

Dynamic Stochastic General Equilibrium Model for the Analysis of Large-Scale Asset Purchases: Lessons Learned for Cambodia

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Abstract

The DSGE model being analyzed involves four key market participants: households, banks, firms, and the central bank. This study's unique contributions, in comparison to other research papers, lie in the fact that households are not only permitted to purchase private securities like stocks and bonds, but also government bonds. However, households who possess a portfolio are required to cover transaction costs associated with their holdings. As the size of the portfolio increases, the transaction costs also increase. This limitation hinders households from engaging in complete arbitrage. In addition to output production firms, there are retail firms and capital production firms, distinguishing them from other papers that focus solely on output production firms. Notably, the central bank had the authority to purchase private securities as well as long-term government bonds. The DSGE model is a vital tool in contemporary economic analysis as it links microeconomics and macroeconomics. With the advancements in Cambodia's financial market and financial instruments, the integration of the DSGE model into policy analysis and formulation is the next logical step for economists and policymakers at the National Bank of Cambodia.

Keywords: DSGE Model, Households, Banks, Firms, Central Bank.

INTRODUCTION

Learning how the global financial crisis did occur is a good starting point before learning how to solve the problem of the crisis. The crisis is mainly caused by the mortgage loan that the banks provided to the households, which is known as the subprime mortgage crisis. During a high growth period, where the market is very competitive, the banks are willing to take more risk by approving the loans to the customers whom in the past did not qualify for those loans in order to prevent the loss of the market share. These outstanding loans have a very high probability of default or the probability that the counterparty do not have enough ability to repay the loans. In order to hedge with the default risk, the banks have to find another party to guarantee the outstanding loans, which is known as a protection seller such as American International Group (AIG), the largest insurance company in the world (American International Group Inc., 2013). If the credit event has occurred or if the default has occurred on the particular loans, the AIG will pay the banks with the principal of those loans. Obviously, as a protection buyer, the banks have to pay a premium for every period, which is referred to the cash flows of particular loans that the banks received from its customers to the AIG.

In order to save the economy and protect the low-income people, this was the first time that we learned about the word “Bailout” from the government of America. Moreover, 800 trillion U.S. dollars was approved by the President Barack Obama in 2008 and put on track for saving the U.S. economy. At the same time, AIG was the first corporation that took over by the U.S. government. The U.S. government held 80 percent of AIG outstanding shares. Nevertheless, the main purpose of this action was to save the American banking system, mainly to save the poor people that had a small amount of money deposited in the banks. If the banks fail, they will die. Generally, during the crisis, the market failure or the market equilibrium could not be determined, the risk in the financial market increases since the probability of default increases. By that we will find that the demand for risk free assets such as government bond as well as the risky assets of high credit rating corporation increases. The increasing in demand for those assets leads to the increasing in prices, which will create the excess returns or extra normal returns. To stimulate the economy, the Federal Reserve Bank of America tried to lower the federal fund rate since 2008, which the Fed expected that the domestic investment would increase to help improving the economic growth. At the same time, the new policy, which is called large-scale asset

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purchases (LSAPs) or quantitative easing (QE), had taken place. According to LSAPs policy, the Fed acted as the financial intermediary in order to eliminate those excess returns in the financial market, which is expected that the cost of doing business would decline. The Fed has no balance sheet constraint when start to raise funds or the central bank has an exclusive right to print the money, which is different from private financial intermediaries since banks always have constraint on their balance sheet.

In September 2008 shortly after the meltdown of the shadow banking system that followed the Lehman Brother failure, the Fed initiated what is now known as QE1: the purchase over time of a variety of high grade securities, including agency mortgage backed securities (AMBS), agency debt, and long term government bonds, with AMBS ultimately accounting for the bulk of the purchases. It is also set up a commercial paper lending facility, which affectively involved the purchase of commercial paper since the Fed accepted these instruments as collateral for the loans made to the facility. In October 2010, the Fed announced a second wave of asset purchases (QE2), this time restricted to long-term government bonds and smaller in scale than QE1. Finally, in September 2011, the Fed embarked on QE3, essentially a sterilized acquisition of long-term government bonds financed by selling some of its short-term bonds. A lengthy empirical literature has emerged attempting to identify the effects of the LSAP program on market interest rates and economic activity.

The primary aims of this investigation are to examine dynamic stochastic general equilibrium (DSGE), to acquire knowledge about LSAP, and to address the subsequent research query: what lessons can Cambodia derive from this event to inform future policy formulation?

Theoretical Framework

Gertler and Karadi use a standard New Keynesian model. The model is modified to allow all banks to transfer funds from households to non-financial firms, as well as to the government. Moreover, there is an agency problem that constrains the ability of banks to obtain funds from households. In order to Habitat formation and flow investment adjustment are added into the dynamic stochastic general equilibrium (DSGE). Habit formation is the utility of consumer that depends on the current consumption relative to the past consumption (Fuhrer, 2000). According to this paper, they divided into five agents in the model, which are households, banks, central bank, production sector, and government.

Households

First, they start with households. Each of household consumes, saves, and supplies labors. Households are saving their money through competitive financial intermediaries and lending funds to the central bank. There are two types of households. First, households are workers, which supply labor and return wage to households, with the fraction of $1-f$. Second, households are bankers with the fraction of f , which manage a financial intermediary, and transfer earning back to households as well.

The probability of the households to be bankers is equal to σ . Therefore, the average survival time for a banker in any given period is $1/((1-\sigma))$. However, in order to prevent the bank to gain from retain earning that they can finance all investments from their own capital, there is an exit time and payout their retain earnings as dividends, which is $(1-\sigma)f$. Moreover, households that used to be bankers will be replaced by new workers, which are provided with the start up funds equal to $X/(1-\sigma)f$ per new banker (Doh, 2010).

The main objective of the households is to maximize their utility function (1) subject to their budget constraint (2) by choosing C_t , L_t , and D_{ht} .

$$u_t = E_t \sum_{i=0}^{\infty} \beta^i \left[\ln(C_{t+i} + hC_{t+i-1}) - \frac{\chi}{1+\varphi} L_{t+i}^{1+\varphi} \right] \quad (1)$$

where u_t is household's discounted utility,

C_t be consumption,

L_t be family labor supply

According to equation (1), you can see that households' discounted utility include the habitat formation, which is hC_{t+i-1} . This means that their utility depends on past period (Adrian et al., 2024).

For the household budget constraint,

$$C_t = W_t L_t + \Pi_t - X + T_t + R_t D_{ht-1} - D_{ht} \tag{2}$$

where R_t is the gross real return from time $t - 1$ to t that both depositors and government debt have to pay,

D_{ht} be the total quantity of short-term debt that households acquire,

W_t be the real wage,

Π_t be the amount of payouts to households,

T_t be the lump-sum taxes,

X be the total transfer that households give to bankers that enter in time t .

Setting the Lagrangian to find the optimal solution for the households' utility maximization problem.

$$\begin{aligned} \mathcal{L} = E_t \sum_{i=0}^{\infty} \beta^i \left\{ \left[\ln(C_{t+i} + hC_{t+i-1}) - \frac{\chi}{1+\varphi} L_{t+i}^{1+\varphi} \right] \right. \\ \left. + \lambda_t [C_t - W_t L_t - \Pi_t + X - T_t - R_t D_{ht-1} + D_{ht}] \right\} \end{aligned} \tag{2.1}$$

The first-order conditions with respect to:

(2)

$$C_t = W_t L_t + \Pi_t - X + T_t + R_t D_{ht-1} - D_{ht}$$

(2.2)

$$C_t: u'_c - \lambda_t = 0$$

$$L_t: -\chi L_t^\varphi + \lambda_t w_t = 0 \tag{2.3}$$

$$d_{ht}: \beta \lambda_{t+1} R_{t+1} - \lambda_t = 0 \tag{2.4}$$

From equation (4.1) and (4.2)

$$u'_c = \frac{\chi}{w_t} L_t^\varphi \tag{2.5}$$

$$u'_c w_t = \chi L_t^\varphi \tag{3}$$

From (4.3)

$$\beta u_{ct+1} R_{t+1} = u_{ct}$$

$$\beta \frac{u_{ct+1}}{u_{ct}} R_{t+1} = 1$$

$$E_t \left(\beta \frac{u_{ct+1}}{u_{ct}} R_{t+1} \right) = 1$$

where $\beta \frac{u_{ct+1}}{u_{ct}} = \Lambda_{t,t+1}$

Therefore,

$$E_t (\Lambda_{t,t+1} \cdot R_{t+1}) = 1 \quad (4)$$

Bank

The second is bankers, which have two types of activities. First, they make loan to non-financial firms to finance their capital. Second, they intermediate all the funding of long-term bonds, since they hold long-term government bonds.

Banks make loan to non-financial firms to finance their capital (Gelfer & Gibbs, 2023).

Given the rate of return to the bank on the loan, defined as

$$R_{kt+1} = \frac{Z_{t+1} + (1 - \delta)Q_{t+1}}{Q_t} \xi_{t+1} \quad (5)$$

Let Z_t be the net income flow of the market value of the security,

δ be the depreciation rate of a unit of a capital,

and ξ_t is a random disturbance.

The real rate of return on the bond is given by

$$R_{bt+1} = \frac{1/P_t + q_{t+1}}{q_t} \quad (6)$$

Let q_t be the price of the bond, and P_t be the price level.

Given the bank's balance sheet,

$$Q_t s_t + q_t b_t = n_t + d_t \quad (7)$$

Rearrange:

$$d_t = Q_t s_t + q_t b_t - n_t \quad (7.1)$$

Net worth of the bank, which is the amount of equity capital, is calculated from the difference between the gross return on assets and the cost of liabilities defined as

$$n_t = R_{kt} Q_{t-1} s_{t-1} + R_{bt} q_{t-1} b_{t-1} - R_t d_{t-1} \quad (8)$$

update 1-period,

$$n_{t+1} = R_{kt+1} Q_t s_t + R_{bt+1} q_t b_t - R_{t+1} d_t \quad (8.1)$$

However, there is a moral hazard or costly enforcement problem. This implies that bankers take an advantage on funds by diverting the fraction of θ of private loan portfolio and the fraction of $\Delta\theta$ from government bond

portfolio. The fraction of private loan is easier to divert since the default risk on government bond are lesser than private loan (Kim et al., 2020).

The objective of financial intermediaries is to maximize the discounted stream of payouts back to household (9) subject to (7), (8), and (10) by choosing s_t, b_t and d_t .

$$V_t = E_t \sum_{i=1}^{\infty} (1 - \sigma)\sigma^{i-1} \Lambda_{t,t+i} n_{t+i} \tag{9}$$

Hence, there must be an incentive constraint must be satisfied so that it will prohibit this kind of moral hazard

$$V_t \geq \theta Q_t s_t + \Delta \theta q_t b_t \tag{10}$$

Solution:

Let $(1 - \sigma)\sigma^{i-1} \Lambda_{t,t+i} \equiv \tilde{\Lambda}_{t,t+1}$

Then

$$V_t = E_t \sum_{i=1}^{\infty} \tilde{\Lambda}_{t,t+1} n_{t+1} \tag{10.1}$$

Setting Lagrangian function:

$$\begin{aligned} \mathcal{L} = E_t \sum_{i=1}^{\infty} [& \tilde{\Lambda}_{t,t+1} n_{t+1} \\ & - \gamma_t (Q_t s_t + q_t b_t - n_t \\ & - d_t) - \lambda_t (-V_t + \theta Q_t s_t + \Delta \theta q_t b_t)] \end{aligned} \tag{11}$$

Insert equation (8.1)

$$\begin{aligned} \mathcal{L} = E_t \sum_{i=1}^{\infty} [& \tilde{\Lambda}_{t,t+1} (R_{kt+1} Q_t s_t + R_{bt+1} q_t b_t - R_{t+1} d_t) - \gamma_t (Q_t s_t + q_t b_t - n_t - d_t) \\ & - \lambda_t (-V_t + \theta Q_t s_t + \Delta \theta q_t b_t)] \end{aligned}$$

$$\begin{aligned} \mathcal{L} = E_t \sum_{i=1}^{\infty} [& \tilde{\Lambda}_{t,t+1} (R_{kt+1} Q_t s_t + R_{bt+1} q_t b_t - R_{t+1} d_t) - \gamma_t (Q_t s_t + q_t b_t - n_t - d_t) \\ & - \lambda_t ((R_{kt+1} Q_t s_t + R_{bt+1} q_t b_t - R_{t+1} d_t) + \theta Q_t s_t + \Delta \theta q_t b_t)] \end{aligned}$$

F.O.C with respect to

$$s_t: E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} Q_t - \gamma_t Q_t + \lambda_t R_{kt+1} Q_t - \lambda_t \theta Q_t) = 0 \tag{11.1}$$

$$b_t: E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} q_t - \gamma_t q_t + \lambda_t R_{bt+1} q_t - \lambda_t \Delta \theta q_t) = 0 \tag{11.2}$$

$$d_t: E_t \tilde{\Lambda}_{t,t+1} (-R_{t+1} + \gamma_t - \lambda_t R_{t+1}) = 0 \tag{11.3}$$

From equation (11.3)

$$\begin{aligned} (-R_{t+1} + \gamma_t - \lambda_t R_{t+1}) &= 0 \\ \gamma_t &= R_{t+1} + \lambda_t R_{t+1} \end{aligned} \quad (11.4)$$

Substitute (11.4) into (11.1)

$$s_t: \quad E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1} - \lambda_t R_{t+1} + \lambda_t R_{kt+1} - \lambda_t \theta) = 0 \quad (11.5)$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1} - \lambda_t R_{t+1} + \lambda_t R_{kt+1}) = \lambda_t \theta$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) + \lambda_t E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) = \lambda_t \theta$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) \cdot (1 + \lambda_t) = \lambda_t \theta$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) = \frac{\lambda_t}{(1 + \lambda_t)} \theta \quad (12)$$

Substitute (11.4) into (11.2)

$$b_t: \quad E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} q_t - R_{t+1} + \lambda_t R_{t+1} q_t + \lambda_t R_{bt+1} q_t - \lambda_t \Delta \theta q_t) = 0$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1} + \lambda_t R_{t+1} + \lambda_t R_{bt+1} - \lambda_t \Delta \theta) = 0$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1} + \lambda_t R_{t+1} + \lambda_t R_{bt+1}) = \lambda_t \Delta \theta$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) + \lambda_t E_t \tilde{\Lambda}_{t,t+1} (R_{t+1} + R_{bt+1}) = \lambda_t \Delta \theta$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) \cdot (1 + \lambda_t) = \lambda_t \Delta \theta$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) = 0 \quad (12.1)$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) = \Delta \frac{\lambda_t}{(1 + \lambda_t)} \theta \quad (13)$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) = 0 \quad (13.1)$$

The expected excess returns on bank assets satisfy equation (12) and (13).

First, we look at the case when the incentive constraint is not binding, which means $\lambda_t = 0$, then equation (12) and (13) becomes

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) = \Delta \frac{\lambda_t}{(1 + \lambda_t)} \theta \quad (3)$$

Equation (12.1) and (13.1) imply that bankers have no incentive to divert funds, and no excess return.

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) = E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1})$$

Second, when the incentive constraint is binding, bankers have incentive to divert funds from private loans and government bonds; however, the excess return on private bonds is more than the excess return on government bonds (Bandera & Stevens, 2024).

Since, the excess return on government bonds has the multiplier of Δ , which is less than one, $\frac{\lambda_t}{(1+\lambda_t)}\theta > \Delta \frac{\lambda_t}{(1+\lambda_t)}\theta$, then $\Delta < 1$.

Under the binding of incentive constraint, equation (9) becomes

$$V_t = \theta Q_t s_t + \Delta \theta q_t b_t \text{ for } \lambda_t > 0$$

$$\text{where } V_t \equiv E_t \tilde{\Lambda}_{t,t+1} n_{t+1}$$

Then, incentive constraint becomes

$$E_t \tilde{\Lambda}_{t,t+1} n_{t+1} = \theta Q_t s_t + \Delta \theta q_t b_t$$

$$E_t \tilde{\Lambda}_{t,t+1} n_{t+1} = \theta(Q_t s_t + \Delta q_t b_t)$$

Substitute equation (8.1)

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} Q_t s_t + R_{bt+1} q_t b_t - R_{t+1} d_t) = \theta(Q_t s_t + \Delta q_t b_t) \tag{3.1}$$

Substitute (7.1) into (13.1)

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} Q_t s_t + R_{bt+1} q_t b_t - R_{t+1} (Q_t s_t + q_t b_t - n_t)) = \theta(Q_t s_t + \Delta q_t b_t)$$

$$E_t \tilde{\Lambda}_{t,t+1} \{ [Q_t s_t (R_{kt+1} - R_{t+1})] + [q_t b_t (R_{bt+1} - R_{t+1})] + R_{t+1} n_t \} = \theta(Q_t s_t + \Delta q_t b_t)$$

$$E_t \tilde{\Lambda}_{t,t+1} Q_t s_t (R_{kt+1} - R_{t+1}) + E_t \tilde{\Lambda}_{t,t+1} q_t b_t (R_{bt+1} - R_{t+1}) + E_t \tilde{\Lambda}_{t,t+1} R_{t+1} n_t = \theta(Q_t s_t + \Delta q_t b_t) \tag{3.2}$$

Since, $\Delta E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) = E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1})$, equation (13.2) becomes

$$E_t \tilde{\Lambda}_{t,t+1} Q_t s_t (R_{kt+1} - R_{t+1}) + \Delta E_t \tilde{\Lambda}_{t,t+1} q_t b_t (R_{kt+1} - R_{t+1}) + E_t \tilde{\Lambda}_{t,t+1} R_{t+1} n_t = \theta(Q_t s_t + \Delta q_t b_t) \tag{3.3}$$

$$E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) (Q_t s_t + \Delta q_t b_t) + E_t \tilde{\Lambda}_{t,t+1} R_{t+1} n_t = \theta(Q_t s_t + \Delta q_t b_t) \tag{3.4}$$

$$E_t \tilde{\Lambda}_{t,t+1} R_{t+1} n_t = \theta(Q_t s_t + \Delta q_t b_t) - E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) (Q_t s_t + \Delta q_t b_t) \tag{3.5}$$

$$E_t \tilde{\Lambda}_{t,t+1} R_{t+1} n_t = (Q_t s_t + \Delta q_t b_t) (\theta - E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1})) \tag{3.6}$$

Then,

$$\frac{E_t \tilde{\Lambda}_{t,t+1} R_{t+1}}{(\theta - E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}))} n_t = (Q_t s_t + \Delta q_t b_t) \tag{3.7}$$

$$(Q_t s_t + \Delta q_t b_t) = \phi_t n_t \quad (4)$$

where

$$\phi_t \equiv \frac{E_t \tilde{\Lambda}_{t,t+1} R_{t+1}}{(\theta - E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}))} \quad (5)$$

Equation (15) is the maximum ratio that the bank may hold assets without violating the incentive constraint.

Since, $(1 - \sigma)\sigma^{i-1}\Lambda_{t,t+i} \equiv \tilde{\Lambda}_{t,t+1}$, and $\tilde{\Lambda}_{t,t+1} \equiv \Lambda_{t,t+i} \cdot \Omega_{t+1}$, which implies that

$$\Omega_{t+1} = 1 - \sigma + \sigma \frac{\partial V_{t+1}}{\partial n_{t+1}} \quad (6)$$

with

$$\frac{\partial V_t}{\partial n_t} = E_t \tilde{\Lambda}_{t,t+1} [(R_{kt+1} - R_{t+1})\phi_t + R_{t+1}]. \quad (6.1)$$

$$\frac{\partial V_{t+1}}{\partial n_{t+1}} = E_t \tilde{\Lambda}_{t,t+2} [(R_{kt+2} - R_{t+2})\phi_{t+1} + R_{t+2}]. \quad (6.2)$$

From equation (16), the “augmented bank’s discount factor” tells us that when the bank exits and has the retained earnings left, those will be transferred to household with probability $1 - \sigma$. Moreover, with probability σ , bank continues and uses net worth to expand their balance sheet (Meyer, 2010).

Aggregation

The aggregate value of assets that banks can hold is the sum of equation (14), which is the sum across the portfolio restriction on each individual bank, and then we can get equation (17) as follows:

$$(Q_t S_{pt} + \Delta q_t B_{pt}) \leq \phi_t N_t \quad (7)$$

We can say that the aggregate value of assets that the bank can hold to be less than or equal to the multiple ϕ_t of total bank equity. When the constraint is binding, the amount of N_t will decrease and a crisis will be more severed.

The total net worth (N_t) for banks is the sum of the retained earning from existing bankers and the transfers from new bankers.

$$N_t = \sigma \left[(R_{kt} - R_t) \frac{Q_{t-1} S_{pt-1}}{N_{t-1}} + (R_{bt} - R_t) \frac{q_{t-1} B_{pt-1}}{N_{t-1}} + R_t \right] N_{t-1} + X \quad (8)$$

S_{pt} be the total quantity of loans that banks intermediate,

B_{pt} be the total number of government bonds they hold,

$\frac{Q_{t-1} S_{pt-1}}{N_{t-1}}$ and $\frac{q_{t-1} B_{pt-1}}{N_{t-1}}$ are the ratios of assets to net worth, which is the bank’s degree of leverage.

From equation (18), we can say that the total net worth of bank comes from the earnings on assets from last period multiplied by the fraction that survive until the current period, σ . Moreover, the higher degree of the bank's leverage is, the more fluctuation on net worth (Yue et al., 2011).

Central Bank Asset Purchases

Excess return on asset arise, if private intermediation is balance sheet constrain as have been suggested by equation (12) and (13). If the balance sheet constraints are particularly tight, as would be in a financial crisis, the excess returns will be unusually high, with negative consequences for the costs of capital and real activity (Eren et al., 2024). With referred to the created model, LSAPs provide a way for the central bank to reduce excess returns and thus mitigate the consequences of a disruption of private intermediation. The authors abstracted from moral hazard considerations emphasized, for example, by Chari and Kehoe (2009). Gertler et al. (2010) address this issue in a framework similar to the one here by allowing banks the options of issuing outside equity as well as deposits, where equity issuance is subject to agency costs. The possibility of LSAPs then reduces banks' incentives to hedge their portfolios. The precise degree is a quantitative issue. We would expect a similar outcome in the framework here but defer an explicit treatment to future.

The model assuming that the LSAPs, which were conducted by CB, is mainly to the purchase of private loans S_{gt} and long term government bonds B_{gt} . CB finances the purchases by issues short-term government debt D_{gt} that pays the safe market interest rate R_{t+1} . In particular, the central bank's balance sheet is given by

$$Q_t S_{gt} + q_t B_{gt} = D_{gt} \quad (9)$$

where they assume that the central bank turns over any profits to the Treasury and receives transfers to cover any losses. For the time being we suppose that the central bank issues the short-term debt to households. Later we discuss an equivalent scenario where D_{gt} is interpretable as interest bearing reserves (essentially overnight government debt) held by banks on account at the central bank. As we discussed earlier, these kinds of asset purchases essentially involve substituting central bank intermediation for private intermediation (Gambetti & Musso, 2020). What gives the central bank an advantage in this situation is that unlike private intermediaries it is able to obtain funds elastically by issuing short-term liabilities. It is able to do so because within our framework the government can always commit credibly to honoring its debt. Accordingly, there is no agency conflict than inhibits the central bank from obtaining funds from the private sector. Put differently, in contrast to private financial intermediation, central bank intermediation is not balance sheet constrained (Azizova et al., 2024).

At the same time, we allow for the central bank being less efficient than the private sector at making loans. In particular, they assume the central bank pays an efficiency cost of τ_s per unit of private loans intermediated and τ_b per unit of government bonds. Accordingly, for asset purchases to produce welfare gains, the central bank's advantage in obtaining funds cannot be offset by its disadvantage in making loans. Its advantage in obtaining funds is greatest when excess returns are large (i.e when limits to private arbitrage are tight), as will be the case in a financial crisis. As for its disadvantage in making loans, it is reasonable to suppose the relative efficiency cost of intermediating government bonds, τ_b , is small. For τ_s , it depends on the type of credit instrument. The types of "private loans" for which one might expect τ_s to be small include highly rated securitized assets such as agency mortgage backed securities as opposed to commercial and industrial loans that involve extensive monitoring (Ben Salem et al., 2024). Accordingly, it is the former type of instrument we have in mind in characterizing central bank purchases of private securities as opposed to the latter.

The way asset purchases affect the real economy is ultimately by affecting the price Q_t and (hence the) excess return on capital $E_t \tilde{A}_{t,t+1} (R_{kt+1} - R_{t+1})$. Accordingly, let S_t and B_t be the total supplies of private loans and long-term government bonds, respectively. Then by definition:

$$S_t = S_{pt} + S_{gt} \quad (10)$$

$$B_t = B_{pt} + B_{gt}$$

where as before S_{pt} and S_{bt} are the total amounts that are privately intermediated. We combine these identities with the balance constraint on the banks to obtain the following relation for total the total value of private securities intermediated, $Q_t S_t$:

$$Q_t S_t \leq \phi_t N_t + Q_t S_{gt} + \Delta(q_t B_{gt} - q_t B_t) \quad (11)$$

When the aggregate balance sheet constraint is not binding, asset prices and returns are determined by frictionless arbitrage. Asset purchases by the central bank of either private loans or long-term bonds are neutral. They simply lead to central bank intermediation displacing some private intermediation, without any effect on asset prices. To the extent central bank intermediation involves efficiency costs, further, asset purchases are clearly welfare reducing in this kind of environment. This neutrality result disappears; however, if the constraint is binding (Darracq & Papadopoulou, 2020). Given the total quantity of bank equity, an increase in the central bank's holding of either private securities or long-term governments raises the total demand for private securities. Intuitively, with limits to arbitrage present on private credit flows, central bank intermediation expands overall asset demand and does not simply displace bank intermediation one for one. Further, given that asset supplies are relatively inelastic in the short run, the enhanced asset demand pushes up Q_t and down the excess return on capital. Equation (21) also reveals that it matters which asset the central bank acquires. In particular, purchases of government bonds will have a weaker effect on the demand for private assets than would the direct purchase of this asset by the factor $\Delta < 1$. Intuitively, the central bank acquiring government bonds frees up less bank capital than does the does the acquisition of a similar amount of private loans. It is effectively by freeing up intermediary capital that asset purchases are able to expand the overall demand for private assets. In the limiting case of frictionless arbitrage in the government bond market (i.e., $\Delta = 0$), bond purchases have no effect (Negro et al., 2011).

Purchases of either asset affect the excess returns of both due to the arbitrage relation implied by equations (12) and (13):

$$E_t \tilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) = \Delta E_t \tilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) \quad (12)$$

Allowing for Direct Household Securities Holdings

Gertler and Karadi (2013) now permit households to directly hold private securities and long-term government bonds. However, they introduce limits on household participation by assuming transaction costs. Absent these costs, households would engage in frictionless arbitrage of asset returns. Moreover, they suppose that for private securities a household faces a holding cost equal to the percentage $\frac{1}{2} \kappa (S_{ht} - \bar{S}_h)^2 / S_{ht}$ of the value of the securities in its respective portfolio for $S_{ht} \geq \bar{S}_h$. Similarly, for government bonds there is a holding cost equal to the percentage $\frac{1}{2} \kappa (B_{ht} - \bar{B}_h)^2 / B_{ht}$ of the total value of government bonds held for $B_{ht} \geq \bar{B}_h$. Accordingly, there is a certain amount of each asset that the household can hold costless. Going above these levels involves transactions costs, which are increasing at the margin. They motivate this cost structure as capturing in a simple way limited participation in asset markets by households that leads to incomplete arbitrage.

Accordingly, the household budget constraint becomes

$$\begin{aligned} C_t + D_{ht} + Q_t \left[S_{ht} + \frac{1}{2} \kappa (S_{ht} - \bar{S}_h)^2 \right] + q_t \left[B_{ht} + \frac{1}{2} \kappa (B_{ht} - \bar{B}_h)^2 \right] \\ = W_t L_t + \Pi_t + T_t + R_t D_{ht-1} + R_{kt} S_{ht-1} + R_{bt} B_{ht-1} \end{aligned}$$

Resolving the household's optimization yields the same first order conditions for labor supply and deposits as before. The choices for private securities and long term government bonds are given by

$$\begin{aligned} S_{ht} &= \bar{S}_h + \frac{E_t \Lambda_{t,t+1} (R_{kt+1} - R_{t+1})}{\kappa} \\ B_{ht} &= \bar{B}_h + \frac{E_t \Lambda_{t,t+1} (R_{bt+1} - R_{t+1})}{\kappa} \end{aligned} \quad (13)$$

Demand for each asset above its frictionless capacity level is increasing in the excess return relative to the respective curvature parameter that governs the marginal transaction cost. Note that as marginal transactions costs go to zero, excess returns disappear: Households are able to engage in frictionless arbitrage of security returns. Conversely, as marginal transactions costs go to infinity, households' asset demands go to their respective frictionless capacity values, \bar{S}_h and \bar{B}_h .

Overall, one can view the household asset demand structure as a parsimonious way to capture two important forms of heterogeneity that are absent from the model. First, in reality, a sizeable fraction of non-financial firms are able to obtain funds by issuing securities directly to households on the open market and do not have to borrow directly from banks. These firms are typically large well-established entities, in contrast to younger and smaller non-financial borrowers that typically require the kind of evaluation and monitoring services that banks offer. Second, households differ in their ability to manage a sophisticated portfolio: A limited supply of "sophisticated" households accordingly prevents frictionless arbitrage of security returns by the household sector. In practice both forms of heterogeneity help explain why both private and government securities holdings are divided between households and banks. Their model provides a very simple way to account for this pattern of asset holdings that is meant to be a stand-in for a more explicit treatment. With households directly participating in securities markets, the equilibrium conditions in the markets for private loans and government bonds now require:

$$\begin{aligned} S_t &= S_{pt} + S_{ht} + S_{gt} \\ B_t &= B_{pt} + B_{ht} + B_{gt} \end{aligned} \quad (14)$$

To understand the implications for central bank asset purchases, note that with direct household participation in securities markets we can rewrite the aggregate bank portfolio constraint (21) as

$$Q_t (S_t - S_{ht}) \leq \phi_t N_t + Q_t S_{gt} + \Delta q_t [B_{gt} - (B_t - B_{ht})] \quad (15)$$

with S_{ht} and B_{ht} given by (23). The portfolio constraint is now a restriction on the total demand for securities net the quantity held by households.

In this general case, the effects of asset purchases on prices and excess returns depend on the responsiveness of household as well as bank portfolios to arbitrage opportunities. Consider first the case where the marginal transaction costs facing the household are infinity (i.e. $\kappa = \infty$). In this instance, a household holds the respective frictionless capacity value of each asset, S_{ht} and B_{ht} and is completely unresponsive to arbitrage opportunities. Here the analysis is very similar to the simple case of no direct household participation analyzed in section 2.2.

The Production Sector

We now close the model by describing the non-financial production sector, government policy, and the general equilibrium.

Non-Financial Firms

There are three types of non-financial firms in the model: intermediate goods producers, capital producers, and monopolistically competitive retailers. The latter are in the model only to introduce nominal price rigidities. We describe each in turn.

Intermediate Goods Producers

Intermediate goods producers make output that they sell to retailers. They are competitive and earn zero profits in equilibrium. Each operates a constant returns to scale technology with capital and labor inputs. Let Y_t be output, A_t total factor productivity, L_t labor, K_t capital, Then:

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (16)$$

Let P_{mt} be the relative price of intermediate goods. Then the firm's demand for labor is given by

$$W_t = P_{mt}(1 - \alpha) \frac{Y_t}{L_t} \quad (17)$$

It follows that we may express gross profits per unit of capital Z_t as follows:

$$Z_t = P_{mt} \alpha \frac{Y_t}{L_t} \quad (18)$$

The acquisition of capital works as follows. At the end of any period t , the intermediate goods producer is left with a capital stock of $(1 - \alpha)K_t$. It then buys I_t units of new capital from capital producers. Its capital stock for $t+1$ is then given by

$$K_{t+1} = \xi_{t+1}[I_t + (1 - \delta)K_t] \quad (19)$$

where ξ_t is a random disturbance that we refer to as a "capital quality" shock. Following the finance literature (Merton, 1973), we introduce the capital quality shock as a simple way to introduce an exogenous source of variation in the return to capital¹². It is best thought of as capturing some form of economic obsolescence, as opposed to physical depreciation. To finance the new capital, the firm must obtain funding from a bank. For each new unit of capital it acquires it issues a state-contingent claim to the future stream of earnings from the unit: $\xi_{t+1}Z_{t+1}$, $(1 - \delta)\xi_{t+1}\xi_{t+2}Z_{t+2}$, $(1 - \delta)^2\xi_{t+1}\xi_{t+2}\xi_{t+3}Z_{t+3}$, .etc. As we discussed earlier, banks are able to perfectly monitor firms and enforce contracts. As a result, through competition, the security the firm issues is perfectly state-contingent with producers earning zero profits state-by-state. In addition, the value of the security Q_t is equal to the market price of the capital underlying security. Finally, the period $t + 1$ payoff is $(Z_{t+1} + (1 - \delta)Q_{t+1})\xi_{t+1}$: the sum of gross profits and the value of the leftover capital multiplied by the capital quality shock, which corresponds to the definition of the rate of return in equation (5). Before proceeding, it is worth emphasizing that the financial frictions that banks face in obtaining funds from depositors affect the cost of capital to non-financial firms. As we saw in the section 2.2, the capital constraints on banks limit the supply of funds they can intermediate, which raises loan rates. As we illustrate later, a financial crisis sharply tightens these capital constraints (Michael, 2010).

Capital Goods Producers

Capital producers make new capital using input of final output and subject to adjustment costs. They sell the new capital to firms at the price Q_t . Given that households own capital producers, the objective of a capital producer is to choose I_t to solve:

$$\max E_t \sum_{\tau=t}^{\infty} \Lambda_{t,\tau} \left\{ Q_{\tau}^i I_{\tau} - \left[1 + f \left(\frac{I_{\tau}}{I_{\tau-1}} \right) \right] I_{\tau} \right\} \tag{20}$$

From profit maximization, the price of capital goods is equal to the marginal cost of investment goods production as follows,

$$Q_t = 1 + f \left(\frac{I_t}{I_{t-1}} \right) + \frac{I_t}{I_{t-1}} f' \left(\frac{I_t}{I_{t-1}} \right) - E_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t} \right)^2 f' \left(\frac{I_{t+1}}{I_t} \right) \tag{21}$$

Profit (which arise only outside of steady state), are redistributed lump sum to households.

Retail Firms

Final output Y_t is a CES composite of a continuum of mass unity of differentiated retail firms that use intermediate output as the sole input. The final output composite is given by

$$Y_t = \left[\int_0^1 Y_{ft}^{\frac{\varepsilon-1}{\varepsilon}} df \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{22}$$

where Y_{ft} is output by retailer f . Retailers simply re-package intermediate output. It takes one unit of intermediate output to make a unit of retail output. The marginal cost is thus the relative intermediate output price P_{mt} . We introduce nominal rigidities following Calvo (1983). In particular, each period a firm is able to freely adjust its price with probability $1 - \gamma$. Accordingly, each firm chooses the reset price P_t^* to maximize expected discounted profits subject to the restriction on the adjustment frequency. Following standard arguments, the first order necessary condition for this problem is given by:

$$\sum_{i=0}^{\infty} \gamma^i \Lambda_{t,t+i} \left[\frac{P_t^*}{P_{t+i}} - \mu P_{mt+i} \right] Y_{ft+i} = 0 \tag{23}$$

With $\mu = \frac{1}{1-\varepsilon}$. From the law of large numbers, the following relation for the evolution of the price level emerges:

$$P_t = [(1 - \gamma)(P_t^*)^{1-\varepsilon} - \gamma(P_{t-1})^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}} \tag{24}$$

Government Policy

Government expenditures are composed of: government consumption, which we hold fixed at G and the net interest payments from an exogenously fixed stock of long term government debt, which we set at \bar{B} Revenues consist of of lump sum taxes and the earnings from central bank intermediation net transaction costs. As discussed in section 2.3, central bank asset purchases are financed by short term government debt. Given the central bank balance sheet (19), we can express the consolidated government budget constraint as:

$$\begin{aligned} G + (R_{bt} - 1)\bar{B} & \tag{25} \\ & = T_t + (R_{kt} - R_t - \tau_s)Q_{t-1}S_{gt-1} \\ & \quad + (R_{bt} - R_t - \tau_b)q_{t-1}B_{gt-1} \end{aligned}$$

We suppose monetary policy is characterized by a simple Taylor rule. Let i_t be the net nominal interest rate, i the steady state nominal rate, and Y_t^* the natural (flexible price equilibrium) level of output. Then:

$$i_t = i + \kappa_\pi \pi_t + \kappa_y (\log Y_t^* - \log Y_t) + \epsilon_t \quad (26)$$

and where ϵ_t is an exogenous shock to monetary policy, and where the link between nominal and real interest rates is given by the following Fisher relation

$$1 + i_t = R_{t+1} \frac{P_{t+1}}{P_t} \quad (27)$$

We suppose that the interest rate rule is sufficient to characterize monetary policy in normal times. In a crisis, however, we allow for large-scale asset purchases. In particular, we suppose that at the onset of a crisis, which for we define loosely to mean a period where excess returns rise sharply, the central bank purchases the fraction φ_{st} of the outstanding stock of private securities and the fraction φ_{bt} of the outstanding stock of long term government bonds:

$$\begin{aligned} S_{gt} &= \varphi_{st} S_t \\ B_{gt} &= \varphi_{bt} B_t \end{aligned} \quad (28)$$

where both φ_{st} and φ_{bt} obey second order stationary stochastic processes. In the next section we clarify how the central bank intervenes in a crisis with asset purchases.

Resource Constraint and Equilibrium

Output is divided between consumption, investment, government consumption, and expenditures on central bank intermediation Φ_t . The economy-wide resource constraint is thus given by

$$Y_t = C_t + \left[1 + f\left(\frac{I_t}{I_{t-1}}\right) \right] I_t + G + \Phi_t \quad (29)$$

with $\Phi_t = \tau_s Q_{t-1} S_{gt-1} + \tau_g q_{t-1} B_{gt-1}$.

Finally, to close the model, we require market clearing in markets for private securities, long-term government bonds and labor. The supply of private securities at the end of period t is given by the sum of newly acquired capital I_t and leftover capital $(1 - \delta)K_t$

$$S_t = I_t + (1 - \delta)K_t \quad (30)$$

The supply of long-term government bonds is fixed by the government:

$$B_t = \bar{B} \quad (31)$$

Finally, the condition that labor demand equals labor supply requires that

$$(1 - \alpha) \frac{Y_t}{L_t} \cdot E_t u_{ct} = \frac{1}{P_{mt}} \chi L_t^\varphi \quad (32)$$

where the inverse of the price of intermediate goods $\frac{1}{P_{mt}}$ is effectively the retail goods price markup. As we show, this markup can rise in a crisis, enhancing the contraction in employment. We note that because of

Walras' Law, once the market for goods, labor, and long-term securities, cleared, the market for riskless short-term debt will be cleared automatically. As we discussed, households may either directly hold the short-term government debt or instead by banks who in turn issue deposits to households. In the latter case, one can interpret the debt as interest bearing reserves. This completes the description of the model.

Model Analysis

The goal of the paper is to provide a concrete numerical example to illustrate the qualitative insights about the effects of LSAPs developed in the previous part.

Calibration

Table 1 lists the choice of parameter values for the baseline model. Overall there are twenty parameters. Twelve are conventional. Eight $(\sigma, \theta, \Delta, W, \bar{K}^h, \bar{B}^h, \kappa, \bar{B})$ are specific to the model.

Team's Simulation

We have tried to replicate the result of model simulation; however, we found that there might be some missing steps that the authors did not provide in the model they proposed. For example, the authors did not mention the process of the shocks, the functional form of adjustment cost (capital goods producers), the linkage between retail firms and intermediate producers. Nonetheless, we have tried another model simulation and the results were quite amazing that they can explain the direction of the LSAP that match the original model simulations.

The main channel of how LSAP works is through lowering interest rate even though the fund rate (central bank tools) reached zero lower bound.

$$P_t Q_t = \sum_{t=0}^{\infty} \frac{1}{(1+i_t)} \quad (33)$$

This identity tells us that the price of the assets and the return are inversely related, the higher the price the lower the return on it. For this model also assume short run inelastic supply of both private security and bond, the purchase of each will result in higher of price. Taking log linear around steady state on this identity, we have

$$i = -q - p \quad (34)$$

What we did in our model simulation was that we make use of this fact together with the fact that and LSAP will have a negative impact of interest rate (which is all this work is about). So, we tried to simulation the linearized version of New Keynesian model that can explained by a few dynamic equations, which are

$$\text{DIS} \quad y = -\left(\frac{1}{\sigma}\right) \cdot (i - \pi - r_n) + E y_{t+1} \quad (35)$$

$$\text{NKPC} \quad \pi = \beta \cdot \pi_{t+1} + \kappa \cdot y \quad (36)$$

$$\text{Interest Rate} \quad i = \phi_y y + \phi_\pi \pi - q \quad (37)$$

Households		
β	0.995	Discount rate
h	0.815	Habit parameter
χ	3.482	Relative utility weight of labor
B/Y	0.450	Steady state Treasury supply
\bar{K}^h/K	0.500	Proportion of direct capital holdings of the HHs
\bar{B}^h/B	0.750	Proportion of long term Treasury holdings of the HHs
κ	1.000	Portfolio adjustment cost
φ	0.276	Inverse Frisch elasticity of labor supply
Financial Intermediaries		
θ	0.345	Fraction of capital that can be diverted
Δ	0.500	Proportional advantage in seizure rate of government debt
ω	0.0007	Proportional transfer to the entering bankers
σ	0.972	Survival rate of the bankers
Intermediate good firms		
α	0.330	Capital share
δ	0.025	Depreciation rate
Capital Producing Firms		
η_i	1.728	Inverse elasticity of net investment to the price of capital
Retail Firms		
ϵ	4.167	Elasticity of substitution
γ	0.779	Probability of keeping the price constant
Government		
$\frac{G}{Y}$	0.200	Steady state proportion of government expenditures
κ_π	1.500	Inflation coefficient in the Taylor rule
κ_X	-0.125	Markup coefficient in the Taylor rule

Table 1: Parameters

and the negative impact on interest rate that explain in both of interest rate equations. With these equations, we can then replicate the results of the model in term of directions. Note that, instead of trying to find the exogenous process, we used a deterministic model where agents do have perfect knowledge of what is going to happen this is because the program was announced in both magnitude and length before. In our simulation, we do not differentiate the different types of asset purchase as in the papers. We specified the shocks occurs for eights quarters to match the QE1 and the parameters follow the authors calibration and the results are as follow

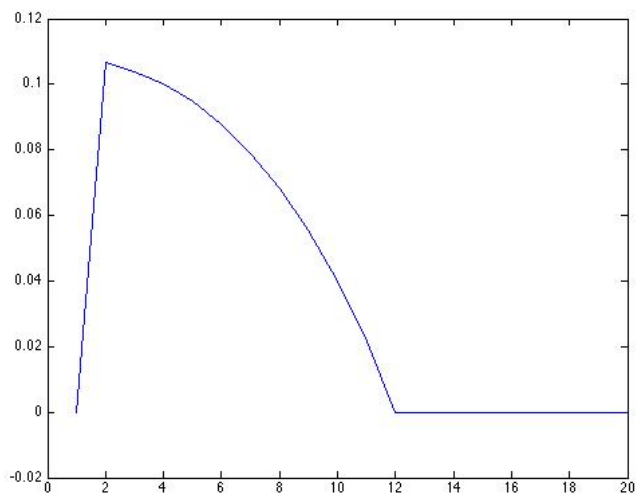


Figure 1 Output (Y)

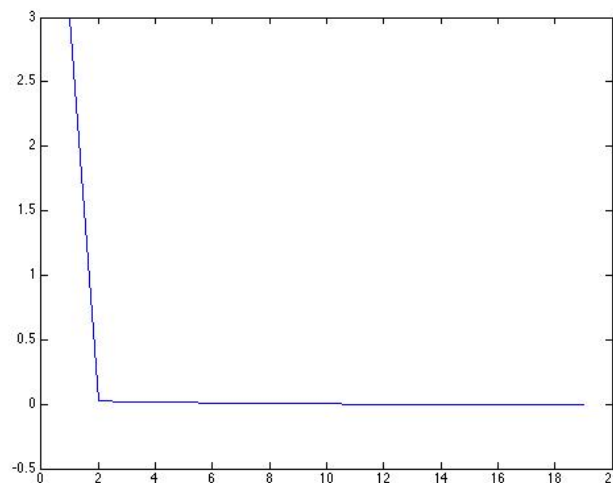


Figure 2 Inflation (π)

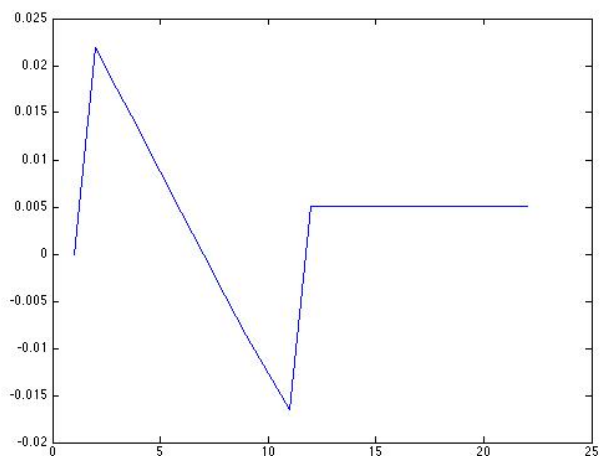


Figure 3 Interest Rate (i)

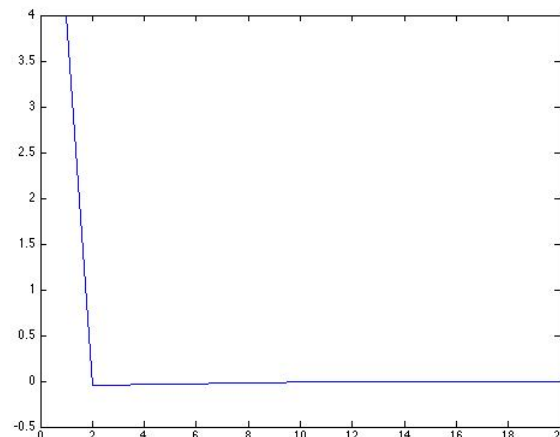


Figure 4 Price of Capital Goods (Q)

Government Bonds of Cambodia

In January 2022, the Ministry of Economy and Finance (MEF) of the Royal Government of Cambodia (RGC) introduced Cambodia's government bonds to the market. The issuance of these bonds was carried out via the National Bank of Cambodia Auction Platform (NBCP) using a bidding system. Governments frequently release these bonds to raise capital for various projects and operational requirements. Although these bonds may attract investors seeking reliable income opportunities, they also carry specific risks like interest rate risk and sovereign risk, which is associated with the government's capacity to meet its financial commitments.

The MEF exclusively released short-term government securities in 2022, with a maturity period of one year, totaling 72.09 billion Riel, which is equivalent to \$US17.51 million (Ministry of Economy and Finance, 2023). The introduction of government bonds marked the beginning of the primary market in Cambodia, spanning three decades after the collapse of the Democratic Kampuchea regime. The main goal was to raise funds for

the nation. The bonds have a face value of 1 million Riel and come with varying maturities of 1, 3, and 5 years. Institutional investors must possess a minimum investment capital of 100 million, whereas individual investors are mandated to have a minimum investment capital of 10 million Riel (Government Bond Service, 2024).

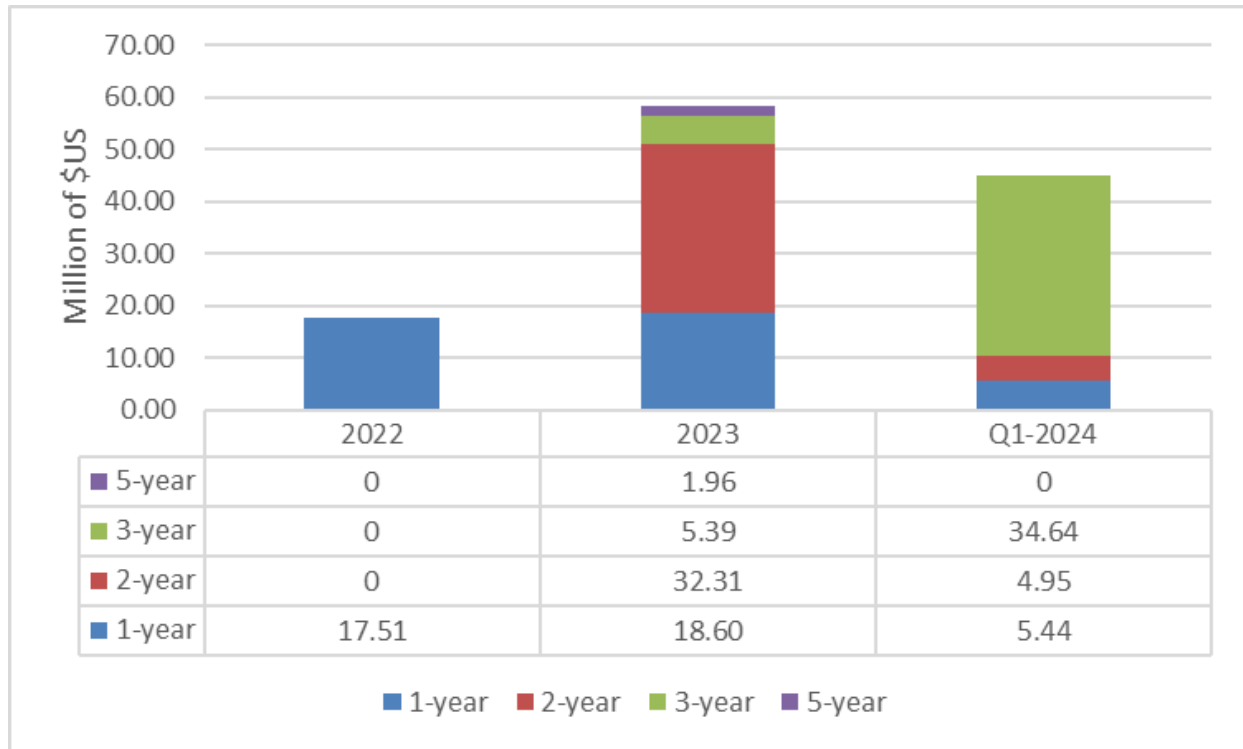


Figure 5 Government securities issuance

Sources: Public Debt Statistical Bulletin, MEF, 2023Q4-2024Q1

During the first six months of 2023, the National Bank of Cambodia facilitated the issuance of a government bond valued at 112 billion Riel, which is approximately \$US27 million. This particular issuance was a component of the overall targeted issuance of 813 billion Riel, equivalent to around \$US200 million. In the same year, the Ministry of Economy and Finance successfully issued a total of 238 billion Riel in government bonds, which is approximately \$58.26 million. During the initial three months of 2024, the government released government bonds with a total value of 182 billion Riel (\$US45.04 million). Out of this amount, 22 billion Riel (\$US5.44 million) were allocated to short-term bonds with a maturity period of 1 year, while the remaining 160 billion Riel (\$US39.59 million) were dedicated to long-term bonds with maturity periods of 2, 3, and 5 years (Ministry of Economy and Finance, 2024).

Monetary and Fiscal Policies in Cambodia

The central bank has been instrumental in ensuring stability in the overall price level within an economy through the effective implementation of monetary policy. The process of implementing a currency substitute, such as dollarization, where a foreign currency like the U.S. dollar serves as the primary medium of exchange, unit of measurement, and store of value alongside the domestic currency, like the Riel in Cambodia, is a complex undertaking that presents various challenges.

The central bank, also known as the NBC, has relinquished its role as a lender of last resort because most lending and borrowing activities within the banking system were denominated in U.S. dollars. As a result, the market interest rate was left to be determined by market forces, making it difficult for the central bank to effectively control it. In order to combat the significant level of dollarization, the central bank made efforts to ensure price stability by focusing on maintaining a stable exchange rate. This approach has long been considered

crucial in achieving price stability. By achieving stability in the overall price level, the economy can experience sustainable growth.

The central bank has maintained a tight control over the money supply, implementing a contractionary monetary policy in response to significant depreciation of the Riel, which could lead to a positive impact on market prices. Conversely, an expansionary monetary policy is put into effect when the Riel experiences substantial appreciation. As per the government's strategic vision, the exchange rate between the Riel and the U.S. dollar is expected to remain stable within the band of 4000 to 4100 Riel per U.S. dollar. Any fluctuations outside of this range may prompt the intervention of the domestic foreign exchange market to maintain stability. The typical approach involves the implementation of a method known as a U.S. dollar auction, where the central bank engages in the buying and selling of U.S. dollars with domestic currency exchangers. The central bank sells U.S. dollars from its international reserve to decrease the money supply of Riel in the market, resulting in a reduction of the international reserve. This action is primarily aimed at managing the currency exchange rates and stabilizing the economy (Lim, 2014).

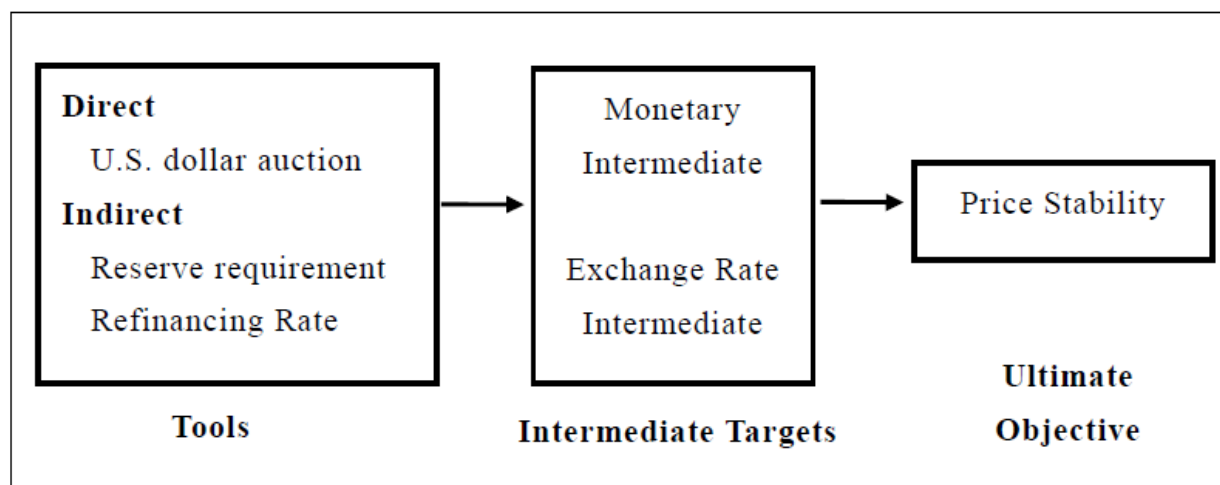


Figure 6 Monetary Policy Strategies of the National Bank of Cambodia

Sources: Constructed by authors

Financial institutions, including banks and MFIs, that are obligated to meet reserve requirements must maintain an adequate amount of eligible assets during the maintenance period. These assets are held with the National Bank of Cambodia to ensure the effective management of liquidity and promote safe and sound operational practices. The assets that can be used to meet the required reserves are restricted to the daily balances maintained in the Institution's reserve requirement and clearing accounts at the National Bank of Cambodia, for both Riel and foreign currencies such as the U.S. dollar, EURO, Thai Baht, and others. Having physical cash available is not deemed as a suitable reserve asset for meeting the minimum reserve requirement obligations. The National Bank of Cambodia must aim to reach the intermediate goals of monetary and exchange rate targets when utilizing reserve requirement and refinancing rate tools. The National Bank of Cambodia has effectively relinquished its role as a lender of last resort to the banking system due to its resistance to dollarization. As a result, the refinancing rate is seldom utilized and is essentially ineffective in the current economic climate of Cambodia (Lim, 2011).

In essence, there are three primary tools that a central bank can utilize to regulate the money supply within an economy. These tools include Open Market Operations (OMO), the discount rate, and reserve requirements. Each of these instruments plays a crucial role in influencing the overall money supply and managing economic stability. OMOs consist of the purchase and sale of government securities (bonds) in the open market. When the central bank purchases securities, it infuses money into the banking system, thereby boosting liquidity and decreasing short-term interest rates. Conversely, selling securities results in the reduction of liquidity and the increase of interest rates. The discount rate refers to the interest rate imposed by central banks on loans

provided to commercial banks and other financial institutions. When the discount rate is decreased, central banks aim to stimulate borrowing and boost the overall money supply. Conversely, increasing the discount rate has an opposing impact, as it elevates borrowing costs and diminishes the money supply. Reserve requirements are the funds that banks must keep in reserve to cover deposits. When reserve requirements are raised, banks have less money available for lending, leading to a decrease in the money supply. On the other hand, lowering reserve requirements allows banks to lend more, which in turn expands the money supply (Mishkin, 2021).

The execution of monetary policy, encompassing the management of money supply, interest rates, and overall economic activity within a nation, heavily relies on the presence and functioning of government bonds. These bonds play a vital role in the hands of central banks as they navigate and regulate various aspects of the economy. An analysis of the relationship between government bonds and monetary policy can be clarified by exploring various factors such as open market operations (OMOs), interest rates, the transmission of monetary policy, inflation management, liquidity control, and financial stability. By carefully assessing these factors, individuals can attain a comprehensive understanding of the intricate relationship between government bonds and the decisions formulated in monetary policy.

The National Bank of Cambodia has faced limitations in implementing the Open Market Operations (OMO) as a monetary policy tool due to the absence of government bonds issued by the Cambodian government before 2022. This has hindered their ability to effectively control monetary aggregates. However, with the introduction of government bonds by the Ministry of Economy and Finance (MEF) in the Cambodia Securities Exchange (CSX) from 2022 onwards, the OMO can now be utilized. The presence of government bonds in the market provides the central bank with the chance to execute monetary policy in the future by engaging in the purchase or sale of government securities. This enables them to regulate the money supply, particularly the Riel that is in circulation within the economy.

The DSGE model combines the principles of microeconomics, including individual decision-making and market interactions, with macroeconomic aggregation and dynamics. This integration creates a comprehensive framework that enables economists and policymakers to analyze the economy. By studying how individual behaviors at the micro-level aggregate to macroeconomic outcomes, and how policy decisions impact the economy over time, the DSGE model provides valuable insights into economic analysis. The DSGE model plays a crucial role in contemporary economic analysis by connecting microeconomics and macroeconomics. With the advancements in Cambodia's financial market and financial instruments, the utilization of the DSGE model for policy analysis and formulation represents the next step for economists and policymakers at the National Bank of Cambodia.

Concluding Remarks

The result of the study revealed that LSAPs could really help to stimulate economic growth in the US. Long-term government bond yield has dropped as the central bank tries to reduce the supply of government bond in the market. The reduction of long-term yield leads to the declining of short-term interest rate, which affects the cost of doing business to decline as well. The decline in both short-term and long-term interest rates has stimulated domestic investment as well as stimulated the economic growth. Nonetheless, the result of this paper consistent with other papers that LSAPs policy not influenced much on the inflation rate. Moreover, the result of our simulation, which is generated from Dynamic Stochastic General Equilibrium (DSGE), is also revealed similar result to this paper. Especially, we found a trade-off between output and inflation.

A popular view of LSAPs — known more broadly as "Quantitative Easing" — is that they reflect money creation. We instead argue that LSAPs should be seen as a central bank intermediation. Just like private intermediaries, the Fed has financed its asset purchases with variable interest bearing liabilities and not money per se. The difference of course is that that Fed's liabilities are effectively government debt. Thus, the Fed's is able to obtain funds elastically in a way that private intermediaries facing financial market frictions are not. As we have shown earlier, it is because of these limits to arbitrage in private intermediation that LSAPs can be effective. While the details of transmission differ, as with conventional monetary policy, LSAPs stimulate the economy by reducing credit costs. Thus, as we have shown, the transmission of real output and inflation is very

similar to the occurring under conventional policy. Unlike conventional policy, LSAPs are an option when the zero lower bound is binding. In addition, LSAPs are actually the most effective in this situation: Holding constant the size of the purchase and the type of the security, an LSAP leads to a larger reduction in long rates the longer is the horizon over, which short term rates are expected not to rise. The framework we presented was designed to provide a unified way to think about the various LSAP programs that the Fed has pursued over the course of the recent crisis. We think that it may also be useful for analyzing new programs under consideration, as well as some LSAPs pursued by other central banks. To illustrate, under consideration at the Fed is "sterilized" QE, which basically involves lengthening the maturity of the liabilities, issued to fund asset purchases from overnight to up to six months. In addition, investors other than banks can hold these liabilities. With sterilized QE, our interpretation of LSAPs as central bank intermediation if anything becomes more obvious. Again, key to the effectiveness of these types of LSAPs are limited on private intermediaries' ability to fund the same long-term securities by issuing liabilities of same (short-term) maturity as the central bank. Finally, though the details differ, the recent long-term refinancing operations (LTROs) undertaken by the ECB have a similar flavor to the LSAPs we have been analyzing.

Under the LTROs, the ECB does not directly purchase assets, but it does so indirectly by accepting the assets as collateral for loans to participating banks. In particular, it provides three-year variable rate credit to banks for loans collateralized by assets it deems acceptable, including certain government bonds, certain asset-backed securities and even certain types of bank loans. The haircuts on the collateral vary according to the risk class. As with LSAPs, for LTROs to be effective, private intermediaries must be limited in their ability to perform the same type of arbitrage as the central bank. We leave for future researches; however, working out the modifications of the model is needed to precisely capture LTROs.

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