This paper studies how the effect of fiscal policy differs by including a home production sector in the New Keynesian and the Real Business Cycle model. To examine the effect of fiscal policy on the economy, I quantify the magnitude of distortionary tax cut multiplier and government spending multiplier. The distortionary tax cut multipliers are defined as the change in output caused by a dollar change in tax revenue following a distortionary consumption or labor tax shock. Government spending multiplier is defined as the change in output caused by a dollar change in government spending. We find that the home production sector increases with government spending multiplier and distortionary tax cut multipliers in the New Keynesian model. The robustness check of baseline model displays that the magnitude of fiscal multipliers varies significantly under distinct fiscal experiments.
FISCAL MULTIPLIERS IN HOME PRODUCTION MODELS

Thesis

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Dedication

This thesis is dedicated to Youhao Lei, Jun Wan, Ying Wan, Sui Wan, Xiaoran Wan, Yuzhen Liu, and Dr. Jonathan Wolff.
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1 Introduction
What impact does home production have on the transmission of fiscal policy? How does this intensive labor decision affect the transmission of fiscal policy? How does the home labor decision affect the economy? The purpose of this paper is to provide an answer to these questions.

Following the 2008 financial crisis, developed economy faced economic recessions with sluggish labor growth. In particular, US labor productivity growth rate remains low at 0.3 after the first quarter of 2008, whereas the productivity growth rate is about 0.7 from 2000-2007. Another noticeable change at the labor market is that a large proportion of population left the traditional labor market, either becoming self-employed or engaging in home production. Baldwin (2003) shows that self-employed workers have lower productivity than traditional workers in general. Thus, the best option for growing an economy in a longer term is to figure out effective policies which bring more people back to conventional market jobs.

We modify the New Keynesian sticky price model popular in the monetary and fiscal policy literature with a home production sector. Baseline results suggest that a home production sector amplifies government spending and tax cut multipliers. Total output is the sum of market output and home output. GDP measures market output, but the value of home output is not directly measured by current statistics. The total output spending multiplier is defined as change in total output caused by one dollar change in government spending. We find a smaller total output spending multiplier in the home production model than the benchmark model since home output decreases in response to the increase in government spending. The consumption tax cut multiplier is also larger in the model with a home production sector than in the benchmark model. As consumption rate decreases, household trade home production for conventional labor activities and market consumption. As a result, total output increases by a smaller scale than the increase in market output. Labor tax multiplier follows the same pattern.

The intuition for amplification of fiscal multipliers is as follows. Government spending increases or tax cuts incentivize market output. It creates an incentive for households to reallocate labor from home production to market production.
substitute both leisure hours and home labor hours for market labor hours. Yet there is no substitution between home hours and market hours in the model without a home production sector. Thus, market output augments by a larger scale in consequence of the extra movement from home hours to market hours.

We construct a number of extensions to consider the robustness of the results. In the baseline exercise, government spending is financed through lump-sum tax only. By Ricardian equivalence, households’ consumption decisions are not affected by the government’s timing of debt finance. Yet the lump-sum financing assumption is not very realistic. We, therefore, relax the lump-sum tax assumption, and allow distortionary consumption and labor tax to adjust to debt repayment. We find that fiscal multipliers are larger than the baseline experiment which only consists of lump sum tax. For example, the government spending multiplier on market output is 0.87 in the baseline experiment, which is larger than the multiplier 0.83 from the extension only has distortionary tax shocks since distortionary taxes have contractionary influence on the economy. Output response to fiscal policy is smaller under the experiment that only has distortionary taxes. Given the multiplier from the extension, we compare it to the baseline.

There is a large strand of literature associated with spending and tax multipliers. Early contributions include Baxter and King (1993), Christiano and Eichenbaum (1992), McGrattan (1994) and Braun (1994). These papers explore the effects of fiscal shocks in the standard RBC model. For more recent research estimating tax multipliers in reduced form, Blanchard and Perotti (2002) find that the tax multiplier was about -1, while Romer and Romer (2009) argue that the estimates of tax multiplier was about -3. Mertens and Ravn (2011, 2012, 2014) identify unanticipated tax shocks and measure tax multipliers in a structural VAR model. Ramey (2011) finds the government spending multiplier was in the range between 0.8 to 1.2. Barro and Redlick (2011) find the multiplier vary from 0.4 to 0.6. Lawrence, Eichenbaum and Rebelo (2011) argue that government spending multiplier are larger in magnitude during recessions. The fiscal multipliers in our model is consistent with those multipliers in the literature.

In addition, extensive work has studied the effect of incorporating a home production sector in the RBC model or the New Keynesian model. Benhabib, Rogerson and Wright
(1991); Mcgrattan, Rogerson and Wright (1997); Greenwood, Hercowitz (1991); Gomme, Kydland, Rupert (2001) examine the macroeconomic implications by including a home production sector in a standard RBC model. In addition, many empirical studies shed light on the economic effects of fiscal policy in a home production model. Regan (2006) argue that day care provided by government can substitute home production for market jobs, within a New Keynesian model. Karabarbouris (2013) studies the relationship between market consumption and marginal utility of consumption in an international business cycle model with a home production sector. That paper delineates details of marginal labor decision between the conventional labor market and home, and applies the across-country data to explain a few stylized facts of the open economy. Lester (2014) investigates the effect of monetary policy on the economy, and he finds that output responses to monetary policy is doubled in the DSGE model with a home production sector. Gnocchi, Hauser, and Pappa (2016) emphasize the complementarity between market consumption and hours, and conduct welfare policy evaluation. Yoshida and Kenmochi (2015) studies the government spending multipliers for output, public goods and public service across different time span. They find government spending increase has a positive effect on public goods in the short-run. There is a positive effect on public service in the long-run resulted from government spending increase. Our paper fills the gap in literatures by quantifying the government spending and tax multipliers in the New Keynesian model.

The remainder of this paper proceeds as follows. Section 2 describes the New Keynesian model. Section 3 displays the calibration of parameters in the model, and explains the baseline results and the intuition. In section 4, I consider several fiscal policy extensions to check the robustness of the baseline results. The final section gives a conclusion, and suggests a potential topic for future research.

2. The Model

We use a standard New Keynesian model with Calvo sticky price and a home production sector. The capital accumulation process is omitted. The model has three economic agents: infinitely lived representative households, firms, and a government. The firm is split into two
parts: final goods firm operate in a perfectly competitive market; and intermediate goods firms operate in a monopolistically competitive market.

2.1 Households

Preferences of households are defined over consumption, leisure and government spending. Households’ utility maximization problem is

\[
\text{Max}_{C_{t,t}, N_t, B_{t+1}} \ E \sum_{t=0}^{\infty} \beta^t \left( \ln C_{T,t} + \psi_n \ln l_t + \Omega_G \ln G_t \right)
\]

\[
C_{T,t} = f(C_{m,t}, C_{h,t})
\]

\[
1 = N_{m,t} + N_{h,t} + l_t
\]

where \(N_{T,t}\) is the time t aggregate of labor, \(N_{m,t}\) is labor of market production, \(N_{h,t}\) is the labor of home production, and \(l_t\) is time of leisure. \(G_t\) is government spending at time \(t\), and households’ choices of consumption and labor over different equilibrium dynamics are unaffected by \(G_t\) as it is additively separable in the utility function. \(C_{T,t}\) is aggregate consumption; \(C_{m,t}\) is consumption of market produced goods; and \(C_{h,t}\) is consumption of home produced good. \(\tau_t^C\) is the consumption tax that the households pay for their purchase of market goods. \(\tau_t^P\) represents the distortionary labor tax.

We assume a concave and increasing function \(f(\cdot)\). The households’ problem is subject to the following constraints:

\[
(1 + \tau_t^C)C_{m,t} + \frac{B_t}{P_t} \leq (1 - \tau_t^P)W_tN_{m,t} - P_tT_t + \pi_t + \frac{(1+i_{t-1})B_{t-1}}{P_t}
\]

\[
C_{h,t} = A_{h,t}f^h(N_{h,t})
\]

Household consumption is financed via wage income, profits from owning firms, and interest payments from savings. Households receive real interest payment from holding bonds \((1 + i_{t-1})B_t/P_t\). Households will either pay a lump-sum tax or receive a transfer payment from the government which is denoted by \(T_t/P_t\), depending on the value of \(T_t\).
Aggregate consumption follows a CES aggregator over market and home consumption $C_{T,t} = \left[ \xi C_{m,t}^\theta + (1 - \xi) C_{h,t}^\theta \right]^\frac{1}{\theta}$, where $\theta \in (0,1)$. $\xi$ governs the household’s preference of consumption over market goods and home-produced goods. Higher values of $\xi$ indicate that the household prefers to consume more market goods and, thus, consume less home-produced goods. $\frac{1}{1-\theta}$ is the elasticity of substitution between market and home consumption. If $\theta = 0$, $C_{T,t} = \left[ \xi C_{m,t}^\theta + (1 - \xi) C_{h,t}^\theta \right]^{1/\theta}$ becomes a Cobb-Douglas production function. Market goods and home produced goods become perfect complements as $\theta$ approaches to negative infinity, and the two type consumption become perfect substitutes as $\theta$ approaches to 1.

The households maximize their utility subject to equations (2)-(5), and the interior solutions are characterized by:

**6.** $\beta \xi C_{T,t}^{\frac{1}{\theta} - 1} \ast C_{m,t}^{\theta - 1} - \mu_t (1 + \tau_t^c) = 0$

**7.** $\beta (1 - \xi) C_{T,t}^{\frac{1}{\theta} - 1} \ast C_{h,t}^{\theta - 1} - \frac{\psi_n}{1 - N_{m,t}} - \frac{C_{h,t}}{A_{h,t}} \ast \frac{1}{A_{h,t}} = 0$

**8.** $-\frac{\psi_n}{1 - N_{m,t}} \ast \frac{C_{h,t}}{A_{h,t}} + \mu_t W_t (1 - \tau_t^n) = 0$

**9.** $\beta \mu_{t+1} (1 + \tau_{t+1}) \ast (1 + \pi_{t+1})^{-1} - \mu_t = 0$

### 2.2 Wage Stickiness

The union negotiates with firms about the wage rate $W_t$. Composite labor good $N_t$ is described as

**10.** $N_t = \left( \int_0^1 N_t (i)^{\epsilon W - 1} \ast \frac{i^{\epsilon W}}{\epsilon W} \ast di \right)^{\frac{\epsilon W}{\epsilon W - 1}}$

where $\epsilon W$ is the labor elasticity of demand. We assume $\epsilon W > 1$ since households have market power in labor markets and they only operate on the elastic portion of the labor demand.
curve. We index differentiated labor inputs by \( i \in (0,1) \). The profit maximization problem of the labor union is:

\[
(11) \quad \text{Max}_{N_t(i)} \Pi_t = W_t N_t - \int_0^1 N_t(i) W_t(i) \, di
\]

where \( W_t(i) \) is the nominal wage rate for \( i \)th labor input. \( N_t(i) \) is the amount of labor input \( i \in (0,1) \). Taking the first order condition with respect to \( N_t(i) \), we have the demand function of the labor input.

\[
(12) \quad N_t(i) = \left( \frac{W_t(i)}{W_t} \right)^{-\epsilon W} N_t
\]

Next, we apply the zero profit condition of labor union, we have the aggregate real wage index

\[
(13) \quad \int_0^1 W_t(i)^{1-\epsilon W} \, di = W_t^{1-\epsilon W}
\]

Define the real wage chosen by household as: \( w_t(i) = \frac{W_t(i)}{P_t} \) and the aggregate real wage is similar to the process of having real aggregate prices level \( w_t = \frac{W_t}{P_t} \).

Households are not able to change their wages freely at each period. There is a probability \( \phi_w \) that households will get stuck at a certain wage. The real wage of a labor supplier at time period \( t+s \) based on the choice of nominal wage at time period \( t \) is

\[
(14) \quad w_{t+s}(i) = \frac{W_t(i)}{P_{t+s}} = \frac{W_t(i)}{P_t} \frac{P_t}{P_{t+s}}
\]

Let \( \frac{P_{t+s}}{P_t} \) be gross inflation from time period \( t \) to \( t+s \). Now we define \( P_t/P_{t-1} = 1 + \pi_t \) and \( P_t^#/P_{t-1} = 1 + \pi_t^# \)

\[
(15) \quad \prod_{m=1}^s (1 + \pi_{t+m}) = \frac{P_{t+1}}{P_t} \times \frac{P_{t+2}}{P_{t+1}} \times \ldots \times \frac{P_{t+s}}{P_{t+s-1}} = \frac{P_{t+s}}{P_t} = 1 + \pi_{t+s}
\]

Households' real wage will change in period \( t+s \), and it can be written as \( w_{t+s}(i) = w_t(i) \frac{P_t}{P_{t+s}} \)

where \( w_t \) is the real wage at time \( t \). Thus, the real wage of the household received for its labor supply at time \( t+s \) is \( \frac{w_{t+s}(i) P_{t+s}}{P_t} = w_t(i) \)
We can rewrite the wage setting problem as:

\[
\mathcal{L} = \sum_{t=0}^{\infty} (\beta \phi_w)^t [\psi_n \ln(1 - N_t(i)) + \mu_t(1 - \tau_i^c)W_t(i)N_t(i) + (1 + i_{t-1})B_{t-1}]
\]

\[
\mathcal{L}_1 = \sum_{t=0}^{\infty} (\beta \phi_w)^t [\psi_n N_t \frac{W_t(i)P_t}{W_{t+s}P_{t+s}^{\epsilon_w}}]_{\epsilon_w} N_{t+s} + \mu_{t+s}P_{t+s}[W_t(i)\frac{P_t}{P_{t+s}}(\frac{W_t(i)P_t}{W_{t+s}P_{t+s}^{\epsilon_w}})]_{\epsilon_w} - (1 + \tau_i^c)C_{m,t}]
\]

The first order condition gives us

\[
\epsilon_w w_t(i)^{-\epsilon_w - 1}E_t \sum_{s=0}^{\infty} (\beta \phi_w)^s \psi_n W_{t+s}^{\epsilon_w} \frac{P_{t+s}}{P_t}^{\epsilon_w} N_{t+s} = \epsilon_w - 1)w_t(i)^{-\epsilon_w}E_t \sum_{s=0}^{\infty} (\beta \phi_w)^s \mu_{t+s}W_{t+s}^{\epsilon_w} \frac{P_{t+s}}{P_t}^{\epsilon_w} N_{t+s}
\]

\[
(17) \quad \frac{\epsilon_w}{\epsilon_w - 1}E_t \frac{\sum_{s=0}^{\infty} (\beta \phi_w)^s \psi_n W_{t+s}^{\epsilon_w} \frac{P_{t+s}}{P_t}^{\epsilon_w} N_{t+s}}{\sum_{s=0}^{\infty} (\beta \phi_w)^s \mu_{t+s}W_{t+s}^{\epsilon_w} \frac{P_{t+s}}{P_t}^{\epsilon_w} N_{t+s}} = w_t(i) = w_t^#
\]

\(w_t^#\) is the reset wage does not involve subscript i. All households will update their wage to the same level and the reset wage is not determined by a particular household.

Simplify the equation above, it gives us that \(w_t(i) = w_t^\# = \frac{\epsilon_w}{\epsilon_w - 1} \frac{H_{t,s}}{H_{t,s}^{\#}}\) where,

\[
(18) \quad H_{t,s} = \psi_n W_t^{\epsilon_w} N_t + \beta \phi_w E_t (1 + \pi_{t+s})^{\epsilon_w} H_{t,s}^{t+1}
\]
(19) \[ H_{2,t} = \mu_t w_t^{\epsilon w} N_t + \beta \phi_w E_t (1 + \pi_{t+1})^{\epsilon w-1} H_{2,t+1} \]

The aggregate real wage index is \( w_t^{1-\epsilon w} = \int_0^1 w_t(i)^{1-\epsilon w} \, di \)

Based on our assumption, \( 1 - \phi_w \) of households will adjust their wage and \( \phi_w \) of them will stay at the nominal wage from last period.

\[
w_t^{1-\epsilon w} = (1 - \phi_w) \, w_t^{#1-\epsilon w} + \int_{1-\phi_w}^1 (W_t(i)/P_t)^{1-\epsilon w} \, di
\]

\[
w_t^{1-\epsilon w} = (1 - \phi_w) \, w_t^{#1-\epsilon w} + \int_{1-\phi_w}^1 (W_t(i)/P_{t-1})^{1-\epsilon w} (P_{t-1}/P_t)^{1-\epsilon w} \, di
\]

\[
w_t^{1-\epsilon w} = (1 - \phi_w) \, w_t^{#1-\epsilon w} + (1 + \pi_t)^{\epsilon w-1} \int_{1-\phi_w}^1 w_{t-1}(i)^{1-\epsilon w} \, di
\]

(20) \[
w_t^{1-\epsilon w} = (1 - \phi_w) \, w_t^{#1-\epsilon w} + \phi_w (1 + \pi_t)^{\epsilon w-1} w_{t-1}^{1-\epsilon w}
\]

The updating households’ dynamic profit maximization decision is described as below. Those differentiated labor suppliers can choose different wages of labor supply so as to achieve the goal of maximizing current value of utility. Labor wedge is defined as the gap between the real wage (marginal product of labor) and the marginal rate of substitution between consumption and leisure. As \( \epsilon_w \) approaches to infinity, wage markup \( \frac{\epsilon_w}{\epsilon_w - 1} \) approaches to 1, which means the labor wedge is shrinking.

2.3 Final Goods Firm

Perfectly competitive firms produce final goods for household consumption. Final goods output \( Y_{m,t} \) is defined by a CES aggregator over a continuum of monopolistically competitive intermediate goods, where \( Y_{m,t}(j) \) is the amount of intermediate goods purchased from firm \( j \).

(21) \[
Y_{m,t} = (\int_0^1 Y_{m,t}(j)^{\epsilon p-1} \, dj)^{\epsilon_p - 1} \quad \text{for all } j \in (0,1)
\]

Final goods firms’ profit maximization problem is
(22) \[ \text{Max}_{Y_{m,t}(j)} \Pi_t = P_t Y_{m,t} - \int_0^1 Y_{m,t}(j) P_t(j) \, dj \]

where \( P_t(j) \) is the price of jth intermediate goods. Taking the first order condition with respect to \( Y_{m,t}(j) \), it results in the demand function of the intermediate good.

(23) \[ Y_{m,t}(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\epsilon_p} Y_{m,t} \]

Notice, \( \epsilon_p \) is the price elasticity of demand. A larger price elasticity of demand implies less market power of the intermediate good firms. we solve for the aggregate price index as

(24) \[ (\int_0^1 P_t(j)^{1-\epsilon_p} \, dj)^{1/(1-\epsilon_p)} = P_t \]

2.4 Intermediate Goods Firm

The Intermediate goods firms’ production function appears as

(25) \[ Y_{m,t}(j) = A_{m,t} N_{m,t}(j) \]

Given demand for their goods from final goods firms, the profit maximization problem can be re-written as a cost minimization problem.

\[ \text{Mini } Y_{m,t}(j) = W_t N_{m,t}(j) \]

s.t. \( Y_{m,t}(j) \geq \left( \frac{P_t(j)}{P_t} \right)^{-\epsilon_p} Y_{m,t} ; Y_{m,t}(j) = A_{m,t} N_{m,t}(j) \)

Building on the assumption that each firm encounters the identical total factor productivity shock and the identical real wages. Thus, we have the following expression for real marginal cost by taking first order condition to \( N_{m,t}(j) \),

(26) \[ W_t / A_{m,t} = mc_t \]

As in Calvo (1983) pointed out, I assume a probability \( \phi_p \in (0,1) \) that firms will be remained at the current price. The updating firms’ dynamic profit maximization decision is
described as below. Those intermediate firms can choose different prices of their product so as to achieve the goal of maximizing current value of profits. The pricing problem is

$$\text{Max}_{P_{t}(j)} \ E \sum_{s=0}^{\infty} \{ (\beta \phi_{p})^{s} \ \frac{U'(C_{t+s})}{U'(C_{t})} \ P_{t+s} \ Y_{m,t+s}(j) - \text{mc}_{t+s} Y_{m,t+s}(j) \}$$

Substitute $Y_{m,t}(j) = \left( \frac{P_{t}(j)}{P_{t}} \right)^{\varepsilon_{p}} Y_{m,t}$ into the above, we have

$$\text{Max}_{P_{t}(j)} \ E \sum_{s=0}^{\infty} \{ (\beta \phi_{p})^{s} \ \frac{U'(C_{t+s})}{U'(C_{t})} \ \left( \frac{P_{t}(j)}{P_{t+s}} \right)^{\varepsilon_{p}} Y_{m,t+s} - \text{mc}_{t+s} \left( \frac{P_{t}(j)}{P_{t+s}} \right)^{\varepsilon_{p}} Y_{m,t+s} \}$$

First order condition gives us that:

$$P_{t}(j) = \left( \frac{\varepsilon_{p}}{\varepsilon_{p}-1} \right) \ E_{s=0}^{\infty} (\beta \phi_{p})^{s} \ \frac{U'(C_{t+s})}{U'(C_{t})} \ P_{t+s} \ Y_{m,t+s}$$

The key point is that the right hand side of equation is independent of firm specific values. That is, all firms will update to the same price $P_{t}^# = P_{t}(j)$. Rewrite $P_{t}(j)$ in a more compact notation as below,

$$P_{t}^# = \left( \frac{\varepsilon_{p}}{\varepsilon_{p}-1} \right) \ X_{1,t} \ P_{t}$$

$$X_{1,t} = U'(C_{t}) \text{mc}_{t} P_{t}^{\varepsilon_{p}} Y_{m,t} + \beta \phi_{p} E_{t} X_{1,t+1}$$

$$X_{2,t} = U'(C_{t}) P_{t}^{\varepsilon_{p}-1} Y_{m,t} + \beta \phi_{p} E_{t} X_{2,t+1}$$

Notice that reset optimal price $P_{t}^#$ depends on the reciprocal of markup $\frac{\varepsilon_{p}}{\varepsilon_{p}-1}$, the probability of get stuck at a certain price $\phi_{p}$, and marginal cost $\text{mc}_{t}$. If $\phi_{p} = 0$, then the optimal reset price

$$P_{t}^# = \frac{\varepsilon_{p}}{\varepsilon_{p}-1} * \text{mc}_{t} P_{t}$$

Define $V_{t}^p = \int_{0}^{1} \left( \frac{P_{t}(j)}{P_{t}} \right)^{-\varepsilon} dj$ as the price dispersion of varied intermediate goods,
\[ V_t^p = \int_0^{1-\phi} (\frac{P_t^#}{P_{t-1}})^{-\epsilon_p} \, dj + \int_{1-\phi}^1 (\frac{P_{t-1}(j)}{P_t})^{-\epsilon_p} \, dj = \int_0^{1-\phi} (\frac{P_t^#}{P_{t-1}})^{-\epsilon_p} \ (\frac{P_{t-1}}{P_t})^{-\epsilon_p} \, dj + \int_{1-\phi}^1 (\frac{P_{t-1}(j)}{P_t})^{-\epsilon_p} \ (\frac{P_{t-1}}{P_t})^{-\epsilon_p} \, dj \]

\[ V_t^p = (1 - \phi_p)(1 + \pi_t^#)^{-\epsilon_p}(1 + \pi_t)^{\epsilon_p} + (1 + \pi_t)^{\epsilon_p} \phi V_{t-1}^p \]

\[ V_t^p = (1 - \phi_p)(1 + \pi_t^#)^{-\epsilon_p}(1 + \pi_t)^{\epsilon_p} + (1 + \pi_t)^{\epsilon_p} \Phi V_{t-1}^p \]

(32) \[ V_t^p = (1 + \pi_t)^{\epsilon_p}[(1 - \phi_p)(1 + \pi_t^#)^{-\epsilon_p} + \phi_p V_{t-1}^p] \]

Apply the demand function of intermediate goods, we have \( Y_{m_t} \),

The final aspect of this the section is: notice equation can be rewritten in the form of inflation, so we have

(33) \[ 1 + \pi_t = (1 + \pi_t) \frac{\epsilon_p}{\epsilon_p - 1} X_{1,t} \]

(34) \[ X_{1,t} = \mu_t mc_t \ Y_t + \beta \phi_p E_t (1 + \pi_t+1)^{\epsilon_p} X_{1,t+1} \]

(35) \[ X_{2,t} = \mu_t \ Y_t + \beta \phi_p E_t (1 + \pi_t+1)^{\epsilon_p - 1} X_{2,t+1} \]

And the aggregate price dispersion, equation, can be expressed in terms of inflation

(36) \[ (1 - \phi_p)(1 + \pi_t^#)^{1-\epsilon_p} + \phi_p = (1 + \pi_t)^{1-\epsilon_p} \]

2.5 Government and Central Bank

Central banks implement monetary policy based on the Taylor rule.

(37) \[ i_t = (1 - \rho_i) i_{ss} + \rho_i i_{t-1} + (1 - \rho_i) \phi_{\pi} (\pi_t - \pi_{ss}) + \epsilon_{i,t} \]

where \( i_t \) represents the nominal interest rate at time \( t \), \( i_{ss} \) is the steady state nominal interest rate, \( \rho_i \) is a parameter, \( \pi_t \) is the inflation rate at time \( t \) and \( \pi_{ss} \) is the steady state inflation target. \( \epsilon_{i,t} \) denotes a monetary policy shock. \( \phi_{\pi} \) is a coefficient which is greater than 1.

The government finances its spending through lump sum tax, distortionary consumption tax, labor tax and debts. The government budget constraint is:

(38) \[ G_t + i_{t-1} \frac{B_t^G}{P_t} = T_t + \tau^c C_{m,t} + \tau^p W_t + \frac{B_{t-1}^G - B_t^G}{P_t} \]
Government spending plus its real interest payments to bond holders equals the sum of its revenue from lump-sum tax, consumption tax, labor tax and real stock of government debt.

The following equations describe the proportion of government spending, lump-sum tax, consumption tax, and labor tax to market output.

\[(39) \quad G_t = Y_{mt}(s_{gt})\]
\[(40) \quad T_t = Y_{mt}(s_{Tt})\]
\[(41) \quad \tau^c_{t} C_{m,t} = Y_{mt}(s_{c}\tau^c_{t} c_{m,t})\]
\[(42) \quad \tau^p_{t} W_t = Y_{mt}(s_{n}\tau^p_{t} w_{t})\]

where \(s_{g}, s_{T}, s_{n}, s_{c}\) are respectively the steady state share of government spending, lump-sum tax, distortionary consumption tax, and labor tax.

In addition, government spending and taxes series follow an exogenous process as government budget constraint binds.

\[(43) \quad \ln g_t = (1 - \rho_g) \ln g_{ss} + \rho_g \ln g_{t-1} + s_{g} \varepsilon_{t,g}\]

where \(\rho_g \in (0,1)\) measures persistence, and \(g_{ss}\) is the steady state value of government spending shock. \(s_{g}\) is the steady state share of government spending, and \(\varepsilon_{t,g}\) is the stochastic shock of government spending.

\[(44) \quad T_t = (1 - \rho_T) T_{ss} + \rho_T T_{t-1} + \gamma_T^B (B_{t-1} - B_{ss}^g) + s_T \varepsilon_{t,T}\]

where \(\rho_T \in (0,1)\) measures persistence. \(T_{ss}\) is the steady state value of lump-sum tax. \((B_{t-1}^g - B_{ss}^g)\) measures the deviation of government bonds from its steady state value. \(\gamma_T^B\) is set up as a positive value so that government can raise revenue from issuing bond. Yet \(\gamma_T^B\) should not be too large in the model. A large value of \(\gamma_T^B\) will let government debt grow to infinity. Accordingly, we define the consumption tax and labor tax process as following

\[(45) \quad \tau^n_{t} = (1 - \rho_n) \tau^n_{ss} + \rho_n \tau^n_{t-1} + \gamma_n^B (B_{t-1}^g - B_{ss}^g) + s_n \varepsilon_{t,n}\]
\[(46) \quad \tau^c_{t} = (1 - \rho_c) \tau^c_{ss} + \rho_c \tau^c_{t-1} + \gamma_c^B (B_{t-1}^g - B_{ss}^g) + s_c \varepsilon_{t,c}\]
2.5 Aggregation and Stochastic Process

We further assume total factor productivity in both market production and home production sector follow an AR(1) process in logs,

\[
\begin{align*}
\ln A_{m,t} &= \rho_{A,m}\ln A_{m,t-1} + \varepsilon_{t,A,m} \\
\ln A_{h,t} &= \rho_{A,h}\ln A_{h,t-1} + \varepsilon_{t,A,h}
\end{align*}
\]

Goods produced in the market are either consumed by households or the governments, so we have

\[
C_{m,t} + G_t = Y_{m,t}
\]

2.6 Equilibrium Systems

The equilibrium system for the New Keynesian Model with a home production sector and fiscal policy sector is composed of twenty eight equations:

\[
C_{m,t}, C_{h,t}, C_{T,t}, N_{m,t}, N_{h,t}, N_{T,t}, i_t, W_t, W_t^*, A_{m,t}, A_{h,t}, x_{1,t}, x_{2,t}, Y_{m,t}, Y_{h,t}, Y_{T,t}, \mu_t, \pi_t, H_{1,t}, H_{2,t}, mc_t, \pi_t^*, V_t^*, T_t, G_t, B_t^*, \tau_t^*, \tau_t^n.
\]

2.7 Parameterization

The list of calibrated parameters is \{\beta, \pi_{ss}, \varepsilon_p, \varepsilon_w, \xi, \theta, \phi_p, \phi_w, sg, s_T, s_n, s_c\}. Parameters affect taxes and government spending process are also calibrated. We take discount factor \beta to be 0.99, and assume the steady state inflation rate to be zero, \(\pi_{ss} = 0\). In the New Keynesian model, discount factor and inflation rate determine that annual risk-free real interest rate is four percent. Price and wage elasticity are set to 10, \(\varepsilon_p = \varepsilon_w = 10\), which is supported by empirical evidence. It implies that steady state price and wage markup is ten percent. According to the data in Table 9 from the American Time Use Survey, we choose market and home labor hours to be \(N_m = 0.33\) and \(N_h = 0.20\). Data in Table 9 suggests that a suitable calibration of \(\theta\) is 0.429. Elasticity between market and home produced goods is \(\frac{1}{1-0}\), which is about 1.6. The weight of consumption is captured by the parameter \(\xi\). In a baseline model without a home production sector, \(\xi\) is set to 1. Households only consume market produced goods and have no consumption of home-produced goods. In our New Keynesian model with a home-production sector, we use the steady state value of home labor hours.
Nh=0.2 to solve the optimal value of $\xi=0.6308$. It means that households have 63.08% share of their total consumption for market produced goods and 36.92% share of total consumption for home produced goods. The calibrated price and wage stickiness parameter is both 0.5 in the baseline experiment, which implies that fifty percent of firms and households cannot adjust their prices or wages. Finally, we set sg to 0.2, meaning the steady state government spending accounts for twenty percent of market output share. In the baseline experiment (a), $\gamma_T^B = 0.1$ and $\gamma_n^B = \gamma_c^B = 0$. For the other two fiscal policy experiments (b) and (c), $\gamma_T^B = 0$ and $\gamma_n^B = \gamma_c^B = 0.2$; $\gamma_n^B = 0.2$ and $\gamma_T^B = \gamma_c^B = 0$.

To investigate how the assumption of wage stickiness amplifies market output response to productivity shock in the New Keynesian model, we run experiments by changing the price stickiness parameter of households. In the baseline model, price stickiness parameter is set to $\phi_p=0.5$. We set $\phi_p$ to 0, which means there is only wage stickiness in the model. We find that market output response to productivity shock is larger when there only exists wage stickiness. The intuition of these mechanisms will be discussed in the following section.

3. Baseline Results

This section explores details about how a home production sector affects the economy between two models: Real Business Cycle model and New Keynesian model. By comparing the version with a home production sector and the version without a home production sector, we find that adding a home-production in the RBC or New Keynesian model generates different quantitative results of fiscal multipliers. Government spending multipliers and tax cut multipliers are generally larger in both the New Keynesian model and RBC model with a home production sector than the baseline models without a home production sector. In the model with a home production sector, households have more labor hours to allocate between conventional labor market and home. The flexibility of reallocation of labor hours allow households to increase market labor hours in a larger scale, and thus engenders larger fiscal multipliers on market output, consumption and labor hours. Besides, the New Keynesian model with features of price and wage stickiness have larger multipliers than RBC model. We will also discuss the mechanism of how wage stickiness amplifies the magnitude of fiscal multipliers.
3.1 Intuition in the New Keynesian Model

Notice in the set-up of our model, households make labor-supply decision between conventional labor market and home-production market. Changes in endogenous and exogenous variables of conventional labor market will create incentive for households to redistribute their labor hour to home-production or leisure. For example, exogenous shocks, such as higher costs of household care aid, may prompt a transition from conventional labor market hours to household care hours. When low wage rates coincide with high costs of household care in recession, some households need to make a decision that either stick with their current market job or quit their jobs to take care of their families. Similar numerous labor decisions are made by households during the periods when real wage fluctuate. Low wage rates dampen households’ traditional labor supply, and they would like to allot their time to home-production or leisure activities. The resource of labor supply reallocates in a massive magnitude if we incorporate the home-production sector into our model. Policy-makers need to take these factors into account for making policies.

In the model, we adjust the value of parameter $\xi$ to generate a home production sector. The consumption function is split into two parts: consumption of market goods and consumption of home-produced good. By assigning the different values on $\xi$, the parameter measures the weight on total consumption in the consumption aggregate, we are able to discuss households’ distinct preferences on consumption goods. We calibrate the model and solve the optimal value of $\xi = 0.6308$ by matching the steady state value of home labor supply and market labor supply with the real data. Under the literature’s conventional method which assumes $\xi = 1$, home-production sector is omitted in the model. The assumption $\xi = 1$ will lead to inaccurate measurements of output, consumption and labor supply responses to fiscal policy changes. Home-production accounts for a large portion of people’s usage of their time. In recession, households boost up the amount of time allocated to home-production since millions of workers lose jobs at traditional labor market. Therefore, we argue that it is important incorporate the home-production sector and then find the optimal value of $\xi$ by matching the real data. Once we have the optimal value of $\xi =$
0.6308, we may compare the responses of output, consumption, and labor decision among several fiscal experiments under different specifications of $\xi$.

We find that output, market consumption, and market labor hour responses to labor tax cuts are larger when there is a larger proportion of home-produced type of labor, equivalently, $\xi$ (share of consumption on market good) is very small. What is the mechanism behind these effects? A higher value of $\xi$ indicates that households prefer to consume more market goods which implies they spend relatively less time of working at home. Consequently, households apply almost all of their work time to conventional labor market, which makes them have less substitutability between market jobs and home-production as the incentive like labor tax cuts implemented. In contrast, a relatively small value of $\xi$ means that households allocate more time for home-production. In advent of fiscal policies which encourage market work, households are able to shift their home-production time to conventional labor market, causing higher market production.

Households, in the model with home-production sector, predict larger responses of consumption, labor hours and output to a consumption tax cut. Recall in our model, the only input for market and home production is labor hours. High weight of market consumption is identical to large conventional market labor hours. The results section will show that effects of consumption tax cuts on stimulating output is smaller in a model without home-production. Since households are already assumed only consume market goods in the model without home-production, the marginal utility gained from an additional unit of consumption is minuscule, implying they would be less responsive to rise consumption. On the other hand, total work hours are strictly constrained because every individual faces identical time endowment, 24 hours a day. For those households which already use all of their work time in conventional jobs, it is extremely difficult to increase additional labor hours in conventional labor market through tax cuts. The compensation needs to be very high for encouraging workers to substitute their leisure time for market hours. A moderate consumption tax cut hardly gives a strong incentive for the movement of labor hours in this economy.
In contrast, households in an economy with home-production predict larger responses to consumption tax cuts. With an incentive of consumption tax cuts, households are making decisions about whether they should reduce home labor hours or leisure to work more in the conventional market. Households in the simulated economy split their time endowment into three activities. They can adjust their marginal decisions by reallocating their hours between market and home. In this scenario, households are more flexible in orchestrating the only input for market production, labor hours. Consumption tax cuts have larger effects in pepping up market consumption and output.

Another important portion of this model is from the wage stickiness. In the model, we assume households cannot adjust their wage level freely in every period. There is a probability $\phi_w$ that households will get stuck at past wage rates, where $\phi_w \in (0,1)$. The assumption of wage stickiness results in a labor wedge, the discrepancy between real wage and marginal rate of substitution between leisure and consumption of market goods. Real wage is defined as the wage markup over the marginal rate of substitution. As $\varepsilon_w$, the wage rate elasticity of demand, approaches to infinity, the wage markup $\frac{\varepsilon_w - 1}{\varepsilon_w}$ approaches to 1. Real wage (marginal cost of labor) approximates to the marginal product of labor (marginal rate of substitution) as the wage markup inches along to 1. The labor market is similar to a competitive labor market since households have tenuous market power, and therefore the market is clearing as real wage equals the marginal product of labor. If the wage adjustment process is sluggish due to wage stickiness, the distortion of labor market tends to be enormous since the wage markup is too high. In recession, market-clearing wage reduces, but wage markup stays at a high level since households cannot adjust wage level in every period. Labor unions which delegate households to negotiate the wage level want a higher aggregate wage than firms’ willingness to pay. Therefore, jobless households can hardly find jobs in the conventional labor market and will engage in more home-production or simply have more leisure. Wage stickiness exacerbates the unemployment issue, and therefore affects the output in short run. So it is necessary to study the responses of output, consumption and labor to productivity shocks under different level of wage stickiness. Wage stickiness will amplify the output response to market productivity shock. Real wage rises up
in response to a positive productivity shock. The wage markup will end up being too low because certain households get stuck nominal wages from previous time period. Over time, aggregate wage markup will dwindle, meaning the economy is less distorted. The economy is more expansionary due to the less distortion resulted from labor market monopoly power. Output will respond in a larger magnitude to a productivity shock in the New Keynesian model.

3.2 Government Spending Multipliers in the New Keynesian Model

Government spending multipliers to market, home and total output is calculated as: \( \frac{\partial y_m}{\partial G} \); \( \frac{\partial y_h}{\partial G} \); \( \frac{\partial y_t}{\partial G} \), where \( y_m \), \( y_h \), \( y_t \), \( G \) and \( g \) denote market output, home output, total output, government spending and government spending shock respectively. The ratio of change in market output over the change in government spending is defined as the government spending multiplier. Similarly, we can define the government spending multiplier to consumption and labor hours : \( \frac{\partial c_m}{\partial G} \); \( \frac{\partial c_h}{\partial G} \); \( \frac{\partial n_m}{\partial G} \); \( \frac{\partial n_h}{\partial G} \); \( \frac{\partial n_t}{\partial G} \), where \( c_m \), \( c_h \), \( c_t \), \( n_m \), \( n_h \), \( n_t \) are market consumption, home consumption, total consumption, market labor hours, home labor hours and total labor hours accordingly. Government multipliers have following interpretation: a dollar increase in government spending will increase output by the corresponding amount of dollars. In Table 1, market output government spending multiplier is 0.83 when \( \xi \) equals 1, meaning that increases government spending by one dollar will rise market output by 0.83 dollar. If \( \xi \) equals 0.6308, the market output government spending multiplier is 0.87. We can also see the responses of home output, total output, market consumption, home consumption, total consumption, market labor hours, home labor hours, and total labor hours to the increase in government spending. Home output in response to government spending is zero when \( \xi \) is one, assuming that households put all of their work time into conventional labor market. Thus, there is no home output response to government spending change. Home consumption and home labor hours, when \( \xi \) equals 1, do not change either in response to government spending or tax changes. The home output government spending multiplier is -0.30 when \( \xi \) is 0.6308, indicating a dollar increase in government spending will decrease home output by 0.30 dollar. Remember total output is simply the addition of market output and home output.
Thus, total output government spending multiplier is 0.83 when $\xi$ equals 1; when $\xi$ equals 0.6308, the same multiplier is 0.87 plus negative 0.30, which equals 0.57. If there is no home-production sector in the model, the stimulus effects on output resulted from government spending is passed along on market output, entirely. So it explains why government spending multiplier on total output (market output plus home output) is greater when there is no home-production sector.

Also notice market consumption government spending multiplier is -0.16 as $\xi$ is 1; and the market consumption government spending multiplier is -0.12 when $\xi$ is 0.6308. Home consumption government spending multiplier is -0.30, which has the same magnitude with home output government spending multiplier and home labor hour government spending multiplier. The explanation is as following. Production function of home-produced good is a linear function of home labor hours with a constant total factor productivity of home production. In our Matlab code, we set the total factor of productivity of home production to $Ah=1$, which gives rise to steady state home labor hours is identical to steady state of home output. Another assumption in our model is that home-produced consumption must be consumed immediately and cannot be saved for future use. Steady state home consumption, thus, equals steady state home output. These properties result in the fact that home output, home consumption, and home labor hour government spending multipliers are identical, both of those three multipliers are -0.30. Besides, notice the total consumption government spending multiplier is -0.19 as $\xi$ is 0.6308. The total consumption multiplier is smaller in absolute term, -0.16, when $\xi$ equals 1. Recall total consumption is a weighted sum of market consumption and home consumption. The market consumption government spending multiplier is -0.16 in the model without a home production sector, and the multiplier is -0.12 in the model with a home production sector ($\xi=0.6308$). It shows that a dollar increase in government spending crowds out private market consumption by 0.16 dollar in a baseline model without a home production sector. In the model with home-production sector, the crowd out effect on market consumption is smaller (0.12 dollar) because of a dollar increase in government spending multiplier. The intuition is that households’ total consumption is market consumption solely in the model without a home production sector, which implies that the government spending crowds out effect is larger on market consumption than the
crowds out effects on market consumption in a model with a home production sector. Government spending rises up makes households feel poor, therefore, they need to work more in the conventional labor market. Increasing market labor hours reduces home-production hours and home output. Another reason for explaining the decrease in home output as government spending increases is that: a part of the government spending is to provide home-care service or other social benefits programs, which reduces home-production hours.

3.3 Consumption Tax and Labor Multipliers in the New Keynesian Model

Tax multipliers resulted from consumption tax shocks are calculated as: \( \frac{\partial y_m}{\partial TR} = \frac{\partial y_m}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); \( \frac{\partial y_h}{\partial TR} = \frac{\partial y_h}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); \( \frac{\partial y_t}{\partial TR} = \frac{\partial y_t}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); where \( y_m, y_h, y_t \) denote market, home and total output respectively. TR measures tax revenue. \( \tau_c \) denotes consumption tax rate. The ratio of change in market output over the change in tax revenue is defined as tax multiplier. Note that the amount of raised tax revenue is a consequence of the change in consumption tax while other factors are hold constant. Thus, the tax multiplier above measures the market output response to consumption tax changes. Apply the same formula, we obtain consumption and labor output responses to consumption tax change, \( \frac{\partial c_m}{\partial TR} = \frac{\partial c_m}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); \( \frac{\partial c_h}{\partial TR} = \frac{\partial c_h}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); \( \frac{\partial c_t}{\partial TR} = \frac{\partial c_t}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); and \( \frac{\partial n_m}{\partial TR} = \frac{\partial n_m}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); \( \frac{\partial n_h}{\partial TR} = \frac{\partial n_h}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \); \( \frac{\partial n_t}{\partial TR} = \frac{\partial n_t}{\partial \tau_c} \frac{\partial \tau_c}{\partial TR} \). In this experiment, we cut consumption tax rate which results in a decrease in tax revenue. Although cut consumption tax will encourage consumption and result in a positive effect in raising tax revenue, most economists agree that the positive effect resulted from higher consumption is less than the negative effect of lowering tax rate. Therefore, cut consumption tax rate will decline tax revenue in most models. Consumption and output will increase in response to the tax cut incentive. Tax multipliers, therefore, are presented as negative values.

As Table 2 shows, market output tax cut multiplier of consumption tax shock is -1.01, and -1.51 as \( \xi \) has the value of 1 and 0.6308 respectively. Consumption tax cut multiplier has larger effect in a model with a home-production sector. When \( \xi \) is 0.6308, households have
more labor hours to allocate between the conventional labor market and home than when \( \xi \) is 1. This flexibility in shifting labor hours allows larger tax cut multipliers. As consumption tax is appealing enough, the household has a higher consumption increase in response to consumption tax cut, which ultimately leads to a larger market output consumption tax multiplier. Notice market consumption tax cut multiplier of consumption tax shock is -1.01, and -1.51, when \( \xi \) equals 1 and 0.6308 accordingly. Home consumption tax cut multipliers resulted from consumption tax shocks are 0 and 0.38, when \( \xi \) is 1 and 0.6308 respectively. Total consumption tax cut multipliers are -0.47 and -0.25, as \( \xi \) is 1 and 0.6308 accordingly. The response of increase in market consumption to a consumption tax cuts is larger in the model has a home-production sector. As the share of home-production increasing in the model, households have more flexibility of labor hours to respond to a consumption tax shock. Households, in a model with a home sector, have the ability to increase their market consumption in a larger scale than households who only consume market consumption. It engenders a larger tax cut multiplier in the model with a home production sector. On the other hand, total consumption multiplier has a smaller scale in absolute value in the model with a home sector. Since total consumption is expressed as a weighted sum of a market consumption and home consumption. There are contradicting responses of market consumption and home consumption to consumption tax cut. Market consumption rises, whereas home consumption reduces in response to the tax cut. Due to the contradicting responses, tax multiplier of total consumption is smaller in absolute value in the model with a home sector. As for labor hours’ responses to a consumption tax cut, households have a higher of home-production portion ends up with a lager scale of multiplier. Households split their working hours to the market production and home production can make more flexible arrangement with their time in response to consumption tax shocks. Consequently, the rise in labor hours is larger in a model with a home sector. Regarding to responses of total labors to consumption tax cut, we see a smaller multiplier in the model with a home sector. Consumption tax cut reduces home hours since households shift their working hours to market production. Due to the offsetting effect of consumption tax cut on market hours and home hours, total consumption multiplier in the new model is less than the multiplier in the baseline model.
Labor tax multipliers are defined as follows: 

\[
\frac{\partial y_m}{\partial \tau} = \frac{\partial y_m}{\partial TR} \cdot \frac{\partial TR}{\partial \tau}, \quad \frac{\partial y_h}{\partial \tau} = \frac{\partial y_h}{\partial TR} \cdot \frac{\partial TR}{\partial \tau} \quad \text{and} \quad \frac{\partial y_t}{\partial \tau} = \frac{\partial y_t}{\partial TR} \cdot \frac{\partial TR}{\partial \tau},
\]

where \( \tau \) denotes labor tax rate. The first three columns of Table 3 summarize the baseline results of labor tax cut multipliers for output, consumption and labor hours. Market output labor tax cut multiplier is \(-0.47\) when \( \xi = 1 \), and \(-0.69\) when \( \xi = 0.6308 \). Home output labor tax cut multiplier is \( 0.38 \) when \( \xi = 0.6308 \). Total output labor tax cut multipliers are \(-0.47\) and \(-0.30\) in respect to \( \xi = 1 \) and 0.6308. Under the assumptions of labor hours is the only input of production, and home produced goods will be consumed right away, we obtain that market hour labor tax cut multiplier is the same with market output labor tax cut multiplier, home hour labor tax cut multiplier equals home output labor tax cut multiplier, and total hour labor tax cut multiplier equals total output labor tax cut multiplier. For consumption labor tax cut multipliers, notice that market consumption and home consumption labor tax cut multipliers are equal to market output and home output labor tax cut multipliers, under the same specification of \( \xi \). Yet total consumption labor tax cut multiplier is \(-0.25\), which is different from total output labor tax cut multiplier \(-0.47\). Total consumption is a weighted sum of market and home consumption, whereas total output is a linear addition of market and home output. In the baseline experiment, labor tax cuts induce higher labor hours, meaning the substitution effect dominates. People work more in the conventional labor markets in response to a labor tax cut. In the model with a home sector, the tax multiplier is larger than the baseline model since households have more time to allocate between the two markets. The increasing amount of total consumption in response to labor tax cut is smaller in the model has a home sector. The contradicting effects of labor tax on market hours and home hours make the tax multiplier smaller in the new model. Notice the output responses have the same magnitude with labor hours’ responses due to the reasons: labor hour is the only input for production; same linear functional form of production functions between the two markets. The discussion of consumption responses to labor tax cut is as following. Labor tax cuts cause more labor supply in the conventional labor markets, which ultimately gives rise to higher market production and consumption. Households with a larger portion of home-production sector are more responsive to labor tax cuts, and thus increase their market
consumption in a larger scale. For analyzing multipliers of total consumption, we need to see different consumption responses to labor tax cut. Home consumption dwindles when a labor tax cut peps up market consumption. The total consumption in response to a labor tax cut is smaller in the model with a home sector due to the offsetting effect of labor tax resulted in market and home consumption.

3.4 New Keynesian Model Vs. RBC Model

In this section, we will compare the government spending multipliers and tax multipliers between New Keynesian model and RBC model. The strategy of generating a RBC model is to turn off the price stickiness and wage stickiness section. In RBC model, firms have no monopolistic power. Table 4 to 6 presents the government spending, consumption, and labor tax multipliers generated from a RBC model.

Market output government spending multiplier in RBC model is 0.71 in both versions with and without home-production sector, which are smaller than the same multiplier of 0.83 or 0.87 in New Keynesian model.

In addition, consumption tax and labor tax multipliers in RBC model have different scales when compare with the multipliers calculated in New Keynesian model. The comparison between Table 2 and Table 4 shows that consumption tax cut multipliers are generally larger in New Keynesian model. For example, when $\xi$ equals 1, the absolute value of market output consumption tax cut multiplier in the New Keynesian model is 1.01 which is larger than the absolute value of the same multiplier 0.82 in the RBC model. When $\xi$ is 0.6308, the market output consumption tax cut multiplier is 1.51 in absolute value. In RBC model, the absolute value of the same multiplier is 1.22. By comparing Table 3 and Table 6, we can see that labor tax multipliers are generally smaller in New Keynesian model. For instance, the market output labor tax cut multiplier in the New Keynesian model has absolute value of 0.47 when $\xi$ is 1. The corresponding multiplier in the RBC has absolute value 0.87.

3.5 Multipliers in the Literature

This sections compare the values of multipliers generated in this research with other studies. As Table 7 shows, we compute the labor tax multiplier under the fiscal exercise which excludes distortionary taxes shocks. Labor tax multiplier on market output is -0.44. It means
that one dollar decrease in tax revenue followed by a cut in labor tax will increase market output by 0.44 dollar. The values of the tax multipliers calculated within our model settle within a sensible range by comparing with literatures. Mertens and Ravn (2011, 2012, 2014) find the tax multiplier should be within the range of -0.4 to -1.5. Uhlig and Draugtzbarg (2011) find long run and short run tax multipliers are between -0.5 to 1. Romer and Romer (2009) find that tax multipliers should be between -2.5 and -3, meaning that 1 dollar cut in taxes leads to 2.5 to 3 dollars increase in output. Their computation of tax multipliers are actually larger than most of the other studies in the related literature. Favero and Giazazzi (2012) reconcile the conflict of estimates between Romers’ and other literature. They measure the tax multiplier estimated by the narrative method in a VAR model, and find the tax multiplier is about -1.

The government spending multiplier calculated in this model is also compatible with the literature. As Table 8 shows below, the government spending multiplier on market output is 0.80 in the New Keynesian model without home-production sector, and the multiplier is 0.83 if there is a home-production sector. Valerie Ramey (2011) calculates the government defense spending multiplier within a range from 0.8 to 1.2. And Barro and Redlick (2011) find the same multiplier is between 0.4-0.6. The estimates of multipliers mentioned above are mostly calculated by time-series macroeconomic models. It is not the goal of this paper to calculate an accurate range of taxes and government spending multipliers. Calculation of those multipliers is extremely difficult since researchers can hardly figure out the counterfactuals, what the economy would behave without the influence of fiscal stimulus packages. Hence, it is difficult to compare the current economy which affected by fiscal policies with the counterfactuals that needed for estimating the multipliers. Another reason contributes to the wide range of multipliers is the sample period. With varied sample periods, the estimation of multipliers’ range can spread apart widely.

4. Extensions

The robustness check is applied to our baseline results. I want to run three fiscal experiments: (a) eliminate the response of distortionary consumption and labor taxes to debt; (b) eliminate lump-sum tax debt response; (c) eliminate lump-sum and distortionary
consumption tax response to debt. The impulse responses resulted from the three experiments help us compare the different behaviors of the concerned economic variables. In experiment (a), where $\gamma_T^B = 0.1$ and $\gamma_n^B = \gamma_c^B = 0$, only lump-sum taxes respond to debt. It fits the canonical assumption of Ricardian equivalence: Households’ consumption decisions are not affected by the government’s financing method. Government debt is irrelevant in households’ decision-making process since forward-looking households anticipate the lump-sum tax levied by government and take it into account of their consumption decision. In experiment (b), $\gamma_n^B = \gamma_c^B = 0.2$ and $\gamma_T^B = 0$. I eliminate the debt response of lump-sum tax and allow distortionary consumption and labor taxes respond to debt. The distortionary taxes will affect households’ through changing the relative prices of consumption goods and wage level. For experiment (c), I set $\gamma_n^B = 0$ and “close off” both lump-sum tax and consumption tax (i.e. $\gamma_T^B = \gamma_c^B = 0$), focusing on the effect of labor tax on output, consumption, and labor hours.

Notice in Table 1, market output government spending becomes gradually smaller as the movement from baseline experiment (a) to experiment (b) and experiment (c). Column (3) to (5) display the government spending multipliers across the three fiscal exercises. When $\xi$ is 1, the market output government spending multiplier is 0.83 in experiment (a), as $\gamma_n^B = \gamma_c^B = 0$ and $\gamma_T^B = 0.1$. As in experiment (b), I set $\gamma_n^B = \gamma_c^B = 0.2$ and $\gamma_T^B = 0$, market output government spending multiplier becomes 0.83. In experiment (c), $\gamma_T^B = \gamma_c^B = 0$ and $\gamma_n^B = 0.2$, market output government spending multiplier is 0.78. In the model with a home production sector, we observe the corresponding multiplier descends in the following order: 0.87, 0.83, 0.81, as running the experiment from (a) to (c).

In Table 2, we can compare the baseline consumption tax cut multiplier with multipliers generated from other experiment (b) and (c). In the model with a home-production sector ($\xi = 0.6308$), the baseline value of market output consumption tax cut multiplier is -1.51, which has larger absolute than the corresponding multipliers in experiment (b) -1.42, and experiment (c) -1.39. Consumption and labor hour consumption tax cut multipliers have the same magnitude with corresponding output consumption tax cut multipliers. Table 3 displays the labor tax multipliers of output, consumption and labor hours in the New Keynesian model. Labor tax multipliers become smaller under the fiscal exercises which
eliminate lump-sum taxes shocks. When $\xi$ is 1, the labor tax multiplier of market output has absolute value of 0.47 in experiment (a). And the absolute values of tax multipliers become 0.44 and 0.42 respectively in experiment (b) and (c). Labor tax multipliers of consumption and labor hour share same magnitude with corresponding output labor tax cut multipliers. The analysis for larger magnitude of multiplier in the baseline model is in the following. In experiment (a), only lump-sum tax is financed by raising debt. By Ricardian equivalence, the government debt will not distort households’ long-run consumption path. In experiment (b) and (c), the distortionary labor and consumption taxes change households’ consumption decision. The distortionary labor and consumption taxes appear in several equilibrium conditions in our model, which will affect households’ long-run consumption behavior. Governments raise tax revenue through distortionary taxes creates contractionary effects on the economy. Figure 1.1 to Figure 4.3 plot the output, consumption, and labor hours responses to government spending, and tax shocks.

Next, we want to see how wage stickiness affects the impulse responses function. In experiment (d), we set parameter of wage stickiness to $\phi_p =0.9$ and compare the impulse responses functions with the baseline parameterization when $\phi_p =0.5$. Government spending multiplier and consumption tax cut multiplier have larger magnitude when facing a more sticky wage level. Market output government spending multiplier is 0.87 when $\phi_p =0.5$, and the multiplier becomes 1.07 when $\phi_p =0.9$. As price stickiness increases, government spending multiplier and consumption tax cut multiplier also increase. Yet labor tax cut multiplier decreases in absolute value as price stickiness increases. Another important implication for the New Keynesian model is that wage stickiness will amplify output responses to market productivity shock. If the distortion of the economy only comes households’ bargaining on labor market, wage markup is the only source of economic distortion. Since households face constraint to adjust their their nominal wage, positive market productivity shock pushes up wage level and creates a discrepancy between wage and marginal product of labor. The wage markup is below the equilibrium value under the assumption of wage stickiness. A lower wage markup means less distortion in the economy, and thus market output response to market productivity shock is larger when there is only wage stickiness in the model. Figure 4.4 plots the impulse response of market output to productivity shock under different wage stickiness and price stickiness. When
there only exists wage stickiness ($\phi_p = 0$), the impulse response of market output is larger than the impulse response when the model has both wage and price stickiness ($\phi_p = 0.5$).

5 Conclusion and Future Extension

This paper provides evidence of macroeconomic implications of a home production sector. Households spend a significant amount of time for home production. We find amplified fiscal multipliers in market output, consumption and labor hours in the New Keynesian model with a home production sector. Fiscal multipliers in home output, consumption, and labor hours have reversed sign. Consequently, we find fiscal multipliers in total output, consumption, and labor hours have smaller absolute value in the model with a home production sector. In addition to the presence of a home production, the New Keynesian has more expansionary multipliers also because of the existence of wage stickiness.

Future research could investigate the role of anticipation in evaluating the fiscal multipliers within a household production model. Young (2005), Mertens and Ravn (2010), House and Shapiro (2005) study how people’s anticipation on the advent of tax cut may actually cause contractionary output response to tax cut. One may examine the role of anticipation and the home production in predicting output response to fiscal policies.
6 References


Table 1: Comparisons of Government Spending Multiplier across Experiments in NK Model

<table>
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<tr>
<th>Variables</th>
<th>$\xi$</th>
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Note: The multipliers measure the change in output, consumption, and hours caused by the change in government spending. Baseline experiment (a) eliminates the debt response of distortionary consumption and labor taxes. Extension (b) eliminates the debt response of lump-sum tax. Extension (c) eliminates the debt response of both lump-sum and consumption tax.
Table 2: Comparisons of Consumption Tax Multipliers across Experiments in NK Model

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<th>Variables</th>
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### Table 3: Comparisons of Labor Tax Multipliers across Experiments in NK Model

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Table 4: Comparisons of Government Spending Multiplier across Experiments in RBC

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Note: The multipliers measure the change in output, consumption, and hours caused by the change in government spending. Baseline experiment (a) eliminates the debt response of distortionary consumption and labor taxes. Extension (b) eliminates the debt response of lump-sum tax. Extension (c) eliminates the debt response of both lump-sum and consumption tax.
### Table 5: Comparisons of Consumption Tax Multipliers across Experiments in RBC Model

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Table 6: Comparisons of Labor Tax Multipliers across Experiments in RBC Model

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<th>(a) $\gamma_T^{B} = .1$</th>
<th>(b) $\gamma_C^{B} = \gamma_n^{B} = .2$</th>
<th>(c) $\gamma_n^{B} = .2$</th>
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</table>

Note: The multipliers measure the change in output, consumption, and hours caused by the change in government spending. Baseline experiment (a) eliminates the debt response of distortionary consumption and labor taxes. Extension (b) eliminates the debt response of lump-sum tax. Extension (c) eliminates the debt response of both lump-sum and consumption tax.
Table 7: Labor Tax Multipliers to Output under Extension Only with Lump-sum Tax

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Multipliers</th>
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<tbody>
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<td>ξ</td>
<td>Market Output</td>
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<td>0.6308</td>
<td>-0.62</td>
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</table>

Note: The multipliers are interpreted as dollar changes in market output caused by one dollar change in tax revenue followed a cut in labor tax rate.

Table 8: Government Spending Multipliers to Output under Extension Only with Lump-sum Tax

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Multipliers</th>
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</thead>
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<td>ξ</td>
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<tr>
<td>0.6308</td>
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</table>

Note: The multipliers are interpreted as dollar changes in output caused by one dollar change in government spending.

Table 9: Hours per Week in Home Work and Market Work Over Time

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<td>Market hours</td>
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<td>32.13</td>
<td>32.13</td>
<td>34.02</td>
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<td>20.30</td>
<td>20.64</td>
<td>17.94</td>
<td>18.00</td>
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<tr>
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<td>1712</td>
<td>3283</td>
<td>5465</td>
<td>15244</td>
</tr>
<tr>
<td>Men</td>
<td>840</td>
<td>776</td>
<td>1465</td>
<td>2533</td>
<td>6752</td>
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<tr>
<td>Women</td>
<td>1022</td>
<td>936</td>
<td>1818</td>
<td>2932</td>
<td>8492</td>
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</tbody>
</table>

Figure 1.1: Government Spending Impulse Responses in the New Keynesian Model under (a)
Figure 1.2: Government Spending Impulse Responses in the New Keynesian Model under (b)
Figure 1.3: Government Spending Impulse Responses in the New Keynesian Model under (c)
Figure 2.1: Consumption Tax Impulse Responses in the New Keynesian Model under

(a)
Figure 2.2: Consumption Tax Impulse Responses in New Keynesian Model under (b)
Figure 2.3: Consumption Tax Impulse Responses in the New Keynesian Model under (c)
Figure 3.1: Labor Tax Impulse Responses in the New Keynesian Model under (a)
Figure 3.2: Labor Tax Impulse Responses in the New Keynesian Model under (b)
Figure 3.3: Labor Tax Multipliers in the New Keynesian Model under (c)
Figure 4.1: Government Spending Multipliers in RBC model under (a)
Figure 4.2: Government Spending Multipliers in RBC model under (b)
Figure 4.3: Government Spending Multipliers in RBC model under (c)
Figure 4.4: Market Output Impulse Response to Market Productivity Shock under the New Keynesian Model

![Graph showing the impulse response function (IRF) of market output to productivity shock under the New Keynesian Model. The graph plots the market productivity response against time periods, with a declining trend line indicating the decrease in response over time.]