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Original Research Article

How Does Monetary Policy Affect Household Income Distribution?

Seyyed Shamseddin Hosseini * **Ahmad Jafari Samimi** †
Hossein Tavakolian ‡ **Nasrin Ghobadi** §

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Over the last decades the research on monetary policy has largely concentrated on the impact of monetary authorities' decisions on inflation and the fine-tuning of the macroeconomic, so that distributional effects of monetary policy which are non-trivial has been ignored. A view that has become increasingly popular since the financial crisis 2008 is that expansionary monetary policy can exacerbate inequality. There is some recent empirical evidence that even in an era of low inflation rates; monetary policy shocks have persistent effects on the distribution of income and consumption across households. However, there has been little formal analysis of "winners" and "losers" from monetary policy. This paper investigates the distributional impact of monetary policy using the data of the Iranian economy based on the Dynamic Stochastic General Equilibrium Models (DSGE) approach. In this framework, the monetary shock via *heterogeneous earnings channel* effects two typical household's income and consumption distribution. As the monetary shock have different effects on the consumption and income of each of typical households relying on model's results, so the distributional effect of monetary policy is confirmed, the reason that monetary authorities must consider distributional effects of their policy besides other goals. The micro-based approach of study is the paper innovation which has been done for the first time in Iran.

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* Faculty of Economics, Allameh Tabataba'i University, Tehran, Iran; Email: Sh.hosseini@atu.ac.ir
† Faculty of Economics and Administrative Science, University of Mazandaran, Babolsar, Iran; Email: jafarisa@umz.ac.ir
‡ Faculty of Economics, Allameh Tabataba'i University, Tehran, Iran; Email: tavakolianh@gmail.com
§ Ministry of Economics and Finance, Tehran, Iran; Email: na_ghobadi@yahoo.com. (Corresponding Author)
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1 Introduction

Over the last decades, the research on monetary policy has largely concentrated on the impact of monetary authorities' decisions on inflation and the fine-tuning of the macroeconomic, so that distributional effects of monetary policy, which are non-trivial, has been ignored. Since households differ in their balance sheet structures and the proportion of received income from various sources, changes in the policy interest rate and purchases of assets from monetary authorities unavoidably affect their income and wealth distribution. Although monetary policy might not be the most significant contributor to overall inequality, its effects on income and wealth distribution cannot be neglected and need to be the subject of detailed scrutiny (Dafermos and Papatheodorou, 2016).

According to the Federal Reserve Act, maximum employment, stable prices, and moderate long-term interest rates are its objectives, so inequality is not a direct object of the Fed's monetary policy. As reflected in these statutory objectives, monetary policy is commonly thought of at the macroeconomic level, responding to and affecting variables such as aggregate employment, inflation, and long-term interest rates. Nonetheless, in pursuing macroeconomic objectives, the tools used by the Fed have the potential to affect inequality. To the extent that household characteristics -like age, type of income, and portfolio composition- are correlated with income or wealth levels and interact with monetary policy changes, they create channels through which monetary policy may affect inequality (Amaral, 2017).

Interestingly, a view that has become increasingly popular since the financial crisis is that expansionary monetary policy can exacerbate inequality. However, there has been little formal analysis of "winners" and "losers" from monetary policy (Doepke et al., 2015). Monetary policy affects the level of aggregate activity and the distribution of income and consumption across households. However, there is some recent empirical evidence that even in an era of low inflation rates, monetary policy shocks have persistent effects on the distribution of income and consumption across households (Coibion et al., 2012).

Knowing how certain monetary policy measures affect different population segments can help policymakers communicate their decisions more effectively. For example, it can help address concerns that episodes of low nominal interest rates as witnessed since the start of the last recession induce a sizable redistribution of wealth. In addition, aggregate economic activity may be affected by the distributional effect of monetary policy

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decisions in ways that are overlooked in a representative-agent setting. In sum, distributional concerns may be an important input for judging the appropriateness of monetary actions and monetary policy stance (Gornemann et al., 2015).

This paper will provide a framework for assessing the distributional effects of monetary policy using the DSGE approach and relying on *heterogeneous earnings channels*. In the next part, we will pay on different Distributional Channels of Monetary Policy. Then Literature Review is presented in section (3). The next section is allocated to the model and its Components. The article is continued with the Model Estimation in section (5). The paper is finished with the conclusion presented in section (6).

2 Monetary Policy Distributional Channels

There is a conventional view that redistribution is a side effect of monetary policy changes, along with the issue of aggregate stabilization. This view is implicit in most models of the monetary policy transmission mechanism, which feature a representative agent.

The *Fisher channel* has a long history in the literature since Fisher (1933). Unexpected inflation revalues nominal balance sheets, with nominal creditors losing and nominal debtors gaining. This has received a great deal of attention in the literature following the work of Doepke and Schneider (2006) who measure the balance sheet exposures of various sectors and groups of households in the United States to different inflation scenarios. On the normative side, Sheedy (2014) asks when the central bank should exploit its influence on the price level to ameliorate market incompleteness over the business cycle. On the positive side, Sterk and Tenreyro (2015) show that the *Fisher channel* can be a source of effects of monetary policy under flexible prices in a non-Ricardian model.

Auclert (2016), besides the Fisher channel, finds two other ones that contribute to the increase in aggregate consumer spending. One is *the earnings heterogeneity channel* of monetary policy. Labor earnings are the primary source of income for most households, and these earnings may respond differently for high-income and low-income households to monetary policy shocks. Carpenter and Rodgers (2004) find that increases in the federal funds rate disproportionately increase the unemployment rates of less-skilled workers and racial minorities. These demographic groups are overrepresented in the lower part of the income distribution. Changes in monetary policy have the potential to affect labor earnings differently, depending on where a household is in the earnings distribution. Similar effects could arise even for

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the employed in the presence of different rates of wage rigidities across the income distribution, varying degrees of complementarities/substitutability with physical capital depending on agents' skill sets (since interest rates affect the relative price of capital and labor), or different endogenous labor supply responses reflecting specific household characteristics such as age and number of children which may systematically differ across the distribution. Heathcote et al. (2010) document that the labor earnings at the bottom of the distribution are most affected by business cycle fluctuations. Coibion et al. (2012) propose an empirical evaluation of this channel by measuring how identified monetary policy shocks affect income inequality in the Consumer Expenditure Survey.

The third *is the interest rate exposure channel* which has not received much attention in monetary policy effect on distribution. This channel relates to redistribution resulting from changes in real interest rates. A fall in real interest rates increases financial asset prices to the extent that the interest rate used to discount future dividends decreases. Net savers whose wealth is concentrated in short-duration assets and net borrowers whose liabilities are of relatively long duration (like fixed-rate mortgages) are benefiting from expansionary monetary policy to the extent that it decreases real interest rates. They do so at the expense of net savers whose wealth is concentrated in long-duration assets and of net borrowers whose liabilities are of relatively short duration (like adjustable-rate mortgages). Of course, one would have to know more about how such assets and liabilities are distributed across the population to infer what would happen to inequality with a change in monetary policy. Doepke and Schneider (2006) called this *Savings redistribution channel* to move inequality in the opposite direction in response to expansionary monetary policy actions. An unexpected increase in interest rates or decrease in inflation will benefit savers and hurt borrowers, thereby generating an increase in consumption inequality (to the extent that savers are generally wealthier than borrowers). They show that the group that would experience larger net wealth increases is middle-aged, middle-class households. It is because these households tend to hold long-term nominally denominated debt in the form of fixed-rate mortgages. On the other hand, older, richer households would lose the most, as they tend to be net savers with deposits and short-term denominated debt .

Another important *channel is* the *income composition channel* emphasized by Ron Paul and Austrian economists; households obtain their incomes from different sources, each of which may respond differently to changes in monetary policy. For example, at the low end of the income distribution, households tend to rely more on transfer income (like unemployment benefits

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and food stamps), while households close to the median will rely on labor income and those at the upper tail of the income distribution will rely relatively more on business and capital income. The implications for inequality stemming from this channel are not clear-cut. Suppose a fall in interest rates stimulates economic activity. In that case, expansionary monetary policy may result in increased wages and decreased unemployment, thereby increasing inequality at the lower end of the distribution, as transfer income will vary little with economic activity.

On the other hand, lower interest rates decrease interest income (mostly accruing to wealthier households), and inequality at the top of the distribution may decrease. This channel could potentially push inequality after expansionary monetary policy toward reduced rather than increased, as suggested by Austrian economists. Because low-income households on average receive a larger share of their income from transfers (e.g.unemployment, benefits, food stamps), and because transfers tend to be countercyclical, this component of income heterogeneity could lead to reduced income inequality after expansionary monetary policy shocks .

La Cava et al. (2016) asserts changes in monetary policy directly affect the household sector through several channels. Lower interest rates can encourage households to save less and bring consumption from the future to the present. It is called the *intertemporal substitution channel*. Lower interest rates can also lift asset prices, such as housing prices, and the resulting increase in household wealth may encourage households to spend more; this is the wealth channel. Additionally, the borrower cash flow channel base follows that lower interest rates reduce the interest payments of borrowing households with variable-rate debt, resulting in higher cash flows and potentially more spending, particularly for households constrained by the amount of cash they have available. At the same time, according to the *lender cash flow channel*, lower interest rates can reduce the interest earnings of lending households, which may lead to lower cash flows and less spending for these households. The household cash flow channel consists of three stages. First, changes in the cash rate are transmitted to changes in the lending and deposit rates faced by households. Second, changes in household lending and deposit rates flow through to changes in household cash flows by changing the required repayments of borrowing households and the net interest earnings of lending households. Third, changes in cash flows can affect household spending, particularly for households constrained by liquidity constraints.

Based on the *financial segmentation channel*, some agents frequently trade in financial markets and are affected by changes in the money supply prior to

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other agents. An increase in the money supply will redistribute wealth toward those agents most connected to financial markets. To the extent that agents who participate actively in financial trades have higher income and consumption on average than unconnected agents, this channel also implies that consumption inequality should rise after expansionary monetary policy shocks.

Also, Dafermos and Papatheodorou (2016) identify four distributional transmission channels of monetary policy: (i) the *interest income channel* that refers to the direct effects of monetary policy stance on the interest income and expenses of households and non-financial firms; (ii) the macroeconomic activity channel which encapsulates the second-round distributional effects of monetary policy via its impact on macroeconomic activity and, thus, on unemployment; (iii) the portfolio reallocation channel that refers to the equity price effects of the portfolio reallocation that stems from a change in the base interest rate; and (iv) the indebtedness channel which is associated with the dynamic interaction between interest expenses, consumption norms, and inequality .

An additional channel pushing in the same direction is the *portfolio channel*. If low-income households tend to hold relatively more currency than high-income households, then inflationary actions on the part of the central bank would represent a transfer from low-income households toward high-income households, which would tend to increase consumption inequality. Also, this channel is called *the Inflation tax channel*. Increases in expected inflation disproportionately erode the purchasing power of households that rely more on cash to conduct their transactions. Conversely, lower-income households tend to use more cash as a percentage of their total expenditures. Erosa and Ventura (2002) find that expected inflation acts as a regressive consumption tax, increasing inequality.

3 Literature Review

Camera and Chien (2012) studied the impact of fully-anticipated inflation in heterogeneous agent economies with endogenous labor supply and portfolio choices. When agents can only self-insure with money, inflation reduces wealth inequality but may raise consumption inequality. Otherwise, inflation reduces consumption inequality but may raise wealth inequality. Due to persistent shocks and an inelastic labor supply, inflation raises average welfare. Coibion et al. (2012) studied the effects and historical contribution of monetary policy shocks to consumption and income inequality in the United States since 1980. Contractionary monetary policy actions systematically

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increase inequality in labor earnings, total income, consumption, and total expenditures. Using detailed micro-level data on income and consumption, they document the different channels via which monetary policy shocks affect inequality. Coibion et al. (2014), Using household-level data on debt accumulation during 2001-2012, show that low -income households in high-inequality regions accumulated less debt relative to income than their counterparts in lower-inequality regions. They argue these patterns are consistent with supply-side interpretations of debt accumulation patterns during the 2000s. The starting point for Doepke et al. (2014), who investigate distributional effects of monetary policy, is a breakdown of nominal asset and liability positions by credit market instrument for households in the United States. They find that announcement of a higher inflation target has sizeable and heterogeneous welfare effects. In particular, middle-aged, middle-class households who currently have the largest mortgage debt burden benefit at the expense of wealthy retirees. In another study (2019), they assess the distributional consequences of monetary policy in the current economic environment in the United States. Through its effect on inflation, monetary policy affects the real value of nominal assets and liabilities and redistributes wealth between borrowers and lenders. In addition, unconventional policies such as "quantitative easing" affect real interest rates and credit availability, once again leading to redistribution effects. They also discuss the recent financial crisis, which has lowered the net worth of many households and tightened financial constraints, has changed the nature of distributional consequences of monetary policy. Gornemann et al. (2015) consider the importance of the earnings and income composition channels in the context of a model in which households differ in their employment status, earnings, and wealth. They find that the redistributive effects of monetary policy are such that contractionary monetary policy shocks increase inequality. The unemployed, in particular, are made worse off by monetary policy tightening, as a contractionary shock tends to prolong their unemployment spell as firms reduce labor demand. Furceri et al. (2016) provide new evidence of the effect of monetary policy shocks on income inequality using a measure of unanticipated changes in policy rates for a panel of 32 advanced and emerging market countries over the period 1990-2013. They find that contractionary (expansionary) monetary actions increase (reduce) income inequality. The effect, however, varies over time, depending on the type of the shocks and the state of the business cycle, and across countries depending on the share of labor income and redistribution policies. Davtyan (2016) evaluates the distributional effects of conventional and unconventional monetary policies

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for the USA. The distributional effects are evaluated for the overall impact on the income distribution, using Gini index. Results show contractionary conventional monetary policy reduces income inequality while expansionary unconventional monetary policy raises it. Surprisingly the distributional impact of conventional monetary policy is stronger. Dafermos and Papatheodorou (2016) study the effects of monetary policy on income and wealth inequality using an agent-based stock-flow consistent model. The model consists of heterogeneous households that differ in skills, employment status, income sources, wealth accumulation, and portfolio choices. Their simulation analysis shows that expansionary monetary policy increases income inequality in the short run. It happens primarily due to the reduction in the interest payments of non-financial firms that increase the dividend income of richer households. They believe the borrower channel is a stronger channel of monetary transmission than the lender channel, such that lower interest rates will typically increase household cash flows and lead to higher spending in aggregate. Based on a panel of Australian households, La Cava et al. (2016) explore whether changes in interest rates affect household consumption by changing the amount of cash that households have to spend. They find when interest rates decline, the cash flows and durable goods spending of households with variable-rate mortgage debt increases relative to comparable fixed-rate borrowers. Flodén et al. (2016) study the cash flow channel in Sweden using administrative data and show that interest rate shocks affect the cash flows of households with variable-rate mortgage debt. It, in turn, has a strong effect on their spending. Auclert (2016) evaluates the role of redistribution in the transmission mechanism of monetary policy to consumption using sufficient statistics shows an interest rate exposure channel is plausibly as large as the intertemporal substitution channel in Italian and in U.S. data. Amaral (2017) examines the link between monetary policy and income and wealth inequality by reviewing the theoretical channels that have been proposed and examining the empirical evidence on their importance. His analysis suggests that the magnitude of any redistributive consequences of conventional monetary policy seems to be small. Feldkircher and Kakamu (2018) examine the effects of monetary policy on income inequality in Japan using a novel econometric approach that jointly estimates the Gini coefficient based on micro-level grouped data of households and the dynamics of macroeconomic quantities. Results indicate different effects on income inequality for different types of households.

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4 Model

The New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model consists of two production sectors and two types of representative households. The DSGE model is used to illustrate how the distributional effects of a monetary policy shock change the economy's structure. Since the heterogeneous earnings channel appears as central to the distributional effects of monetary policy, our model is absent from some of the channels. In following, the model's agents are described:

4.1 Two Households

There are two types of an infinitely-lived representative household, X and Z; each of which has two types of members; one member that supplies its labor inputs to one of the two sectors exclusively, and another member that can split its labor inputs, supplying its labor inputs to both sectors. We refer to these as attached and mobile labor inputs, respectively. Households receive utility from consumption Ct and real money balances (m_t), and disutility from working hours of the first type of member denoted as Nt; and those of the second type of member denoted as Ht: The expected utility function (1) is described in the following manner.

$$\mathrm{Us,t} = E_t\left[\sum_{q=0}^{\infty} \beta^{\mathrm{q}}\left(\log\left(\mathrm{C}_{s,t+q} - bC_{s,t+q-1}\right) - \theta\frac{\mathrm{N}_{s,t+q}^{1+\eta}}{1+\mu} - \emptyset\frac{H_{s,t+q}^{1+\delta}}{1+\delta} + \tau\frac{m_{s,t+q}^{1-\lambda}}{1-\lambda}\right)\right] \quad (1)$$

For s = X and Z: Here, $\beta \in (0,1)$is the discount factor, b > 0 captures the degree of habit formation, $\eta, \sigma, \lambda > 0$; are respectively the inverse of the Frisch labor-supply elasticity and money balances elasticity, and $\theta, \phi > 0$ are the weighting assigned to attach and mobile labor inputs, respectively. The budget constraint for each of the households is given by:

$$m_{s,t} + C_{s,t} + I_{s,t} + bo_{s,t} = w_{s,t}N_{s,t} + w_t H_{\mathbf{s,t}} + \mathrm{r_t k_{s,t-1}} + \mathrm{R_{t-1}}\frac{bo_{s,t-1}}{\pi_t} + \frac{\mathbf{m_{s,t-1}}}{\pi_t} \quad (2)$$

Where $\mathrm{bo_{s,t}}$ is the nominal bond holding and ws;t and wt are the real wages paid to the attached labor inputs of the household s; for s = X and Z; and the mobile labor inputs, respectively. Notice that the real wage for attached labor inputs ws;t differs across household types, and mobile labor inputs wt is common across household types. K.X. and K.Z.; is the share of capital stock held by the household s; Rt-1 is the nominal return to bonds holding. The rule of capital accumulation is as follows; ν is depreciation rate:

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$$k_t = (1 - v)k_{t-1} + \mathrm{I_t} \tag{3}$$

4.2 Firm's Goods Production

The economy consists of two sectors, X and Z; and each sector has final goods firms and a continuum of intermediate goods firms. Perfectly competitive final goods firms use a continuum of intermediate goods $\mathrm{i} \in (0; 1)$for sector X and $\mathrm{j} \in (0; 1)$ for sector Z; and produce the gross output Xt and Zt that are used for constructing the consumption basket Ct. The gross output is produced using the following production technology;

$$\tilde{X}_t = \left[\int_0^1 x_t\,(i)^{1-\epsilon^{-1}} di\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{4}$$

$$\tilde{Z}_t = \left[\int_0^1 z_t\,(j)^{1-\epsilon^{-1}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{5}$$

Where $\epsilon \in (1; 1)$ denotes the elasticity of substitution between differentiated products and xt (i) and zt (j) are products of intermediate goods firms in the two sectors.

The demand functions for the differentiated products produced by firms i and j are derived from the optimization behavior of the final goods firms, and they are represented by:

$$x_t\,(i) = \left[\frac{P_{x,t}(i)}{P_{x,t}}\right]^{-\varepsilon} \tilde{X}_t \tag{6}$$

$$z_t\,(j) = \left[\frac{P_{z,t}(j)}{P_{z,t}}\right]^{-\varepsilon} \tilde{Z}_t \tag{7}$$

Where $\{P_{x,t}(i)\}$ and $\{P_{z,t}(j)\}$ for i; j ∈ [0; 1] are the nominal price of the differentiated products, and $P_{x,t}$and $P_{z,t}$ are the price indices of the two final goods that are expressed as:

$$P_{\mathrm{X,t}} = \left[\int_0^1 P_{x,t}(i)^{1-\varepsilon}\, di\right]^{\frac{1}{1-\varepsilon}} \tag{8}$$

$$P_{\mathrm{Z,t}} = \left[\int_0^1 P_{z,t}(j)^{1-\varepsilon}\, dj\right]^{\frac{1}{1-\varepsilon}} \tag{9}$$

Each intermediate goods firm produces goods from two labor inputs and the sector-specific capital stock, with the Cobb-Douglas production technology described below.

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$$x_t(i) = Aa_{x,t} \mathrm{N}_{\mathrm{x,t}}^{\alpha\mu} \mathrm{U}_{\mathrm{x,t}}^{\alpha(1-\mu)} \mathrm{K}_{\mathrm{x}}^{1-\alpha} \quad (10)$$

$$z_t(j) = Aa_{z,t} \mathrm{N}_{\mathrm{z,t}}^{\alpha\mu} \mathrm{U}_{\mathrm{z,t}}^{\alpha(1-\mu)} \mathrm{K}_{\mathrm{z}}^{1-\alpha} \quad (11)$$

Here, A is the technology level that is common to the two sectors; $N_{x,t(i)}$ and $N_{z,t(j)}$; $U_{x,t(i)}$ and $U_{z,t(j)}$; and $K_{x,t(i)}$ and $K_{z,t(j)}$; are the attached labor inputs, mobile labor inputs, and sector-specific capital inputs used by the firm i and j; and α and μ are the parameters that govern the production technology.

4.3 Firms' Price Setting

Differentiated firms i and j are monopolistic competitors in the product's market. A firm i in the sector X sets the price for its products $P_{x,t}(i)$ in reference to the demand given by the equation (9): It can reset the prices solving the following problem; Price indexation is imposed in budget constraint, so inflation rate would not be zero in steady-state. In this case, current inflation is not just affected by future expected inflation but is influenced by past inflation; Price indexation in a DSGE framework:

$$\max_{P_{X,t(i)}} E_t \left[\sum_{q=0}^{\infty} \beta^{t+q} \frac{\Lambda_{t+q}}{\Lambda_t} \frac{\Pi_{t+q,X}(i)}{P_{t+q}} \right] \quad (12)$$

$$s.t: \Pi_{t+q,X}(i) = P_{X,t+q}(i)\, x_{t+q}(i) - MC_{X,t+q}(i)\, x_{t+q}(i) - \frac{kX}{2} \left(\frac{\frac{P_{X,t+q}(i)}{P_{X,t+q-1}(i)}}{\frac{P_{X,t+q-1}(i)}{P_{X,t+q-2}(i)}} - 1 \right)^2 P_{X,t+q} X_{t+q} \quad (13)$$

where Λ_{t+q} is the Lagrange multiplier associated with budget constraint (8) of the household in the period t + q; $MC_{x;t+q(i)}$ is the nominal marginal cost derived from the production function (10); that is given as follows.

$$MC_{s,t} = \frac{\bar{\phi}_{MC} w_{s,t}^{\alpha\mu} w_t^{\alpha(1-\mu)} R_{S,t}^{1-\alpha}}{A} \quad (14)$$

$$\bar{\phi}_{MC} \equiv (\alpha\mu)^{-\alpha\mu} \left(\alpha(1-\mu)\right)^{-\alpha(1-\mu)} (1-\alpha)^{\alpha-1} \quad (15)$$

4.4 Aggregations

There are agents named aggregators that purchase each of the value-added goods, which we denote as Xt and Zt and defined below, and construct the composite of consumer goods from the two goods, using the following technology, and sell the goods to households in a competitive manner.

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$$C_t = X_t^{\rho} Z_t^{1-\rho}; \quad (16)$$

Where $\rho \in [0,1]$ which is the technology parameter associated with the aggregation. Note that the cost minimization problem of aggregators given the aggregation technology (15) implies that the aggregate price index is expressed as

$$P_t = \rho^{-\rho}(1-\rho)^{\rho-1} P_{x,t}^{\rho} P_{z,t}^{1-\rho}: \quad (17)$$

Note that using this price index, the demand for each of the two goods can be shown as follows.

$$X_t = \rho\left(\frac{P_t}{P_{X,t}}\right) Y_t \; and \; Z_t = (1-\rho)\left(\frac{P_t}{P_{Z,t}}\right) Y_t$$

Throughout the simulation, we assume that $\rho > 1-\rho$ and $k_x > k_z$. Because model parameters associated with two representative agents and two sectors are symmetric in other aspects, the first assumption implies that household X receives higher earnings than does household Z at the steady-state, and therefore enjoys a higher level of consumption than does household Z. In other words, both earnings and consumption inequality across households are present at the steady-state. In addition, this assumption implies that the value-added of sector X is larger than that of Z at the steady-state. The second assumption implies that a monetary policy differently affects the two goods sectors around the steady-state. It is because the price of goods X; $P_{x,t}$t is adjusted at a slower pace than that of goods Z; P.z.,t; in the wake of a monetary policy shock. When an expansionary monetary policy shock is considered, this assumption further implies that goods X attract a greater demand than goods Z; because goods X becomes cheaper than goods Z.

4.5 Government and Central Bank

Considering the interaction between Government and Central Bank in Iran, we put them together in one framework. The government aims to balance the budget; the Central Bank's concentration is on price and economic growth stability. Government expenditure is provided from lump-sum tax, publishing bonds, and oil revenue. If the government could balance its budget, there would be no need for money creation. Then Central Bank performs monetary policy without government budget consideration. Otherwise, the government is used to borrowing from the central bank or withdrawing his deposits in Central Bank, causing money creation. Since the government converts its oil

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revenue to current money, government budget constraints include monetary base deviations. In this situation, budget constraint is as follows:

$$g_t + (1 + r_t)\frac{bo_{t-1}}{\pi_t} = t_t + \mathrm{bo_t} + \left(m_t - \frac{m_{t-1}}{\pi_t}\right) \quad (18)$$

Suppose the government budget follows the first-order autoregressive process:

$$\log g_t = \rho_G \log g_{t-1} + \varepsilon_t^G \quad (19)$$

Monetary base or central bank balance sheet is defined as:

$$M_t = DC_t + \mathrm{F.R._t} \quad (20)$$

Which DC is domestic credits, and F.R. is the net foreign resource. This equation based on real value is written as follows:

$$m_t = \mathrm{d}c_t + \mathrm{fr_t} \quad (21)$$

The central bank's foreign resource is supposed:

$$fr_t = \frac{fr_{t-1}}{\pi_t} + o_t \quad (22)$$

We will suppose the central bank uses the growth rate of money volume (Liquidity changes) as a monetary policy tool[1]. It is the best assumption that describes monetary policymaking in I. R. Iran. So, the Central bank is able to control the volume of money in the economy by affecting the money supply or monetary aggregate by changing in money base and the money multiplier. But the central bank has two goals: Optimal inflation (targeted inflation) and optimal production (yt). Central bank determined liquidity growth rate to reach its goals (Optimal inflation and optimal production). Therefore, in the response function, we assume that just monetary authorities are informed about targeted inflation, and other agents do not know anything about it. Suppose that this implicit targeted inflation is based on following the first-order autoregressive process, which $\rho\pi$ is close to 1, so conditional expectation of targeted inflation in period t is too close to the conditional expectation of targeted inflation last period. The reason for this assumption is

[1] Tavakolia and komijani(2012)

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that the monetary policymaker tries to keep the average inflation constant over time; although sometimes achieving this goal is failed.

According to this, the monetary authority's reaction function is defined as a log-linear function as follows[1]:

$$\hat{m}_t = \rho_m \hat{\mathrm{m}}_{t-1} + \rho_\pi(\hat{\pi}_t - \hat{\pi}_t^*) + \rho_y(\hat{y}_t - \hat{y}_t^*) + \varepsilon_{m,t} \quad (23)$$

Log linearized of oil revenue is formulated as:

$$\hat{O}_t = \rho_o \hat{O}_{t-1} + \varepsilon_t^0 \ , \varepsilon_t^0 \approx (0, \sigma_0^2) \quad (24)$$

4.6 Resource constraint

The resource constraints for three production inputs are given as follows:

$$\int_0^1 N_{x,t}(i)di = N_{x,t} \ and \ \int_0^1 N_{z,t}(j)dj = N_{z,t}$$
$$\int_0^1 N_{x,t}(i)di + \int_0^1 N_{z,t}(j)dj = H_{x,t} + H_{z,t}$$
$$\int_0^1 K_{x,t}(i)di = K_x \ and \ \int_0^1 K_{z,t}(j)dj = K_z$$

Note that two terms in the left-hand side of the equation (20) stands for the number of labor inputs by mobile workers to sector X and Z; while those on the right-hand side of the equation stands for the amount of labor input supplied by mobile workers in household X and Z: We hereafter denote the total labor inputs of mobile workers in the two sectors by UX;t and U.Z.;t. The resource constraints for the gross output produced by final goods producers ~ Xt and ~ Zt are given as follows.

$$\tilde{X}_t = \left(1 + \frac{\kappa_X}{2}\left(\frac{P_{x,t}}{P_{x,t-1}} - 1\right)^2\right) * X_t \quad (25)$$

$$\tilde{Z}_t = \left(1 + \frac{\kappa_Z}{2}\left(\frac{P_{z,t}}{P_{z,t-1}} - 1\right)^2\right) * Z_t \quad (26)$$

Total consumption includes both X and Z households consumption, capital of X and Z production sectors consist total capital of economy; total government expenditure is allocated two both sectors. These are shown in equations 27 to 29:

$$C_t = C_{x,t} + C_{z,t} \quad (27)$$
$$k_t = k_{x,t} + k_{z,t} \quad (28)$$

[1] Tavakolian and komijani (2012)

[DOI: 10.29252/jme.17.1.1]

$$g = g_x + g_z \tag{29}$$

We assume the value-added of sector X is larger than that of Z at the steady-state, so this sector invests some of its production, and another sector's production is totally consumed by individuals or government than we have:

$$x_t = c_{xt} + g_{xt} + i_t \tag{30}$$

$$Z_t = C_{zt} + G_{zt} \tag{31}$$

5 Model Estimation

Linear estimation of the model during 1367-96 using annual data of money growth, oil revenue, government expenditure, production, and inflation of X and Z sectors is presented here. The Hodrick-Prescott filter is used to smooth the data logarithms. Some parameters are calculated based on variables on the steady-state, and there is no need to estimate. Others are variables ratio in S.S. So, calibrated indexes based on the Iranian economy are shown in Table (1). The data are extracted from the database of the Central Bank and the Statistics Center of Iran and include the variables of the labor market and production of goods and consumption of households.

Table 1
Model calibrated parameters based on Iran Economics Data

$\bar{c}$	$\bar{c}_x$	$\bar{c}_z$	$\bar{x}$	$\bar{z}$	$\bar{g}_x$	$\bar{g}_z$	$\bar{h}_x$	$\bar{h}_z$	$\bar{u}_x$	$\bar{u}_z$
14.63	13.67	14.14	14.592	14.597	13.02	14.17	15.745	14.918	14.451	15.894
$\bar{\pi}$	$\bar{\pi}_x$	$\bar{\pi}_z$								
0.164	0.174	0.169								
$\frac{\bar{c}}{\bar{y}}$	$\frac{\bar{g}}{\bar{y}}$	$\frac{\bar{\imath}}{\bar{y}}$	$\frac{\bar{o}}{\bar{fr}}$	$\frac{\bar{dc}}{\bar{m}}$	$\frac{\bar{fr}}{\bar{m}}$	$\frac{\bar{k}_x}{\bar{k}}$	$\frac{\bar{k}_z}{\bar{k}}$	$\frac{\bar{m}_x}{\bar{m}}$	$\frac{\bar{m}_z}{\bar{m}}$	$\frac{\bar{\imath}}{\bar{x}}$
0.499	0.359	0.14.	1.2	0.41	0.59	0.618	0.382	0.716	0.284	0.288

Source: Research Findings

For empirical analysis, linearized equations in the Dynar environment under Matlab software applying the Bayesian approach are used to estimate the parameters. Before simulating the shocks, a calibration method was used to estimate the model parameters. So, we should choose prior distributions for the parameters which are added to the likelihood function. The prior distribution of each parameter is selected based on its characteristics compared with the distribution's character. One of the best methods for parameter estimation is the Bayesian method. Bayesian inference combines the prior belief (knowledge) with the empirical data to form a posterior distribution,

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which is the basis for statistical inference. Table (2) reports the posterior mean and standard devotions for the structural parameters.

Table 2
Model parameters using Bayesian approach

Interval confidence	Post mean	Prior mean standard deviation	distribution	description	parameter
0.4473-0.4792	0.4636	0.450 0.0095	beta	mobile labor elasticity in sector z	α_x
0.3569-0.3879	0.3734	0.370 0.0102	beta	mobile labor elasticity in sector x	α_z
0.9682-0.9820	0.9750	0.970 0.0041	beta	The rate of consumer preferences	β
2.8557-3.4802	3.1722	3.5 0.1795	gamma	attached labor supply elasticity	η
2.0828-2.7294	2.4048	2.39 0.1943	gamma	Reverse of real money balance elasticity	λ
0.6815-0.7143	0.6978	0.7 0.0095	beta	attached labor elasticity in sector x	μ_x
0.5884-0.6215	0.6046	0.6 0.0094	beta	attached labor elasticity in sector z	μ_z
0.8730-0.9017	0.8871	0.85 0.0085	beta	Percentage of firms in sector x unable to adjust their prices	ω_x
0.6013-0.6335	0.6172	0.6 0.0101	beta	Percentage of firms in sector z unable to adjust their prices	ω_z
0.8821-0.9159	0.8984	0.9 0.0108	beta	coefficient of government expenditures autoregressive process	ρ_g
0.7738-0.8067	0.7903	0.790 0.0107	beta	coefficient of Monetary autoregressive process in monetary policy reaction function	ρ_m
-2.1923-(-1.3048)	-1.7543	-2.250 0.2564	normal	Inflation significance coefficient in the monetary policy reaction function	ρ_π
-0.7438-(-0.3216)	-0.5101	-2.230 0.1581	normal	Production significance coefficient in the monetary policy reaction function	ρ_y
0.5738-0.6233	0.5983	0.510 0.0142	normal	The share of good x in production	ρ
0.2553-0.3206	0.2888	0.286 0.0211	beta	Coefficient of autoregressive process of oil revenue shock	ρ_o
0.5173-0.5773	0.5457	0.456 0.0191	beta	Coefficient of autoregressive process of technology shock in x production function	ρ_x
0.3059-0.3769	0.3410	0.327 0.0207	beta	Coefficient of autoregressive process of technology shock in z production function	ρ_z
1.8169-2.2257	2.0211	1.500 0.1189	gamma	Discount factor	σ

[DOI: 10.29252/jme.17.1.1]

Source: Research Findings

To investigate estimation accuracy, Brooks and Gelman's (1998) diagnostic test is used. It evaluates MCMC convergence by analyzing the difference between multiple Markov chains. The convergence is assessed by comparing each model parameter's estimated between-chains and within-chain variances. Large differences between these variances indicate no convergence. Prior and post-distribution of parameters in Brooks and Gelman's (1998) diagnostic framework are reported in Annex (1), showing their densities are close. Comparing post and prior mean of parameters considering Interval confidence satisfies the relative success of model simulation.

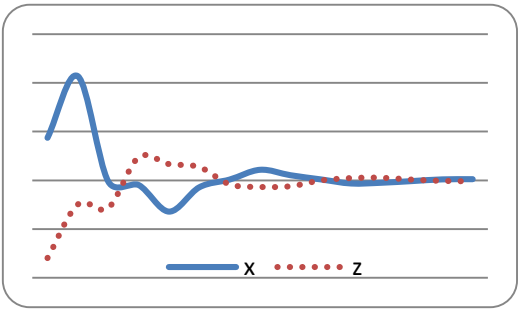
After estimating model indices, we use them to simulate the Iran economy. The impulse response function of endogenous variables in response to exogenous stochastic shocks in accordance with the theoretical framework is another suitable tool to evaluate model fitness. In this regard, the impact of the monetary shock on model variables emphasizing indexes affecting household consumption is analyzed.

Asymmetry Effects of monetary policy on two representative households are visible on (1) diagram. In response to the monetary shock, at first, the capital Volume in Sector x had a higher value-added increase; in contrast, the capital Volume of Sector z decreased. The same effect is correspondingly seen in the production of two sections. It increases the demand for attached labor and, of course, increases its wages. As household x has a higher portion of this kind of labor, it enjoys more income increase.

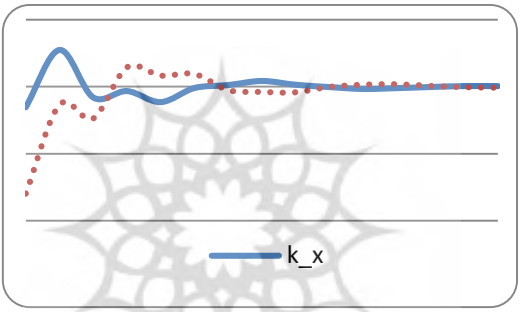
Higher employment of attached labor in two sectors reduces the demand for mobile labor and its wage. Consider this effect is stronger in sector z. Households' x income from the attached labor has increased due to rising wages and supply. Mobile labor employment and its wages have declined in both sectors, but the impact of this decline on household x is offset by increased attached labor income. In contrast, the declining household's z income is noticeable due to declining mobile labor incomes, considering less earning from attached labor's increased income. This process, in sum, increases income and consumption of household x and leads to consumption and income inequality.

[DOI: 10.29252/jme.17.1.1]

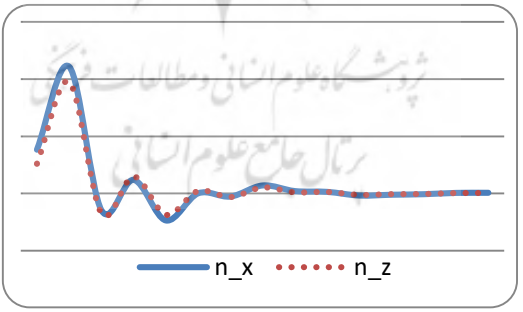
a) Impulse Response functions of production



b) Impulse Response functions of capital



c) Impulse Response functions of attached labor supply



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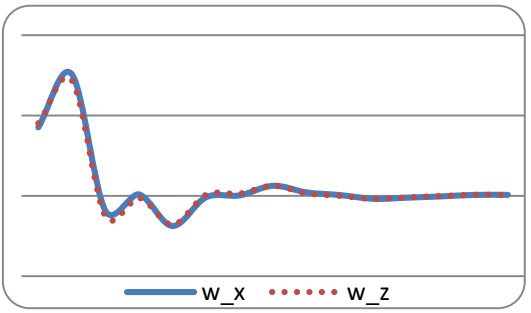
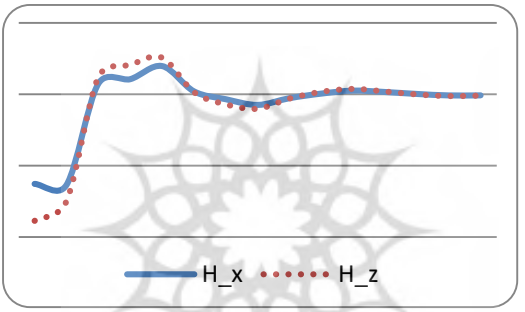
d) Impulse Response functions of attached labor wage



e) Impulse Response functions of mobile labor supply



f) Impulse Response functions of attached labor wage

[DOI: 10.29252/jme.17.1.1]

g) Impulse Response functions of households consumptions

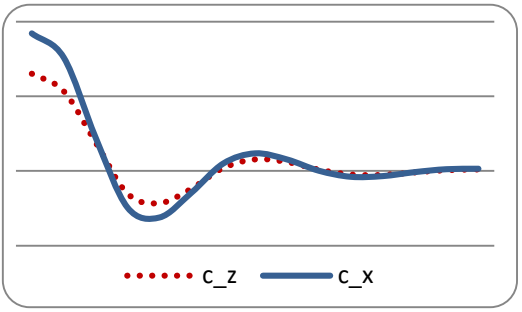


Figure 1. Impulse Response functions of monetary shock.

Source: Research Findings

6 Conclusion

Income and wealth distribution equality are challenging in all societies, especially in developing countries. But, this has usually been considered from fiscal policy and has not received much attention for monetary policy. The primary objective of monetary policy is to achieve stable inflation rate and restrict its fluctuation, and to enjoy a long-term GDP growth trend. Moreover, any distributional effects is not considered for it. But a view that has become increasingly popular since the financial crisis is that expansionary monetary policy can exacerbate inequality. However, there has been little formal analysis of "winners" and "losers" from monetary policy (Doepke et al., 2015). Monetary policy affects the level of aggregate activity and the distribution of income and consumption across households. (Coibion et al., 2012).

Knowing how certain monetary policy measures, such as changes in the inflation target, affect different segments of population can help policymakers communicate their decisions more effectively. More of it, aggregate economic activity may be affected by the distributional effect of monetary policy decisions in ways that are overlooked in a representative-agent setting. In sum, distributional concerns may be an important input for judging the appropriateness of monetary actions and the stance monetary policy (Gornemann et al., 2015).

The purpose of this article was to examine the effects of monetary policy on a household's income and consumption distribution based on micro-bases analysis by using the data of the Iranian economy based on the Dynamic Stochastic General Equilibrium Models (DSGE) approach. In this approach,

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the equations are derived from optimization and have the foundations of microeconomics. It also depicts the dynamic reactions of variables to shocks. Another important feature of the model is the study of the behavior of variables in the context of general equilibrium, which is superior to partial equilibrium patterns. Meanwhile, domestic studies had often examined the effect of monetary policy in the context of econometric models, so that they estimate the effect of monetary policy on the Gini coefficient as an indicator of the income distribution.

The results confirm the impact of monetary policy on the distribution of household income and consumption. Since the monetary shock did not have the same effects on the consumption and income of two typical households, monetary authorities must consider distributional effects of monetary effects besides other goals.

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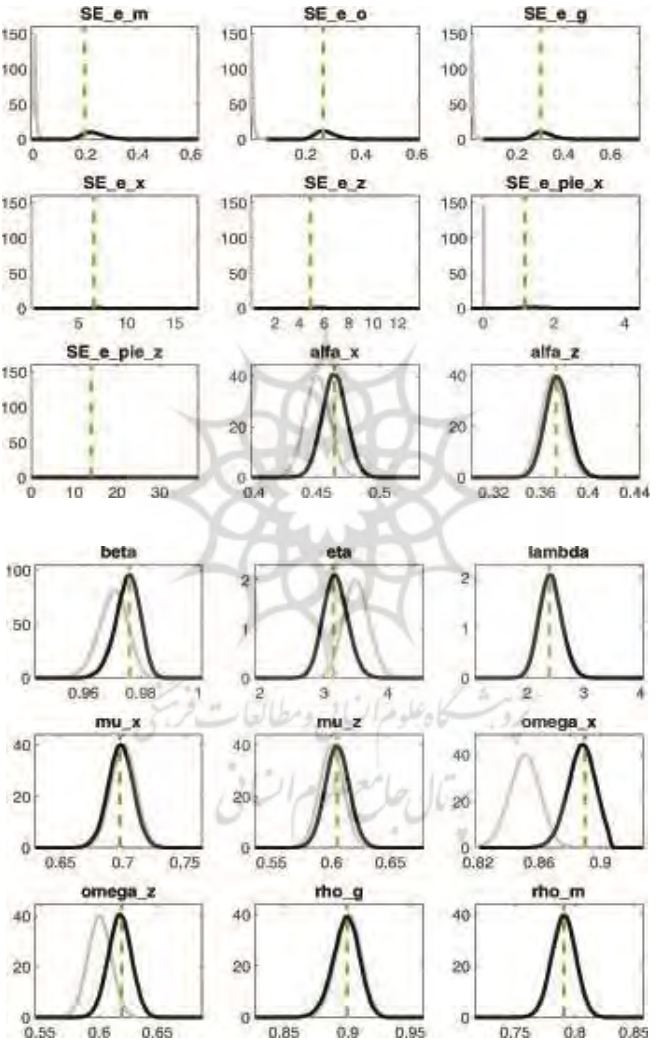
Annex (1)

Post and the prior distribution of Estimated model indices and Brooks and Gelman diagnostic test.



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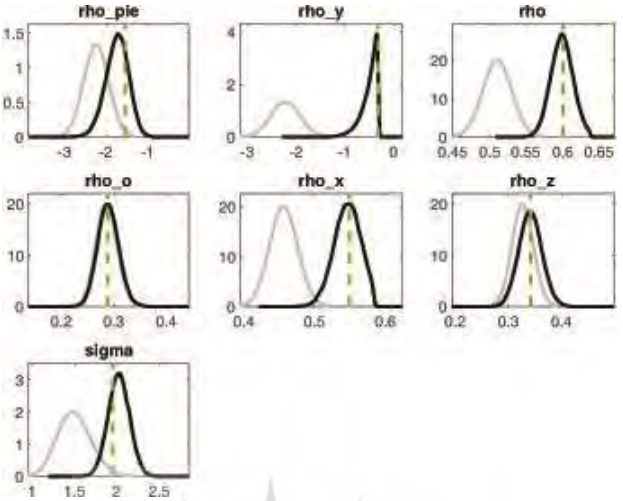

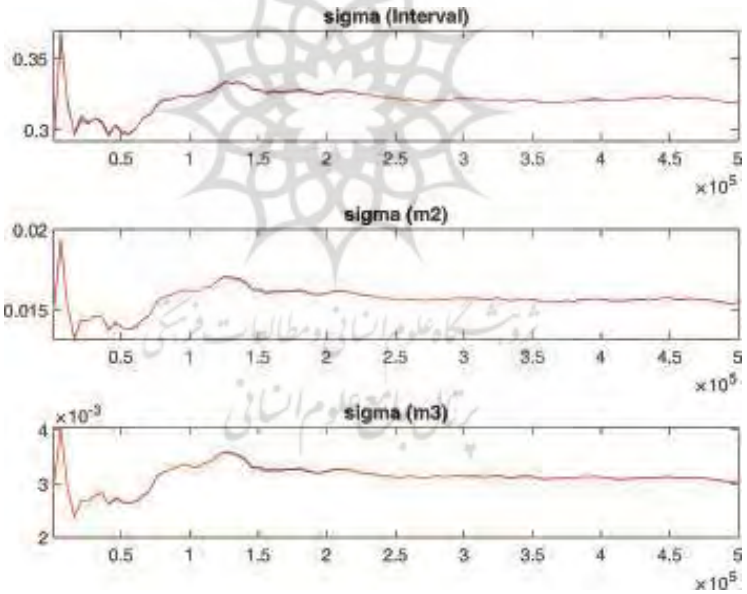

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