# Financial friction, Labor market friction and Monetary policy rules

**A S M Shakil Haider**[⋆]
*Department of Agricultural and Applied Economics, Texas Tech University*

**Abstract.** *This paper investigates the effect of introducing a financial friction on labor market friction in a New Keynesian framework in the presence of different monetary policy rules. The model assumes monopolistic competition, price rigidity, wage rigidity and labor market matching friction in consumption (i.e. non-durable) goods sector. Financial friction is introduced by a borrowing constraint depending on housing collateral. Housing is assumed to be the durable good, provides utility and face a perfect competition in the durable goods production sector. However, it is found that, when the consumers consume both non-durables and durable goods and their expenditure can be financed by loans (where the borrowing is constrained by the value of the collateral), a one period productivity shock or government spending shock with unemployment stabilizing monetary policy rule, causes an increase in output and consumption even though there is an initial decrease in wage along with a decrease in job creation. On the other hand, these two shocks with standard Taylor rule cause more fluctuations in the economy.*

*JEL classification*: **E44, E24, E52**

**Keywords:** *collateral constraints, financial friction, labor market friction, monetary policy*

## 1 Introduction

In recent years, it has been found that, introducing a financial friction in RBC models can explain the observed movements of labor market variables, such as, employment, volatile and cyclical real wages and consumption (Altug and Kabaca, 2014). Hence, inspecting some of the previous research outcomes on employment and wage volatility where there was no financial friction, it was concluded that, in a search and matching framework, real wage rigidity reduces labor market friction and volatility in real wage (Hall, 2005 ; Shimer, 2005). Therefore, the question arises, whether it will be possible to explain the labor market frictions in a more rational way if a financial friction and labor market friction can be introduced in a New Keynesian framework where the key assumptions are monopolistic competition, price rigidity and wage rigidity. However, to

[⋆] E-mail: asmshakil.haider@ttu.edu ; Tel: +1-917-353-6478

answer this question, a model has been formulated in this paper using the previously mentioned New Keynesian framework where the monopolistic competition and the frictions are in the consumption goods (i.e. non-durable) market. In the model, financial friction is assumed via a borrowing constraint, which is based on housing collateral. The housing is considered as durable goods, gives utility to the consumer and face a perfect competition. As there is always a relation among monetary policy, unemployment and wage, different monetary policy rules are used as well.

There are two important results. First, when the consumers consume both non-durables and durable goods and their expenditure can be financed by loans (where the borrowing is constrained by the value of the collateral), a one period productivity shock or government spending shock with unemployment stabilizing monetary policy rule, causes an increase in output and consumption even though there is an initial decrease in wage along with a decrease in job creation. Second, using a standard Taylor rule, with productivity shock or government spending shock, the economy faces more fluctuations in output, consumption, inflation and labor market.

The rest of the paper proceeds as follows: Section 2 discusses about the model. Section 3 explains the monetary policy. Section 4 explains the calibration. Section 5 describes the dynamic responses to shocks. Section 6 explains the limitations and future research scopes. Section 7 concludes.

## 2 Model

The economy is populated with an infinitely lived continuum of agents who consume non-durable and durable goods, work, save and can take loans. The households can save in securities and can take loan to finance expenditure. The loan can be taken based on the amount of collateral they have, hence, the loan is constrained by a collateral constraint. The agents can be either employed or unemployed and their wage is determined based on a Nash bargaining. In the production sector, there are two types of firms who produce non-durable and durable goods respectively. The non-durable goods producing firms produce consumption goods and face a monopolistic competition. The non-durable goods production and monopolistic competition is analyzed by using a standard framework stated in Faia and Illiopulos (2011) and Faia (2008). However, the durable goods producing firm produces housing and there is perfect competition in this durable good market. The labor market for non-durable goods sector only has matching frictions and exogenous job separation. To compute the labor relations, standard Mortesen and Pissarides (1999) framework is used.

### 2.1 Households

Agents maximize the following expected discounted sum of utility:

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t U(C_{I,t}, N_t) \right\} \tag{1}$$

Here, total labor hours are denoted by $N_t$ (normalized to 1 as labor hour is supplied inelastically) and total aggregate consumption consisting of non-durable (i.e. consumption goods) and durable goods (i.e. housing) is denoted by:

$$C_{I,t} = \left( C_t^{\frac{\sigma-1}{\sigma}} + x^{1/\sigma} h_t^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

Non-durable goods (i.e. $C_t$) is given by a Dixit-Stiglitz consumptin aggregator[1]. $P_t$ is the aggregate price index[2] for non-durable goods.The durable goods consumption (i.e. $h_t$) is assumed to be proportional to the housing stock[3]. Here, $\sigma$, is the elasticity of substitution and $x$, is the importance of housing in preferences. Housing price (i.e. $q_t$ follows an AR(1) process[4]. However, the labor in this economy in both the sectors earn a wage of $w_t$ and it is obtained by a Nash bargain taken place in the labor market of the non-durable goods. Here, $w_t(n_{1t} - u_t)$, refers to the wage earning[5] of the employed people in non-durable sector The unemployed people, $u_t$, receives an unemployment benefit of the amount, $b$. It is assumed that, the labors in the durable goods market take the wage which is set in the non-durable good's labor market. The agents invest in bonds $b_t$ and it pays a gross nominal interest rate of $(1 + r_t^n)$ and for expenditure can take loan (i.e. $B_t$) based on their available collateral. However, agents receive profits from the non-durable and durable sectors (i.e. $\Theta_{1t}, \Theta_{2t}$ respectively) and pays a lump sum tax equivalent to $\tau_t$. Therefore, the real budget constraint becomes:

$$c_t + \frac{b_t}{P_t} + \frac{B_t}{P_t} \leq w_t(n_{1t} - u_t) + bu_t + \frac{\Theta_{1t}}{P_t} + \frac{\Theta_{2t}}{P_t} - \frac{\tau_t}{P_t} + (1 - r_{t-1}^n)\frac{b_{t-1}}{P_t} \tag{3}$$

According to Kehoe et al. (2016), the borrowing constraint based on collateral can be expressed as:

$$B_{t+1} \geq -\omega q_t h_{t+1} \tag{4}$$

Here, eq. (4) suggests that, the maximum loan, $-B_{t+1}$, an agent can take in period $t$ is a fraction, $\omega$, of the value of the house, $q_t h_{t+1}$. Therefore, $\omega$ is nothing but the maximum loan to value ratio.

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[1] $C_t = \int_0^1 [(C_t^i)^{\frac{a-1}{a}} di]^{\frac{a}{a-1}}$

[2] $P_t = \int_0^1 [(P_t^i)^{\frac{a-1}{a}} di]^{\frac{a}{a-1}}$

[3] Assumed to be one by Kehoe et al. (2016) and explained as follows: $\int h_t^i di = 1$

[4] Following Nagaraja et al. (2011), $ln(q_t) = (1-d)ln(\bar{q}) + dln(q_{t-1}) + v$

[5] $N_t = n_{1t} + n_{2t}$; Here, $n_{1t}$ is dedicated to the non-durable goods sector and $n_{2t}$ is dedicated to the housing sector.

The household maximizes Eq. (1) subject to Eq. (3) and Eq. (4). The lagrange multiplier is defined as $\lambda_t$. Hence, the following optimality conditions should hold:

$$\lambda_t = c_t^{\frac{-1}{\sigma}} \left( c_t^{\frac{\sigma-1}{\sigma}} + x^{1/\sigma} h_t^{\frac{\sigma-1}{\sigma}} \right)^{\frac{1}{\sigma-1}} \tag{5}$$

$$c_t^{\frac{-1}{\sigma}} = \beta(1 + r_t^n) E_t \left\{ c_{t+1}^{\frac{-1}{\sigma}} \frac{P_t}{P_{t+1}} \right\} \tag{6}$$

$$\omega q_{t-1} = \frac{x^{\frac{1}{\sigma}} h_t^{\frac{-1}{\sigma}}}{c_t^{\frac{-1}{\sigma}}} \tag{7}$$

Eq. (5) gives the marginal utility of non-durable consumption, Eq. (6) gives the Euler condition and Eq. (7) gives the condition for durables. The no-Ponzi condition is also satisfied here.

### 2.2 Non-durable goods production sector

Non-durable goods producing firms face monopolistic competition, use labor (i.e. $n_{1t}$ for non-durable goods production) as input and face quadratic adjustment cost[6]. Changes in prices over time is defined as inflation, $\pi_t$[7]. There is a fixed cost associated as the cost of posting the vacancy and it is defined as $\kappa$. However, the representative firm chooses $P_t^i, n_{1t}, v_{i,t}$ to solve the maximization problem:

$$\max \Pi_{1,t} = E_o \sum_{t=0}^{\infty} \beta \frac{\lambda_t}{\lambda_o} \{ \frac{P_t^i}{P_t} y_t^i - w_{i,t} n_{1t} - \kappa v_{i,t} - \frac{\psi}{2} (\pi_t - 1)^2 y_t \} \tag{8}$$

s.t.

$$y_i^t = (\frac{p_i^t}{p_t})^{-\epsilon} y_t = z_t n_{1t} \tag{9}$$

$$n_{1t} = (1 - \rho)(n_{1t-1} + v_{i,t-1} q(\theta_{i,t-1})) \tag{10}$$

Defining, $mc_t$, as the Lagrange multiplier for Eq. (9) as the marginal cost of firms and the Lagrange multiplier $\mu_t$ for Eq. (10) as the marginal value of one worker. Now from the profit maximization, the first order conditions provide:

$$\mu_t = mc_t z_t - w_t + \beta E_t (\frac{\lambda_{t+1}}{\lambda_t}) [(1 - \rho)\mu_{t+1}] \tag{11}$$

$$\frac{\kappa}{q(\theta_t)} = \beta E_t (\frac{\lambda_{t+1}}{\lambda_t}) [(1 - \rho)\mu_{t+1}] \tag{12}$$

[6] Quadratic adjustment cost, $\frac{\psi}{2}(\pi_t - 1)^2 y_t$

[7] Here, $\pi_t = \frac{p_t^i}{p_{t-1}^i}$

$$1-\psi(\pi_t-1)\pi_t+\beta E_t(\frac{\lambda_{t+1}}{\lambda_t})[\,\psi(\pi_{t+1}-1)\pi_{t+1}(\frac{y_{t+1}}{y_t})]\,=(1-mc_t)\epsilon \tag{13}$$

Rearranging Eq. (12) and (13) gives the $mc_t$:

$$mc_t=\frac{[\,\mu_t-\frac{\kappa}{q(\theta_t)}]}{z_t}+\frac{w_t}{z_t} \tag{14}$$

### 2.3 Durable goods production sector

In the durable goods production sector, it is assumed that there is perfect competition. The firms use labor (i.e. $n_{2t}$ as input to produce durable goods) and there is no adjustment cost in this sector. Therefore, the firms maximize:

$$\max \Pi_{2t}=q_t h_t-w_t n_{2t} \tag{15}$$

s.t.

$$h_t=z_t n_{2t} \tag{16}$$

After the optimization, the optimal pricing condition comes as:

$$q_t=\frac{w_t}{z_t} \tag{17}$$

### 2.4 The labor market

The labor market of non-durable goods sector only has the search and matching friction. Hence, based on a constant return to scale (CRS) matching technology, which converts the unemployed workers $u$ and vacancies $v$ into matches $m$, the probability of finding a worker is determined.

$$m(u_t,v_t)=mu_t^{\xi}v_t^{1-\xi} \tag{18}$$

Defining the labor market tightness:

$$\theta_t\equiv\frac{v_t}{u_t} \tag{19}$$

The firm meets unemployed workers at rate:

$$q(\theta)=\frac{m(u_t,v_t)}{v}=m\theta_t^{-\xi} \tag{20}$$

Unemployed workers meet the vacancies at the rate:

$$\theta_t q(\theta_t)=m\theta_t^{1-\xi} \tag{21}$$

The firm in the monopolistic good sector operates the following technology:

$$y_{i,t} = z_t n_{1t} \tag{22}$$

Here, $z_t$ is the aggregate productivity shock which follows an AR(1) process:

$$e^{z_t} = e^{\rho_z z_{t-1}} \epsilon_{z,t} \tag{23}$$

The law of motion for the workers employed and the ones seeking for a job:

$$n_{i,t} = (1-\rho)(n_{1t-1} + v_{i,t-1} q(\theta_{i,t-1})) + n_{2t-1} \tag{24}$$

However, Unemployment is calculated as:

$$u_t = 1 - n_{1t} - n_{2t} \tag{25}$$

Therefore, the job creation condition is:

$$jc_t = \frac{(1-\rho) v_{t-1} q(\theta_{t-1})}{n_{1t-1} + n_{2t-1}} \tag{26}$$

### 2.5 Wage setting

The wage schedule is determined based on a Nash bargain where marginal values of workers and the firms are suppose to match[8]. The marginal discounted value of vacancy for firm:

$$V_t^J = -\frac{\kappa}{q(\theta_t)} + E_t(\beta \frac{\lambda_{t+1}}{\lambda_t})((1-\rho) V_{t+1}^t) \tag{27}$$

The arbitrage condition considering the zero profit condition:

$$\frac{\kappa}{q(\theta_t)} = E_t(\beta \frac{\lambda_{t+1}}{\lambda_t})((1-\rho) V_{t+1}^t) \tag{28}$$

The values for being employed and unemployed can be found from:

$$V_t^E = [\, w_t + E_t[(\beta \frac{\lambda_{t+1}}{\lambda_t})((1-\rho) V_{t+1}^E + \rho V_{t+1}^U)]] \tag{29}$$

$$V_t^U = [\, b + E_t[(\beta \frac{\lambda_{t+1}}{\lambda_t})(\theta_t q(\theta_t)(1-\rho) V_{t+1}^E + (1 - \theta_t q(\theta_t)(1-\rho) V_{t+1}^U]] \tag{30}$$

The optimal sharing rule of the standard Nash bargaining is given by:

$$(V_t^E - V_t^U) = \frac{\varsigma}{1-\varsigma} V_t^J \tag{31}$$

Now, using the Nash bargaining process, the following wage schedule can be obtained:

$$w_t = \varsigma(mc_t z_t + \theta_t \kappa) + (1-\varsigma) b \tag{32}$$

[8] For this wage setting process, the method explained in Faia (2008) is used.

### 2.6 Market clearing

As the labors are dedicated and specific to two of the sectors, the market clearing for labor market implies:

$$N_t = n_{1t} + n_{2t} \tag{33}$$

The aggregate output should be consisting of the total production of non-durable and the durable goods along with substracting the cost associated with search and matching (in the non-durable sector). To clear the market, total production should be equalized with total demand. Aggregate output equation can be stated as:

$$y_t = n_{1t}z_t + n_{2t}z_t - \kappa v_t - \int_0^1 \frac{\psi}{2}(\pi_t - 1)^2 y_t^i \tag{34}$$

With the assumption of steady state inflation[9], Eq.(34) becomes:

$$y_t = n_{1t}z_t + n_{2t}z_t - \kappa v_t \tag{35}$$

The resource constraint here is:

$$y_t = c_t + h_t + g_t \tag{36}$$

Here, net supply of bond is assumed to be zero and $g_t$ is exogenous government spending which is financed by lump-sum tax. $g_t$ follows an AR(1) process here.

## 3 Monetary Policy

From several previous research[10], it is assumed that, monetary policy is implemented based on an interest rate reaction function of the following form:

$$ln(\frac{1+r_t^n}{1+r^n}) = (1-\phi_\pi)(\phi_\pi ln(\frac{\pi_t}{\pi}) + \phi_y ln(\frac{y_t}{y}) + \phi_u ln(\frac{u_t}{u})) + \phi_r ln(\frac{1+r_{t-1}^n}{1+r^n}) \tag{37}$$

Different restrictions are imposed on equation (37) to check the effect of different monetary policy rules (such as standard Taylor rule and Response to unemployment). The restrictions are imposed by specifying different values of $\phi_\pi, \phi_u, \phi_y, \phi_r$ based on the policy rules.

[9] Steady state inflation is assumed as, $\pi_t^{ss} = 1$

[10] See for instance, Pirozhkova (2017) ; Faia (2008).

## 4 Calibration

The discount factor is set as, $\beta = 0.98$, and the elasticity of substitution between consumption and housing is set as, $\sigma = 0.5$. The elasticity of substitution between consumption and housing is very important for analysis as, reducing the value of $\sigma$, amplifies the effect of credit constraints on employment, while raising it reduces the effect[11]. Furthermore, the importance of housing in preferences is set as, $x = 0.32$, following Kehoe et al. (2016). The value of discount factor and importance of housing in preferences are set as described due to have risk-free rate equal to 2%, in line with U.S. evidence. The maximal loan-to-value ratio, $\omega$ is set as 0.80.

In production sector, adjustment cost parameter is set as, $\psi = 50$. The value added mark-up prices over marginal cost generates the price elasticity of demand, $\epsilon = 6$ (Blanchard and Diamond, 1991). The matching technology in labor market is set as, $\xi = 0.4$, by following Blanchard and Diamond (1991). The steady state firm matching rate, $q(\theta)$ is set as 0.7 (den Haan et al., 2000). Following Merz (1995), exogenous separation probability, $\rho$, is set as 0.07. The wage rigidity, $\lambda$, is set as 0.6 (Smets and Wouters, 2003). Bargaining power of worker, $\zeta = 0.5$, The $b/w$ ratio is set as 0.5 (Nickell and Nunziata, 2001).

The productivity shock $z_t$ follows an AR(1) process:

$$z_t = (1 - \rho_z)\bar{z} + \rho_z z_{t-1} + \epsilon_z \tag{38}$$

Here, $\rho_z = 0.95$ and $\sigma_z = 0.008$. Following Perotti (2004), the government expenditure follows an exogenous AR(1) process[12]. Here, $\sigma_g = 0.008$ and $\rho_g = 0.9$.

## 5 Dynamic responses to Shocks

Figure 1 shows the dynamic response of selected variables to a 1% productivity shock in the economy. In the case of Figure 1, the monetary policy is set to respond to inflation and unemployment together[13]. Here, it can be stated that, the total output and consumption of non-durable goods in the economy is increasing along with a decrease in inflation. There is a little fluctuation in output and consumption response for a first few quarters and then it smoothly goes to the steady state level. The reason behind that can be stated that, the non-durable (i.e. monopolistic) production sector plays dominant role compared to the durable (i.e. perfect competition) sector. Therefore, when the shock (which is an AR(1) process) is realized in durable goods sector along with the non-durable sector, output and consumption jumped, but it didn't go down immediately to

[11] See Kehoe et al. (2016).
[12] $ln(\frac{g_t}{g}) = \rho_g ln(\frac{g_{t-1}}{g}) + \epsilon_t^g$
[13] $\phi_\pi$= 1.5 , $\phi_y$=0, $\phi_u = 0.6/4$

the steady state value as the effect of the shock exists in the non-durable sector due to the presence of financial friction and labor market friction in non-durable goods sector. The consumption also followed the path of the output as the consumers can borrow for their expenditure based on the value of their housing. However, Job creation initially decreases which supports the theory, as in this model, job creation is is also a function of labor in the durable goods sector along with the non-durable sector's labor (which are additively in the denominator of the job creation equation (26)). Hence, explaining the response to wage, due to a less job creation and increase in productivity, wage initially increases in the economy. Hence, the wage rigidity is also decreased initially. However, vacancy decreases along with increase in unemployment and market tightness.

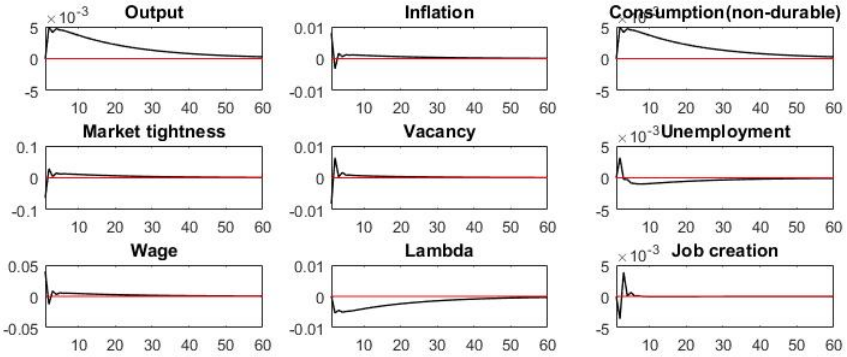


**Fig. 1.** *Impulse responses to productivity shock (response to unemployment and inflation policy rule)*

Figure 2 shows the responses to productivity shock with a standard Taylor rule[14]. Here, the output decreases with an increase in inflation initially and there are more fluctuations in the labor market variables.

Figure 3 suggest responses to government spending shock with monetary policy rule considering unemployment and inflation. The results in Figure 3 are similar to Figure 1. However, output increases comparatively less but inflation decreases similarly compared to Figure 1. Output doesn't decrease just after the shock realized as the non-durable goods sector plays a dominant role compared to the durable goods sector and the frictions play a crucial role as well.

[14] $\phi_\pi$= 1.5 , $\phi_y$=0.5/4, $\phi_u$ = 0

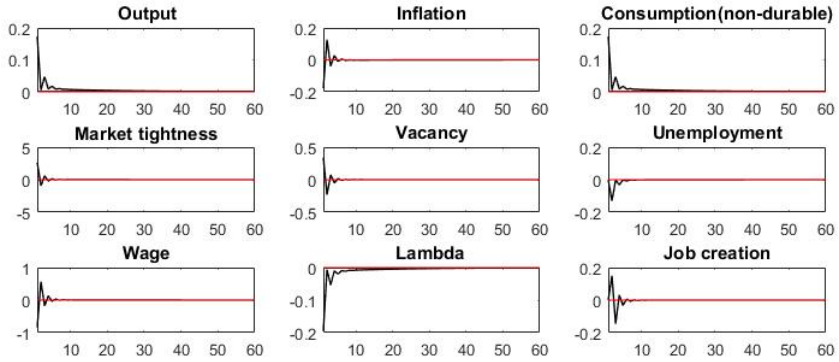


**Fig. 2.** *Impulse responses to productivity shock (Standard Taylor Rule)*

Figure 4 shows impulse responses to government spending shock with a standard Taylor rule. There is an increase in output and consumption of the non-durable goods which causes an initial increase in vacancies, decrease in labor market tightness, decrease in wage rigidity. However, the fluctuations are more in the economy with standard Taylor rule compared to stabilizing approach towards unemployment and inflation.

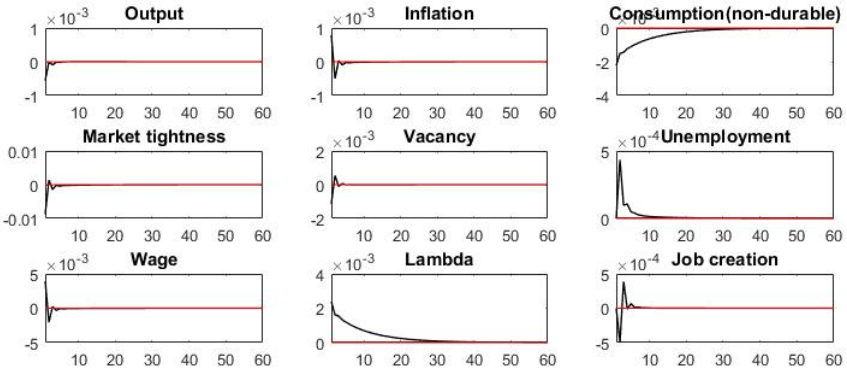


**Fig. 3.** *Impulse responses to government spending shock (response to unemployment and inflation policy rule)*

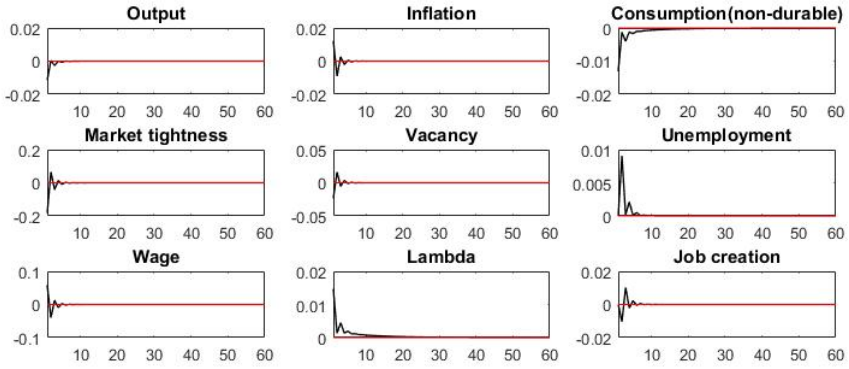


**Fig. 4.** *Impulse responses to government spending shock (Standard Taylor Rule)*

## 6 Limitations and future research

One of the very strong assumptions in this research is, assuming equal wages for both durable and non-durable goods production sectors even though labors are assumed to be sector specific. However, based on skill index, it is possible that the labors are having same skill levels, thus, they are getting same wages in different sectors, it will be interesting to analyze the model with sector specific wage. Furthermore, the labor hours are assumed to be indivisible here, where as divisible labor hours might provide a better result.

The models in production sector incorporates monopolistic competition and perfect competition for two different goods and assumes frictions only in monopolistic competition. Including monopolistic competition in both the sectors along with the frictions can provide more realistic results (as the durable goods production sector also face monopolistic competition in reality).

For simplicity, it is assumed that there are only final goods in this economy. Incorporating intermediate good producing sector can provide more interesting results.

This paper doesn't analyze the welfare of the economy. Welfare analysis based on Social planner's framework or Ramsey planner framework can provide a better understanding of financial market friction and labor market friction on the economy.

## 7 Concluding Remarks

This paper demonstrates that, in an economy where both monopolistic competition and perfect competition exists, introducing a financial friction can explain

the labor market frictions better when different monetary policy rules are imposed. It is found that, when the consumers consume both non-durables and durable goods and their expenditure can be financed by loans (where the borrowing is constrained by the value of the collateral), a one period productivity shock or government spending shock with unemployment stabilizing monetary policy rule, causes an increase in output and consumption even though there is an initial decrease in wage along with decrease in job creation. Furthermore, using a standard Taylor rule, it is found that, with productivity shock or government spending shock, the economy faces more fluctuations in output, consumption, inflation and labor market.

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