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Stock Market Bubbles and Business Cycles: A DSGE Model for the Iranian Economy

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Abstract

This paper investigates the movement between stock market bubbles and fluctuations in aggregate variables within a DSGE model for the Iranian economy. We apply a new Keynesian monetary framework with nominal rigidity in wages and prices based on the study by Ikeda (2013), which is developed with appropriate framework for the Iranian economy. We consider central bank behavior different from Taylor Rule, and we suppose an economy with oil export. In order to study the role of money in economy, we apply "Money in Utility" approach. We study the TFP shock, the monetary policy shock, the government spending shock, the oil income shock and the sentiment shock. Bubbles in our model emerge through a positive feedback loop mechanism supported by self-fulfilling beliefs. Moreover, a sentiment shock drives the movements of bubbles that explain most of the stock market fluctuations and variations in real economy. The result of calibrated model reveals a relation between moments of variables in the model and moments of real data in the economy. Therefore, this model can help us to analyze the effect of stock market bubbles on macroeconomic variables in the economy.

Keywords: DSGE Model, New Keynesian, Nominal Rigidity, Share Exchange Market Bubbles.
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1. Introduction

Evidence shows that asset price bubbles and their collapse typically

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precede financial crises. US Great Recession in 2007 and Asian financial crisis in 1997 are historical examples accompanying by asset price bubbles. The stock market is one of the most important financial markets, since it reflects asset prices more than other markets and it is usually very vulnerable to economic conditions. On the other hand, the stock market movement on macroeconomic quantities is a controvertible issue. Accordingly, identifying the effective variables to obtain the highest position in economic growth and development meanwhile, the appropriate policy responses to these fluctuations are important. Therefore, this paper aims to provide a theoretical and empirical study to address this question: Are developments in stock exchange market source of fluctuations in aggregate variables?

In recent years, there has been a growing interest in research regarding the effects of asset market fluctuations on macroeconomic quantities. (see e. g. Hansen and Singleton, 1983; Mehra and Prescott, 1985; Kent and Lowe, 1997; Bernanke and Gertler, 1999; Cecchetti et al., 2000; Christiano et al., 2008; Castelnuovo and Nistico, 2010; Christiano et al., 2010; Funke et al., 2010; Gali, 2011; Martin and Ventura, 2011; Miao and Wang, 2011a,b, 2015,2012; Miao et al., 2012, 2016; Farmer, 2012a,b; Nistico, 2012; Ikeda, 2013; Miao et al., 2015). However, identifying and explaining the asset price bubbles and their movement affecting real economy are important. Until the global financial crises in 2007-2009, there were few studies addressing rational asset market bubbles, but there is an increasing list of studies seeking to develop models incorporating bubbles since the crises. (see e. g. Kocherlakota, 2009; Hirano and Yanagawa, 2010; Aoki and Nikolov, 2012; Farhi and Tirole, 2012; Carvalho et al., 2012; Martin and Ventura, 2011; Miao and Wang, 2012; Ikeda, 2013; Miao et al., 2015).

In rational asset price bubble models, such as Ikeda (2013) and Miao et al. (2015), the aggregate stock market value is equal to the capital value (Tobin's marginal *Q*) plus a bubble (or speculative) component. They present that a positive feedback loop mechanism generates stock price bubbles when firm uses its assets as collateral to borrow from the lender in order to finance investment. Supporting people's initial optimistic beliefs, they assume that firms face stochastic investment opportunities and bubbles improve investment efficiency. In response to a positive sentiment shock, the bubble and the stock price rise. This relaxes firms' credit constraints and raises their investments. Importantly, the rise in the bubble has a capital reallocation effect, making resources move to firms that are more productive. This makes investment more efficient. Tobin's marginal *Q* falls as the capital stock rises. This induces the labor demand to rise. The wealth effect due to the bubble rise in stock prices causes consumption to rise and the labor supply to fall. It turns out that the rise in the labor demand dominates the fall in the labor supply, and hence labor hours increase. The increased hours and capital together raise output (see e.g. Miao et al., 2015).

During the last decade, the Stock market plays more significant role in Iranian economy. This market has experienced volatile stock price index. Figure (1) presents the Iranian real Stock Price Index and macroeconomic variables during 1996:1-2013:4. Starting from 1999Q2, the stock market rose persistently and peaked in 2005Q3. Following the peak in 2005Q3, the stock market crashed, reaching the bottom in February 2009Q4. Then the stock market went up again and reached the peak in 2013Q4. Output, consumption, investment and

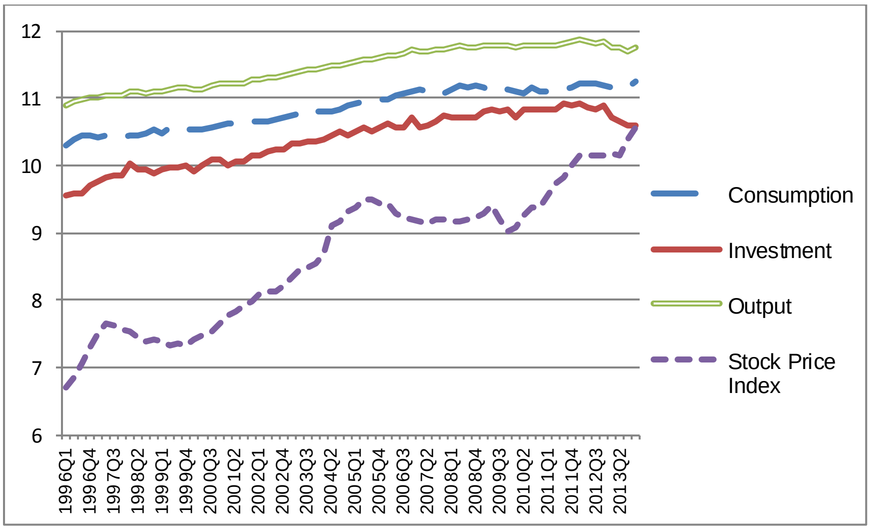

Figure 1: Real Stock Price Indexes and Real Macroeconomic Variables
Source: The CBI[1]

1. The Central Bank of Iran

stock market price were procyclical during this period. The boom phase is somewhat associated with high macroeconomic quantities while the bust phase is sometimes associated with economic downturns. From 2012Q1, the output decreases, but stock price growth is highly positive which is duo to international sanctions imposed on oil industry.

To the best of authors’ knowledge, there are few empirical and theoretical studies on assessing the stock market bubbles for the Iranian economy. Bashiri et al. (2016a), based on the study by Ikeda (2013), investigate the monetary policy rule including money growth and optimal Ramsey policy in restraining the stock market fluctuations. They provide a theoretical and empirical study to address this question: How should monetary policy be conducted during stock market bubbles? Their results show that applying Ramsey optimal monetary policy decreases the central bank’s loss function, relative to monetary policy rule with money growth.

Also, Bashiri et al. (2016b) study the relationship between monetary policy and stock market fluctuations for the Iranian economy within a DSGE model. They model the role of monetary policy in two monetary regimes including money growth and Taylor rule with traditional factors and optimal simple rule. Following Ikeda (2013), bubbles in their model emerge through a positive feedback loop mechanism supported by self-fulfilling beliefs. Results show that: first, using an optimal simple rule and determining the optimal coefficients of the Taylor rule by policy makers decrease the loss function. Second, using an optimal simple rule and determining the optimal coefficients of the Taylor rule with stock price fluctuations by policy makers decrease the loss function and it confirms that monetary policy should respond to stock market bubbles.

In this study, we investigate the movement between share exchange market bubbles and business cycles with applying dynamic stochastic general equilibrium models for better understanding the sources of business cycles in Iran's economy. Thus, we set up our model for rational asset price bubbles according to Ikeda (2013) and Miao et al. (2015).

Miao et al. (2015) estimate a DSGE model of stock market bubbles and business cycles using Bayesian methods for the US. Their model consists of households, firms, capital goods producers and financial intermediaries. In addition, they do not consider money or monetary policy and study a real model of business cycles. In their model, bubbles emerge through a positive feedback loop mechanism supported by self-fulfilling beliefs. They identify a sentiment shock that explains most of the stock market fluctuations and sizable fractions of the variations in real quantities. It generates the co-movement between stock prices and the real economy and is the dominant force behind the internet bubbles and the Great Recession.

Also, we develop Ikeda’s monetary DSGE model with appropriate framework for the Iranian economy. Ikeda (2013) investigates the asset price bubble and agency costs in firm’s price setting decisions into a monetary DSGE framework. Ikeda (2013) sets up his model on the study by Miao et al. (2015), and he extends latter model to a monetary one with credit constraints on working capital. He also introduces nominal price and wage rigidities in the study. Ikeda argues that inflation remains moderate in the boom, because a release in financial tightness lowers the agency costs and adds downward pressure on inflation. The optimal monetary policy calls for monetary tightening to restrain the boom.

This paper contributes to the literature different from Ikeda’s study in several aspects. First, we employ quarterly Iranian data, a small economy with oil export, which is subject to oil price shocks frequently. Second, In order to study the role of money in economy, we apply “Money in Utility” approach that looks more plausible to utilize for studying the Iranian economy. Third, in addition to the TFP shock, the monetary policy shock, the government spending shock, the sentiment shock such as study by Ikeda (2013), we study the oil income shock. Fourth, we consider the CBI's behavior different from Taylor Rule. Fifth, this paper uses different specifications for balancing government budget, which are financed through lump-sum taxation to households, oil income and issuing money. Sixth, this paper sets up a calibrated model. Our results reveal a close relation between moments of variables in the model and moments of realized data. Therefore, this model can help us to analysis the effect of stock market bubbles on macroeconomic variables in economy.

The rest of the paper is structured as follows. Section 2 outlines our model. Section 3 discusses the data and calibrated parameters. Section 4 presents and interprets our main results, and finally section 5 concludes the paper.

2. The Modal

We consider an infinite-horizon economy that consists of wholesale goods firms, retailers, final goods firms, investment goods firms, households, the government and the central bank. Households maximize their utility function subject to a budget constraint, and supply labor to wholesale goods firms. Wholesale goods firms which produces wholesale goods own capital, and they use an identical technology to combine capital and labor in order to produce goods. They are subject to credit constraint because of which a stock price bubble emerges. Retailers are acting in monopolistically competitive markets, and transforming one unit of wholesale goods into one unit of retail goods. Retailers face nominal price rigidities. Final goods firms purchase the retail goods and combine them to produce final goods. Investment goods firms produce investment or capital goods subject to adjustment costs. Wholesale goods firms purchase capital goods from investment goods producers. Model setup is based on new Keynesian framework with nominal rigidities in both wages and prices. The government in this economy spends resources on consumption of the final goods, and the central bank conducts monetary policies in the economy. International trade depends on oil market and it is one of the sources of financing the government budget. Model is inspired by Ikeda (2013) and Miao et al. (2015).[1]

2.1 Households

There is a continuum of identical households placed on unit interval with measure unity, $j \in [0,1]$. Each household obtains utility from consumption, leisure and holding money balances according to the following discounted utility function,

1. Bashiri et al. (2016a, b) in their model use the same model based on Ikeda (2013), and they analyze the optimal monetary policy in the Iranian economy.

$$E_t \sum_{s=0}^{\infty} \beta^s \left\{ \log(C_{t+s} - hC_{t+s-1}) - \psi_L \frac{L_{t+s,j}^{1+v}}{1+v} + \frac{\upsilon}{1-\sigma_q} (\frac{M_{t+s}^d}{P_{t+s}})^{1-\sigma_q} \right\}, \qquad 0 < \beta < 1 \tag{1}$$

Where β is the subjective discount factor, E_t is the expectation operator, h is habit persistence in preferences, whereas υ and ψ_L are weights associated with utility from money holdings and leisure, respectively. Moreover, C_t indicates consumption, L_t indicates labor, M_t indicate the nominal money balances, and P_t indicates the price of final goods.

This representative household maximizes his utility function subject to a budget constraint,

$$P_t C_t + M_t^d - M_{t-1}^d + S_t e_{t+1} + D_t \leq W_{t,j} L_{t,j} + (\pi_t^s + S_t) e_t + R_{t-1} D_{t-1} + \pi_t^p + T_t \tag{2}$$

where W_t is nominal wage, D_t is nominal bonds, e_{t+1} is stock holdings, R_t is nominal interest rate, S_t is average stock price, π_t^s is average dividends, π_t^p is profit of producers, T_t is lump-sum Taxes.

The household's consumption-saving problem is formulated as follows. The first order conditions with respect to C_t, M_t^d and D_t are,

$$P_t \Lambda_t = \left(\frac{1}{C_t - hC_{t-1}} - \beta h E_t \frac{1}{C_{t+1} - hC_t} \right) \tag{3}$$

$$\Lambda_t - E_t \beta \Lambda_{t+1} = \upsilon (\frac{M_t^d}{P_t})^{-\sigma_q} \frac{1}{P_t} \tag{4}$$

$$1 = E_t \left(\beta \frac{\Lambda_{t+1}}{\Lambda_t} R_t \right) \tag{5}$$

where Λ_t is the Lagrange multiplier on the budget constraint in period t. Using equation (5), demand for real money balances could derive from equation (4),

$$1 - \frac{1}{R_t} = \upsilon (\frac{M_t^d}{P_t})^{-\sigma_q} \frac{1}{\Lambda_t P_t} \tag{6}$$

where, the real demand of money is a function of interest rate, price level and consumption. In equilibrium, demand and supply of money are equal; therefore, money market equilibrium determines the interest rate.

Following Christiano et al. (2005) and Ikeda (2013), a household can optimize its wage rate with probability $1-\xi_w$ in each period. With probability ξ_w, the household cannot optimize its wage; in this case it sets its wage rate $W_t(j)$ as follows,

$$W_{t+s}(j) = \begin{cases} \overline{W_t}(j) & if \quad s=0 \\ \left[\Pi_{k=1}^{s}(\pi_{t+k-1} z_{t+k-1})^{lw} (\pi z)^{1-lw}\right] \overline{W}(j) & if \quad s=1,2,... \end{cases} \tag{7}$$

where π_t denotes the gross rate of inflation, π denotes steady state inflation and lw is the wage indexation to product past inflation and the past growth rate of TFP. If household j^{th} had reset the wage in period t and kept it constant until $t+s$, the wage could be expressed as $W_{t+s}(j) = \overline{W}_t(j)\Pi^{w}_{t,t+s}$.

The wage-setting problem can be expressed from maximizing the household utility (1) subject to demand curve for labor,

$$L_{t+s}(j) = \left(\frac{W_{t+s}(j)}{W_{t+s}}\right)^{\frac{\lambda_w}{1-\lambda_w}} L_{t+s} \tag{8}$$

The wage-setting equation is as follows:[1]

$$0 = E_t \sum_{s=0}^{\infty} (\beta\xi_w)^s \hat{\lambda}_{t+s} \frac{L_{t+s}(j)}{1-\lambda_w} \left\{ \overline{w}_t \hat{w}_t \overline{\Pi}^{w}_{t,t+s} - \zeta_{t+s}\psi_L \lambda_w \frac{L_{t+s}(j)^{v}}{\hat{\lambda}_{t+s}} \right\} \tag{9}$$

Real effective wage is defined as $\hat{w}_t = W_t / P_t A_t$, and relative wage is defined as $\overline{w}_t = \overline{W}_t / W_t$, which is the ratio of optimized wage to aggregate wage level (which includes both optimizers and non-

1. Bashiri et al. (2016a) provide an appendix with the details about derivation of the equations used in the model.

optimizers), and $\hat{\lambda}_t = P_t A_t \Lambda_t$. In the Calvo setup, because optimizers (and hence non-optimizers) are randomly chosen from the population, the average wage of non-optimizers in $t-1$ (which must keep their wage constant) is equal to the overall wage index in $t-1$ no matter when they optimized for the last time. Hence, $\overline{W_t}(j)$ depends only on aggregate states, and j is omitted hereafter. According to Bashiri et al. (2016a), dividing through by W_{t-1} and rearranging yields the relative wage of optimizers as an increasing function of the inflation rate,

$$\overline{w}_t = \left(\left[1 - \xi_w \left(\frac{\hat{w}_{t-1}}{\hat{w}_t} \frac{\Pi^w_{t-1,t}}{\pi_t z_t} \right)^{\frac{1}{1-\lambda_w}} \right] (1-\xi_w)^{-1} \right)^{1-\lambda_w} \tag{10}$$

Following the household wage-setting maximization problem in equation (9), we can transform the wage setting condition as follows.

$$F_{w,t} = E_t \sum_{s=0}^{\infty} (\beta \xi_w)^s \frac{\hat{\lambda}_{t+s}}{1-\lambda_w} \left(\frac{\hat{w}_t}{\hat{w}_{t+s}} \right)^{\frac{\lambda_w}{1-\lambda_w}} \left(\overline{\Pi}^w_{t,t+s} \right)^{\frac{1}{1-\lambda_w}} L_{t+s} \tag{11}$$

$$K_{w,t} = E_t \sum_{s=0}^{\infty} (\beta \xi_p)^s \zeta_{t+s} \psi_L \frac{\lambda_w}{1-\lambda_w} \left(\frac{\hat{w}_t}{\hat{w}_{t+s}} \right)^{\frac{\lambda_w(1+v)}{1-\lambda_w}} \left(\overline{\Pi}^w_{t,t+s} \right)^{\frac{\lambda_w(1+v)}{1-\lambda_w}} L^{(1+v)}_{t+s}$$

$$\overline{w}_t = \left(\frac{1}{\hat{w}_t} \frac{K_{p,t}}{F_{p,t}} \right)^{\frac{1-\lambda_w}{1-(1+v)\lambda_w}}$$

We write $F_{w,t}$ recursively as follows.

$$F_{w,t} = \frac{\hat{\lambda}_{t+s}}{1-\lambda_{w,t+s}} L_t + \beta \xi_w E_t \left(\frac{\hat{w}_t}{\hat{w}_{t+1}} \right)^{\frac{\lambda_w}{1-\lambda_w}} \left(\overline{\Pi}^w_{t,t+1} \right)^{\frac{1}{1-\lambda_w}} F_{w,t+1} \tag{12}$$

Arranging $K_{w,t}$ recursively is as follows.

$$K_{w,t} = \zeta_t \psi_L \frac{\lambda_w}{1-\lambda_w} L^{(1+v)}_t + \beta \xi_w E_t \left(\frac{\hat{w}_t}{\hat{w}_{t+1}} \right)^{\frac{\lambda_w(1+v)}{1-\lambda_w}} \left(\overline{\Pi}^w_{t,t+1} \right)^{\frac{\lambda_w(1+v)}{1-\lambda_w}} K_{w,t+1} \tag{13}$$

2.2 Wholesale Good Firms

There is a continuum of wholesale good firms, indexed by j. Firms which produce wholesale goods own capital, and they use an identical technology to combine capital K_t^j and labor L_t^j to produce goods Y_t^j with the following production function,

$$Y_t^j = (K_t^j)^{\alpha}(A_t L_t^j)^{1-\alpha}, \qquad 0<\alpha<1, \qquad z_t \equiv A_t / A_{t-1} \tag{14}$$

where z_t is the growth rate of total factor productivity (TFP) following an $AR(1)$ process,

$$\log(z_t / z) = \rho_z \log(z_{t-1} / z) + \varepsilon_{z,t}, \qquad 0 \le \rho_z < 1 \tag{15}$$

with $\varepsilon_{z,t} \sim N(0,\sigma_z^2)$. The firm's capital stock evolves according to:

$$K_{t+1}^j = (1-\delta)K_t^j + \varepsilon_t^j I_t^j, \qquad 0<\delta<1 \tag{16}$$

where I_t^j, δ, ε_t^j denote respectively investment, the capital depreciation rate, the idiosyncratic shock to investment.

The ε_t^j is iid across firms and over time and follows the Pareto distribution Φ as follows,

$$\Phi : [1,\infty) \longrightarrow [0,1]$$

$$\Phi(\varepsilon) = 1-\varepsilon^{-\eta}, \qquad \eta > 0 \tag{17}$$

In order to formulate the financial friction in capital market, it is assumed that the wholesale good firms have to finance the cost of investment and working capital at the beginning of production process. Let $V_t^j(K_t^j)$ represents the stock market value of the firm with assets K_t^j at time t. The wholesale good firm j^{th} faces a borrowing constraint, given by,

$$P_t^I I_t^j + W_t L_t^j \le (1-\delta_e) E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} \overline{V}_{t+1}^j(\kappa K_t^j) \tag{18}$$

where δ_e is the probability by which a firm may exit the market and has no value. Similar to Miao et al. (2015), firm j pledges a fraction

$\kappa \in (0,1)$ of capital stock K_t^j as the collateral at the beginning of period t. Therefore, the parameter κ reflects the friction of collateral in the credit market and represents the degree of financial market imperfections. The stock market value of the collateral is equal to $E_t(\beta\Lambda_{t+1}/\Lambda_t)\overline{V}_{t+1}^j(\kappa K_t^j)$ at the end of period t. The lender never allows the loan repayment to exceed this value. If firm j loan above $P_t^I I_t^j + W_t L_t^j$, it may walk away and leave the collateralized assets κK_t^j behind. In this case, the lender runs the firm with the collateralized assets κK_t^j at the beginning of period $t+1$ and obtains the smaller firm value $E_t(\beta\Lambda_{t+1}/\Lambda_t)\overline{V}_{t+1}^j(\kappa K_t^j)$ at the end of period t.

As the investment is irreversible at firm level, the firm's value satisfies the following Bellman equation with maximizing its value, subject to (14), (16) and (18):

$$V_t^j(K_t^j) = \max_{\{I_t^j \geq 0, L_t^j \geq 0\}} P_t^w Y_t^j - (W_t L_t^j + P_t^I I_t^j) + (1-\delta_e) E_t \frac{\beta\Lambda_{t+1}}{\Lambda_t} V_{t+1}^j(K_{t+1}^j) \tag{19}$$

The first-order condition with respect to L_t^j yields the following equations,

$$P_t^w = \frac{W_t(1+\xi_t^j)}{(1-\alpha)Y_t^j / L_t^j} = \frac{W_t(1+\xi_t^j)}{(1-\alpha)(K_t^j)^\alpha A_t^{1-\alpha}(L_t^j)^{-\alpha}} \tag{20}$$

$$L_t^j = \left[\frac{P_t^w(1-\alpha)A_t^{1-\alpha}}{W_t(1+\xi_t^j)}\right]^{\frac{1}{\alpha}} K_t^j \tag{21}$$

where ξ_t^j is the Lagrange multiplier on the credit constraint. After solving the labor choice problem, we obtain the operating profits:

$$R_t^j K_t^j = \left[P_t^w (K_t^j)^\alpha (A_t L_t^j)^{1-\alpha} - W_t L_t^j\right] = \frac{\alpha+\xi_t^j}{1+\xi_t^j}\left[\frac{(1-\alpha)A_t}{(1+\xi_t^j)W_t}\right]^{\frac{1-\alpha}{\alpha}} (P_t^w)^{\frac{1}{\alpha}} K_t^j \tag{22}$$

Substituting the above expression into problem (19) the wholesale firm problem maximizing yields,

$$V_t^j(K_t^j) = \max_{\{I_t^j \geq 0\}} R_t^j K_t^j - P_t^I I_t^j + (1-\delta_e) E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} V_{t+1}^j (K_{t+1}^j) \tag{23}$$

subject to,

$$P_t^I I_t^j + \frac{1-\alpha}{\alpha + \xi_t^j} R_t^j K_t^j \leq (1-\delta_e) E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} V_{t+1}^j (\kappa K_t^j) \tag{24}$$

Following Ikeda (2013) and Miao et al. (2015), the value of firm is conjectured to take the following form:

$$V_t^j(K_t^j) = Q_t^j K_t^j + B_{t,\tau}^j \tag{25}$$

where Q_t^j and $B_{t,\tau}^j$ are defined in equation (26) and (27), represent the shadow price of capital, or marginal Q and the bubble component of the asset value, respectively.

Miao and Wang (2011b) defined the credit easing effect, firm j can use the bubble $B_{t,\tau}^j$ to raise the collateral value and relax the collateral constraint. In this way, firm j can make more investment and raise the market value of its assets. If lenders believe that firm j's assets have a high value possibly because of the existence of bubbles and if lenders decide to lend more to firm j; then firm j can borrow and invest more, thereby making its assets indeed more valuable. This process is self-fulfilling and a bubble may sustain.

$$Q_t = (1-\delta_e) E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} Q_{t+1}^j \tag{26}$$

$$\overline{B}_{t,\tau}^j = (1-\delta_e) E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} B_{t+1,\tau+1}^j \tag{27}$$

Using (23), (25), (26), (27) and capital stock (16), problem (19) can be written as:

$$Q_t^j K_t^j + B_{t,\tau}^j = \max_{\{I_t^j \geq 0\}} R_t^j K_t^j + (Q_t \varepsilon_t^j - P_t^I) I_t^j + Q_t (1-\delta) K_t^j + \overline{B}_{t,\tau}^j \tag{28}$$

By maximizing problem (28) subject to credit constraint (24) and definition of value of firm (25), the investment defines as follows:

$$P_t^I I_t^j = \begin{cases} Q_t(\kappa K_t^j) + \overline{B}_{t,\tau}^j - \dfrac{1-\alpha}{\alpha+\xi_t^j} R_t^j K_t^j & if \quad \varepsilon_t^j \geq \varepsilon^* \\ 0 & if \quad \varepsilon_t^j < \varepsilon^* \end{cases} \tag{29}$$

Following Miao et al. (2015), the cost of one unit of investment is the purchasing price P_t^I. The benefit how that is the marginal Q_t. Because of linearity in I_t^j, it is straightforward that the constraint is binding and the investment is maximized when $Q_t \geq P_t^I$, and the investment is zero otherwise.

The investment threshold is $\varepsilon_t^* = P_t^I / Q_t$. Following Ikeda (2013), only firms with idiosyncratic productivity above threshold ε_t^* raise funds up to their credit limit and make investments. Other firms with productivity blew ε_t^* do not invest at all.

Following Ikeda (2013), the FOC with respect to I_t^j yields the Lagrangean as. Equation (29) reflects that only firms with $\varepsilon_t^j > \varepsilon_t^*$ make investment.

$$\varepsilon_t^* = P_t^I / Q_t, \ \xi_t^j = \frac{\varepsilon_t^j}{\varepsilon_t^*} - 1 \geq 0 \tag{30}$$

Substituting the investment rule (29) into problem (28) gives,

$$\begin{aligned} Q_t^j K_t^j + B_{t,\tau}^j &= R_t^j K_t^j + Q_t(1-\delta)K_t^j + \overline{B}_{t,\tau}^j \\ &+ \max\left(\frac{\varepsilon_t^j}{\varepsilon_t^*} - 1, 0\right)\left[Q_t(\kappa K_t^j) + \overline{B}_{t,\tau}^j - \frac{1-\alpha}{\alpha+\xi_t^j} R_t^j K_t^j\right] \end{aligned} \tag{31}$$

Matching coefficients yields:

$$Q_t^j = \begin{cases} R_t^j + Q_t(1-\delta) + \left(\dfrac{\varepsilon_t^j}{\varepsilon_t^*} - 1\right)\left[Q_t \kappa - \dfrac{1-\alpha}{\alpha+\xi_t^j} R_t^j\right] & if \quad \varepsilon_t^j \geq \varepsilon^* \\ R_t^j + Q_t(1-\delta) & if \quad \varepsilon_t^j < \varepsilon^* \end{cases} \tag{32}$$

$$B_{t,\tau}^{j} = \begin{cases} \overline{B}_{t,\tau}^{j} + \left(\dfrac{\varepsilon_t^j}{\varepsilon_t^*} - 1\right)\overline{B}_{t,\tau}^{j} & if \quad \varepsilon_t^j \geq \varepsilon^* \\ \overline{B}_{t,\tau}^{j} & if \quad \varepsilon_t^j < \varepsilon^* \end{cases} \tag{33}$$

where,

$$G_t = \int_{\varepsilon \geq \varepsilon_{t+1}^*} \left(\frac{\varepsilon}{\varepsilon_t^*} - 1\right) d\phi(\varepsilon) \tag{34}$$

Substituting Q_t^j and $B_{t,\tau}^j$ from equations (32) and (33) in equation (26) and (27) yield:

$$Q_t = (1-\delta_e)E_t \frac{\beta\Lambda_{t+1}}{\Lambda_t}\left[R_{t+1}^j + Q_{t+1}(1-\delta) + \int_{\varepsilon \geq \varepsilon_{t+1}^*}\left(\frac{\varepsilon}{\varepsilon_{t+1}^*} - 1\right)\left[Q_{t+1}\kappa - \frac{1-\alpha}{\alpha + \xi_{t+1}^j} R_{t+1}^j\right] d\phi(\varepsilon)\right] \tag{35}$$

$$\overline{B}_{t,\tau}^{j} = (1-\delta_e)E_t \frac{\beta\Lambda_{t+1}}{\Lambda_t}\overline{B}_{t+1,\tau+1}^{j}(1+G_{t+1}) \tag{36}$$

Equation (35) is the discounted marginal value of capital. The dividends from capital consist of the net return R_{t+1}^j, the value of undepreciated capital $Q_{t+1}(1-\delta)$ and the investment benefit $\left[Q_{t+1}\kappa - \frac{1-\alpha}{\alpha+\xi_{t+1}^j}R_{t+1}^j\right]G_{t+1}$ of an additional unit increase in capital.

Equation (36) determines the bubble. The bubble generates dividends and it increases the borrowing capacity. This allows the firm to make more investment, generating additional dividends for the idiosyncratic shock, ε_{t+1}^j at time $t+1$.

2.3 Retailers

There is a continuum of firms indexed by i, on the interval $(0,1)$. They purchase wholesale good at price P_t^w and transform one unit of wholesale good into one unit of specialized retail good, $Y_t(i)$.

2.4 Final Goods Firms

There is a chain of final good producers, operating under perfect competition. The firm produces the final good Y_t by continuum combining retail goods, using the CES technology:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{\lambda_p}} di \right]^{\lambda_p} \qquad \lambda_{p,t} > 1 \tag{37}$$

where $\lambda_p / 1 - \lambda_p$ governs the degree of substitution between types of goods. The representative firm takes the price of final goods, P_t and the price of retail goods, $P_t(i)$ as given. Profit maximization leads to the following first order condition;

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{\frac{\lambda_p}{1-\lambda_p}} Y_t \tag{38}$$

Model setup is based on new Keynesian framework while prices are sticky in a time dependent manner. We assume that firms set prices according to a variant of the mechanism suggested by Calvo (1983). In each period, a retailer faces a constant probability, $0 < 1 - \xi_p < 1$, of being able to re-optimize its nominal price. The ability to re-optimize its price is independent across firms and time. Firms that cannot re-optimize their price simply index to lag inflation. The i^{th} retailer's problem is:

$$\max_{\{\bar{P}_t(i)\}} E_t \sum_{s=0}^{\infty} (\beta \xi_p)^s \Lambda_{t+s} [P_{t+s}(i) Y_{t+s}(i) - P_{t+s}^w Y_{t+s}(i)] \tag{39}$$

subject to the demand curve (38), with

$$P_t(i) = \begin{cases} \bar{P}_t(i) & if \quad t = 0 \\ \bar{P}_t(i) \Pi_{k=1} (\pi_{t+k-1})^{lp} (\pi)^{1-lp} & if \quad t = 1,2,... \end{cases} \tag{40}$$

where π is inflation and $lp \in [0,1]$ indicates the degree of indexation to past prices, for firms which are not allowed to re-optimize.

Therefore, the criterion facing a firm presented with the opportunity to reprice, when $P_{t+s}(i)$ is expressed as $P_{t+s}(i) = \overline{P}_t(i)\Pi^p_{t,t+s}$ and with substituting the $P_{t+s}(i)$ and $Y_{t+s}(i)$, is given by;

(41)

$$\max_{\{\overline{P}_t(i)\}} E_t \sum_{s=0}^{\infty} (\beta\xi_p)^s \Lambda_{t+s} Y_{t+s} P_{t+s} [\left(\frac{\overline{P}_t(i)\Pi^p_{t,t+s}}{P_{t+s}}\right)^{\frac{1}{1-\lambda_p}} - p^w_{t+s}\left(\frac{\overline{P}_t(i)\Pi^p_{t,t+s}}{P_{t+s}}\right)^{\frac{\lambda_p}{1-\lambda_p}}]$$

Consequently, the first-order condition associated to the profit is;

$$0 = E_t \sum_{s=0}^{\infty} (\beta\xi_p)^s \Lambda_{t+s} P_{t+s} \frac{Y_{t+s}(i)}{1-\lambda_p}\left[\left(\frac{\overline{P}_t(i)\Pi^p_{t,t+s}}{P_{t+s}}\right) - \lambda_p p^w_{t+s}\right] \tag{42}$$

As a result, the price-level in our models evolves in the following way, in which dividing through by P_{t-1} and rearranging yields the relative price of optimizers as an increasing function of the inflation rate;

(43)

$$P_{t,}^{\frac{1}{1-\lambda_p}} = (1-\xi_p)\overline{P}_t^{\frac{1}{1-\lambda_p}} + \xi_p[(\pi_{t-1})^{lp}(\pi)^{1-lp} P_{t-1}]^{\frac{1}{1-\lambda_p}}$$

$$\overline{p}_t = \left(\frac{1-\xi_p(\Pi^p_{t-1,t})^{\frac{1}{1-\lambda_p}}}{1-\xi_p}\right)^{1-\lambda_p} \equiv \overline{p}(\pi_t)$$

Following the price-setting maximization problem in equation (41), we can transform the price setting condition as follows.

(44)

$$F_{p,t} = E_t \sum_{s=0}^{\infty} (\beta\xi_p)^s \hat{\lambda}_{t+s} \frac{\hat{Y}_{t+s}}{1-\lambda_p}\left(\overline{\Pi}^p_{t,t+s}\right)^{\frac{1}{1-\lambda_p}}, \qquad A_{t+s} = \hat{\lambda}_{t+s}\frac{\hat{Y}_{t+s}}{1-\lambda_p}$$

$$K_{p,t} = E_t \sum_{s=0}^{\infty} (\beta\xi_p)^s \hat{\lambda}_{t+s} \frac{\hat{Y}_{t+s}\lambda_p p^w_{t+s}}{1-\lambda_p}\left(\overline{\Pi}^p_{t,t+s}\right)^{\frac{\lambda_p}{1-\lambda_p}}$$

$$\overline{\rho}(\pi_t) = \frac{K_{p,t}}{F_{p,t}}$$

We write $F_{p,t}$ recursively as follows.

$$F_{p,t} = A_t + \beta \xi_p E_t \left(\overline{\Pi}_{t,t+1}^{p}\right)^{\frac{1}{1-\lambda_p}} F_{p,t+1} \tag{45}$$

Now we write $K_{p,t}$ recursively as follows.

$$K_{p,t} = \lambda_p p_t^w A_t + \beta \xi_p E_t \left(\overline{\Pi}_{t,t+1}^{p}\right)^{\frac{\lambda_p}{1-\lambda_p}} K_{p,t+1} \tag{46}$$

2.5 Investment Goods Firms

There are competitive investment goods producers with the CEE[1] investment adjustment costs. They produce investment goods from final goods subject to adjustment costs and sell those to wholesale firm with price P_t^I (see, Christiano et al., 2005; Gertler and Kiyotaki, 2011). The objective function of a capital producer is to choose I_t to solve:

$$\max_{\{I_t\}} E\sum_{t=0}^{\infty}\beta^t \frac{\Lambda_{t+s}}{\Lambda_t}\left\{P_{t+s}^I I_{t+s} - \left[1+\frac{S''}{2}\left(\frac{I_{t+s}}{I_{t+s-1}}-z\right)^2\right]P_{t+s} I_{t+s}\right\} \qquad S''>0 \tag{47}$$

where z is the steady-state growth rate of aggregate investment, S'' is the adjustment cost. The optimal level of investment goods satisfies the first-order condition:

$$P_t^I = 1+\frac{S''}{2}\left(\frac{I_t}{I_{t-1}}-z\right)^2 + S''\left(\frac{I_t}{I_{t-1}}-z\right)\frac{I_t}{I_{t-1}} - \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} S''\left(\frac{I_{t+1}}{I_t}-z\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \tag{48}$$

2.6 Central Bank

This model also contains the central bank and the government. The government in this economy spends resources on government consumption of final goods, and its aim is to keep balanced budget every period. The central bank is dependent on government. Hence, we cannot model government and central bank in the separate sections.

1. Christiano, Eichenbaum and Evans (2005)

We assume that international trade in Iran depends on oil market and it is one of the sources for financing the government budget. Iranian economy is a price taker and its international trade is limited to oil exports. Therefore, the inclusion of oil revenues in the model like most of general equilibrium models for oil-producing countries follows the first order autoregressive process.

$$Ln(or_t) = (1-\rho_{or})Ln(\overline{or}) + \rho_{or}Ln(or_{t-1}) + e_{or,t} \tag{49}$$

where $\varepsilon_{or,t} \sim i.i.d.N(0,\sigma_{or}^2)$ denotes the oil revenue shock, $\overline{or}$ is the steady-state amount of oil income.

Due to the structure of the Iranian economy, the monetary authority applies in a way that the oil revenues implicitly affect the monetary condition. The growth rate of money is considered the first order autoregressive process. In addition, oil income shocks can affect the planned growth rate of money. In other words, the growth rate of the money can be displayed as follows;

$$\frac{M_{t+1}}{P_{t+1}} = g_{m,t}\frac{M_t}{P_{t+1}} = m_{t+1}^r = \frac{g_{m,t}}{\pi_{t+1}}m_t^r \tag{50}$$

$$Ln(g_{m,t}) = (1-\rho_{mp})Ln(\overline{g}_m) + \rho_{mp}Ln(g_{m,t-1}) + \vartheta e_{or.t} + e_{mp,t} \tag{51}$$

where $g_{m,t}$ and m_t^r denote the nominal money growth and real money balances, respectively. Moreover, $\varepsilon_{mp,t} \sim i.i.d.N(0,\sigma_{mp}^2)$ shows a monetary policy shock, ϑ represents the effect of oil revenue shocks on money growth in Iranian economy.

The government expenditure and subsidies are financed through lump-sum taxation to households, oil income and issuing money; therefore, the government runs a balanced budget every period as,

$$GA_t = \frac{T_t}{P_t} + \frac{M_t - M_{t-1}}{P_t} + \frac{or_t}{P_t} \tag{52}$$

Government conducts fiscal policy and sets the amount of expenditure GA_t according to $AR(1)$ process:

$$\ln\left(GA_t\right) = \left(1-\rho_g\right)\ln\left(\overline{GA}\right) + \rho_g \ln\left(GA_{t-1}\right) + \varepsilon_{g,t} \tag{53}$$

The expression $\varepsilon_{g,t}$ denotes an *iid* normal government spending shock with mean zero and standard deviation σ_g^2.

2.7 Bubble

Following Miao et al. (2015), a sentiment shock θ_t is introduced to model households' beliefs about the fluctuations in bubbles. Households are assumed to believe that the relative size of the bubbles at date $t+\tau$ for any two firms born at date t and $t+1$ evolves according to

$$\frac{\bar{b}_{t+\tau,\tau}}{\bar{b}_{t+\tau,\tau-1}} = \theta_t \qquad \bar{b}_{t,0} \equiv b_t^*, \qquad \tau \geq 1 \tag{54}$$

where $\bar{b}_{t,\tau} \equiv \bar{B}_{t,\tau}^j / P_t$ denote the real average bubble of firm with age τ in period t. Then, θ_t follows an exogenously given process:

$$\ln(\theta_t) = \rho_\theta \ln(\theta_{t-1}) + \varepsilon_{\theta,t}, \qquad 0 \leq \rho_\theta < 1 \tag{55}$$

where $\varepsilon_{\theta,t} \sim i.i.d.N(0,\sigma_\theta^2)$. Following Ikeda (2013) and Miao et al. (2015), household beliefs about the movement of bubbles may change randomly over time. It evolves as,

$$\bar{b}_{t,0} = b_t^*, \qquad \bar{b}_{t,1} = \theta_{t-1} b_t^*, \qquad \bar{b}_{t,2} = \theta_{t-1}\theta_{t-2} b_t^*, \ldots, \bar{b}_{t,\tau} = \prod_{k=1}^{\tau} \theta_{t-k} b_t^* \tag{56}$$

It is clear from the equation that the sizes of new bubbles, b_t^* and old bubbles, $\bar{b}_{t,\tau}$ are linked by the sentiment shock. The sentiment shock affects current bubbles relative to a newly born bubble in next period.

In the paper following Ikeda (2013) and Miao et al. (2015), the total bubble born in period t with probability δ_e, which implies the firms with bubble in its stock price and exit the market, is given by:

$$b_t = \sum_{\tau=0}^{t}(1-\delta_e)^{\tau}\delta_e \bar{b}_{t,\tau} = \sum_{\tau=0}^{t}(1-\delta_e)^{\tau}\delta_e\left(\prod_{k=1}^{\tau}\theta_{t-k}\right)b_t^* =$$
$$\delta_e b_t^* + (1-\delta_e)\delta_e\theta_{t-1}b_t^* + (1-\delta_e)^2\delta_e\theta_{t-1}\theta_{t-2}b_t^* + ... = m_t b_t^* \tag{57}$$

where,

$$m_t = m_{t-1}(1-\delta_e)\theta_{t-1} + \delta_e \tag{58}$$

The bubble is stationary in the neighborhood of steady state as long as $(1-\delta_e)\theta<1$. From (36), (57) the total bubble evolves according to,

$$b_t = (1-\delta_e)E_t\beta\frac{\Lambda_{t+1}P_{t+1}}{\Lambda_t P_t}\frac{m_t}{m_{t+1}}\theta_t b_{t+1}(1+G_{t+1}) \tag{59}$$

Equations (58) and (59) show that a sentiment shock θ_t affects the relative size m_t and hence the total bubble.[1]

2.8 Aggregation and Equilibrium

Aggregating L_t^j, given by (21), over idiosyncratic shocks, ε_t^j yields the demand for labor as follows;

$$\bar{L}_t^j = (1-\alpha)^{\frac{1}{\alpha}}\left(\frac{P_t^w A_t^{1-\alpha}}{W_t}\right)^{\frac{1}{\alpha}}\left[\Phi(\varepsilon_t^*) + \int_{\varepsilon\geq\varepsilon_t^*}\left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1}{\alpha}}d\Phi(\varepsilon)\right]K_t^j \tag{60}$$

Aggregating demand for labor over j yields;

$$L_t = \int_j \bar{L}_t^j dj = (1-\alpha)^{\frac{1}{\alpha}}\left(\frac{P_t^w A_t^{1-\alpha}}{W_t}\right)^{\frac{1}{\alpha}}\left[\Phi(\varepsilon_t^*) + \int_{\varepsilon\geq\varepsilon_t^*}\left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1}{\alpha}}d\Phi(\varepsilon)\right]K_t \tag{61}$$

where the demand for labor, L_t, must be equal to its supply, L_t^*.

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1. A firm whose stock price has been inflated by a bubble is able to borrow more than firms whose stock price is not inflated. The additional borrowing allows firm to take advantage of high return of investment available and to make more profits if it is hit by a great idiosyncratic shock in the next period. These additional benefits are summarized by in equation (59).

$$\int_j \overline{L}_t^j dj = \int_0^1 L_t(i)di = L_t^* \tag{62}$$

Aggregating output over an idiosyncratic shock ε_t^j yields,

$$\overline{Y}_t^j = (K_t^j)^{\alpha}(A_t)^{1-\alpha} \frac{\Phi(\varepsilon_t^*) + \int_{\varepsilon \geq \varepsilon_t^*} \left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1-\alpha}{\alpha}} d\Phi(\varepsilon)}{\left[\Phi(\varepsilon_t^*) + \int_{\varepsilon \geq \varepsilon_t^*} \left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1}{\alpha}} d\Phi(\varepsilon)\right]^{1-\alpha}} (\overline{L}_t^j)^{1-\alpha} \tag{63}$$

Aggregating over j yields;

$$Y_t = \int_j \overline{Y}_t^j dj = (K_t)^{\alpha}(A_t)^{1-\alpha} \frac{\Phi(\varepsilon_t^*) + \int_{\varepsilon \geq \varepsilon_t^*} \left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1-\alpha}{\alpha}} d\Phi(\varepsilon)}{\left[\Phi(\varepsilon_t^*) + \int_{\varepsilon \geq \varepsilon_t^*} \left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1}{\alpha}} d\Phi(\varepsilon)\right]^{1-\alpha}} (L_t)^{1-\alpha} \tag{64}$$

where, the supply of whole sale good, Y_t^*, must be equal to its demand, Y_t;

$$\int_j \overline{Y}_t^j dj = \int_0^1 Y_t(i)di = Y_t^* \tag{65}$$

Aggregating investment over an idiosyncratic shock ε_t^j yields

$$I_t = \frac{(1-\Phi(\varepsilon_t^*))(Q_t \kappa K_t + B_t) - \int_{\varepsilon \geq \varepsilon_t^*} \left(\frac{\varepsilon_t^*}{\varepsilon}\right)^{\frac{1}{\alpha}} d\Phi(\varepsilon)(1-\alpha)^{\frac{1}{\alpha}} \left(\frac{W_t}{A_t}\right)^{-\frac{1-\alpha}{\alpha}} (P_t^w)^{\frac{1}{\alpha}} K_t}{P_t^I} \tag{66}$$

As Ikeda expressed, the first term in equation (66) describes the amount of borrowing of wholesale goods firms and the second term denotes the amount of borrowing assigned to working capital for firms conducting investment. Therefore, this equation represents the amount of investment in final goods.

Following Ikeda (2013), there are newly born firms that collect a fraction φ of capital stock accumulated by exit firms. Then, the aggregate capital stock of all firms in the end of period t after the realization of an exit shock is

$$K_{t+1} = (1-\delta_e + \delta_e \varphi) K'_{t+1} \tag{67}$$

K'_{t+1} denotes the capital stock in the end of period t before the realization of the exit shock, is given by;

$$K'_{t+1} = (1-\delta) K_t + \mu_t \left[\int_{\varepsilon \geq \varepsilon_t^*} \varepsilon d\Phi(\varepsilon) \frac{(1-\Phi(\varepsilon_t^*))(Q_t \kappa K_t + B_t) - \int_{\varepsilon \geq \varepsilon_t^*} \left(\frac{\varepsilon_t^*}{\varepsilon} \right)^{\frac{1}{\alpha}} d\Phi(\varepsilon) (1-\alpha)^{\frac{1}{\alpha}} \left(\frac{W_t}{A_t} \right)^{-\frac{1-\alpha}{\alpha}} (P_t^w)^{\frac{1}{\alpha}} K_t}{P_t^I} \right] \tag{68}$$

A competitive equilibrium consists of stochastic processes of 26 aggregate endogenous

variables, C_t, M_t^d, λ_t, R_t, $\overline{W}_t$, w_t, F_w, K_w, P_t^w, ε_t^*, Q_t, $\overline{P}_t$, π_t, F_p, K_p, P_t^I, or_t, m_t^r, $g_{m,t}$, GA_t, m_t, b_t, L_t^*, Y_t, I_t, K_t, which satisfies (3), (4), (5), (6), (10), (11), (12), (13), (20), (30), (35), (43), (44), (45), (46), (48), (49), (50), (51), (53), (58), (59), (61), (64), (66) and (68).

2. Data and Calibrated Parameters

Our model is stationary in the growth rate of total factor productivity (TFP) shock; we transform the equilibrium system into a stationary one. Also, we use a calibrated model to fit the model for Iranian data. Our model has five shocks: the TFP shock, the monetary policy shock, the government spending shock, the sentiment shock and the oil revenue shock.

We calibrate some of the parameters of the model. Some key parameters are evaluated based on previous studies suck as Ikeda (2013), Miao et al. (2015) and some are based on authors for maximum compatibility between simulated and realized data. In brief, table (1) and (2) present the values assigned to the calibrated parameters.

3. Results

The model's empirical implications based on the calibrated parameters are computed using the simulated data (20,000 periods). This paper uses quarterly data of the Iranian economy covering the period of

Table1: Key Parameters

Parameters	Explanation	Value	Source
φ	Start-up capital	1	Ikeda (2013)
δe	Exit rate of firms	0.01	Ikeda (2013)
$\varepsilon^{-\eta}$	Fraction of firms investing in SS	0.17	Ikeda (2013)
κ	Credit constraint	0.11	Ikeda (2013)
z	SS TFP growth rate	1	Ikeda (2013)
λ_p , λ_w	Price markup, Wage markup	1.15	Bashiri et al (2016a)
β	Preference discount rate	0.99	Boostani (2013)
ν	Inverse Frisch elasticity	2.17	Taee (2007)
ρ_z	TFP growth shocks, AR	0.92	Afshari et. al (2014)
ρ_θ	Sentiment shocks, AR	0.82	Bashiri et al (2016a)
σ_q	weights associated with utility of money	1.32	Davoodi and Zarepour (2007)

Table 2. Key Parameters

Parameters	Explanation	Value	Explanation
α	Capital income share	0.38	C/Y is equal to 0.53
h	Consumption habit	0.77	C/Y is equal to 0.53
δ	Capital depreciation rate	0.05	I/Y is equal to 0.24
S''	Investment adjustment costs	0.1	I/Y is equal to 0.24
π	SS quarterly inflation	1.041	realized data
ξp	Calvo prices	0.5	In Model
ξw	Calvo wages	0.75	In Model
lp , lw	Price indexation, Wage indexation	0.5	In Model
ρ_{mp}	Monetary policy shocks, AR	0.29	$AR(1)$ process
ρ_g	Government spending shocks, AR	0.11	$AR(1)$ process
ρ_{or}	Oil revenue shocks, AR	0	$AR(1)$ process
ϑ	effect of oil revenue shocks on money	0.001	$AR(1)$ process
$\bar{g}_m$	SS amount of nominal money growth	1.041	realized data
$\overline{or}$	SS amount of oil income	0.16	Oil/G is equal to 0.46
$\overline{GA}$	SS government expenditure	0.34	G/Y is equal to 0.13
$\bar{L}$	Log hours in SS	0.28	In Model
δ_z	TFP growth shocks, Std	0.01	std of I is 6.24
δ_{mp}	Monetary policy shocks, Std	0.15	Residual of $AR(1)$ process
δ_g	Government spending shocks, Std	0.11	Residual of $AR(1)$ process
δ_θ	Sentiment shocks, Std	0.035	std of PS is 19
δ_{or}	Oil revenue shocks, Std	0.5	Residual of $AR(1)$ process

1986-2012. All series are logged and de-trended with the HP filter. The columns labeled *Y* , *C*, *I*, G, *PS*, *Oil* and *M* refer, respectively, real per capita GDP, real per capita consumption, real per capita investment, real per capita government expenditure, real per capita oil income, real per capita stock prices and real money balances.

We present the ratio of real economic and simulated variables relative to Y in Table (3). Table (4) shows the business cycles statistics using the simulated data. As Table (3) and (4) indicate, the estimated model fits the empirical moments from the realized data quite well. In addition, it explains the stock market volatility in the data. Also, the persistence of macroeconomic variables and stock prices are matched as well as their co-movements.

Table 3: The Ratio of Real Economic and Simulated Variables Relative to Y

	C/Y	I/Y	G/Y	Oil/G
Data	0.5376	0.2452	0.1300	0.4688
Baseline Model	0.6033	0.2149	0.1817	0.4733

Source: Authors' calculation

Table 4: Business Cycles Statistics (In Percent)

Standard Deviations					
	Y	**C**	**I**	**G**	**PS**
Data	2.71	3.16	6.24	4.62	19.99
Baseline Model	4.35	5.37	10.90	4.60	14.72
No Sentiment Shock	3.15	3.23	10.60	4.58	3.97
Standard Deviations Relative to Y					
Data	1.00	1.16	2.30	1.70	7.33
Baseline Model	1.00	1.23	2.50	1.05	3.37
No Sentiment Shock	1.00	1.02	3.36	1.45	1.26
Correlation with Y					
Data	1.00	0.50	0.77	0.32	0.32
Baseline Model	1.00	0.83	0.64	0.16	0.84
No Sentiment Shock	1.00	0.65	0.73	0.23	0.88

Source: Authors' calculation

We use variance decomposition to evaluate the relative importance of the five structural shocks in driving fluctuations in the stock prices and macroeconomic quantities at the business cycle frequency. Table (5) reports the variance decomposition across the shocks.

Table 5: Variance Decomposition (In Percent)

		Sentiment	TFP	Money	Oil income	Government
Output	Baseline Model	47.98	0.28	48.97	0.05	2.72
	No Sentiment Shock	---	0.55	94.12	0.10	5.23
Consumption	Baseline Model	61.20	13.56	25.13	0.03	0.08
	No Sentiment Shock	---	34.95	64.77	0.07	0.21
Investment	Baseline Model	7.98	26.06	65.31	0.07	0.58
	No Sentiment Shock	---	28.33	70.97	0.08	0.63
Stock Price	Baseline Model	92.22	0.84	6.90	0.01	0.03
	No Sentiment Shock	---	10.77	88.70	0.10	0.43

Source: Authors' calculation

Table (5) shows that the sentiment shock explains about 48, 61 and 8 percent of the fluctuations in output, consumption and investment respectively. The sentiment shock is the dominating force driving the fluctuations in consumption. This is due to the large wealth effect caused by the fluctuations in the stock market value. As Table (5) indicates the sentiment shock accounts for about 92 percent of the stock market fluctuations. The contributions of the other shocks are negligible.

The money growth shock is important in explaining variations in macroeconomic quantities, but the oil income shock does not explain much of the fluctuations in output, consumption, investment, and stock price. According to equation (51), oil income shocks affect money growth and this rise effects on macroeconomic variables much.

The government's consumption shock reports a tiny fraction of fluctuations in stock prices, investment, consumption, except output.

The TFP shock plays a critical role on economic fluctuations at business cycles. The TFP shock is correlated with consumption and investment. However, it does not explain much of the fluctuations in output and stock price. TFP shock due to changes in the marginal product of capital and labor will cause households to respond optimally to these changes. This release mechanism led to changes in the economy. Changes in government spending make no transition mechanism and the impact of government spending shock in the economy is limited.

As indicated in Figure (2), we consider the impulse responses to a one standard-deviation of five structural shocks in driving fluctuations in macroeconomic quantities and stock price at the business cycle frequency.

In the case of positive oil shock, the oil income increases and it leads to budget surplus, increases the output, consumption, inflation, investment, hours worked. It raises marginal *Q*, the bubble and the stock price. As Fakhrehosseini et al. (2012) mentioned, high inflation in Iranian economy is influenced by the large amount of oil shocks. Due to the structural problems in the economy, the supply side cannot be able to adapt itself from the effects of oil price fluctuations. However, the oil shock that affects the demand side through government budget will cause deviations of inflation.

Figure (2) shows the response function of macro variables relative to government’s consumption shock. Increasing in government expenditure is the fiscal policy and it raises the output. It causes to money transactions grow and interest rate growth. With decrease of available credit and crowding out effects, investment falls for few quarters.

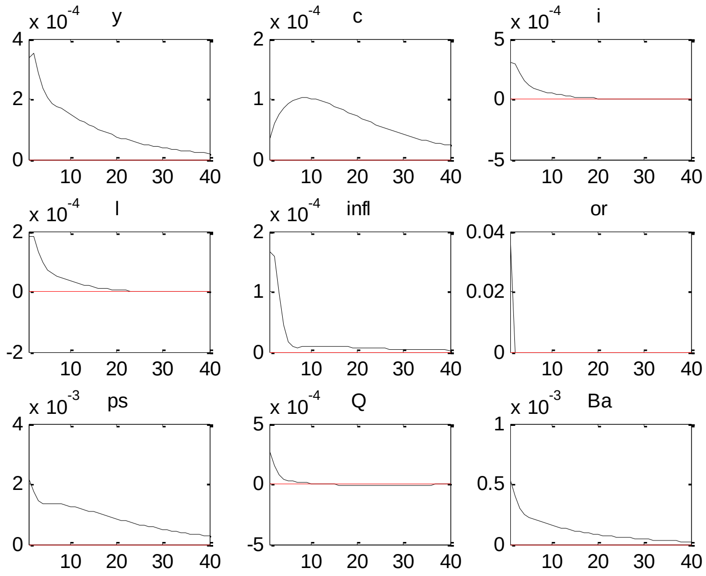
The prices decline in response to the government consumption shock. It raises the present value of the stream of taxes over time that generates a negative wealth effect that brings down private consumption. Christiano and Eichenbaum (1992) and Baxter and King (1993), among others described this prediction of the RBC model. The government expenditure shock reduces the marginal *Q*, the bubble and leads to negative effect on the stock price.

The money growth shock increases demand and leads to increase the output and consumption. In addition, it leads to high inflation. This inflation reduces the real wage and real capital rental. In this situation, labor demand and investment rises. And it leads to increase production. Furthermore, high inflation and reduction in real interest rates tend to increase the investment in alternative markets such as the stock. Therefore, it raises the marginal *Q*, the bubble and the stock price. This shock plays a critical role on Iranian economic fluctuations. As indicated in table (5), it explains much of the fluctuations in output, consumption, investment and stock price after the sentiment shock.

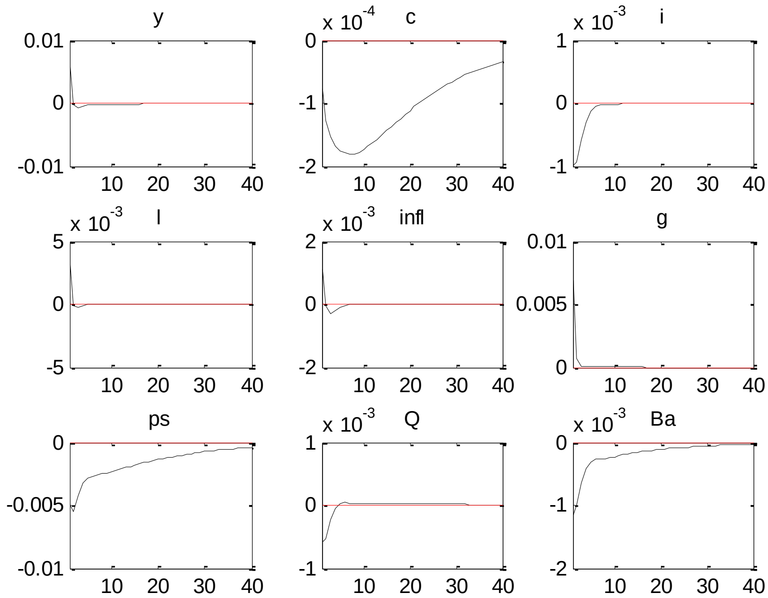
A Positive TFP shock increases output, labor supply and investment, but it reduces the future marginal utility of consumption due to the wealth effect. TFP shock raises both marginal *Q* and the bubble, but its net impact on the stock price is negative and small. It cannot be an important driver of the stock market movements. With a positive technology shock, capital and labor productivity goes up. As a result, firms increase demand for labor and capital; therefore, labor income and rental rate capital increase. More capital and labor supplied, leading to increased production.

Figure (2) presents the impact of a sentiment shock. A positive sentiment shock raises the size of the bubble. It causes the credit constraints to be relaxed. Thus, firms make more investment. As capital accumulation rises, marginal *Q* falls so that the fundamental value of the stock market also falls. But this fall is dominated by the rise in the bubble component, causing the stock price to rise on impact, and afterward raise investment. This in turn causes consumption to rise due to the wealth effect and raises output. This result indicates that the sentiment shock can generate a large volatility of the stock market relative to that of consumption, investment, and output. The sentiment shock has a negative impact on inflation. The capital stock also rises due to positive sentiment shock, causing the labor hours to rise.

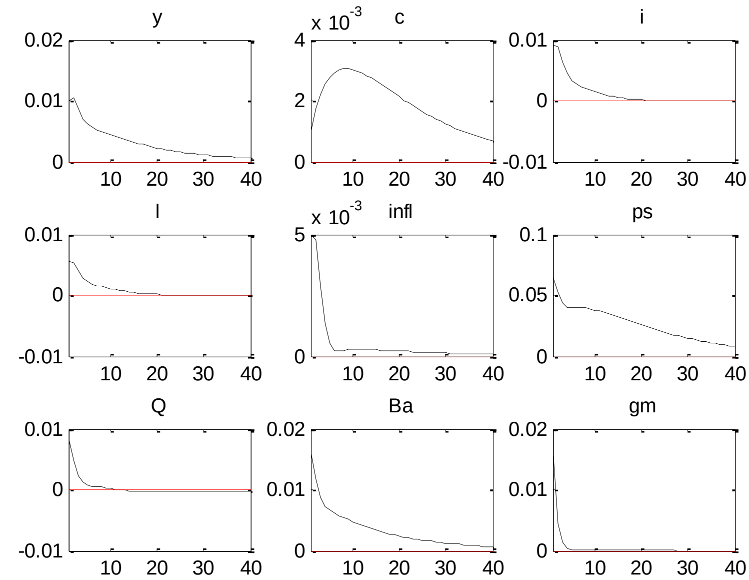
Impulse Responses to an Oil Income Shock



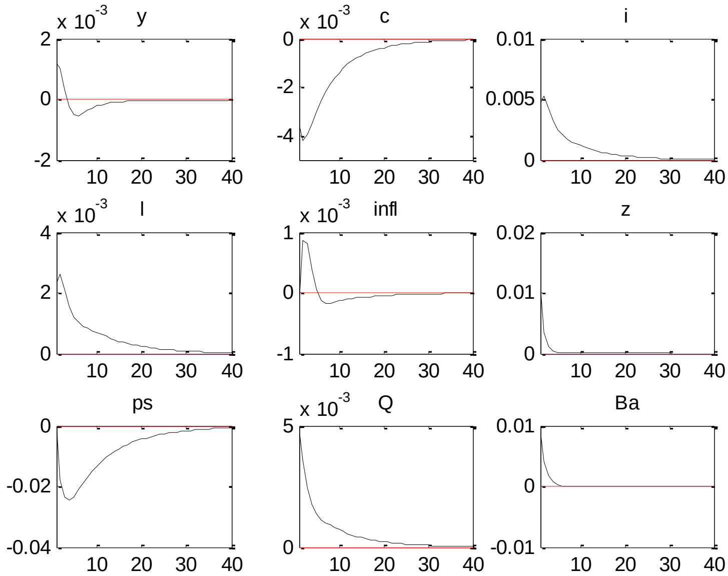
Impulse Responses to a Government's Consumption Shock



Impulse Responses to a Monetary Policy Shock



Impulse Responses to a TFP Shock



Impulse Responses to a Sentiment Shock

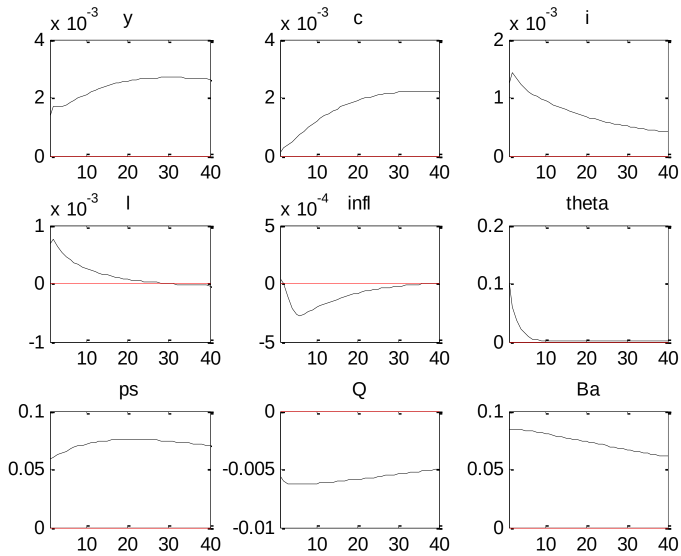


Figure 2: Impulse Responses to a One-Standard-Deviation Oil Income Shock, Government's Consumption Shock, Monetary Policy Shock, TFP and Sentiment Shocks

Note: The vertical line shows the standard deviation of shocks. And the Horizontal line represents the duration of time the shock developed.

Source: Authors calculation

4. Conclusion

In recent years, there has been increasing interest in modelling rational bubbles in the literature. This paper investigates the movement between share exchange market bubbles and fluctuation in aggregate variables within a dynamic stochastic general equilibrium (DSGE) model for the Iranian economy.

We apply a new Keynesian monetary framework with nominal rigidity in both wages and prices based on the study by Ikeda (2013). We develop Ikeda’s monetary DSGE model with appropriate framework for the Iranian economy. We consider Iran’s central bank behavior different from Taylor Rule and suppose a small economy with oil export, which is subject to oil price shocks frequently. In order to study the role of money in economy, we apply “Money in Utility” approach which looks more plausible to utilize for studying Iranian economy. In addition to the TFP shock, the monetary policy shock, the government spending shock, the sentiment shock such as study by Ikeda (2013), we study the oil income shock.

Bubbles in our model emerge through a positive feedback loop mechanism supported by self-fulfilling beliefs. In addition, a sentiment shock drives the movements of bubbles that explain most of the stock market fluctuations and variations in real economy. Following Miao et al. (2013), the sentiment shock is transmitted from the stock market to the real economy through the credit constraints. A positive sentiment shock raises the size of the bubble, and it causes the credit constraints to be relaxed. Therefore, it causes the fluctuations in the credit limit and hence affects firms' investment decisions. Thus, firms make more investment. As capital accumulation rises, marginal *Q* falls so that the fundamental value of the stock market also falls. But this fall is dominated by the rise in the bubble component, causing the stock price to rise on impact, and afterward raise investment. This in turn causes consumption to rise due to the wealth effect and raises output. This result indicates that the sentiment shock can generate a large volatility of the stock market relative to that of consumption, investment, and output. This in turn affects aggregate investment and aggregate output.

The results of calibrated model revealed a relation between moments of variables in the model and moments of real data in the economy. Therefore, this model can help us to analysis the effect of stock market bubbles on macroeconomic variables in economy.

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