MSc Economics

Fiscal Policy in the Presence of an Illiquid Asset and Household Heterogeneity

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Michael Reiter

Zoltán Rácz

1527530

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INSTITUT FÜR HÖHERE STUDIEN
INSTITUTE FOR ADVANCED STUDIES
Vienna

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26 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Abstract

The effect of fiscal policy greatly depends on how households react to different income shocks. In this paper, utilizing the model of Violante et al. (2015), I investigate the effects of several fiscal policy measures in the presence of heterogeneity among households who save in two kinds of assets, including an illiquid asset subject to adjustment costs.

1 Introduction

Will households spend the received money or keep it? This is the main question of any policy maker, who wants to affect consumption and therefore economic activity with fiscal policy measures.

The size of the fiscal multiplier - by how much output changes in response to a fiscal policy shock of 1% of GDP - is still a highly debated issue in both the empirical and the theoretical literature. The main reason for the lack of consensus is the huge variety of ways to measure fiscal policy changes and the many different methods to deal with endogeneity. An important overview of results on the spending multiplier is by Ramey (2011) who found that the US multiplier of temporary, deficit financed government spending shocks is probably between 0.8 and 1.5, but nothing between 0.5 and 2 can be rejected. Based on new results using narrative measures (e.g. Romer and Romer (2010) and Leigh et al. (2011)) the multiplier of tax changes is significantly higher, close to 3. A very interesting observation is by Jorda and Taylor (2013) who showed using three different models that the fiscal multiplier is much larger (by two percentage points) during recession than in boom times.

In theoretical models the effect of fiscal policy is generally much smaller, as in the most widespread New Keynesian dynamic stochastic general equilibrium models the path of consumption is determined by the consumption smoothing feature of these models. A short term change in income is spread over the horizon changing the whole path of consumption, but causing little change in contemporaneous consumption. However, not only income effects, but also the possible substitution effects of fiscal policy are substantially mitigated in these models. A monetary authority acting according to a Taylor rule can largely diminish changes in real interest rates by setting nominal rates.

It follows that one can hope for larger fiscal multipliers only if the intertemporal smoothing mechanism is hindered in some way, or the path of real interest rate is not kept nearly constant by the monetary authority. During the recent crisis, many economists have argued that expansionary fiscal policy should be used to encourage economic growth, as monetary policy is useless due to the zero lower bound, which makes fiscal policy more effective. For example, Eggertsson (2009) in his New Keynesian DSGE found a multiplier of 2.27 at zero lower bound as opposed to 0.32 in normal times. However, to explain the size of fiscal multipliers in normal times, something else is needed.

A possible solution would be to follow Campbell and Mankiw (1989): to assume that a certain fraction of households cannot enter the asset market, therefore they do not save at all but simply consume their whole contemporaneous income at each period. This setup, however has at least two drawbacks. First, not having capital incomes, hand-to-mouth households must have smaller income, therefore smaller consumption, which is empirically not obvious. Second, this model does not explain why hand-to-mouth households exist in the economy.

An interesting approach is by Violante et al. (2015). They build an economy with heterogeneous households facing idiosyncratic labor productivity shock. Households can save in a liquid and an illiquid asset, which includes real assets and productive capital. They assume that changing the level of the illiquid asset involves adjustment costs as making good deals at the real estate or stock market needs great effort or the services of financial intermediaries. In the steady state distribution rich quasi-hand-to-mouth consumers emerge: households that have large income from owning illiquid assets, but holding little amount of liquid asset might act as hand-to-mouth consumers, if they are reluctant to change their level of illiquid assets due to the adjustment costs. In this setup, they show that the transmission mechanism of monetary policy is completely different than usual: instead of the direct intertemporal substitution mechanism monetary policy dominantly affects the economy through indirect income effects.

In this paper I am attempting to use the above model to investigate the effects of different fiscal policy measures. This is an interesting challenge for two reasons: the presence of the illiquid asset destroys Ricardian equivalence, which gives an importance to fiscal policy. Second, the emergence of rich quasi-hand-to-mouth consumers might significantly alter the usual dynamics of savings and consumption to an income shock.

2 The Model

In this section I introduce the model, almost exactly following Violante et al. (2015). Some important differences are listed below:

- As I use a toolkit developed for discrete time models, I convert the model from continuous to discrete time.
- I completely leave out housing from the model.
- Due to computational difficulties there are only two possible levels of the illiquid asset instead of a continuum. This also means that I do not need the sophisticated adjustment cost function from the original one, it is replaced by one having only one parameter.
- I do not try to match the endogenous steady state distribution to data, so I replace the original labor productivity process with a simpler one.

The model consists of the following elements:

1. A continuum of households subject to idiosyncratic productivity shocks solving a utility maximization problem
2. A production sector identical to standard New Keynesian DSGE models
3. A competitive investment fund sector connecting household savings and productive capital
4. A monetary authority setting the nominal interest rate according to a Taylor rule
5. A government financing debt and government spending with distortive taxes.

The model is in discrete time, one period corresponds to one quarter.

2.1 Households

The economy is inhabited by a continuum of households who solve an infinite horizon utility maximization problem subject to budget constraints corresponding to each period. Households are indexed with $i \in [0, 1]$, periods are indexed with $t = 0, 1, \ldots, \infty$. The households are subject to idiosyncratic productivity shocks (z_{it}), which follow a Markov process. Households can save into two kinds of assets: a liquid asset (amount held by i in the beginning of period t is denoted by b_{it}) and an illiquid asset (a_{it}). Changing the amount of illiquid asset involves an adjustment cost equals $\chi|a_{i,t+1} - a_{i,t}|$. Hence the state of a household is given by the triple (z_{it}, a_{it}, b_{it}). Similarly, as in this model there is no aggregate uncertainty, when there are no fiscal policy shocks the state of the economy is completely characterized by the joint distribution $\mu_t(z, a, b)$.

Instantaneous utility is given by consumption (c_{it}), hours worked (l_{it}) and the exogenous labor productivity. As usual, to ensure inner solutions the utility function is assumed to be strictly increasing and strictly concave in c and strictly decreasing and strictly convex in l. Preferences are time separable and households discount the future by factor $0 < \beta < 1$.

The liquid asset is government bond, while the illiquid asset consists of shares in investment funds. Owners of investment fund shares obtain interest income and profit for the capital and firms own by the investment fund.

Household income consists of labor income, government transfers (T_t) and interest income (at rates r_t^a and r_t^b) and it is used to finance consumption and changes of asset levels. Labor income and interest income on the illiquid asset are subject to income taxes, consumption to sales tax. Holding a negative amount of illiquid asset is not possible. Households can hold negative liquid assets until a threshold $-\underline{b}$, however they pay an interest increased by a margin κ. To simplify notation, we write

$$r_{it}^b(b_{it}) = \begin{cases} r_t^b & \text{if} \quad b_{it} \geq 0 \\ r_t^b + \kappa & \text{if} \quad b_{it} < 0 \end{cases}$$

Households take the path of productivity, government transfers, taxes, rates on the two assets and real wages (w_t) given and solve their utility maximization problem in $\left\{(a_{it}, b_{it}, c_{it}, l_{it})_{t=0}^{\infty}\right\}$ subject to the budget constraints.

$$\max \quad \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_{it}, l_{it}, z_{it}) \right]$$

$$\begin{aligned} a_{it} + b_{it} =& (1 + r_{it}^b(b_{i,t-1}))b_{i,t-1} + (1 + r_t^a(1 - \tau_t^a))a_{i,t-1} + (1 - \tau_t^l)w_t z_{it} l_{it} + T_t \\ & - \chi|a_{it} - a_{i,t-1}| - (1 + \tau_t^c)c_{it} \end{aligned}$$

$$b_{it} \geq -\underline{b}$$

$$a_{it} \geq 0$$

Correspondingly, the households' optimization problem can also be described by the following Bellman-equation in steady state:

$$V(a_{t-1}, b_{t-1}, z_t) = \max_{c,l,a_t} \Big(u(c,l,z_t) + \mathbb{E}\big[V(a_t, b_t, z_{t+1} \mid z_t)\big] \Big)$$

$$\begin{aligned} b_t =& (1 + r_t^b(b_{t-1}))b_{t-1} + (1 + r^a(1 - \tau^a))a_{t-1} + (1 - \tau^l)wz_t l + T \\ & - \chi|a_t - a_{t-1}| - (1 + \tau^c)c - a_t \\ b_{it} \geq& - \underline{b} \\ a_{it} \geq& 0 \end{aligned}$$

Next, we solve the households' intratemporal consumption problem. For simplicity we assume the following utility function:

$$u(c,l,z) = \log \Big(c - v(l,z) \Big)$$

where v is disutility from labor given by:

$$v(l,z) = \psi z \frac{l^{1+\frac{1}{\varphi}}}{1 + \frac{1}{\varphi}}$$

In an optimal solution it must be true that the pair (c_{it}, l_{it}) maximizes contemporaneous utility for all t given the path of the state variables. By solving the households' intratemporal consumption problem we find that the solution is characterized by the following MRS condition:

$$w \frac{(1 - \tau^l)}{(1 + \tau^c)} = \psi l^{\frac{1}{\varphi}} \tag{1}$$

The above equation means that labor supply is independent from individual productivity and depends only on global variables:

$$l = \left(\frac{w(1 - \tau^l)}{\psi(1 + \tau^c)} \right)^{\varphi}$$

Optimal consumption is then determined by the path of state variables and the optimal labor choice.

2.1.1 Parametrization

As with the construction of the model, I very closely follow Violante et al. (2015) with the calibration strategy as well. The few differences will particularly be emphasized. The elasticity of labor supply to real wage is set to $\varphi = 0.5$. The disutility parameter of labor (ψ) will be calibrated such that in steady state labor supply equals $1/3$. Interest rate wedge κ is 6.4% annually.

I use a completely different (z_{it}) income process from Violante et al. (2015) for two reasons. First, they assume that income shocks follow a Poisson process, which does not have an obvious counterpart in a discrete time model. Second, I do not attempt to get a completely realistic distribution of asset holdings endogenously, therefore I do not need a sophisticated income process like the one used in Violante et al. (2015) (with six parameters). Instead, I borrow the parametrization from the paper by Chang and Kim (2007), in which - similarly to this thesis - a quarter based discrete time model is used with heterogeneous agents facing idiosyncratic income shocks. The income process evolves according to

$$z_{it} = \exp(\tilde{z}_{it}) \qquad \text{with} \qquad \tilde{z}_{it} = \rho \tilde{z}_{i,t-1} + \xi_t \qquad \xi_t \sim \mathcal{N}(0, \sigma),$$

where $\rho = 0.929$ and $\sigma = 0.227$. In computations the discretized approximation of the ergodic distribution is used with 9 states.

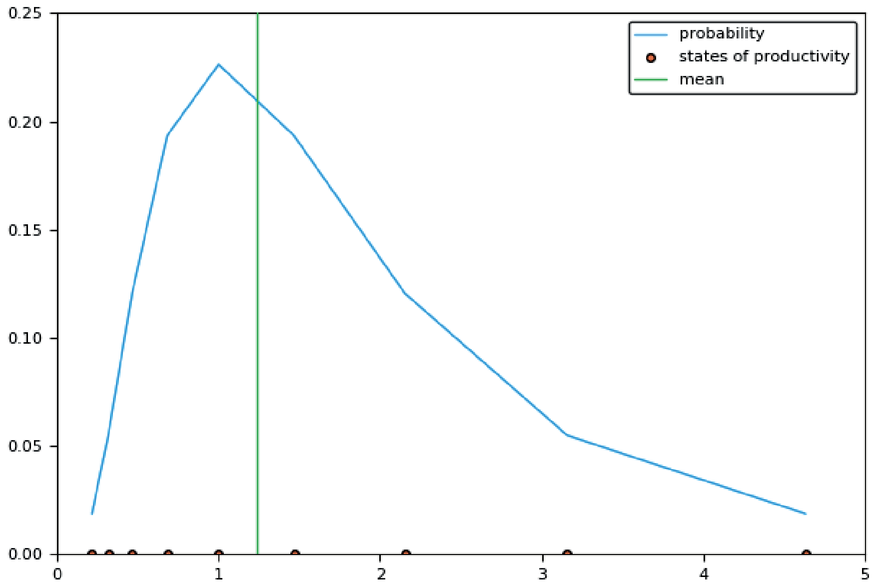

Figure 1: The discretized productivity distribution

Due to computational difficulties, the asset choice problem of the households is simplified in the following way. There are two possible levels of a_{it}: either 0 or $\bar{a}$. As the aggregate amount of illiquid asset must match the amount of capital, $\bar{a}$ determines the fraction of households holding illiquid asset in steady state. I chose $\bar{a} = 12$ solely on the basis that it leads to a numerically stable solution (it implies that 71% of the households owns illiquid asset in steady state). Similarly, χ is chosen to be 0.1 mainly for computational reasons. However, it is also close to the relative cost of median transaction sizes in Violante et al. (2015).

Parameter β will be set in the steady state section.

2.2 Production

The production side of the model follows the standard New Keynesian models, except that instead of the more widespread Calvo and Taylor staggered price models Rotemberg pricing is applied. There is a continuum of intermediate goods (indexed with j), which are produced in monopolistic competition where the firms are subject to price adjustment costs. The intermediate goods are aggregated by the competitive final good sector into the final good with the Dixit-Stiglitz aggregator (see Dixit and Stiglitz (1977)).

2.2.1 Final good sector

The representative final good producer takes the price of the intermediate goods and the final good given and maximizes its profit:

$$\max_{y_{jt} \text{ for } j\in(0,1)} P_t Y_t - \int_0^1 p_{jt} y_{jt} \, \mathrm{d}j$$

$$\text{s. t.} \quad Y_t = \left(\int_0^1 y_{jt}^{\frac{\epsilon-1}{\epsilon}} \, \mathrm{d}j \right)^{\frac{\epsilon}{\epsilon-1}}$$

From the first order condition we obtain the demand function for intermediate goods

$$y_{jt} = \left(\frac{p_{jt}}{P_t} \right)^{-\epsilon} Y_t$$

and after substituting in the optimal demands from the zero profit condition we get that the price of the final good must be a sort of mean of the prices of the intermediate goods:

$$P_t = \left(\int_0^1 p_{jt}^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}$$

2.2.2 Intermediate good sector

Each firm j produces its individual intermediate good from capital and labor according to the following production function:

$$y_{jt} = F(k_{jt}, n_{jt}) = Z k_{jt}^{\alpha} n_{jt}^{1-\alpha}$$

Capital is rented at rate r_t^k from a competitive capital rental market, labor is hired at wage w_t in a competitive labor market. By solving the cost minimization problem we can calculate how factor prices are connected to the intermediate producers' real marginal cost:

$$m_{jt}\frac{\partial F(k_{jt},n_{jt})}{\partial k}=r_t^k \quad \text{and} \quad m_{jt}\frac{\partial F(k_{jt},n_{jt})}{\partial n}=w_t$$

For simplicity, price adjustment costs are as in Rotemberg (1982). Cost of price changing is a quadratic function of the price change and it is expressed in real terms, as a fraction of total output:

$$\Theta_t(p_{jt},p_{j,t-1})=\frac{\theta}{2}\Big(\frac{p_{jt}-p_{j,t-1}}{p_{j,t-1}}\Big)^2 Y_t$$

where $\theta > 0$ is a parameter for price stickiness. The intermediate good producers are maximizing the discounted sum of future real profits (that is, profit is expressed in terms of the final good). We assume that they discount future profits with the rate of return on illiquid asset (r^a), as firms are owned by investment funds (described in the next section) and their cost of raising capital is r^a. The intermediate producers therefore solve the following optimization problem:

$$\max_{(p_{jt})_{t=0}^{\infty}}\sum_{t=0}^{\infty}\Big(\prod_{s=0}^{t}\frac{1}{1+r_s^a}\Big)\left[\Big(\frac{p_{jt}}{P_t}-m_{jt}\Big)\Big(\frac{p_{jt}}{P_t}\Big)^{-\epsilon}Y_t-\Theta_t(p_{jt},p_{j,t-1})\right]$$

The first order condition is the following:

$$\begin{aligned}0=&\frac{1}{P_t}\Big(\frac{p_{jt}}{P_t}\Big)^{-\epsilon}Y_t-\epsilon\Big(\frac{p_{jt}}{P_t}-m_{jt}\Big)\Big(\frac{p_{jt}}{P_t}\Big)^{-\epsilon-1}\frac{1}{P_t}Y_t\\&-\theta\Big(\frac{p_{jt}-p_{j,t-1}}{p_{j,t-1}}\Big)\frac{1}{p_{j,t-1}}Y_t+\frac{\theta}{1+r_{t+1}^a}\Big(\frac{p_{j,t+1}-p_{jt}}{p_{jt}}\Big)\frac{p_{j,t+1}}{p_{jt}^2}Y_{t+1}\end{aligned}$$

Assuming that the initial price level is the same for all firms, the intermediate good producers solve the same optimization problem at each period. Therefore $p_{jt}=P_t$ for all t. By including this information in the first order condition and reorganizing we obtain the equation describing the dynamics of inflation:

$$\epsilon\big(1-m_t\big)=1-\theta\big(1+\pi_t\big)\pi_t+\frac{\theta}{1+r_{t+1}^a}\big(1+\pi_{t+1}\big)\pi_{t+1}\frac{Y_{t+1}}{Y_t} \tag{2}$$

Having the same prices all intermediate good producers face the same demand, hence $y_{jt}=Y_t$ for all j, which also means that the demand for the capital and labor must also be the same for firms. As the Cobb-Douglas production function can be aggregated, we obtain

$$Y_t = Zk_t^{\alpha} n_t^{1-\alpha}$$

with $k_t = k_{jt}$ and $n_t = n_{jt}$ for all j.

2.2.3 Parametrization

The elasticity of substitution of intermediate goods is set to $\epsilon = 10$, which implies a steady state value of $m = 9/10$, therefore a profit share of 10%. The weight on capital in the intermediate good producers' production function is $\alpha = 1/3$, so the capital and labor shares are 30% and 60%, respectively. From equation (2) one can derive the New Keynesian Phillips curve with a slope of ϵ/θ. Assuming a slope of 0.1, which is standard according to Schorfheide (2008) results $\theta = 100$. Z is to be calibrated during the solution for the steady state.

2.3 Investment fund sector

As the profit of intermediate good producers is positive in this model, it is necessary to settle how profit income is distributed to households. It is assumed that all capital is owned by a competitive investment fund sector and profit incomes are proportional to the capital owned. Utilization rate of capital is flexible, however higher utilization entails faster depreciation. The representative investment fund decides about the amount of capital held, investment and utilization rate. To finance its activity, it issues an asset that the households hold as illiquid asset. It follows that future profits are discounted with r^a. Therefore the representative investment fund solves the following profit maximization problem:

$$\max_{(K_t,u_t,I_t)_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty} \left(\prod_{s=0}^{t} \frac{1}{1+r_s^a} \right) \left[r_t^k u_t K_{t-1} + q_t K_{t-1} - I_t + A_t - A_{t-1} - r_t^a A_{t-1} \right]$$

$$\text{s.t.} \quad K_t = K_{t-1} - \delta(u_t) K_{t-1} + I_t$$

where q_t denotes profit net price adjustment cost per unit of capital that is

$$q_t = \frac{\left(1-m_t\right) Y_t - \theta \pi_t^2 Y_t / 2}{K_{t-1}}.$$

The first order conditions imply optimal utilization of capital

$$r_t^k = \delta'(u_t) \tag{3}$$

and also an equilibrium condition on r^a:

$$r_t^a = r_t^k u_t - \delta(u_t) + q_t$$

Using the latter condition and assuming $A_t = K_t$ in every period we get that the investment fund has zero profit, therefore all the capital income is payed to the households in form of the interest rate r^a.

2.3.1 Parametrization

Depreciation function δ has the following form:

$$\delta(u_t) = \bar{\delta} + \frac{r_{stst}^k}{\gamma}\left(u_t^\gamma - 1\right)$$

As $\delta'(u_t) = r_{stst}^k u_t^{\gamma-1}$ from equation (3) it follows that in steady state utilization is 1 and depreciation equals $\bar{\delta}$. As in Violante et al. (2015), $\bar{\delta}$ is set such that annual steady state depreciation would be 10% and the elasticity parameter is set to $\gamma = 1.2$. Therefore depreciation is increasing and convex in the utilization rate.

2.4 Monetary authority

The monetary policy maker sets the nominal rate on government bonds according to a standard Taylor rule

$$i_t = \bar{r}^b + \phi^m \pi_t + sh_t^m$$

where ϵ_t is to interpreted as an unexpected shock in monetary policy. From the nominal rate and inflation the real rate on government bonds is calculated with the Fisher equation:

$$1 + i_t = (1 + r_t^b)(1 + \pi_t).$$

2.4.1 Parametrization

Steady state nominal rate is set to 2.5% annually, the Taylor coefficient is 1.25.

2.5 Government

The government finances transfers to the households (T_t) and government spending (G_t) by collecting distortive taxes (Tax_t) and issuing debt (B_t). The governments actions must satisfy the budget constraint

$$B_t + Tax_t = (1 + r_t^b)B_{t-1} + G_t + T_t$$

where total tax income is given by

$$Tax_t = \int c_{it}\tau_c + a_{it}r_t^a\tau_a + z_{it}w_t l_{it}\tau_l \ \mathrm{d}\mu_t$$

2.5.1 Parametrization

Steady state government transfer and labor tax rate is set as in Violante et al. (2015): T_{stst} is 7.5% of steady state output, $\tau_{stst}^l = 25\%$. As in the US capital gains are subject to the same income taxes as labor, τ_{stst}^a is also 25%. Steady state sales tax rate is set to equal 8.5%, an average of sales tax rates in US states.

As the main side of this paper is to examine responses to different fiscal policy shocks, it is essential that fiscal policy variables should be able to move independently. Hence, outside of the steady state B needs to keep the government budget balanced. In equilibrium r^b will always adjust such that supply and demand for government debt equals.

2.6 Equilibrium

An equilibrium of this economy is given as a path of prices $(w_t, r_t^k, r_t^b, r_t^a)$, government policy variables $(\tau_t^a, \tau_t^c, \tau_t^l, T_t, G_t, B_t, sh_t^m)$, productivity shocks (z_{it}), household decision variables $(c_{it}, l_{it}, a_{it}, b_{it})$, production and investment fund sector variables $(Y_t, K_t, N_t, m_t, \pi_t, I_t, u_t)$ and nominal rate i_t such that

i) households, final good producers, intermediate good producers and investment funds solve their constrained optimization problem taking prices given,

ii) the government budget constraint holds,

iii) the Taylor rule and the Fisher equation holds for each period,

iv) total holding of the liquid asset equals government debt

$$B_t = \int b_{it} \, \mathrm{d}\mu_t,$$

v) household saving in illiquid asset equals total capital

$$K_t = A_t = \int a_{it} \, \mathrm{d}\mu_t,$$

vi) labor market clears

$$N_t = \int z_{it} l_t \, \mathrm{d}\mu_t,$$

vii) and the good market clears

$$Y_t = C_t + C_t^f + G_t + I_t + \Theta_t$$

with $Y_t = Z\big(u_t K_t\big)^\alpha N_t^{1-\alpha}$. Θ_t represents the waste from price adjustment cost, while C_t^f stands for consumption of financial services including adjustment costs of illiquid asset and the interest rate wedge payed by households indebted in the liquid asset:

$$C_t^f = \int \chi |a_{i,t+1} - a_{it}| \, \mathrm{d}\mu_t + \int \kappa \max\{0, -b_{it}\} \, \mathrm{d}\mu_t.$$

3 Calibration and Finding the Steady State

Utilizing the fact that there is still a number of free parameters, we set the values of the following variables:

- Labor supply l_{stst} is normalized to $1/3$.
- Following Violante et al. (2015) the amount of capital is set to match US data: we are looking for a steady state, in which productive capital equals 2.13 times annual output.
- Y_{stst} is normalized to 1. It follows that $K_{stst} = 4 \cdot 2.13$.

The labor productivity process of the households is completely exogenous, therefore its ergodic distribution can be found (it is approximated by discrete distribution ν on 9 states). Knowing its expected value we can calculate aggregate labor by the formula:

$$N_{stst} = \int \frac{1}{3} z \ \mathrm{d}\nu(z)$$

As we already know, steady state utilization rate is 1, now parameter Z can be calculated from $Y_{stst} = Z\big(u_{stst}K_{stst}\big)^{\alpha} N_{stst}^{1-\alpha}$. We are solving for a zero inflation steady state, so at this point we can easily calculate steady state $m, w, r^k, \delta, q, r^a, i, r^b$. After getting w, ψ is calibrated such that $l = 1/3$ satisfies the labor supply equation.

At this point the steady state values are known for all the variables that households take as given when making their decision. The households' problem is solved with the Hetsol toolkit by Michael Reiter based on Reiter (2009). The remaining parameter (β) is calibrated such that total amount of illiquid asset matches capital.

Solving the households' problem results in the steady state distribution of states among households. Therefore the government's tax income can be calculated and G is determined by the government's budget constraint as a residual.

4 Understanding the steady state

4.1 The steady state distribution

I summed the steady state distribution $\mu(a, b, z)$ over the last dimension so that the joint distribution of assets can be more easily examined. It follows already from the parametrization that approximately 71% of the households keeps illiquid asset, so the only remaining interesting question is how the steady state distribution of liquid assets compares between households holding or not holding illiquid asset. To simplify the comparison, I normalized both distributions to 1 and displayed them on one figure.

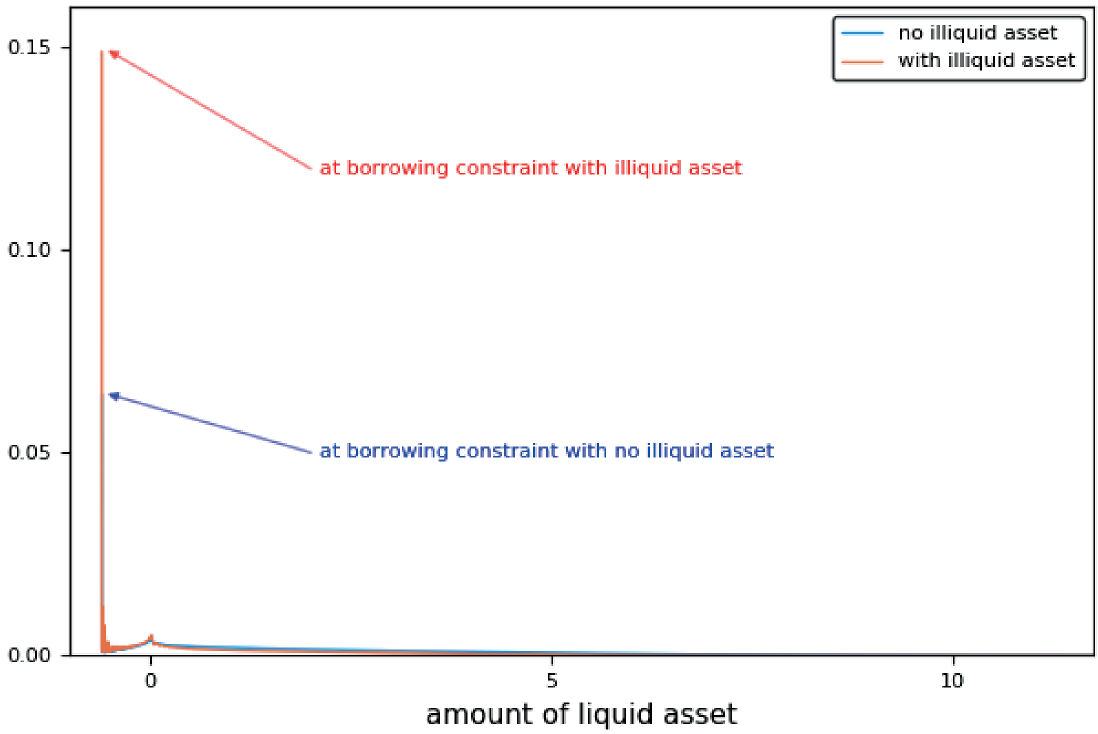

Figure 2: Distribution of liquid asset holdings

The first thing to notice is that for both types a significant fraction of the households are at the borrowing constraint ($14, 9\%$ and $6, 4\%$ for households with and without illiquid assets, respectively). These households are at a boundary solution, which means that they spend everything they can, as their marginal utility is very high. Therefore, if they got extra cash, they would spend it on consumption until the point where their current marginal utility decreases enough to satisfy their Euler equation. Hence, similarly to Violante et al. (2015) this model succeeds in creating such a steady state distribution endogenously, where a large fraction of households are hand-to-mouth consumers from the local point of view.

There is a spike at 0 as well. This is due to the wedge between borrowing and lending rates, which means that there is kink in the Euler equation for the liquid asset. All the households that would go slightly negative in the liquid asset without the borrowing wedge but not in presence of it, choose to stay at 0 and consume less than they wanted. These households also act locally as hand-to-mouth consumers.

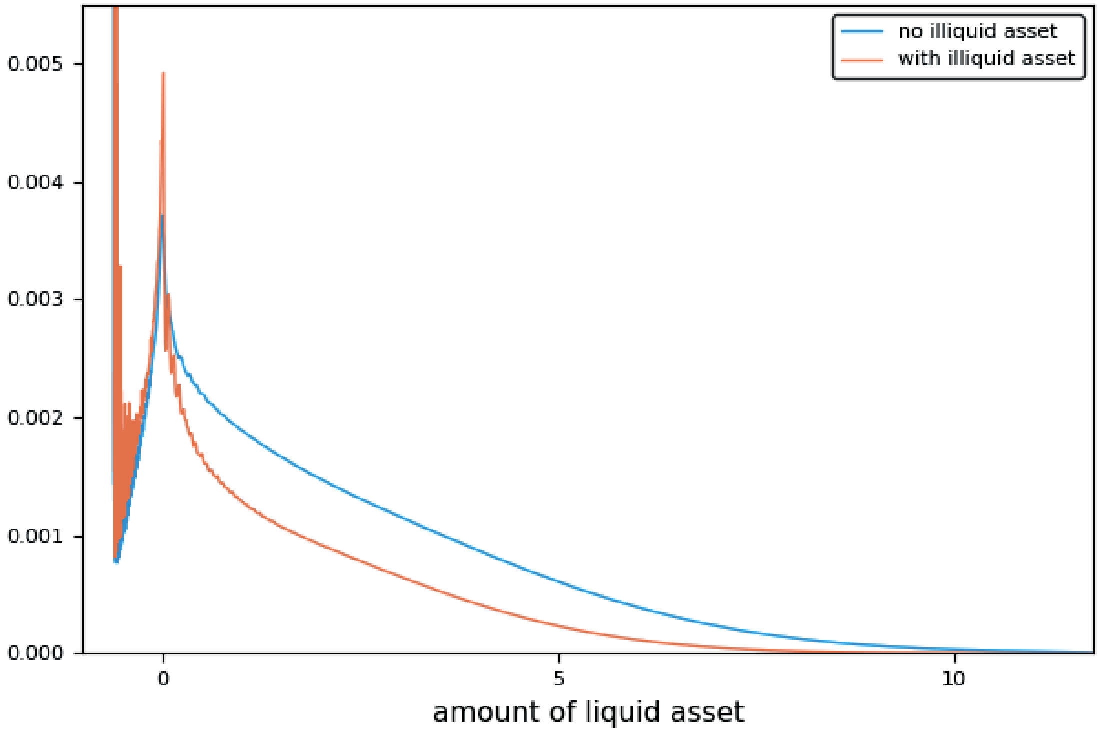

Figure 3: Distribution of liquid asset holdings (magnified)

As it can be seen from the figure above, the distribution of households with illiquid assets is slightly less skewed to the right compared to that of households not holding illiquid asset. This is so because for households without illiquid asset the liquid asset is not only useful for consumption smoothing, but it is also the vehicle to accumulate enough wealth to obtain illiquid asset. Therefore the value of hording liquid asset includes the possibility of obtaining illiquid asset promising significantly higher returns and hence higher future consumption. This motivation is missing from the owners of illiquid asset due to the parametrization, which enables only $a \in \{0, \bar{a}\}$. Furthermore, the counterpart of this effect is also missing from the model: One could think that the fear of losing the illiquid asset should make the owners try to avoid being at the borrowing constraint. However, as owners never lose their illiquid asset (seen in next subsection) this phenomenon is absent from the model. Instead, the distribution of owners of illiquid asset is entirely driven by the Euler-equation for liquid asset and the income process. As

$$\frac{1}{1+r^b_{stst}+\kappa} < \beta < \frac{1}{1+r^b_{stst}},$$

households both with positive and negative amount of liquid asset slowly tend to 0 conditional on constant income, but the asset levels are dispersed due to the stochastic income process.

So is it true that similarly to Violante et al. (2015) this model generates a large number of rich quasi-hand-to mouth consumers? Actually, regardless of their liquid asset level all the households owning illiquid asset can be called relatively rich. Even households with illiquid asset at the borrowing constraint have a significant amount of asset income: calculating with steady state values $\bar{a} \cdot r_a \cdot (1-\tau_a) - \underline{b}(r_b+\kappa) = 0.172$, which is more than third of expected per period labor income. This size of asset income could be obtained with over 27 units of liquid asset, which counts as extremely large in this economy. Therefore in steady state there are rich households who locally act as hand-to-mouth consumers.

4.2 The policy function

On the figures below I represented the optimal choices of households of the level of illiquid asset in steady state, depending on the individual state of the household. On the y-axis, level 1 represents not having illiquid asset, level 2 means having $\bar{a}$ illiquid asset.

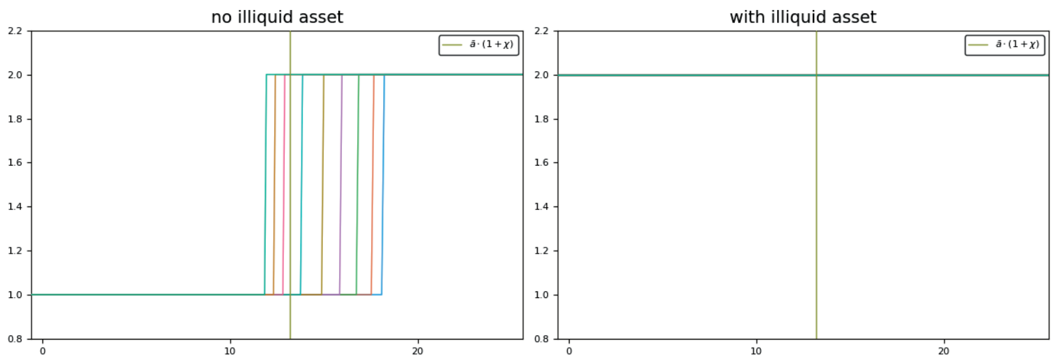

Figure 4: Policy function

As it can be seen from the figure, households without illiquid asset jump to the other state if they have approximately the sufficient amount of liquid asset ($\bar{a}(1+\chi)$). The exact location of the change is dispersed according to the contemporaneous productivity. On the other hand, owners of illiquid asset in no case change to the other state.This is because the difference in the returns on the liquid and illiquid assets is so huge that it is worth sticking to the illiquid asset even at the borrowing constraint with the lowest possible productivity.

This means that having illiquid asset is an absorbing state. How can this fact be consistent with having a steady state with a positive amount of households without illiquid asset? In the steady state distribution of households without illiquid asset the region where the change happens gets a very small weight. Therefore, even though the flow from the poor state to the rich state is positive and zero to the other direction, the difference remains below the tolerance level, households almost never change their state of illiquid asset. Correspondingly, as described in the impulse response section, the response in capital to global shocks is nearly negligible, therefore this model can be thought of having quasi-fixed capital.

5 Results

In this section I analyze the effect of five different contractionary fiscal policy shocks with impulse response functions: a decrease in transfers and government spending and an increase in the three tax rates. To make responses comparable, all shocks are normalized in a way such that government debt decreases by 1% of per period output on impact. This makes sense as the drop in debt is a good proxy of the extra financial sources provided by the better government budget balance. Except for the shocks and the rates ($r^a, r^b, r^k, Pi, nr = i$), for each variable percentage point deviation from steady state is shown. The persistence of shocks is 0.9 per quarter.

5.1 Shock to government transfers

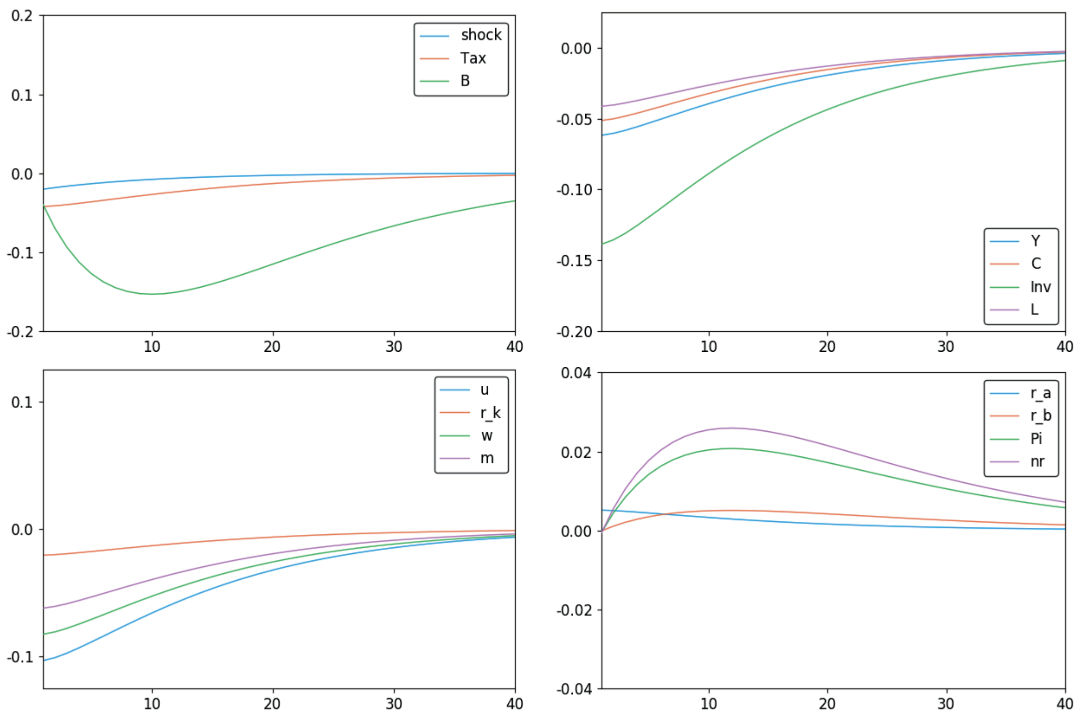

Figure 5: Impulse responses to a shock in T

Due to the multiplicative effect of decreasing demand, a pure negative income shock to the households affects the economy very severely. Answering a shock in transfers approximately of size -0.02, consumption drops by 0.03 (-5% from steady state value 0.61) and savings into liquid asset drops by 0.01 (which was the aim of the normalization). In total, the shock causes a 6.18% percentage decrease in output. To reach the desired 0.01 improvement in the government budget balance a shock of size 0.02 is needed to compensate for the decreasing tax income. This phenomenon nicely illustrates one of the pitfalls of measuring the effects of fiscal policy: depending on whether one defines the fiscal multiplier based on a change in a single fiscal policy vehicle or on a change in government balance (therefore taking indirect effects into account), one can obtain drastically different results.

The drop in consumption and therefore in output has a negative effect on labor demand, hence wage and labor will decrease, further decreasing household income. Smaller labor input also implies smaller marginal product of capital, therefore smaller r^k, hence optimal utilization rate will drop, which leads to a decrease in investment, as with smaller utilization rate less investment is enough to replace depreciated capital. Impulse response of capital level is not displayed, as changes of capital are nearly negligible: about 0.06% percent of changes in investment represent actual changes in capital, the rest is replacement of depreciated capital.

Decreasing marginal products on labor and capital lead to smaller real marginal costs, which increases profit rates. This drives an increase in r^a and also has an effect on inflation: as it follows from equation (2), a below steady state marginal cost implies either a growing path of inflation or a quickly growing output path ($Y_{t+1} > (1+r^a_{t+1})Y_t$). The resulting growth in inflation is countered by a larger increase in the nominal rate by the central bank. The growth of r^b is caused by low demand (lower income to save) and high supply (more government resources) for liquid asset. The amount of liquid asset held start to increase after 3 years, when the effect of the shock starts to fade away. This reverses the dynamics of r^b, the nominal rate and inflation.

5.2 Shock to asset income tax

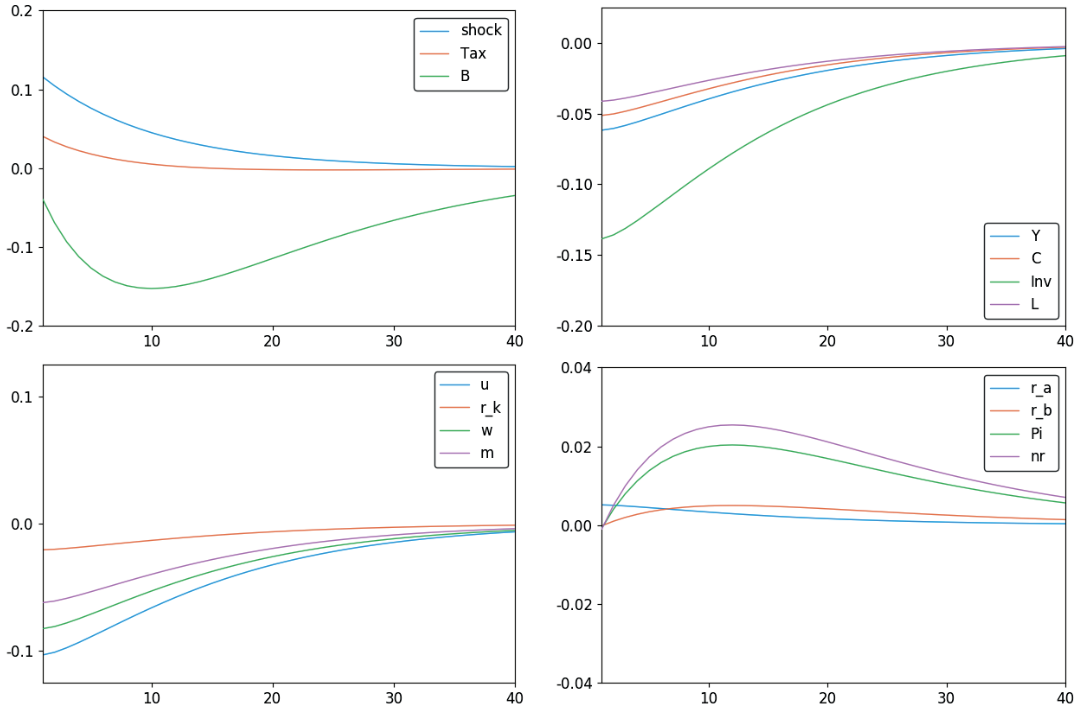

Figure 6: Impulse responses to a shock in τ_a

Apart from the fact that in contrast to a change in government transfer a change in capital income tax is apparent in the increase of the Tax variable, the responses to the capital income tax are nearly identical to the responses to the pure income shock. This highlights a rather unrealistic feature of the model: as the cost to obtain any amount of illiquid asset is large and the difference between the return on liquid and illiquid asset is huge, investment decisions are not affected by small changes in returns. Whether or not a household is buying $\bar{a}$ illiquid asset does not depend on the exact incentive from the difference in return (if it is not very different from steady state). The only question is whether the household has an amount of $(1 + \chi)\bar{a}$ liquid asset to invest or not. Similarly, households owning illiquid asset will not sell their illiquid asset holdings because of a marginal increase in tax rate. The adjustment costs are big and holding liquid asset instead would mean earning lower asset income.

5.3 Shock to sales tax

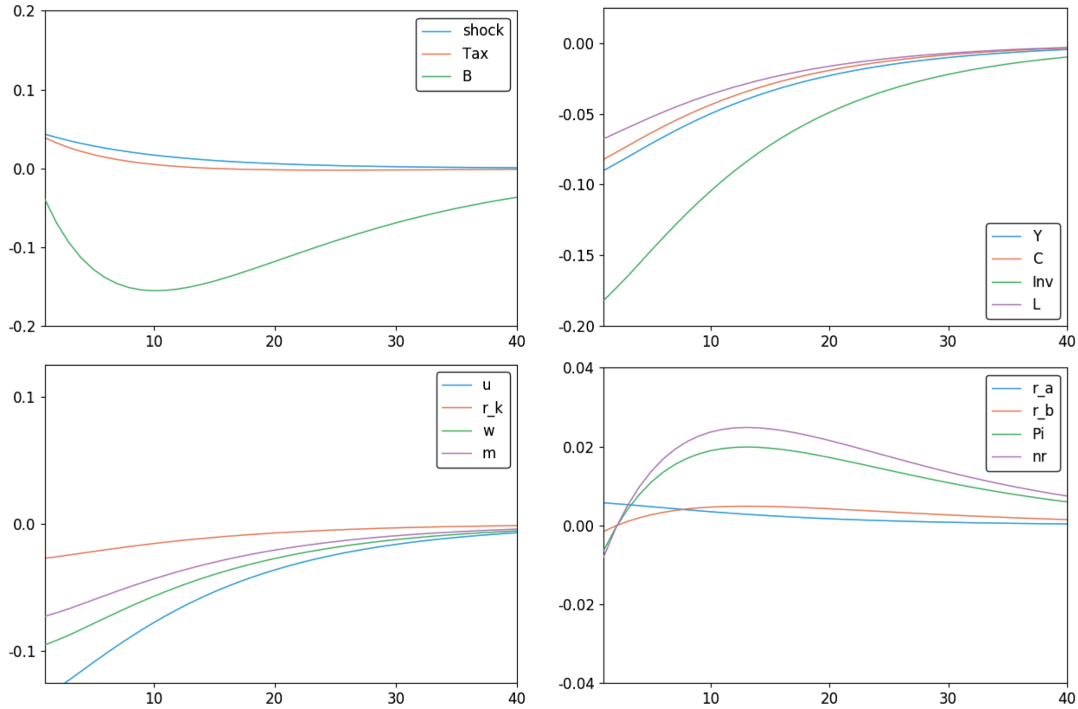

Figure 7: Impulse responses to a shock in τ_c

While the responses to a sales tax shock are qualitatively similar to that of an income shock, for several reasons the effects are more severe. First, now from the same amount of money households can buy less consumption goods, which decreases demand, output and therefore labor income. Second, the decreasing path of the sales tax rate implies that the growth in consumption following the shock must be steeper than with a pure income shock of the same size (because of the Euler-equation). This means that the contemporaneous response to the sales tax shock must be larger. Third, as it can be seen from the MRS condition (1), larger sales tax means less valuable labor, therefore it is cheaper to obtain utility from leisure, labor input will decrease.

As a result, in this case output decreases by 9%, consumption by 8.2%. The more severe drop in marginal cost does not only cause a growing path of inflation, but also a deflation on impact.

5.4 Shock to labor income tax

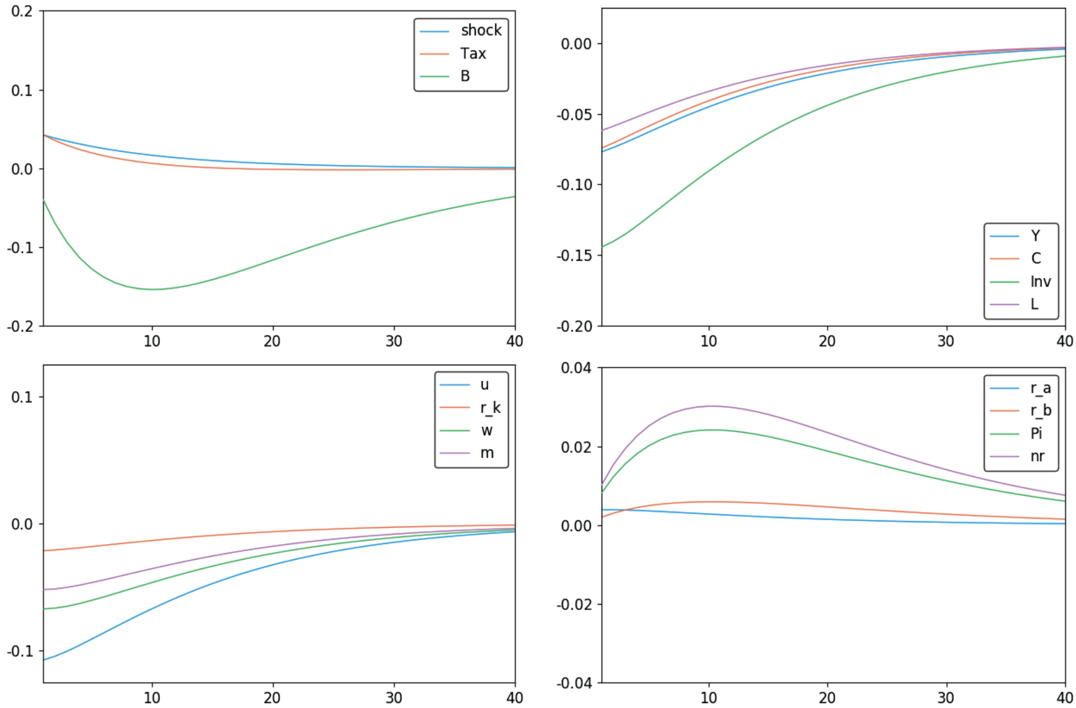

Figure 8: Impulse responses to a shock in τ_l

A shock to labor tax affects the economy quite similarly to the sales tax shock. It also acts through the MRS condition, making labor relatively less valuable. However, even though this distortion makes the labor tax shock more harmful than a simple negative shock on transfers, it is still less devastating than the penalty on consumption imposed by the sales tax shock: Even labor input decreases slightly less than in the case of shock to τ_c.

The only qualitative difference is that due to the smaller drop in wage and real marginal cost (higher labor tax means relatively more expensive labor), in this case there is no deflation on impact.

5.5 Shock to government spending

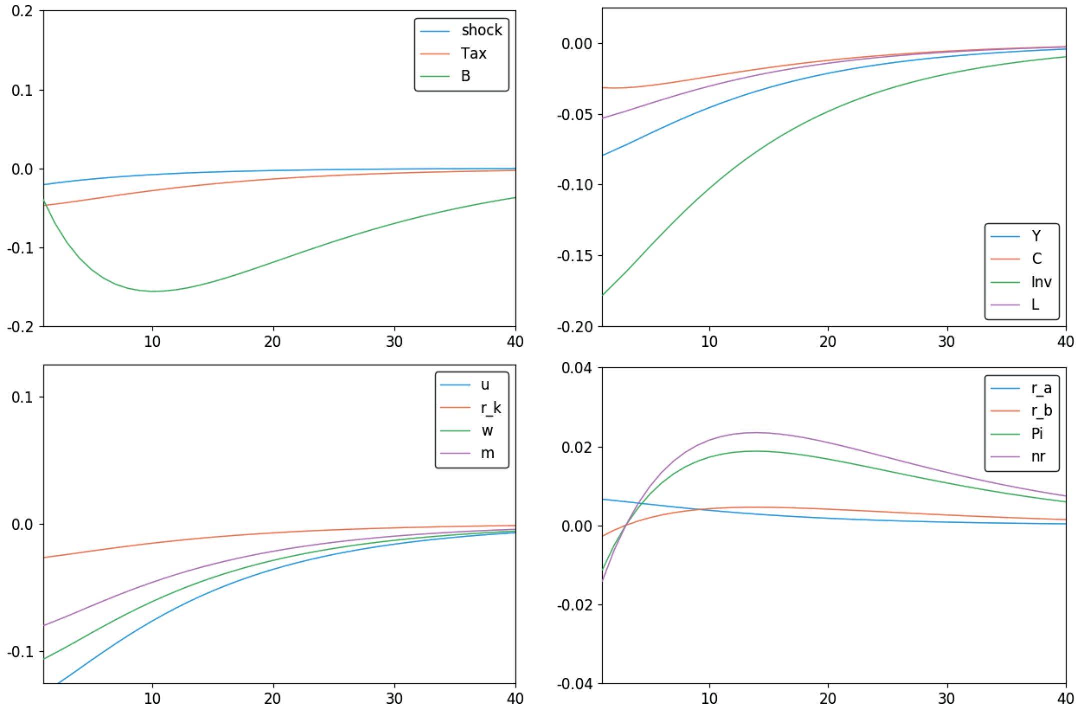

Figure 9: Impulse responses to a shock in G

A negative shock to government spending means a negative shock to demand, so it is natural that the effects are almost identical to the sales tax shock. However, for two reasons the effects are somewhat less severe: First, the distortionary effects of the sales tax increase are missing. Second, the decreasing government spending is partially substituted by private consumption, which diminishes the drop in consumption, mitigating the negative effects on demand and therefore household income.

6 Conclusion

In my thesis I attempted to apply the model by Violante et al. (2015) to investigate the efficiency of fiscal policy in the presence of rich hand-to-mouth consumers. To do so, I built a model as similar to theirs as possible and extended it with a number of different fiscal policy shocks. I obtained a significant amount of hand-to-mouth consumers in the steady distribution, even though it is still less than in the original model. I represented the effect of fiscal shocks by impulse responses around the steady state. In the following table it is summarized how much government debt, output and consumption react to contractionary fiscal policy shocks. To simplify comparison, all changes are expressed as percentages of per quarter output.

	B	Y	C
shock to T	-1%	-6.18%	-3.11%
shock to τ^a	-1%	-6.18%	-3.11%
shock to τ^c	-1%	-9.02%	-4.98%
shock to τ^l	-1%	-7.7%	-4.5%
shock to G	-1%	-7.96%	-1.91%

Table 1: Effect of different fiscal shocks

Therefore, the model says that to improve government budget balance by 1 unit we need to reduce output by $6-9$ units. Can these numbers be called fiscal multipliers? In a sense they can, as changes in government budget balance are a popular measure of fiscal policy actions. However, this numbers are unusually high and this is so because of a reason: to obtain an equilibrium with decreasing government debt it is not sufficient that the government has enough extra income, it is also necessary that households want to save less. On one hand I normalized shocks in a way that government budget balance improves by 1 unit. On the other hand I normalized them in a way to make households suffer enough to save 1 unit less. This is so as in this economy the lenders of the state are the same as the objects of its fiscal policy. I think this feature of the model leads to overestimated fiscal multipliers.

In my opinion an interesting extension of the current model would be to introduce foreign investors partially substituting households in holding government debt. This would enable examining the effects of fiscal policy changes on households and on government balance more separately, without the unrealistically tight connection between government debt and household savings.

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A Equations

$$s_t^m = \rho^s s_{t-1}^m + \epsilon_t^m \tag{4}$$

$$\tau_t^a = (1-\rho^s)\tau_{stst}^a + \rho^s \tau_{t-1}^a + \epsilon_t^a \tag{5}$$

$$\tau_t^c = (1-\rho^s)\tau_{stst}^c + \rho^s \tau_{t-1}^c + \epsilon_t^c \tag{6}$$

$$\tau_t^l = (1-\rho^s)\tau_{stst}^l + \rho^s \tau_{t-1}^l + \epsilon_t^l \tag{7}$$

$$T_t = (1-\rho^s)T_{stst} + \rho^s T_{t-1} + \epsilon_t^T \tag{8}$$

$$G_t = (1-\rho^s)G_{stst} + \rho^s G_{t-1} + \epsilon_t^G \tag{9}$$

$$r_t^k = F_K(effKNratio_t)m_t \tag{10}$$

$$w_t = F_N(effKNratio_t)m_t \tag{11}$$

$$w_t \frac{(1-\tau^l)}{(1+\tau^c)} = \psi l_t^{\frac{1}{\varphi}} \tag{12}$$

$$\epsilon(1-m_t) = 1 - \theta(\Pi_t - 1)\Pi_t + \frac{\theta}{1+r_{t+1}^a}\frac{Y_{t+1}}{Y_t}(\Pi_{t+1}-1)\Pi_{t+1} \tag{13}$$

$$effKNratio_t = \frac{effK_t}{N_t} \tag{14}$$

$$0 = r_t^k - r_{stst}^k u_t^{\gamma-1} \tag{15}$$

$$effK_t = K_{t-1}u_t \tag{16}$$

$$N_t = \int l_t z_{it} \ \mathrm{d}\mu_t \tag{17}$$

$$Y_t = F(effK_t, N_t) \tag{18}$$

$$agg\Theta_t = \theta/2(\Pi_t - 1)^2 Y_t \tag{19}$$

$$q_t = ((1 - m_t)Y_t - agg\Theta_t)/K_t \tag{20}$$

$$r_t^a = r_t^k u_t - \delta(u_t) + q_t \tag{21}$$

$$i_t = r_{StSt} + \phi^m(\Pi_t - 1) + s_t^m \tag{22}$$

$$r_t^b = (1 + i_t)/\Pi_t - 1 \tag{23}$$

$$B_t = \int b_{it} \ \mathrm{d}\mu_t \tag{24}$$

$$K_t = \int a_{it} \ \mathrm{d}\mu_t \tag{25}$$

$$I_t = K_t - K_{t-1}(1 - \delta(u_t)) \tag{26}$$

$$agg\chi_t = \int \chi|a_{i,t+1} - a_{it}| \ \mathrm{d}\mu_t \tag{27}$$

$$agg\kappa_t = \int \kappa \max\{0, -b_{it}\} \, \mathrm{d}\mu_t \tag{28}$$

$$\begin{aligned} C_t = {} & (B_{t-1}(1 + r_t^b) - agg\kappa_t + T_t + w_t N_t(1 - \tau_t^l) - \\ & - (K_t - K_{t-1}) + K_{t-1} r_t^a (1 - \tau_t^a) - agg\chi_t - B_t)/(1 + \tau_t^c) \end{aligned} \tag{29}$$

$$Tax_t = w_t N_t \tau_t^l + K_{t-1} r_t^a \tau_t^a + C_t \tau_t^c \tag{30}$$

$$B_t + Tax_t = B_{t-1}(1 + r_t^b) + G_t + T_t \tag{31}$$

B Parameters and Steady State Values

Parameters:	Steady state values for variables :
β :0.979061748741	r_k :0.0348591549296
ρ^s :0.9	r_b :0.00619224632564
γ :1.2	r_a :0.0205962441316
$\bar{\delta}$:0.026	w :1.46340279575
κ :0.0158682847828	i :0.00619224632564
r_{StSt} :0.00619224632564	q :0.0117370892021
Z :0.893174127599	u :1.00000000002
α :0.33	K :8.5200014892
φ :0.5	I :0.221520038724
ψ :9.10411877543	l :0.333333333333
σ :0.227	N :0.412053333333
ρ :0.929	Tax :0.246070149978
ϵ :10	B :0.258399488039
θ :100	Y :1
τ^a_{stst} :0.25	$agg\Theta$:0
τ^c_{stst} :0.085	$agg\kappa$:0.00370523435292
τ^l_{stst} :0.25	$agg\chi$:8.92774202998$e-06$
T_{stst} :0.075	Π :1
G_{stst} :0.169470076698	m :0.9
ϕ^m :1.25	$effK$:8.52
χ :0.1	C :0.605295791881
$\bar{a}$:12.0	τ^a :0.25
	τ^c :0.085
	τ^l :0.25
	sh^m :0
	T :0.075
	G :0.169470076698

C Monetary Shock

For comparison, below the impulse responses to a monetary shock of size 0.01 are provided.

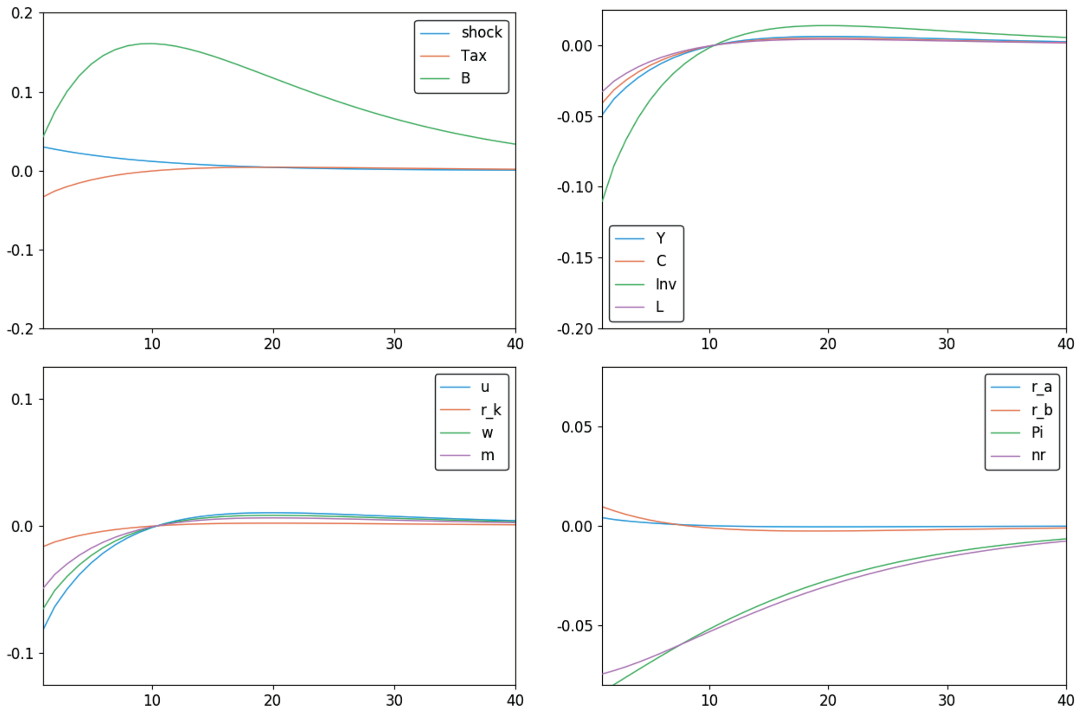

Figure 10: Impulse responses to a shock in s^m