Fiscal policy with heterogeneous agents, banks and financial frictions

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Abstract

We assess the role of banks to the transmission of fiscal policy reforms to the economy. We built-up a dynamic stochastic general equilibrium model with heterogeneous agents, banks and government to find that banks and their associated capital-adequacy constraint mitigate the negative spill-over effects to the economy from higher taxes. Specifically, housing taxes exhibit negative effects to the economy in the short-run and weakly positive in the long-run, if they are welfare enhancing. Borrowers are affected the most from higher housing taxes. The existence of banks benefits impatient households from higher consumption taxes, whereas higher housing tax targeted on patient households and entrepreneurs, decreases agents' welfare.

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1 Introduction

This paper introduces a fiscal sector in a real business cycle model with banks and financial frictions. The importance of banks in macroeconomic modelling has been well documented in the literature (see e.g. Brunnermeier and Sannikov (2014), Kollman et al. (2011) and Meh and Moran (2010)). However, the role of banks and the associated borrowing constraints, faced by households and entrepreneurs, under fiscal policy reforms has not drawn the required attention in the literature.

This is specifically relevant under the current economic climate where fiscal policy is being used as the main source for enhancing economic growth and the role of banks is re-evaluated. Moreover, it is crucial to examine under this environment the role of the various financial frictions in the economy with housing being the key source of collateral. Housing is the key asset for the vast majority of households in the U.S with 65% of the population owning a house[1]. In addition, the value of housing is even higher than that of gross domestic product (GDP). As a result, housing affects significantly the financial constraints of agents in the economy (see also Alpanda and Zubairy, 2016 and references therein) and it is even more pronounced under the presence of banks (Iacoviello, 2015).

In this paper we want to investigate how various fiscal policy reforms might affect the economy in terms of output and welfare under the presence of banks and financially constrained agents using a dynamic stochastic general equilibrium (DSGE) model. Therefore, we want to fill the gap in the literature that examines the role of banks and fiscal policy separately, with an ultimate aim to examine how the existence of banks and financial frictions affect the economy following various fiscal policy reforms.

Our model follows Kiyotaki and Moore (1997) and Iacoviello (2005) work by introducing banks and implementing financially constrained households and entrepreneurs with housing as a collateral. The objective is to assess the interaction of banks as financial intermediaries with a government and their associated effects on inequality and welfare.

Alpanda and Zubairy (2016), in a similar approach to our work, extend Iacoviello (2005) earlier work by introducing a fiscal sector and renters to the economy and by allowing housing to be endogenously determined. We also allow for housing to be endogenously determined and we also introduce a rich fiscal sector but we do not introduce renters and we deviate from nominal rigidities[2]. In addition, Alpanda and Zubairy (2016) did not include a bank-

[1] Data on Homeownership Rates for the US and Regions are for the period 1965-2015, from Table 14 of the U.S. Census Bureau.

[2] Introducing renters in our model would be very interesting but we leave that for future

ing sector, as in Iacoviello (2015) and our paper, and their focus was on the housing-related tax changes and not on the role of banks to the propagation mechanism of various fiscal policy reforms to the economy, as in our paper.

Gertler and Karadi (2011) and Gertler and Kiyotaki (2010), among others, have established the importance of banks as financial intermediaries, applying a balanced sheet constraint. Iacoviello (2005) was the first to introduce a housing sector and monetary policy to assess the propagation mechanism of various shocks to the economy. Later on Iacoviello (2015) extended his work introducing banks as financial intermediaries in a Real Business Cycle model, without monetary and fiscal policy, to assess the importance of various financial shocks in the economy.

On the fiscal policy aspect, most of the related papers apply an overlapping generations model and examine the effects of various real estate related taxes (i.e. property tax, mortgage interest tax etc.) on home owners and renters, i.e. Gervais (2002) and Chambers et al. (2009). More recently, Alpanda and Zubairy (2016) implemented a dynamic general equilibrium model to examine housing tax related policies. However, to the best of our knowledge, there is no work on the propagation effects of fiscal policy in a framework with banks as financial intermediaries, heterogeneous households and financial frictions.

Therefore, we introduce a fiscal sector in a dynamic stochastic general equilibrium model with banks, heterogeneous households and entrepreneurs so as to be able to assess the various, and possibly asymmetric, effects of fiscal policy reforms on different agents in the economy. Specifically we follow a standard calibration approach so as to match the key U.S. data over the past three decades and we assess the effects of permanent changes to fiscal policy instruments. In particular, we examine the effect of a permanent increase in government spending, housing tax, labour tax and consumption tax under the presence of banks. We also examine the spillover effects to the economy with banks from a permanent increase in agent specific housing tax, labour tax and consumption tax.

The main questions we would like to answer are: 1) How the existence of banks affects the propagation of higher government spending to the economy? 2) How the existence of banks affects the transmission of various fiscal policy reforms to the economy? 3) What are the welfare implications in each agent? 4) How a structural change in the financial frictions can affect the transmission of the shocks to the economy?

An overview of the main findings is the following: i) The existence of

research. Alpanda and Zubairy (2016) introduced renters because they examined housing specific tax polixy reforms.

banks can mitigate the negative spillover effects to the economy from higher taxes under fiscal policy reforms; ii) Housing taxes exhibit negative spillover effects to the economy in the short run and weakly positive in the long run if they are welfare enhancing; iii) Shocks that decrease the net worth of loan suppliers amplify the negative spillover effects to the economy; iv) Borrowers' welfare exhibits the most significant negative reaction from the increase in housing tax and government spending; v) Income redistribution via transfers due to higher labour income taxes is mainly beneficial for patient households for the case without banks; vi) Under higher consumption tax the income redistribution is beneficial for the impatient households only when banks are present; vii) Every agent is worse-off for the cases of higher real estate tax on patient households and entrepreneurs; viii) Our main results are robust in changes to the financial frictions specification.

The remainder of the paper is organised as follow. Section 2 presents and describes the model. Section 3 outlines the calibration. Section 4 presents and discusses the results and Section 5 presents the robustness checks. Finally, Section 6 draws the conclusions.

2 Model

We employ a real business cycle model with two types of households (patient and impatient), entrepreneurs, banks and a government. Patient households are assumed to be the savers and owners of housing. They also work, consume, make one-period deposits to banks and have access to one-period government bonds. Impatient households consume, work, own housing and have access to one-period bank loans. The impatient households are under a borrowing constraint determined by the value of their housing which is used as collateral (i.e. Kiyotaki and Moore (1997) and Iacoviello (2015)). Entrepreneurs hire workers from the two households, accumulate real estate and borrow from banks. They are also under a borrowing constraint which is determined by the value of their collateral and the wage rates paid in advance, as in Neumeyer and Perri (2005). Banks borrow from patient households, in the form of deposits, and provide one-period loans to impatient households and entrepreneurs. Finally, government spending is financed via debt, lump-sum transfers, consumption, labour and housing taxes.

2.1 Patient households

Patient households have the following objective function:

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \left[\log C_{P,t} + j \log H_{P,t} + \eta \log(1 - N_{P,t})\right] \tag{1}$$

where E_0 is the conditional expectations operator at period 0; $0 < \beta_P^t < 1$ is the time discount factor; $C_{P,t}$ and $N_{P,t}$ are private consumption and working hours respectively at period t; and $H_{P,t}$ is housing at period t. The parameters j and η capture the weights of real estate and leisure on the welfare respectively.

The representative patient household chooses consumption, labour, housing, bonds and deposits, $C_{P,t}$, $N_{P,t}$, $H_{P,t}$, B_t and D_t respectively, so as to maximize equation (1) subject to the following budget constraint:

$$\begin{aligned} &\left(1 + \tau_{P,t}^C\right) C_{P,t} + D_t + B_t + q_t \left(H_{P,t} - \left(1 - \tau_{P,t}^H\right) H_{P,t-1}\right) \\ &= R_{P,t-1} D_{t-1} + R_{B,t-1} B_{t-1} + \left(1 - \tau_{P,t}^W\right) W_{P,t} N_{P,t} + tr_{P,t} \end{aligned} \tag{2}$$

where we assume that patient households have deposits, D_t, at the bank earning a gross return $R_{P,t}$. It is further assumed that patient households have access to government bonds, B_t, with a gross return $R_{B,t}$. In addition, q_t denotes the relative price of housing and $\tau_{P,t}^H$ is the property tax rate on housing. $W_{P,t}$ is the wage rate and $\tau_{P,t}^W$ is the labour tax rate. Finally, patient households receive lump-sum transfers from the government, $tr_{P,t}$, and they are subject to a consumption tax, $\tau_{P,t}^C$.

2.2 Impatient households

Impatient households have the following objective function:

$$\max E_0 \sum_{t=0}^{\infty} \beta_I^t \left[\log C_{I,t} + j \log H_{I,t} + \eta \log(1 - N_{I,t})\right] \tag{3}$$

where $0 < \beta_I^t < 1$ is the time discount factor with $0 < \beta_I^t < \beta_P^t$; $C_{I,t}$ and $N_{I,t}$ are private consumption and working hours respectively at period t; and $H_{P,t}$ is housing at period t.

The representative impatient household chooses consumption, labour, housing and loans, $C_{I,t}$, $N_{I,t}$, $H_{I,t}$ and $L_{I,t}$, respectively, so as to maximize equation (3) subject to the following budget constraint:

$$\begin{aligned} &\left(1 + \tau_{I,t}^C\right) C_{I,t} + R_{I,t-1} L_{I,t-1} + q_t \left(H_{I,t} - \left(1 - \tau_{I,t}^H\right) H_{I,t-1}\right) \\ &= L_{I,t} + \left(1 - \tau_{I,t}^W\right) W_{I,t} N_{I,t} + tr_{I,t} \end{aligned} \tag{4}$$

where we assume that impatient households receive bank loans, $L_{I,t}$, with gross interest rate $R_{I,t}$. It is further assumed that impatient households do not have access to government bonds and they are subject to a property tax rate on housing $\tau^H_{I,t}$. Their wage rate is defined as, $W_{P,t}$, and it is subject to a labour tax rate, $\tau^W_{I,t}$. Impatient households also receive lump-sum transfers from the government, $tr_{I,t}$ and are subject to a consumption tax, $\tau^C_{I,t}$.

Impatient households are assumed to be constraint on the amount they are able to borrow given their stock of real estate:

$$L_{I,t} \leq \rho_I L_{I,t-1} + (1-\rho_I)\, m_I E_t \left(\frac{q_{t+1}}{R_{I,t}} H_{I,t} \right) \tag{5}$$

where ρ_I captures the inertia in the adjustment of the borrowing constraint over time and the parameter m_I determines the loan-to-value ratio in terms of the real estate used as a collateral.[3]

2.3 Entrepreneurs

Entrepreneurs behave similarly to impatient households with the following objective function:

$$\max E_0 \sum_{t=0}^{\infty} \beta_E^t \left[\log C_{E,t} \right] \tag{6}$$

where we assume that $0 < \beta_E \left(1 - \left((1-\beta_B)\,\rho_B + (1-\rho_B)\,\gamma \right) \frac{1-\beta_B R_P}{1-\beta_B \rho_B} \right) < \beta_B$.[4]

The representative entrepreneur chooses consumption, $C_{E,t}$, housing, $H_{E,t}$ and loans $L_{E,t}$, so as to maximize equation (6) subject to the following budget constraint:

$$\begin{aligned} &\left(1+\tau^C_{E,t}\right) C_{E,t} + R_{E,t} L_{E,t-1} + q_t H_{E,t} + W_{P,t} N_{P,t} + W_{I,t} N_{I,t} \\ &= Y_t + L_{E,t} + q_t \left(1-\tau^H_{E,t}\right) H_{E,t-1} + tr_{E,t} \end{aligned} \tag{7}$$

where $L_{E,t}$ denotes the bank loans with gross interest rate $R_{E,t}$. It is further assumed that entrepreneurs are subject to a property tax rate on housing $\tau^H_{E,t}$, receive lump-sum transfers from the government, $tr_{E,t}$, and they are subject to a consumption tax, $\tau^C_{E,t}$.

[3] Following, Iacoviello (2015) the borrowing constraint is binding around the steady state if the time discount factor of impatient households satisfies the following: $\beta_I < \left(1 - \left((1-\beta_B)\,\rho_B + (1-\rho_B)\,\gamma \right) \frac{1-\beta_B R_P}{1-\beta_B \rho_B} \right) \beta_B$.

[4] See Iacoviello (2015) for more details on this restriction.

Furthermore, entrepreneurs are subject to the following borrowing constraint:

$$L_{E,t} \leq \rho_E L_{E,t-1} + (1-\rho_E) \begin{bmatrix} m_{EH} E_t \left(\frac{q_{t+1}}{R_{E,t+1}} H_{E,t} \right) \\ -m_{EN} \left(W_{P,t} N_{P,t} + W_{I,t} N_{I,t} \right) \end{bmatrix} \tag{8}$$

where, as in the impatient households, ρ_E captures the inertia in the adjustment of the borrowing constraint over time. The parameter m_{EH} determines the loan-to-value ratio in terms of their real estate stock used as collateral. The term m_{EN} captures the assumption that a fraction of the wage payment needs to be made in advance, following Iacoviello (2015) and Neumeyer and Perri (2005).

Entrepreneurs combine real estate and labour supply from patient and impatient households to produce the final output given by:

$$Y_t = A_{Z,t} \left(H_{E,t-1} \right)^v \left(N_{P,t} \right)^{(1-v)(1-\sigma)} \left(N_{I,t} \right)^{(1-v)\sigma} \tag{9}$$

where v determines the share of entrepreneur's real estate on the production process and σ determines the relative share of impatient labour supply in the production.

Total factor productivity, $A_{Z,t}$, is assumed to follow a stochastic exogenous AR(1) process:

$$\log \left(A_{Z,t+1} \right) = (1-\rho_{A_Z}) \log \left(A_Z \right) + \rho_{A_Z} \log \left(A_{Z,t} \right) + \varepsilon_t^{A_Z} \tag{10}$$

where $\varepsilon_t^{A_Z}$ is independently and identically distributed Gaussian random variable with zero mean and standard deviation given by σ_{A_Z}.

2.4 Banks

Banks have the following objective function:

$$\max E_0 \sum_{t=0}^{\infty} \beta_B^t \log C_{B,t} \tag{11}$$

where, following Iacoviello (2015) we set $0 < \beta_B < \beta_P$.

The representative bank chooses consumption, $C_{B,t}$, deposits, D_t, and the loans given to impatient households and entrepreneurs, $L_{I,t}$ and $L_{E,t}$ respectively, so as to maximize (11) subject to the following budget constraint:

$$\begin{aligned} &\left(1 + \tau_{B,t}^C\right) C_{B,t} + R_{P,t-1} D_{t-1} + L_{E,t} + L_{I,t} \\ &= D_t + R_{E,t} L_{E,t} + R_{I,t-1} L_{I,t-1} + tr_{B,t} \end{aligned} \tag{12}$$

where $\tau^C_{B,t}$ is the consumption tax rate and $tr_{B,t}$ are the lump-sum transfers.[5]

The bank is also subject to a capital adequacy constraint:

$$L_t - D_t \geq \rho_B \left(L_{t-1} - D_{t-1}\right) + (1-\gamma)\left(1-\rho_B\right) L_t \tag{13}$$

where it states that bank equity must exceed a fraction of bank assets. The parameter γ captures the liabilities to asset ratio and the parameter ρ_D captures the inertia in the capital adequacy constraint.

2.5 The government

The government's budget constraint is given by:

$$\begin{aligned} &\tau^H_{P,t} H_{P,t-1} + \tau^H_{I,t} H_{I,t-1} + \tau^H_{E,t} H_{E,t-1} + \tau^W_{P,t} W_{P,t} N_{P,t} \\ &+\tau^W_{I,t} W_{I,t} N_{I,t} + \tau^C_{P,t} C_{P,t} + \tau^C_{I,t} C_{I,t} + \tau^C_{E,t} C_{E,t} + \tau^C_{B,t} C_{B,t} \\ &= G_t + R_{B,t-1} B_{t-1} - B_t + tr_{P,t} + tr_{I,t} + tr_{E,t} + tr_{B,t} \end{aligned} \tag{14}$$

where G_t denotes public spending.

Following Leeper et al. (2010) and Alpanda and Zubairy (2016) we allow for transfers to adjust with government debt so as for the government not to run a Ponzi scheme.

$$\hat{tr}_{j,t} = -\gamma_{Yj} \hat{Y}_t - \gamma_{Bj} \hat{B}_{t-1}$$

where $j = P, I, E$ for patient, impatient households and entrepreneurs.[6] The parameter γ_{Yj} and γ_{Bj} are the reaction coefficients of the percentage change of transfers to the percentage deviation of current output and lagged debt.[7]

We further assume that spending follow an exogenous AR(1) process:

$$\log\left(G_{t+1}\right) = \rho_g \log\left(G_t\right) + \left(1-\rho_g\right)\log\left(G\right) + \varepsilon^G_t \tag{15}$$

where G is the level of government spending at the steady-state and ε^G_t is independently and identically distributed Gaussian random variable with zero mean and standard deviation given by σ_G.

[5] Banks lump-sum transfers by the government are being set to zero. We only use them as a robustness check towards the end of the paper.

[6] The hatted-variables, $\hat{x}$, denote the percent deviations from the steady-state of that variable.

[7] In our experiments we want to have transfers to savers and borrowers only. Therefore, transfers to banks are assumed to be zero throughout the paper, apart from a robustness check towards the end of the paper. However, they do not significantly afffect our results if they follow a similar pattern witht the rest of the transfers. These results are available upon request.

2.6 Market clearing conditions

The market clearing conditions for private consumption and housing are given by:

$$C_{P,t} + C_{I,t} + C_{E,t} + C_{B,t} = C_t \tag{16}$$

$$H_{P,t} + H_{I,t} + H_{E,t} = 1 \tag{17}$$

To solve the model dynamics we use Dynare and we estimate our model using a non-linear version of the system of equations and under the assumption that all the constraints outlined above are binding.

2.7 Decentralized competitive equilibrium

Given initial levels of the assets, $H_{j,0}$, B_0, the initial deposits of patient households D_0, the stationary stochastic processes for technology and government spending $\{A_{Z,t}, G_t\}_{t=0}^{\infty}$ for $j = P, I, E$, the decentralized competitive equilibrium system of equations is characterized by a sequence of allocations $\{C_{P,t}, C_{I,t}, C_{E,t}, C_{B,t}, H_{P,t}, H_{I,t}, H_{E,t}, N_{P,t}, N_{I,t}, B_t, D_t, L_{I,t}, L_{E,t}\}_{t=0}^{\infty}$ and prices $\{W_{P,t}, W_{I,t}, q_t, R_{P,t}, R_{B,t}, R_{I,t}, R_{E,t}\}_{t=0}^{\infty}$ such that: (i) both types of households, entrepreneurs and banks maximize their welfare, taking prices as given; (ii) the government budget constraint is satisfied in each time period and (iii) all markets clear.[8]

3 Calibration

For our calibration we follow the papers of Iacoviello (2015) and Leeper et al. (2010), along with annual U.S. fiscal data obtained from Bureau of Economic Analysis (BEA) and Federal Reserve Economic Data (FRED) from St. Louis Federal Reserve Bank. The calibrated parameters are summarized in Table 1.

The welfare parameters, time preferences and the parameters regarding the financial frictions are set as in Iacoviello (2015). Moreover, the consumption tax and the reaction coefficients of the fiscal rules are set as in Leeper et al. (2010).[9]

Furthermore, in our model we calibrate the government spending over output ratio so as to get a steady-state debt to output ratio of about 53%,

[8] The first order conditions of our model are presented and briefly discussed in the appendix.

[9] Note that here we assume that all the transfers rules are identical. An interesting extension of the paper would be to estimate the various rules for each agent and then assess the impact of the policy reforms. We leave that for future research.

in annual terms. The data we used on total public debt are for the period 1979-2014 from FRED.[10] As a result the implied government spending to output ratio in our model is about 25%. Moreover, we normalize transfers to be equal to zero at the steady-state.

The effective labour income tax is calculated using data from ECFIN and applying Martinez-Mongay (2000) approach.[11] Regarding the property tax we use data from the Minnesota Taxpayers Association (2011) study.

Table 1: Model parameters

Parameter	Value	Definition	Source
$0 < \beta_P < 1$	0.9925	time discount factor patient hh	Iacoviello (2015)
$0 < \beta_I < 1$	0.940	time discount factor impatient hh	Iacoviello (2015)
$0 < \beta_E < 1$	0.940	time discount factor entrepreneurs	Iacoviello (2015)
$0 < \beta_B < 1$	0.945	time discount factor for banks	Iacoviello (2015)
j	0.075	real estate weight in utility	Iacoviello (2015)
η	2.000	weight of leisure in utility	Iacoviello (2015)
m_I	0.900	loan-to-value ration - impatient hh	Iacoviello (2015)
m_{EH}	0.900	loan-to-value ration - entrepreneurs	Iacoviello (2015)
m_{EN}	1.000	advanced wage payment for entrepr.	Iacoviello (2015)
ρ_I	0.711	inertia impatient's borr. constr.	Iacoviello (2015)
ρ_E	0.631	inertia entrepreneur's borr constr.	Iacoviello (2015)
ρ_B	0.234	inertia in bank's capital adequacy	Iacoviello (2015)
γ	0.900	bank's liabilities to asset ratio	Iacoviello (2015)
v	0.050	share of real estate in output	Iacoviello (2015)
σ	0.3273	wage share in output	Iacoviello (2015)
$\gamma_{YP} = \gamma_{YI} = \gamma_{YE}$	0.130	reaction of transfers to output	Leeper et al. (2010)
$\gamma_{BP} = \gamma_{BI} = \gamma_{BE}$	0.500	reaction of transfers to debt	Leeper et al. (2010)
$0 < \frac{G^c}{Y} < 1$	0.250	government spending	calibration
$0 < \frac{B}{Y} < 1$	0.530	debt to output ratio	data
$\tau_P^W = \tau_I^W$	0.220	effective labour income tax	data
$\tau_P^H = \tau_I^H = \tau_E^H$	0.014	average property tax	data
$\tau_P^C = \tau_I^C = = \tau_E^C = \tau_B^C$	0.023	average consumption tax	Leeper et al. (2010)
$\tau r_P = \tau r_I = = \tau r_E = \tau r_B$	0.000	lump-sum transfers	assumption
ρ_{A_Z}	0.988	AR(1) coefficient of TFP	Iacoviello (2015)
ρ_g	0.800	AR(1) coefficient of gov. spending	data

[10] The series for total public debt refers to GFDEBTN series published by FRED.

[11] In particular, we use the LITR rate for effective average labour income tax. The exact data series required for this construction are described in Martinez-Mongay (2000).

For the calibration of the autocorrelation parameter of the government spending series we utilize annual data from the U.S. BEA for the period 1979-2014.[12] We then estimate the persistence of the AR(1) process, ρ_g, using the cyclical component of the series through an HP-filter. The constant terms in the process for total factor productivity (TFP) is normalized to unity (i.e. $A_Z = 1$) and the autocorrelation parameter of TFP is set equal to 0.988 following the estimate of Iacoviello (2015).

4 Solution and results

In order to analyze the role of banks on the economy we also create another economy without banks for comparison. In that case the patient households become the financial intermediary instead of banks and provide loans to impatient households and entrepreneurs, similarly to Iacoviello (2005) and Alpanda and Zubairy (2016).

4.1 Impulse response analysis

Initially, we want to check the effects of the banking sector to the economy following a temporary total factor productivity (TFP) and government spending shock. The case of the TFP shock is being used to establish the robustness of our model. Our main focus is on the fiscal policy and the transmission of various fiscal policy reforms to the economy with and without banks.

Figures 1-2

Figures 1 and 2 present the impulse responses following a temporary 1% increase in TFP and government spending. Regarding the temporary 1% increase in TFP (Figure 1) the results for consumption and output do not differ significantly between the case with and without banks, similarly to Iacoviello (2015). However, our results indicate that without banks the TFP shock will increase the deposits and loans substantially in the short run due to the higher disposable income via trasnfers and the elimination of the capital adequacy constraint. This leads to higher stock of real estate for the borrowers and lower for the savers. Moreover, debt will deviate from its steady state more for the case with banks because patient households are restricted from transforming their saving to investment due to the bank's

[12] This series refers to government consumption expenditures and gross investment from NIPA Table 1.1.5.

capital adequacy constraint. Patient households manage to keep a similar level of consumption compared to the case with banks even with a lower supply of labour due to the higher returns from bonds and deposits.

Figure 2 presents the impulse responses from a temporary 1% increase in government spending. In this case, similarly to the TFP case, deposits fluctuate slightly more without banks compared to the case with banks. The drop in the deposits, due to the imposed fiscal rule and the higher real estate stock of patient households, leads also to a drop in the loans and the real estate stock as a consequence. Moreover, the wage rates will decline more in the case without banks because of the lower loans the entrepreneurs receive and the assumed restriction of paying their wage bill in advance. Finally, debt deviates more in the case with banks for the same reasons as in the TFP case.

4.2 Fiscal policy reforms

Table 2 below presents the effects on output after a permanent 1% increase in government spending (G), 1% increase in the housing tax of each agent simultaneously (τ^H), the labour tax of the two households simultaneously (τ^W) and the consumption tax of each agent simultaneously (τ^C).[13] In addition, we perform this analysis for the case with banks (Panel A) and for the case without banks (Panel B).

[13] Another approach would be to use a policy reform that would raise a certain amount of tax revenue as a share of output, i.e. 2% of output. Applying a change that will raise a certain amount of income can be highly unbalanced for certain taxes. For example, the returns from the consumption tax on entrepreneurs is 0.15% of output. Therefore, this tax would need to increase about 12 times to raise the required income, whereas their housing tax returns are about 1.75% of output and they would need to double. As a result, this approach would not be helpful for our welfare analysis and comparison later on. In addition, the main focus of the paper is on the qualititative aspect of the effects and not on their magnitude.

Table 2: Effects on output as a percentage deviation from the steady-state

	$T = t + 1$	$T = t + 10$	$T = t + 100$	$T \to \infty$
		Panel A: With Banks		
G	0.1233	0.1299	0.1363	0.1367
τ^H	-0.0569	-0.0369	-0.0030	-0.0004
τ^W	-0.1202	-0.1122	-0.1017	-0.1009
τ^C	-0.0083	-0.0088	-0.0092	-0.0092
		Panel B: Without Banks		
G	0.1252	0.1302	0.1398	0.1403
τ^H	-0.0428	-0.0441	-0.0035	-0.0005
τ^W	-0.2079	-0.2099	-0.2090	-0.2089
τ^C	-0.4e^{-4}	-0.0251	-0.0193	-0.0184

In terms of the government spending shock (first row in each panel) we observe that the results are similar in both cases, with and without banks. This is probably due to the fact that we have assumed that government spending is not-productive in our setup[14]. These results might differ if we extend our model to incorporate productive or other forms of government spending (i.e. spending on education).[15]

In the case of a housing tax we observe similar patterns in both cases. However, we should note here the stronger initial reaction of the economy to a permanent 1% increase in the real estate tax when banks are present. Even in the case without banks the borrowing constraints are still present but the patient households are not constraint in providing loans, in contrast to the banks that are subject to the capital adequacy constraint. Therefore, the initial impact of the housing tax is stronger with banks, but in the long run banks can mitigate the impact with minor spillover effects to the economy. That happens mainly through the restriction of transforming savings to investment.[16]

The results form the labour income tax policy reform are very interesting. Under the case with banks the effect of a permanent increase in the labour income tax is negative to the economy with an initial decrease of about 0.12% in output. In the long run though this initial negative effect slowly decreases and in the long run it stabilizes at about -0.1%. When we move on to the case without banks we observe that the negative effect on the economy is doubled. In addition, this higher initial negative impact on the economy

[14] Asimakopoulos et al. (2016) provide an analysis on how productive government spending affect the economy and consumption in particular.

[15] This is a very interesting extension that we will pursue in the near future.

[16] A more detailed discussion is provided below in Table 3 when we discuss the individual policy reforms.

doesn't decline in the long-run, as in the case with banks, and it stays at the level of about -0.21%, which is more than double compared to the negative effect in the economy for the case with banks.

Therefore, under the case of constrained banks, that effectively control the amount of savings transformed into investment goods, the negative effects from a higher labour income tax are mitigated, whereas under a frictionless economy, where patient households provide the loans without any constraint, these effects are amplified.[17] This result provides an interesting extension of Iacoviello (2015) that shows that banks matter only for the case where there are redistribution shocks that transfer resources away from banks. Our result intuitively means that due to the higher labour income tax the households would like to smooth their consumption via the use of their savings (patient households) and loans (impatient households). However, the existence of banks prevents the frictionless transformation of savings to investment goods (this result is illustrated in more detail below in Table 3).

Under the case of a permanent increase in the consumption tax we observe that the initial negative impact on the economy is stronger with banks and milder without banks. However, in the medium term the negative effect becomes stronger for the case without banks, which is three times higher compared to that with banks. In the long run we find that the negative spillover effect to output from that fiscal policy reform will be twice as in the case with banks.

To sum up, all the aggregate tax policy reforms have qualitatively similar negative effects on output. It is notable though the interesting asymmetry in the quantitative effect of the change in labour income tax. The negative result is not as pronounced for the case of higher real estate tax due to the borrowing constraints of the impatient households and entrepreneurs, where they use their real estate as a collateral.

[17]Note that without banks all savings can be transformed into investment goods at no cost.

Table 3: Effects on output as a percentage deviation from the steady-state

	$T = t+1$	$T = t+10$	$T = t+100$	$T \to \infty$
		Panel A: With Banks		
τ_P^H	-0.0408	-0.0179	0.0102	0.0122
τ_I^H	-0.0079	-0.0033	0.0016	0.0020
τ_E^H	-0.0082	-0.0156	-0.0148	-0.0145
τ_P^W	-0.0838	-0.0777	-0.0693	-0.0687
τ_I^W	-0.0364	-0.0345	-0.0323	-0.0322
τ_P^C	-0.0051	-0.0054	-0.0057	-0.0057
τ_I^C	-0.0024	-0.0025	-0.0026	-0.0026
τ_E^C	-0.0007	-0.0008	-0.0008	-0.0008
τ_B^C	-0.4e^{-4}	-0.5e^{-4}	-0.5e^{-4}	-0.5e^{-4}
		Panel B: Without Banks		
τ_P^H	-0.0320	-0.0208	0.0105	0.0125
τ_I^H	-0.0064	-0.0038	0.0024	0.0027
τ_E^H	-0.0044	-0.0195	-0.0163	-0.0158
τ_P^W	-0.1755	-0.1781	-0.1793	-0.1793
τ_I^W	-0.0324	-0.0318	-0.0297	-0.0296
τ_P^C	-0.0059	-0.0061	-0.0066	-0.0066
τ_I^C	-0.0022	-0.0023	-0.0024	-0.0025
τ_E^C	-0.0007	-0.0007	-0.0008	-0.0008
τ_B^C	-	-	-	-

Table 3 presents a more detailed analysis of the various policy reforms on individual taxes. In particular, it presents the effects on output when the government imposes a permanent 1% increase in the housing tax of each agent separately, the labour tax of the two households separately and the consumption tax of each agent separately.

This table is very helpful in understanding the driving forces of the results mentioned in Table 2. In particular, we observe that an increase of real estate tax on either household will have a negative impact to the economy in the short-run, with stronger negative impact through the real estate tax on patient households. Patient households reduce their housing stock due to the higher tax and they also reduce their labour supply due to the higher inflow of transfers following the decline in output and debt. The outcome is similar also for the impatient households when they are under a higher real estate tax, but the impact on the economy is stronger under the reduction of the patient labour supply due to their assumed higher share in the production process. However, this initial negative effect disappears in the long-run leading to positive economic growth mainly due to the increased housing stock for the entrepreneurs via the lower prices of housing driven from the higher

real estate tax. The higher real estate tax imposed on entrepreneurs has the opposite effects in the economy. Initially, we have a minor negative effect but in the medium and long term this negative effect becomes stronger. This result is again driven mainly from the lower housing stock for the entrepreneurs due to the higher real estate tax.[18]

Therefore, the aggregate neutral long run effect observed previously under the single real estate tax is driven by the two opposite effects for the households and entrepreneurs. The source of this result is the fact that entrepreneurs do not have direct utility gains from the real estate. They only have indirect gains through the use of real-estate as an input in the production process. Therefore, the households care more about increasing their housing stock compared to the entrepreneurs due to the direct utility gains. Finally, these results are qualitatively similar between the case with and without banks, with a similar pattern as in the aggregate results presented in Table 2.

Regarding the labour income tax we observe that the main driving force of the aggregate results above is the labour income tax on patient households. A permanent increase of 1% in the labour income tax of patient households will constantly have a stronger negative impact to the economy compared to the same policy reform on the impatient households. An interesting result of the comparison of the cases with and without banks is that the labour income tax on impatient households has similar effects to the economy in both cases, but the negative effects are doubled in the case of the labour income tax on patient households under the no-banks case. Having a labour tax on patient households without banks is similar to having a reduction in the net worth of banks. As Iacoviello (2015) has shown, a reduction in the net worth of banks leads to a reduction in the supply of loans affecting output. Therefore, the negative spillover effects to the economy from an increase in the labour income tax of patient households are amplified under the no-banks case.

Finally, under the case of a permanent increase in the consumption tax we observe again that when this policy reform is focused on the patient households, the negative propagation effects to the economy are stronger compared to the policy reform being focused on the impatient households. When the increase in the consumption tax is focused on the entrepreneurs we observe very small negative effects to the economy and even smaller when banks are targeted. Comparing the cases with and without banks, we observe similar results with the labour income taxes. The policy reform targeted to patient households has stronger negative propagation effects to the economy

[18]Note that the inputs in the production function are: the stock of real estate of the entrepreneurs and the labour supply of patient and impatient households.

compared to the other agents that exhibit similar results across the two cases.

4.3 Welfare effects of fiscal policy reforms

In this section we report the welfare effects from the various policy reforms presented above using the consumption equivalence approach. Assuming that the welfare of each agent after the policy reform is given by W_J^{pr} and before the policy reform by W_J^0, then the consumption equivalent gain/loss of each agent from that reform is calculated as:

$$W_J^0\left(\lambda_j, C_j^0, H_j^0, N_j^0\right) = W_J^{pr}\left(C_j^{pr}, H_j^{pr}, N_j^{pr}\right) \tag{18}$$

$$\sum_{t=0}^{\infty}\beta_j^t U\left(\left(1+\lambda_j\right)C_j^0, H_j^0, N_j^0\right) = \sum_{t=0}^{\infty}\beta_j^t U\left(C_j^{pr}, H_j^{pr}, N_j^{pr}\right) \tag{19}$$

where λ_j is the consumption equivalent gain/loss of the policy reform.

Using the logarithmic utility function applied in our analysis we get the following expression for the consumption equivalent gain/loss:

$$\lambda_j = \exp\left(\left(W_J^{pr} - W_J^0\right)\frac{1}{\sum_{t=0}^{\infty}\beta_j^t}\right) - 1 \tag{20}$$

As a result, Tables 4 and 5 present the values of the consumption equivalent in percentage terms for each agent (in columns) and for each policy reform (in rows). We should note here that the steady state of our economy is different for the case with and without banks, similar to Iacoviello (2015). In particular, the capital requirement constraint of the banks is not present under the no-banks case and as a result there are no frictions in the transformation of savings to investment. This leads to higher levels of consumption, stock of real-estate and loans in the economy without banks. This needs to be taken into account when we perform the welfare analysis below and as a result it is not consistent to compare the values from Panel A to that from Panel B. We can only compare the outcome within each Panel.

Positive values indicate that the agent is better off under the policy reform and vice versa. Moreover, the values reported in Tables 4 and 5 are for $t \to \infty$.[19]

[19] We also have the results for intermediate periods but we do not present them here to save space. These results are available upon request.

Table 4: Welfare effects (% of consumption equivalent)

	Patient hh	Impatient hh	Entrepr.	Bank
	Panel A: With Banks			
G	-0.1175	-0.3422	-0.9852	-0.0526
τ^H	-0.0133	-0.0587	-0.1063	-0.9899
τ^W	-0.1916	-0.0416	0.6573	-0.2082
τ^C	-0.0142	0.0048	0.0424	-0.0177
	Panel B: Without Banks			
G	-0.0731	-0.3984	-1.1023	-
τ^H	-0.0144	-0.1079	-0.1942	-
τ^W	0.0645	-0.1984	0.4505	-
τ^C	-0.0375	-0.0876	0.1817	-

The results in Panel A and Panel B of Table 4 show that the welfare of every agent is decreasing under the case of higher government spending, with a more significant effect on the borrowers. The higher spending is financed via debt, which then affects negatively the transfers via the fiscal rules, causing a reduction in the disposable income. Agents that are borrowers, impatient households and entrepreneurs, rely more on their disposable income compared to patient households. Hence we observe larger negative welfare effects for them.

For the case of a higher real estate tax we observe similar reaction in the welfare of all agents in Panel A and B. It is noticeable though that the welfare decrease is larger for the borrowers when there are no banks. In Panel A banks are mostly affected in this case due to the decline in the real estate stock and as a result the borrowing constraints become stricter. These results are consistent with our earlier discussion and the case where the existence of banks mitigates the negative effects to the economy.

The welfare of both households is reduced under a higher labour income tax when banks are present, with higher decrease in the welfare of patient households. However, when banks are not present we observe a significant increase in the welfare of the patient households, whereas the borrowers are still better off because they are not subject to a labour tax and they receive higher transfers due to the income redistribution. However, the difference between the two households is amplified under the no-banks case, which means that patient households gain all the benefits from the income redistribution.

Regarding the consumption tax, under the case with banks patient households are negatively affected from the income redistribution via transfers, whereas impatient households and entrepreneurs are positively affected. Banks are negatively affected as expected since we have assumed that they do not receive any lump-sum transfers. However, in the case without banks, only

the entrepreneurs gain from the income redistribution via the higher consumption tax.

Table 5: Welfare effects (% of consumption equivalent)

	Patient hh	Impatient hh	Entrepr.	Bank
		Panel A: With Banks		
τ_P^H	-0.0240	-0.0229	-0.0219	-0.2821
τ_I^H	0.0089	-0.0386	0.0093	-0.1807
τ_E^H	-0.0017	-0.0013	-0.0851	-0.5832
τ_P^W	-0.2197	0.1789	0.4354	-0.0847
τ_I^W	0.0344	-0.2018	0.2267	-0.1231
τ_P^C	-0.0173	0.0162	0.0394	0.0022
τ_I^C	0.0024	-0.0137	0.0183	0.0010
τ_E^C	0.0007	0.0023	-0.0156	0.0003
τ_B^C	0.0001	0.0001	0.0003	-0.0212
		Panel B: Without Banks		
τ_P^H	-0.0221	-0.0450	-0.0386	-
τ_I^H	0.0085	-0.0434	0.0061	-
τ_E^H	-0.0035	-0.0248	-0.1360	-
τ_P^W	0.0453	0.0152	0.2328	-
τ_I^W	0.0199	-0.1938	0.2203	-
τ_P^C	-0.0189	0.0218	0.0485	-
τ_I^C	0.0013	-0.0131	0.0181	-
τ_E^C	0.0004	0.0025	-0.0155	-
τ_B^C	-	-	-	-

Table 5 illustrates how fiscal policy reforms on individual taxes affect the welfare of each agent in the economy. In most of the cases we observe that the agent for which we have a higher tax due to the assumed policy reform is worse off, whereas the remaining agents receive the benefits from the income redistribution. An exception to that rule is the case of the higher real estate tax on patient households. In this case every agent is worse off. On the one hand, for the case with banks, patient households provide the liquidity to banks via their deposits, thus the tax will decrease their disposable income and deposits, as a consequence, leading to lower supply of loans from banks. On the other hand, for the case without banks, patient households are the loan providers and they get a lower net worth due to the tax, leading again to lower supply of loans.

Similar results are observed for the case of the housing tax on entrepreneurs, but here the driving force is different. The economy overall is directly affected from this tax because the stock of real estate of the entrepreneurs is part of the production process.

A final remark of the results presented in Table 5 is for the case of the labour income tax on patient households and for the case without banks. In this case we observe that every agent is better off in the long-run, even patient households that are subject to that tax. This result is driven from the fact that patient households decrease their labour supply, due to the tax, and also increase their stock of real estate, due to its lower value, leading to higher welfare in the long run.

5 Robustness checks

In this section we assess the spillover effects to the economy from the fiscal policy reforms under several assumptions around the imposed financial constraints. The ultimate aim of this analysis is to assess how the change in the financial frictions can affect the transmission of the shocks to the economy. Thus, Table 6 presents the results in terms of percentage change in output from the benchmark steady-state. These results can then be directly compared to the last column of Tables 2 and 3 and for the case with banks, to assess whether the imposed structural changes assumed in this section can boost the economy

Under the first experiment we assume that bank's adequacy of capital is lower, $\rho_B^{new} = 0.5\rho_B$ (first column in Table 6). In this case we do not observe significant changes compared to our benchmark calibration.

Then we assess the case where bank's liabilities to asset ratio is reduced, $\gamma^{new} = 0.75\gamma$, which means that banks face a stricter screening process for giving out their loans (second column in Table 6). In this case the significant change appears to be on the spillover effect of housing tax to output which becomes positive. As we can see from Panel B, this result is driven from the higher positive effects of a higher housing tax on patient households and the decline in the negative effect from the housing tax on entrepreneurs. However, we should note that still the overall effect on the economy is very small.

Another experiment we perform is through the borrowing constraints of the impatient households and entrepreneurs. In particular, we assume that they are more restricted in terms of the loans they can obtain given their collateral, $m_I^{new} = 0.75m_I$ (third column in Table 6) and $m_{EH}^{new} = 0.75m_{EH}$ (fourth column in Table 6). In both cases, we observe only minor changes compared to the benchmark calibration coming from the higher positive spillover effects to the economy from the increased government spending and housing tax.

Finally, we assess the impact of a direct transfer to banks from the gov-

ernment of a size similar to the quantitative easing that took place in the US. For that reason we assume that banks receive a transfer of about 5% of the overall output in the economy (last column in Table 6). Interestingly in this case we do not observe any significant improvement to the economy apart from the minor improvement in the negative effects from the higher labour income tax. However, we should note that our results in this case are biased because we only provide transfers to banks without any other changes in the assumed financial frictions.

Overall, we conclude from these experiments that our results from the benchmark calibration are robust to changes in various parameters of the imposed financial constraints.

Table 6: Effects on output as a % deviation from the steady-state

	$0.5\rho_B$	0.75γ	$0.75m_I$	$0.75m_{EH}$	$tr_B = y \times 5\%$
	Panel A: With Banks and aggregate policy reforms				
G	0.1367	0.1359	0.1378	0.1364	0.1371
τ^H	-0.0003	0.0021	0.0028	-0.0004	-0.0005
τ^W	-0.1009	-0.0997	-0.0994	-0.1001	-0.0975
τ^C	-0.0092	-0.0092	-0.0093	-0.0092	-0.0096
	Panel B: Effects from agent specific tax reforms				
τ_P^H	0.0122	0.0137	0.0134	0.0124	0.0121
τ_I^H	0.0020	0.0011	0.0022	0.0016	0.0019
τ_E^H	-0.0145	-0.0126	-0.0129	-0.0143	-0.0145
τ_P^W	-0.0687	-0.0675	-0.0676	-0.0682	-0.0676
τ_I^W	-0.0322	-0.0323	-0.0318	-0.0327	-0.0299
τ_P^C	-0.0057	-0.0057	-0.0057	-0.0057	-0.0057
τ_I^C	-0.0027	-0.0026	-0.0026	-0.0027	-0.0026
τ_E^C	-0.0008	-0.0008	-0.0009	-0.0008	-0.0007
τ_B^C	$-0.5e^{-4}$	$-0.8e^{-4}$	$-0.1e^{-4}$	$-0.4e^{-4}$	-0.0007

6 Conclusions

In this paper we introduced a fiscal sector in a real business cycle model with banks, heterogeneous households, entrepreneurs and financial frictions, and we found that the existence of banks can mitigate the negative spillover effects to the economy from higher taxes under various fiscal policy reforms.

Moreover, we found that housing taxes had a negative spillover effect to the economy in the short-run but in the long-run became positive if they were welfare enhancing. In addition, higher housing taxes and government spending affected mostly borrowers'welfare, whereas a higher consumption

tax was beneficial for impatient households when banks were present. Entrepreneurs were better off following an increase in the consumption tax due to the income redistribution via trasnfers.

In addition, we found that a higher real estate tax on patient households and entrepreneurs was the least preferefarble in terms of welfare for every agent. Shocks that decreased the net worth of loan suppliers amplified the negative spillover effects to the economy. Finally, we found that our main results were robust in changes to the calibration of the financial constraints.

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Appendix A: FOCs for patient, impatient households, entrepreneurs and banks

Patient households

The first-order conditions of patient households with respect to their choice variables are:

FOC for labour:

$$\frac{U_{C_P}(t)}{\left(1+\tau_{P,t}^{C}\right)}\left(1-\tau_{P,t}^{W}\right)W_{P,t}+U_{N_P}(t)=0 \tag{A1}$$

shows that patient households want to equate the after-tax returns from labour to the marginal rate of substitution between consumption and labour.

FOC for deposits:

$$\beta_P E_t\{\frac{U_{C_P}(t+1)}{\left(1+\tau_{P,t+1}^{C}\right)}R_{P,t}\}-\frac{U_{C_P}(t)}{\left(1+\tau_{P,t}^{C}\right)}=0 \tag{A2}$$

shows that patient households want to equate the interest income from deposits to the marginal cost of forgone consumption from higher deposits.

FOC for housing demand:

$$\beta_P E_t\{\frac{U_{C_P}(t+1)}{\left(1+\tau_{P,t+1}^{C}\right)}\left(1-\tau_{P,t}^{H}\right)q_{t+1}\}+U_{H_P}(t)-q_t\frac{U_{C_P}(t)}{\left(1+\tau_{P,t}^{C}\right)}=0 \tag{A3}$$

shows that patient households want to equate the expected after-tax return from housing to the marginal utility gain from the additional housing and the marginal cost of obtaining a higher stock of housing.

FOC for bonds:

$$\beta_P E_t\{\frac{U_{C_P}(t+1)}{\left(1+\tau_{P,t+1}^{C}\right)}R_{B,t}\}-\frac{U_{C_P}(t)}{\left(1+\tau_{P,t}^{C}\right)}=0 \tag{A4}$$

where $U_{C_P}(t)=\frac{1}{C_{P,t}}$, $U_{N_P}(t)=-\frac{\eta}{1-N_{P,t}}$ and $U_{H_P}(t)=\frac{j}{H_{P,t}}$.

Similarly to deposits, the first order condition for bonds shows that patient households want to equate the interest income from bonds to the marginal cost of forgone consumption from higher bond holdings.

Impatient households

FOC for labour:

$$\frac{U_{C_I}(t)}{\left(1+\tau^C_{I,t}\right)}\left(1-\tau^W_{I,t}\right)W_{I,t}+U_{N_I}(t)=0 \tag{A5}$$

similarly to patient households, it shows that impatient households want to equate the after-tax returns from labour to the marginal rate of substitution between consumption and labour.

FOC for housing demand:

$$\begin{aligned}0=\beta_I E_t\{\frac{U_{C_I}(t+1)}{\left(1+\tau^C_{I,t+1}\right)}\left(1-\tau^H_{I,t}\right)q_{t+1}\}+U_{H_I}(t)-q_t\frac{U_{C_I}(t)}{\left(1+\tau^C_{I,t}\right)}+ \\ +\lambda_{I,t}(1-\rho_I)m_I\left(1-\tau^H_{I,t}\right)E_t\{\frac{q_{t+1}}{R_{I,t}}\}\frac{U_{C_I}(t)}{\left(1+\tau^C_{I,t}\right)}\end{aligned} \tag{A6}$$

shows that impatient households want to equate the expected after-tax return from housing to the marginal utility gain from the additional housing and the marginal cost of obtaining a higher stock of housing. The additional term $\lambda_{I,t}$ measures the credit constraint faced by the impatient households and introduces an intertemporal wedge to the housing demand.

FOC for loans:

$$\beta_I E_t\{(R_{I,t}-\rho_I\lambda_{I,t+1})\frac{U_{C_I}(t+1)}{\left(1+\tau^C_{I,t+1}\right)}\}=(1-\lambda_{I,t})\frac{U_{C_I}(t)}{\left(1+\tau^C_{I,t}\right)} \tag{A7}$$

where $U_{C_I}(t)=\frac{1}{C_{I,t}}$, $U_{N_I}(t)=-\frac{\eta}{1-N_{I,t}}$ and $U_{H_I}(t)=\frac{j}{H_{I,t}}$.

The first order condition for loans shows that impatient households want to equate the interest payment on loans and the marginal cost of future forgone consumption to the marginal gain of current consumption. The lagrange multiplier associated with the borrowing constraint of the impatient households, $\lambda_{I,t}$, introduces an intertemporal wedge again to loans demand as in the first order condition for housing demand.

Banks

FOC for deposits:

$$(1-\lambda_{B,t})\frac{U_{C_B}(t)}{\left(1+\tau^C_{B,t}\right)}=\beta_B E_t\{(R_{P,t}-\rho_B\lambda_{B,t+1})\frac{U_{C_B}(t+1)}{\left(1+\tau^C_{B,t+1}\right)}\} \tag{A8}$$

shows that banks want to equate the pay-off from an additional consumption today due to higher deposits to the cost of paying back the interest on deposits and the marginal cost of lower future consumption. $\lambda_{B,t}$ measures the credit constraint faced by banks and introduces an intertemporal wedge to the demand for deposits.

FOC for loans to impatient households:

$$\begin{aligned}&(1-(\gamma(1-\rho_B)+\rho_B)-\lambda_{B,t})\frac{U_{C_B}(t)}{\left(1+\tau^C_{B,t}\right)}\\&=\beta_B E_t\{(R_{I,t}-\rho_B\lambda_{B,t+1})\frac{U_{C_B}(t+1)}{\left(1+\tau^C_{B,t+1}\right)}\}\end{aligned} \tag{A9}$$

FOC for loans to entrepreneurs:

$$\begin{aligned}&(1-(\gamma(1-\rho_B)+\rho_B)-\lambda_{B,t})\frac{U_{C_B}(t)}{\left(1+\tau^C_{B,t}\right)}\\&=\beta_B E_t\{(R_{E,t+1}-\rho_B\lambda_{B,t+1})\frac{U_{C_B}(t+1)}{\left(1+\tau^C_{B,t+1}\right)}\}\end{aligned} \tag{A10}$$

where $U_{C_B}(t)=\frac{1}{C_{B,t}}$ and the variable $\lambda_{B,t}$ is the lagrange multiplier associated with the borrowing constraint.

In both conditions above banks want to equate the additional consumption today via lower loans to the marginal utility cost of tighter borrowing constraint. $\lambda_{B,t}$ measures the credit constraint faced by banks and introduces again an intertemporal wedge to the supply of loans.

Entrepreneurs

FOC for loans:

$$(1-\lambda_{E,t})\frac{U_{C_E}(t)}{\left(1+\tau^C_{E,t}\right)}=\beta_E E_t\{(R_{E,t}-\rho_E\lambda_{E,t+1})\frac{U_{C_E}(t+1)}{\left(1+\tau^C_{E,t+1}\right)}\} \tag{A11}$$

The first order condition for loans shows that entrepreneurs the interest payment on loans and the marginal cost of future forgone consumption to the marginal gain of current consumption. The lagrange multiplier associated with the borrowing constraint of the entrepreneurs, $\lambda_{E,t}$, introduces an intertemporal wedge again to the demand for loans.

FOC for real estate:

$$\begin{aligned}&(q_t - \lambda_{E,t}\left(1-\rho_E\right) m_{EH} E_t\{\left(1-\tau^H_{E,t}\right)\frac{q_{t+1}}{R_{E,t+1}}\})\frac{U_{C_E}\left(t\right)}{\left(1+\tau^C_{E,t}\right)}\\&= \beta_E E_t\{q_{t+1}(1+R_{V,t+1})\frac{U_{C_E}\left(t+1\right)}{\left(1+\tau^C_{E,t+1}\right)}\}\end{aligned} \tag{A12}$$

where $U_{C_E}\left(t\right) = \frac{1}{C_{E,t}}$ and the variable $\lambda_{E,t}$ is the lagrange multiplier associated with the borrowing constraint.

The condition above shows that entrepreneurs equate the expected after-tax return from real estate to the marginal cost of obtaining a higher stock of real estate. The additional term $\lambda_{E,t}$ measures the credit constraint faced by the entrepreneurs and introduces an intertemporal wedge to their real estate demand.

Additionally, we combine the above conditions with the following standard first order conditions of the production process were marginal return equals marginal cost of the factors taking into account the credit constraint of the entrepreneur:

$$\nu Y_t = R_{v,t} q_t H_{E,t-1} \tag{A13}$$

$$(1-\nu)(1-\sigma)\frac{Y_t}{N_{P,t}} = W_{P,t}\left(1+\left(1-\rho_E\right) m_{EN}\lambda_{E,t}\right) \tag{A14}$$

$$(1-\nu)\sigma\frac{Y_t}{N_{I,t}} = W_{I,t}\left(1+\left(1-\rho_E\right) m_{EN}\lambda_{E,t}\right) \tag{A15}$$

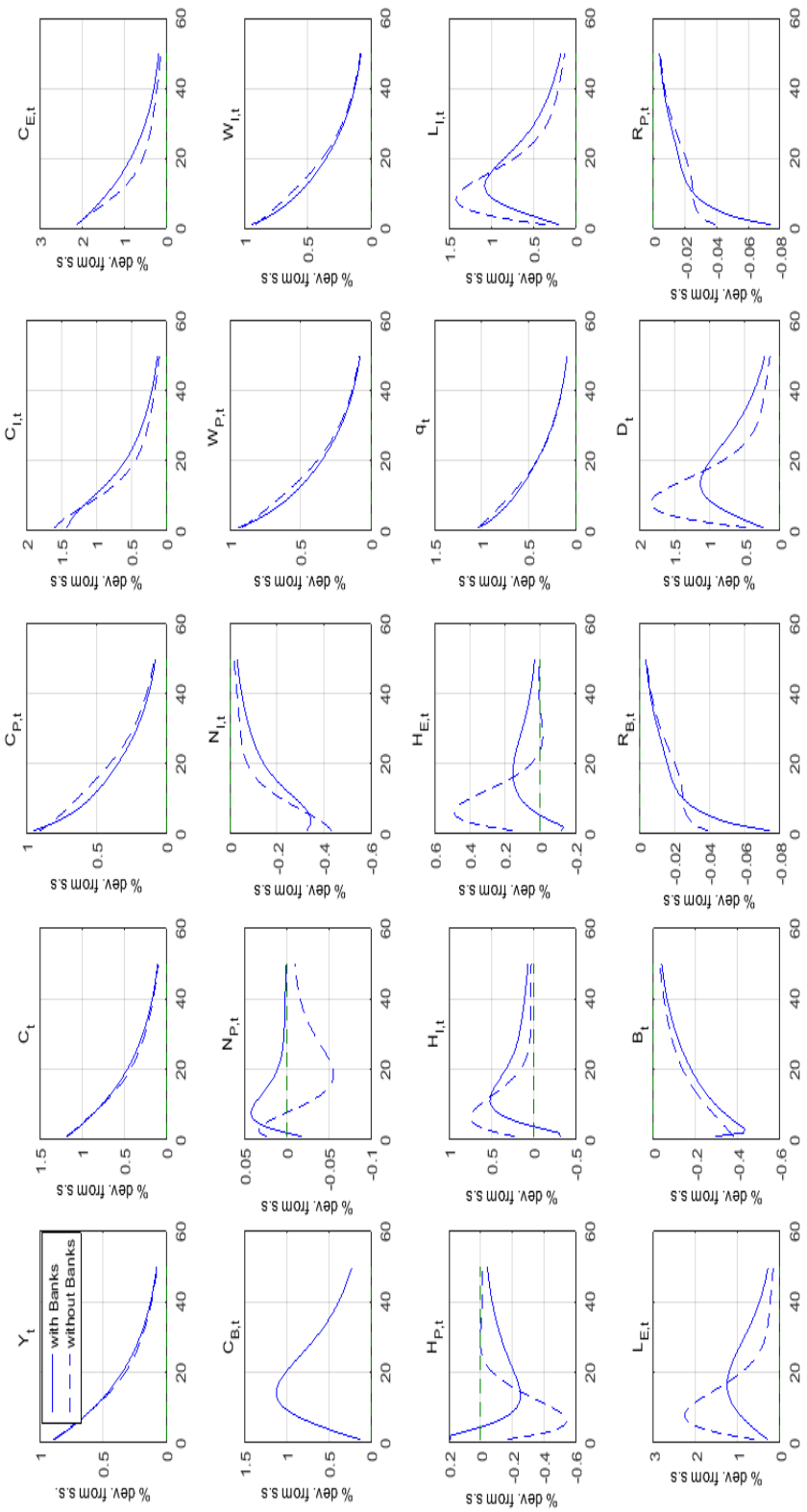

Figure 1: IRs after a 1 percent temporary increase in TFP

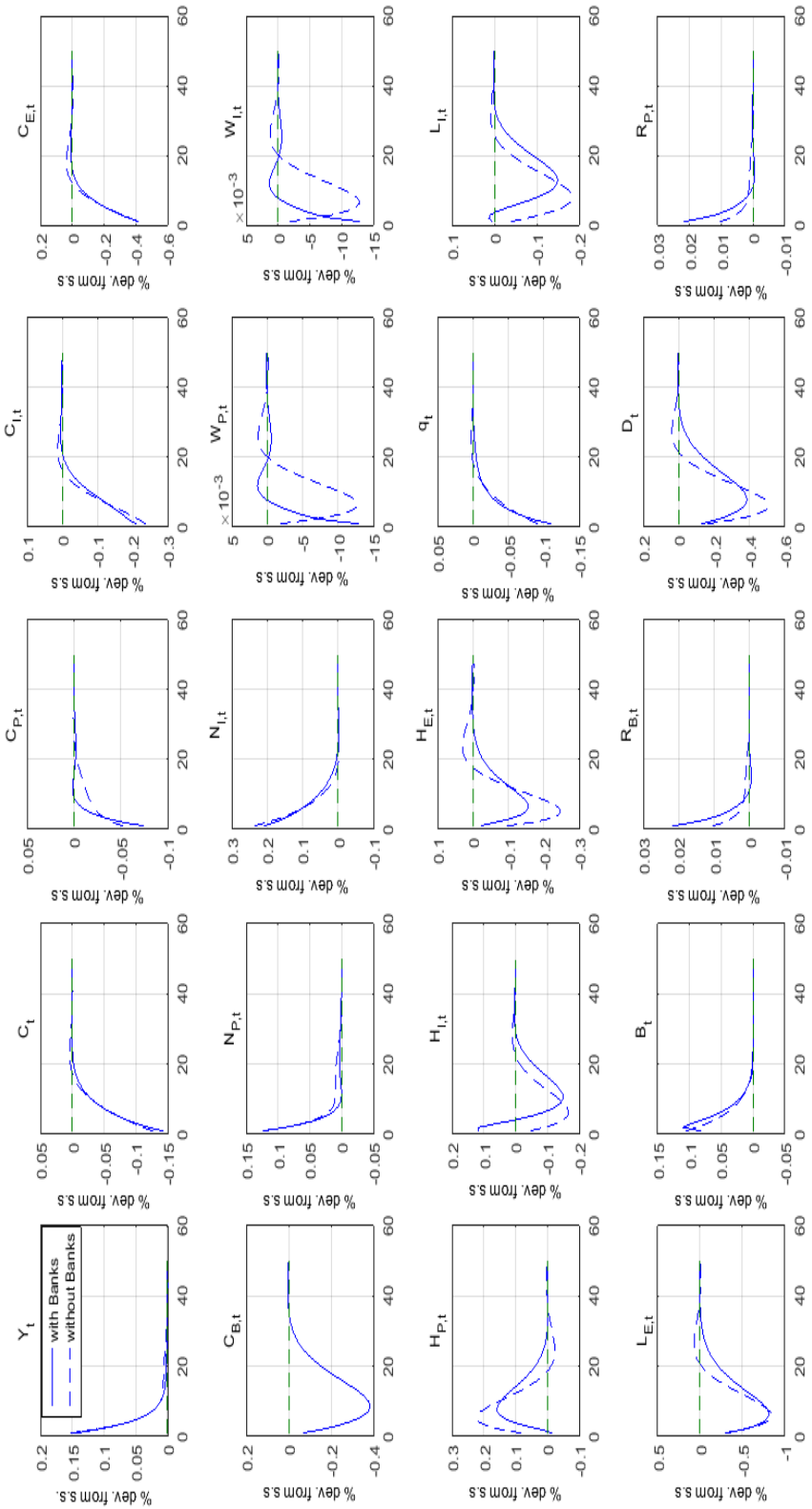

Figure 2: IRs after a 1 percent temporary increase in government spending