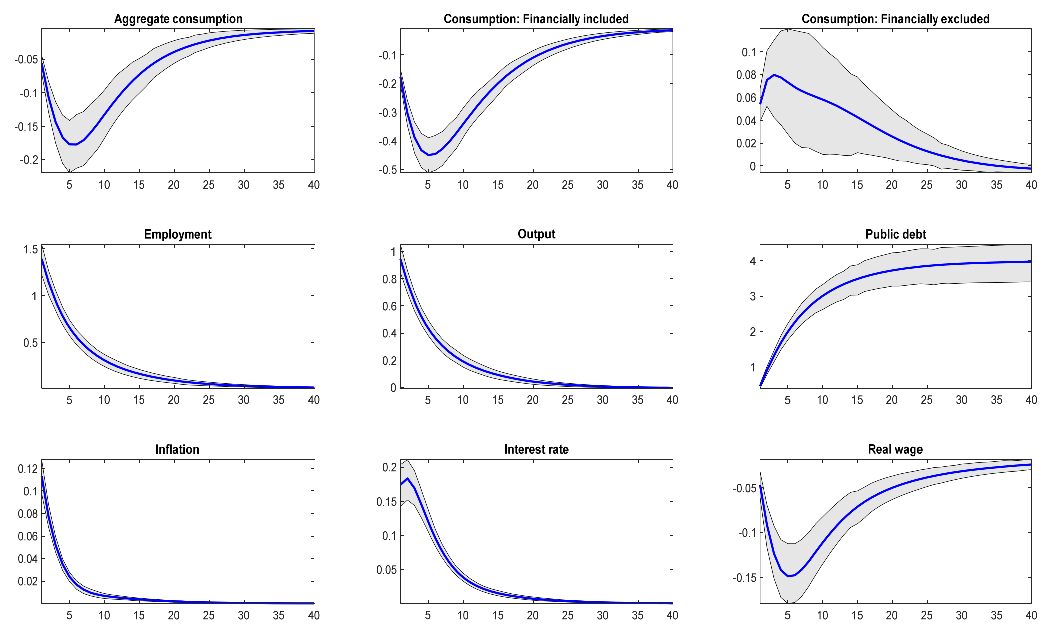

Figure 2: Response of macroeconomic variables to government spending shock (Model 2: Sticky wage dynamics)

4.2.3. Consumption tax shock

The responses of the key macroeconomic variables to a positive consumption tax shock are shown in Figure 4. This shock has negative effects on the economy. The hike in consumption tax rate reduces aggregate consumption and output. Also, the reduction in aggregate demand exerts downward pressure on the prices of inputs and goods and services. Thus, inflation falls leading to an increase in real wage. The decrease in aggregate demand translates into a reduction in employment. As a result, aggregate employment immediately falls by about 1.15 percentage points and peaking at 3.02 percentage points below its steady state value. It can be seen that the consumption of both households decreases on impact. To mitigate the damping effect on their consumption, financially excluded households increased their working hours by about 6.24 percentage points. That is, due to lack of access to the financial sector and savings, the only alternative is to increase their hours of work to increase disposable income. However, their included counterparts, having full access to financial sector, to some extent mitigate the fall in their consumption by tapping into their previous savings and rather decreased their hours of work by about 9.18 percentage points. Sadly, despite the increase in working hours of financially excluded households and the decrease in working hours of financially included ones, the former saw a larger reduction in their consumption than the latter. Specifically, the consumption of financially excluded households falls by nearly 2.07 percentage points, continued to fall until the fifth quarter, peaking at 4.54 percentage points. However, the consumption of financially included households saw a fall of about 0.76 percentage points, reaching a minimum of only 1.64 percentage points in the fifth quarter. These results suggest that financially excluded households are less resilient in terms of absorbing shocks than their included counterparts.

4.2.4. Labor income tax shock

Figure 5 presents the impulse responses of the select variables to a rise in labor income tax innovation. The rise in labor income tax discourages working and as a result aggregate employment decreased by about 0.003 percentage points on impact. Consequently, disposable income decreased, leading to a reduction in consumption and output. It can also be seen that the consumption of both financial included and excluded households was negatively affected. In particular, the fall in the disposable income induces a reduction in the consumption of finically excluded households by approximately 0.005 percentage points, whereas that of financially included ones was reduced by 0.0002 percentage points. Again, to insulate their consumption from the rise in labor income tax, financially excluded households had no option except to increase their working hours. That is, they increased their working hours by 0.024 percentage points. On the other hand, financially included households had their working hours reduced by approximately 0.033 percentage points. With access to the financial sector and availability of savings, they respond negatively to the rise in the labor income tax, but, still their consumption fell less than that of financially excluded households. In short, conditions grew worse for financially excluded households.

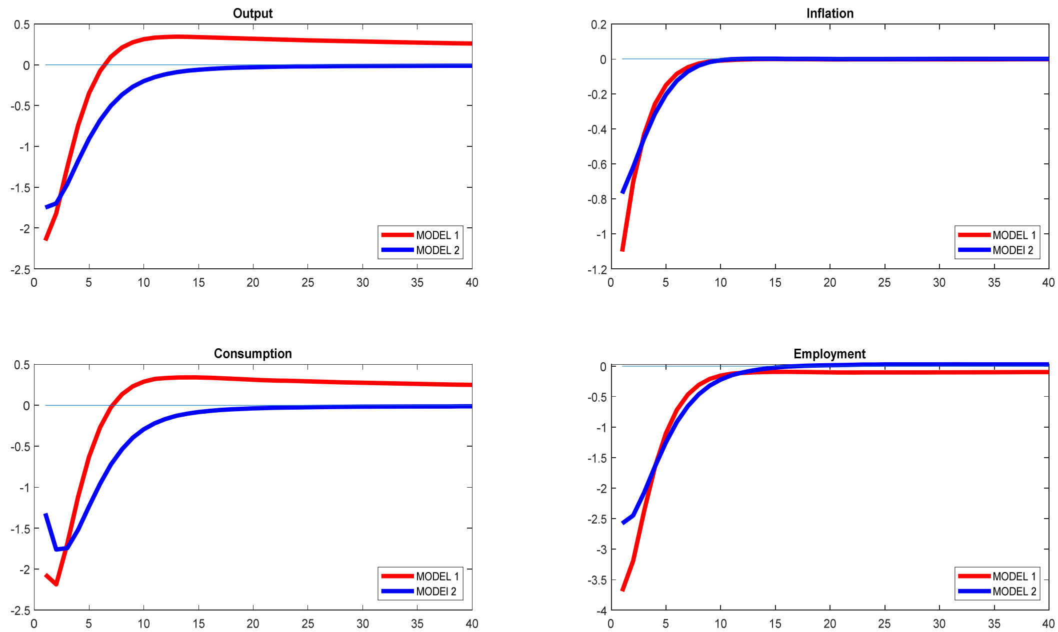

Figure 3: Response of output, inflation, consumption, and employment to monetary policy shock (the plots are the posterior means for models 1 and 2).

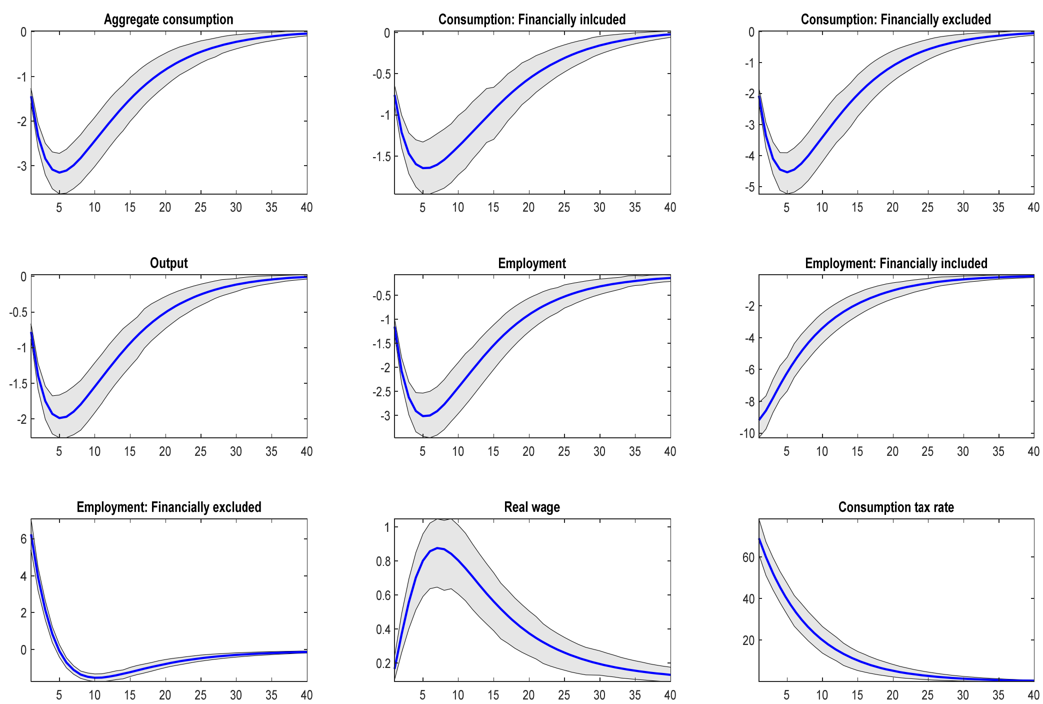

Figure 4: Response of macroeconomic variables to consumption tax shock (Model 1)

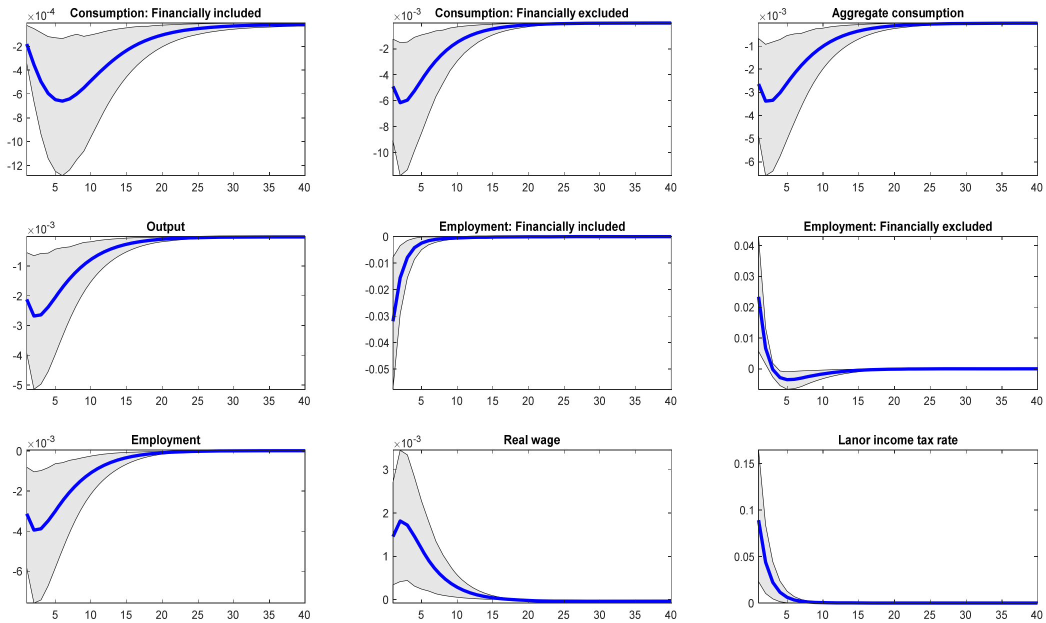

Figure 5: Response of macroeconomic variables to labor income tax shock (Model 1)

4.3. Forecast Error Variance Decomposition

In this section, we carry out variance decomposition analysis from the estimated model to examine the drivers of business cycle in the Ghanaian economy. In particular, we analyze the contribution of each of the shocks in the model to the variations in output, consumption, employment, and inflation. Table 2 reports the results at different horizons for those four variables. We follow Smet and Wouters (2003), and define 1-4 quarters (one year) as the short run, 10 quarters (2.5 years) as the medium run, and 100 quarters (25 years) as the long run. At a glance, it can been that whereas consumption tax shock appears to be an important driver of those four variables in the Ghanaian economy at all horizons, government spending and labor income tax shocks are less important in driving those variables.

In the very short term (one year), the key drivers of output is found to be price mark-up, technology, consumption, and monetary policy shocks. At that horizon, price mark-up shock was the main driver of output, contributing to about 45% variation in output, followed by technology shock (29%), consumption tax shock (19%), and monetary policy shock (5%). However, after the initial four quarters, technology shock overtook price mark-up shock to be the main driver of output in both medium and long terms. Specifically, it contributes to about 73% in the variability of output in the long-run, followed by consumption tax shock (18%), and price mark-up shock (8%).

Turning to the drivers of consumption in the Ghanaian economy, it can be seen that, price mark-up shock, technology shock, consumption tax shock, and monetary policy shock are the most important. In terms of their contributions to the fluctuation in consumption, price mark-up contributes largely (about 52%) in the short run, followed by consumption tax shock (32%), technology shock (10%), and monetary policy shock

(6%). The medium and long runs, however, had technology and consumption tax shocks dominating in driving consumption in the economy.

With regard to the determinants of employment, price mark-up, technology, and consumption tax shocks are found to be the main drivers at all the horizons. In particular, on average, price mark-up shock is seen to be the main and most important driver of employment among the four shocks, accounting for about 58%, 37%, and 24% in the short, medium, and long terms, respectively. Also, technology and consumption tax shocks moderately drive employment at all horizons in the Ghanaian economy.

Finally, similar results are found regarding the determinants of inflation. That is, price mark-up, technology, consumption tax, and monetary policy shocks are found to be main contributors to the fluctuation in inflation at all the horizons. In terms of their quantitative importance, price mark-up shock dominates, accounting for 59% in the long-run, followed by technology shock (31%), with consumption tax and monetary policy shocks moderately influencing inflation in the long-run.

Table 2: Forecast Error Variance Decomposition (in percent)

Shocks	**Output**	**Consumption**	**Employment**	**Inflation**
		Forecast horizon: 1st Quarter		
Technology	29.39	10.15	24.98	23.39
Price mark-up	44.63	51.63	57.54	67.63
Monetary policy	5.43	6.47	7.61	2.78
Government spending	1.22	0.05	0.65	0.06
Consumption tax	19.33	31.69	9.21	6.14
Labor income tax	0.00	0.00	0.00	0.00
		Forecast horizon: 4th Quarter		
Technology	46.38	35.97	9.07	30.20
Price mark-up	26.71	29.21	58.08	59.88
Monetary policy	1.46	1.63	3.97	3.63
Government spending	0.40	0.01	0.34	0.08
Consumption tax	25.05	33.18	28.54	6.21
Labor income tax	0.00	0.00	0.00	0.00
		Forecast horizon: 10th Quarter		
Technology	64.39	58.53	25.74	30.53
Price mark-up	11.96	0.57	36.90	59.49
Monetary policy	0.58	12.40	2.17	3.59
Government spending	0.21	0.00	0.20	0.08
Consumption tax	22.87	28.50	34.98	6.31
Labor income tax	0.00	0.00	0.00	0.00
		Forecast horizon: 100th Quarter		
Technology	73.35	70.75	49.40	30.88
Price mark-up	7.96	7.69	23.63	59.12
Monetary policy	0.53	0.46	1.40	3.57
Government spending	0.18	0.03	0.14	0.08
Consumption tax	17.97	21.07	25.44	6.36
Labor income tax	0.00	0.00	0.00	0.00

5. Conclusion and Policy Implications

In this paper, we examine the impact of fiscal policy shocks on key macroeconomic variables in the Ghanaian economy, where a substantial portion of the population are financially excluded. Specifically, we analyze the effects of government spending, consumption tax, and labor income tax shocks on both aggregate and disaggregate consumption, on employment, and on other macroeconomic variables. To do that, we adopt a traditional New Keynesian DSGE model which features heterogeneous households: financially included and excluded households. We redesign the model by introducing two distortionary taxes, namely: consumption and labor income taxes. In addition, we consider two alternative labor markets: perfectly and monopolistically competitive labor markets. In short, we consider flexible wage and sticky wage dynamics in parallel. We then estimate the model's parameters using Bayesian inference methods for the Ghanaian economy, using quarterly time series data from 1985Q1 to 2017Q4 on consumer price index, nominal interest rate, real household consumption expenditure, real GDP, and real government expenditure. We then analyze [1] the posterior mean estimates, [2] the Bayesian impulse response functions, and [3] the forecast error variance decomposition.

To begin with, the estimate of the fraction of financially excluded households yielded slightly different values. That is, estimates of 35% and 52% were found under the two alternative models, respectively. Also, the parameter estimates in the Taylor rule suggest that BOG has responded more aggressively to inflation than output growth. Further, the estimates of the parameters governing the three fiscal policy rules indicate that the response of income tax rate, as a fiscal policy instrument, to debt-to-output ratio is the largest, followed by government spending and consumption tax rate.

Moreover, the results from the Bayesian impulse response analysis show that t increased government spending has an expansionary effect on consumption, output, employment, and inflation, but turns to crowd-out consumption when wages are sticky. The output multipliers are found to be almost less than one under both flexible wage and sticky wage dynamics. At the aggregate level, the response of output and inflation to expansionary fiscal policy is somewhat stronger in a market where wages are perfectly competitively determined. Under both flexible and sticky wage dynamics, an increase in government spending has a decreasing effect on the consumption of households who enjoy full financial inclusion but has an expansionary effect on that of financially excluded ones. The excluded group is found to experience a decrease in their consumption due to an upward adjustment in the nominal interest rate by the monetary authorities aimed at moderating the inflationary pressures caused by that shock. Also, the sticky wage in the model induces a fall in real wage which also exerts a downwards pressure on their consumption.

Furthermore, a hike in consumption and labor income taxes discourages working and, thus, leads to a decreased employment, output, and consumption. At the disaggregated level, the results signal that lack of access to the financial sector and savings leave financially excluded households with alternative to increase their working hours in order to mitigate the negative effect of those shocks on their consumption. On the contrary, households that are financially included use the financial sector mechanism for tapping into their savings to insulate themselves from those shocks and rather reduce their working hours. Sadly, despite those inter-temporal optimal decisions by both households, both shocks decrease the consumption of the former more than that of the latter. That finding which supports the full financial inclusion agenda. Thus, we have empirically confirmed that when households are faced with shocks financially excluded households experience higher volatility in their consumption than financially included ones. Moreover, financially exclude households are less resilient in absorbing those shocks than their included counterparts.

In addition, a contractionary monetary policy leads to a significantly fall in inflation and other real variables including output, employment, and consumption. The impulse analysis shows that the response of those variables to a positive monetary positive shock is stronger under flexible wage dynamics than under sticky wage dynamics. Thus, monetary policy is found to be more effective in achieving its targets when the labor when wages are flexible.

Finally, the results of the variance decomposition analysis show that, from non-policy shocks side, technology and price mark-up shocks are most important drivers of key macroeconomic variables including output, inflation, employment, and consumption in the Ghanaian economy. In terms of policy shocks, consumption tax shock emerges as the main driver of output, inflation, employment, and consumption in the economy with monetary policy shock playing a minor role.

From the policy perspective, government spending is effective in increasing the consumption of financially excluded households although it decreases that of financially included ones. Also, effective coordination between the fiscal and monetary authorities is necessary to help design an optimal policy mix that can foster growth and improve the livelihood of the citizenry. Again, the finding that productivity and price mark-up (costs-push) shocks drive the key macroeconomic variables in the Ghanaian economy suggests that those shocks affect the transmission mechanisms of both fiscal and monetary policies. Thus, the government of Ghana needs to make frantic efforts to reduce the cost of production for firms and to also embark on technological research. For example, the Ghanaian economy has experienced electricity power outages over the past decade: one way to reduce the cost of production for firms is for the government to improve the electricity power supply to limit the power shortages, as power outages serve as a positive cost-push shock to the economy.

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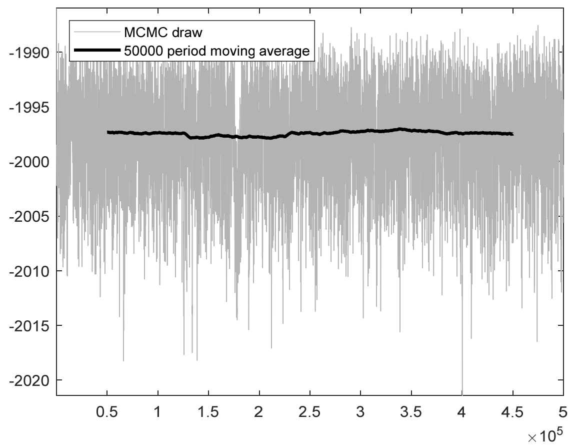
APPENDIXES

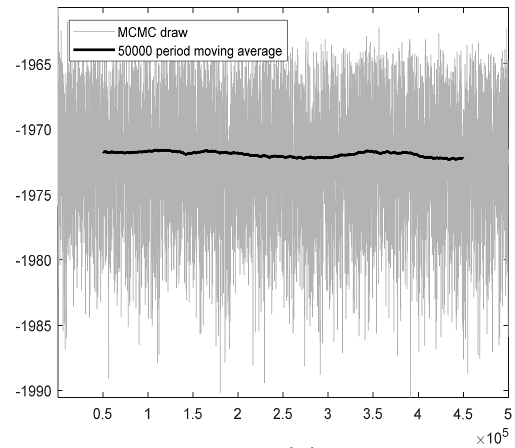
Appendix A

Trace Plots of some selected parameters

Posterior density (Model 1)

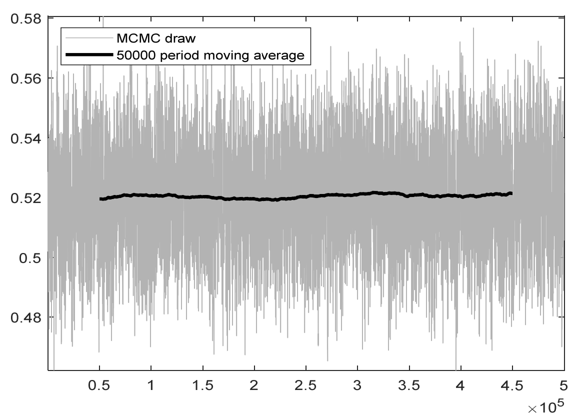
Posterior density (Model 2)

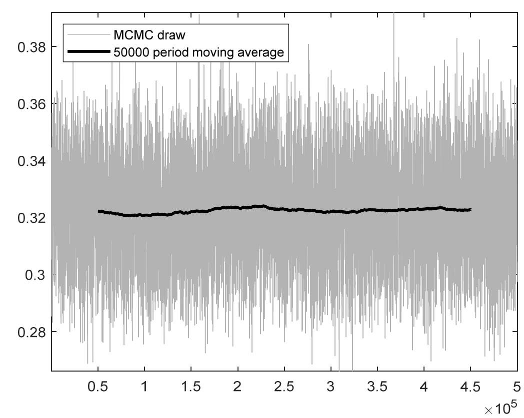




lambda

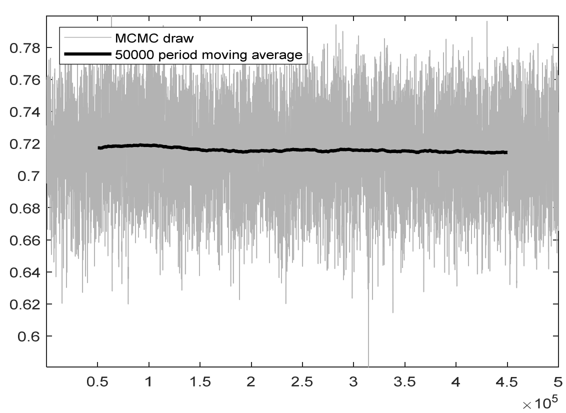
alpha

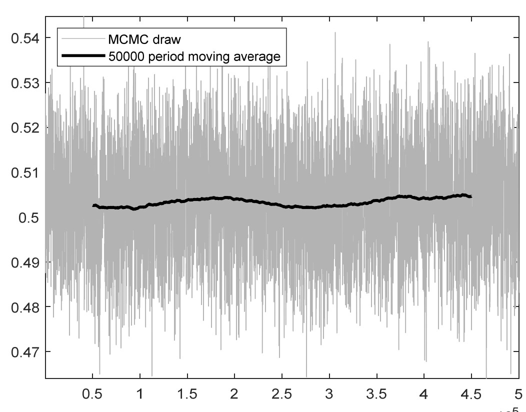




rho_r

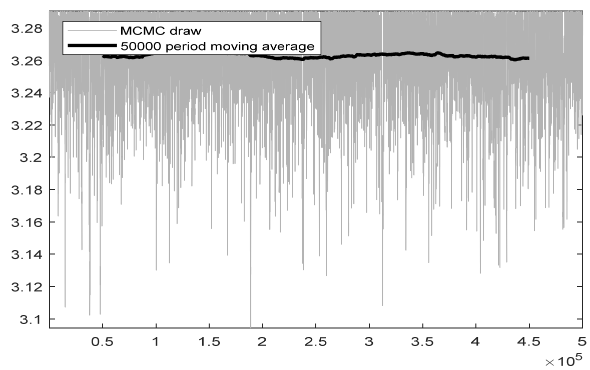
phi



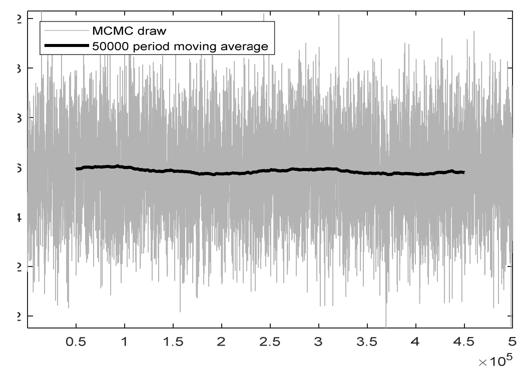


Appendix A continues

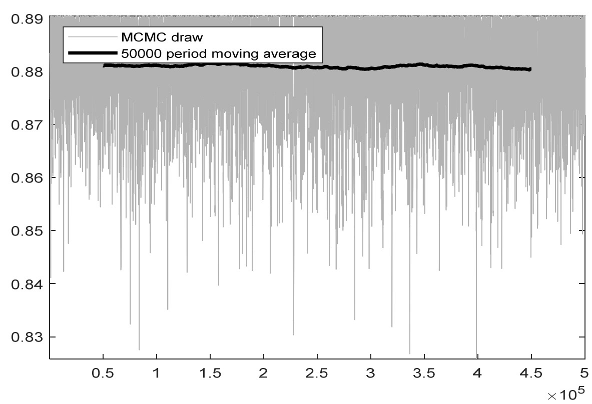
phi_pi



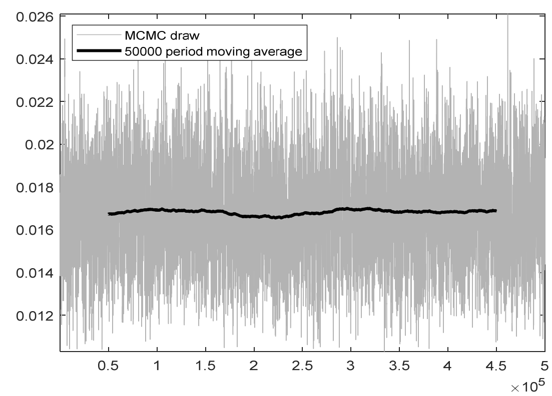
phi_y



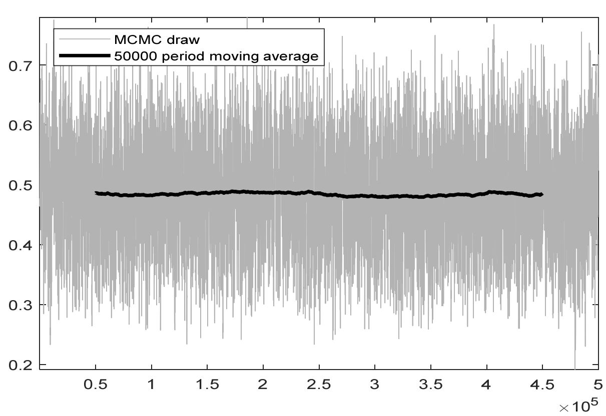
rho_g



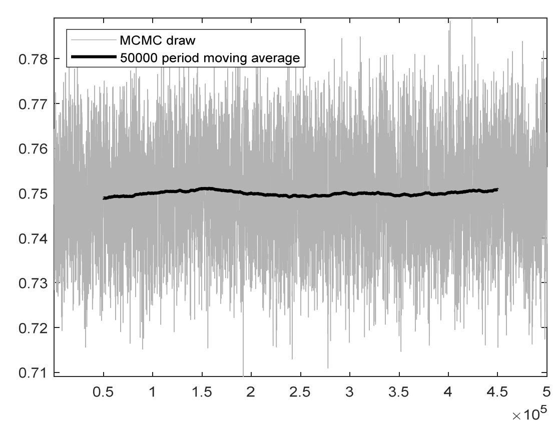
theta



rho_tau_n



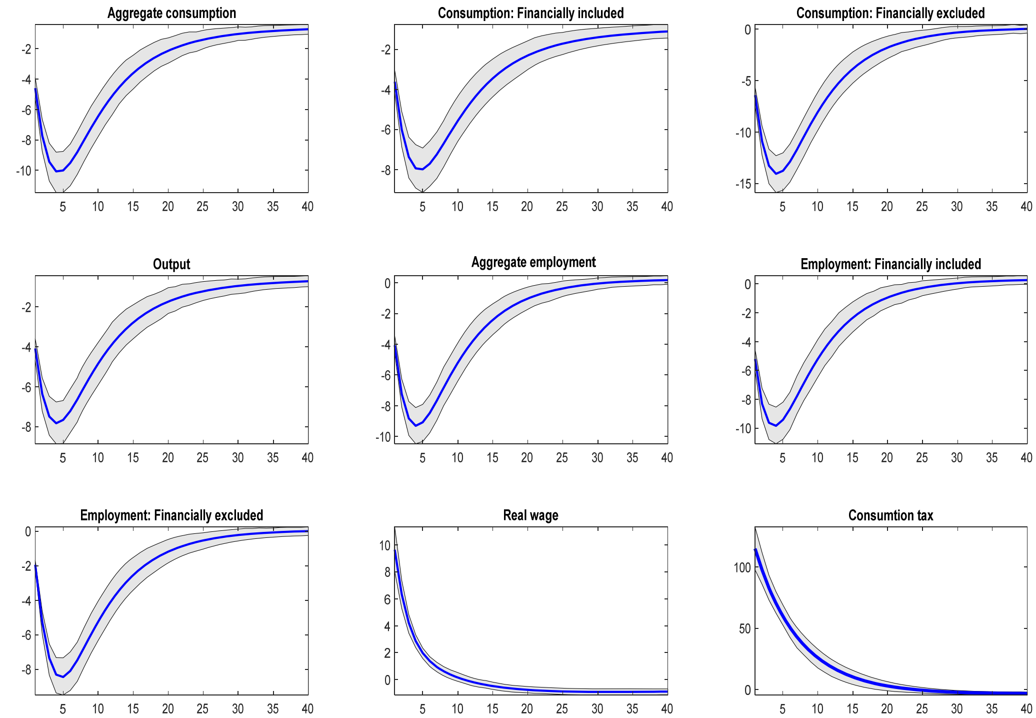
theta_w



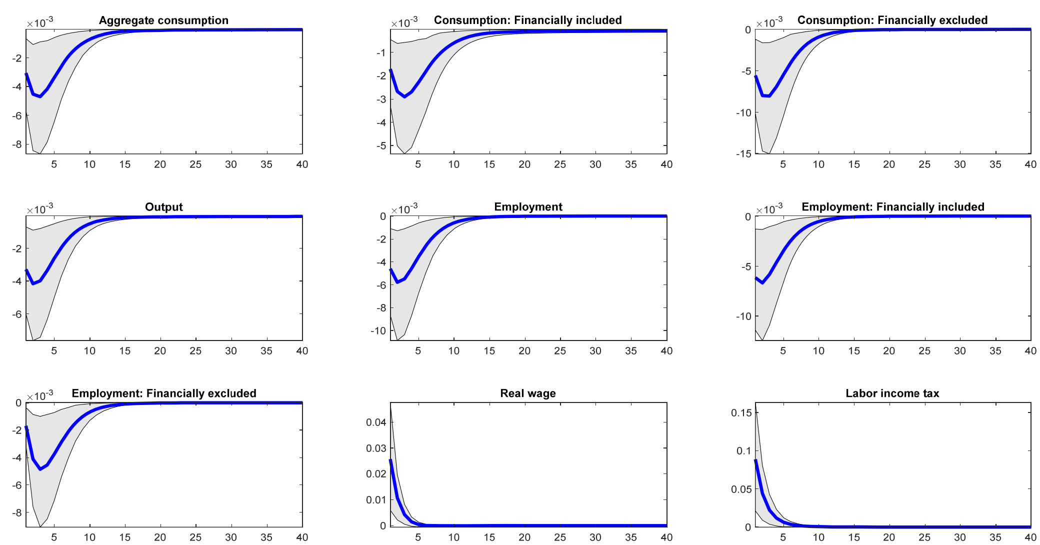
Appendix B

Impulse responses functions from model 1.

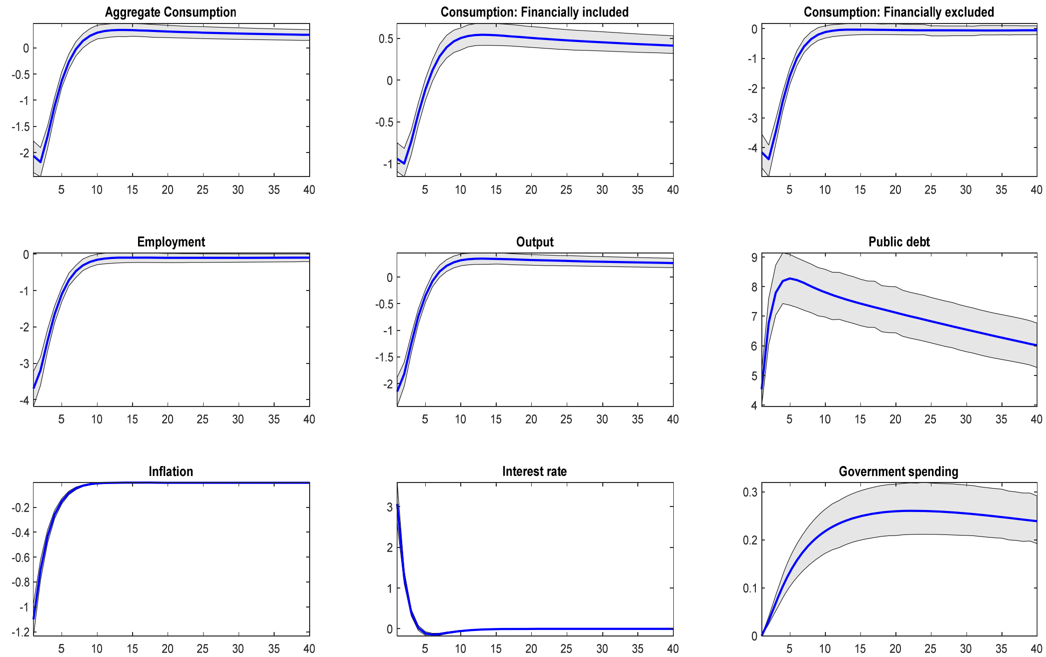
Consumption Tax Shock



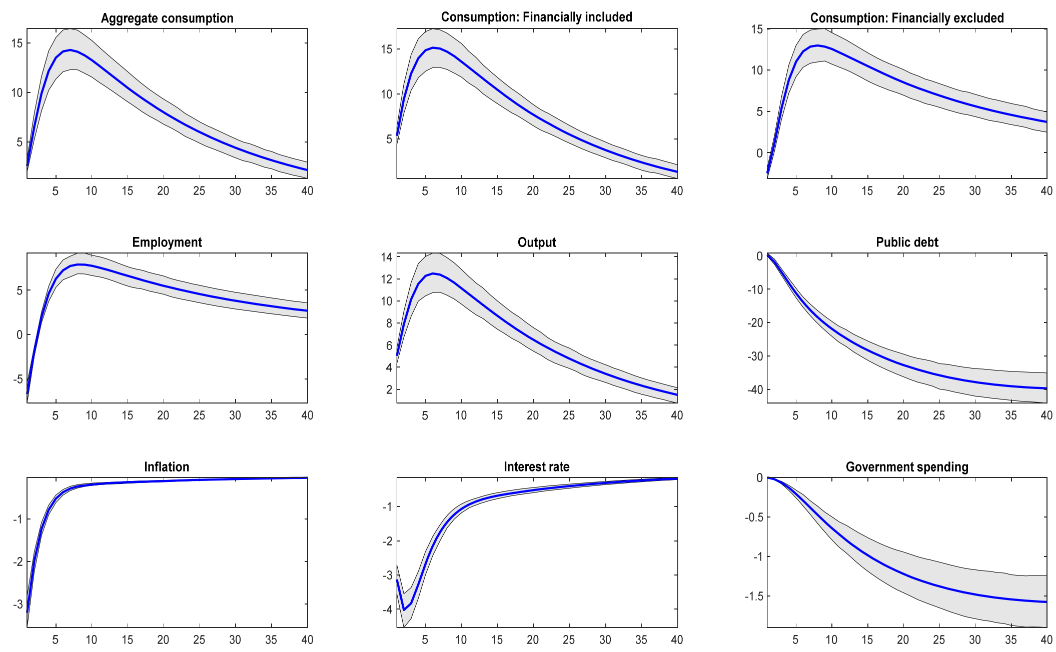
Labor Income Tax Shock



Monetary Policy Shock



Technology Shock



Price Mark-up Shock