Make it in America? Business Subsidies and Employment in the Great Recession*

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Abstract

There is evidence that housing prices have played a major role in recent US business cycle episodes. The conventional wisdom is that housing prices matter because housing can be used as a collateral and a higher value of collateral relaxes financial constraints thereby promoting consumption, investment and overall aggregate activity. But the price of housing, which private agents take as given, is affected by the aggregate level of income and employment. So employment is inefficiently low which justifies subsidizing job creation. In this paper we study the properties of optimal subsidies. We estimate a DSGE version of our model, which exploits time variation across US states over the Great Recession, and evaluate the effects of 'Make it in America' government policies aimed at subsidizing businesses in certain states to promote job creation in the US economy. We compare these effects with those that would arise under the optimal policy.

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1 Motivation

In recessions there is often demand to support economic activity and promote aggregate employment. But the motivation for these interventions is somewhat unclear. In this paper we show that subsidizing business activity is welfare improving in financially driven recessions and we study the properties of optimal business subsidies.

We also construct a unique data set collecting information on business subsidies granted by state governments since the 2000's. We document that over the US Great Recession the incidence of business subsidies has increased substantially (especially in certain states such as Michigan). These subsidies have been particularly generous to the manufacturing sector. This is why these policies are sometimes referred to as 'Make it in America' policies. We use these data to evaluate whether business subsidies were welfare improving and how do they compare with optimal subsidies.

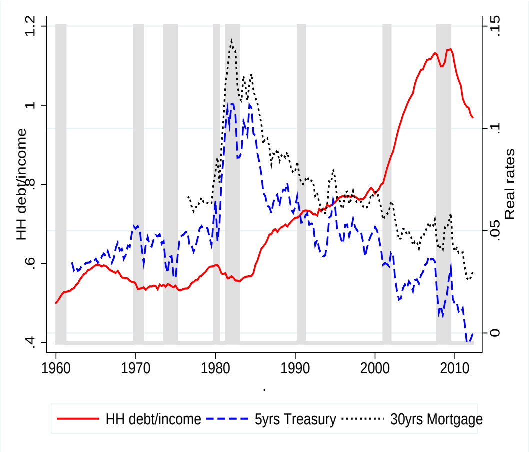
Our explanation is motivated by the following facts:

1. *Asset prices matter for economic activity.* Housing prices have played a major role in recent US recessions. Midrigan and Philippon (2011), Mian and Sufi (2011), Chaney, Sraer, and Thesmar (2012) and Liu, Wang, and Zha (2013) provide evidence that housing prices play an important role in relaxing households financial constraints and in promoting greater levels of consumption, investment, and output.

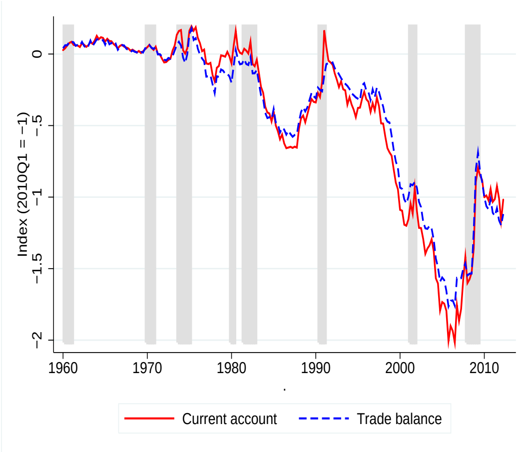
2. *Aggregate debt has played a major role in the great recession.* There is evidence that household debt has increased in recent years and that the US economy has undergone a substantial deleveraging in the current recession. Mian and Sufi (2012) and Mian, Rao, and Sufi (2013) provide direct evidence that the dramatic household deleveraging has led to falls in consumption and aggregate demand, which in turn contributed substantially to the low employment levels observed in the Great Recession. Panel (a) of Figure 1 documents the pronounced increase in household leverage previous to the recession and the sharp contraction of debt during the recovery. Panel (b) documents the reversal of the current account in the US. In this sense the US has experienced a "sudden stop" episode similar to those experienced by typical emerging economies. Panel (c) and (d) of Figure 1 document the strong link across US states between household debt previous to the recession and the changes in housing prices and employment during the great recession.

3. *House prices and the amount of de-leveraging are related to the level of economic activity.* There is evidence that housing prices are strongly related to the amount of economic activity and negatively to the amount of debt deleveraging. In general house prices are strongly positively related to the difference between the real level of Gross National Product (GNP) and the current account balance (CA). The present value of $X_t \equiv GNP_t - CA_t$ will be the key pricing factor of housing in our model. We calculate the correlation between the log change in house prices q_t and the log change in the value of $X_t \equiv GNP_t - CA_t$. We refer to X_t as the house pricing factor. Nominal quantities are converted into real by using the

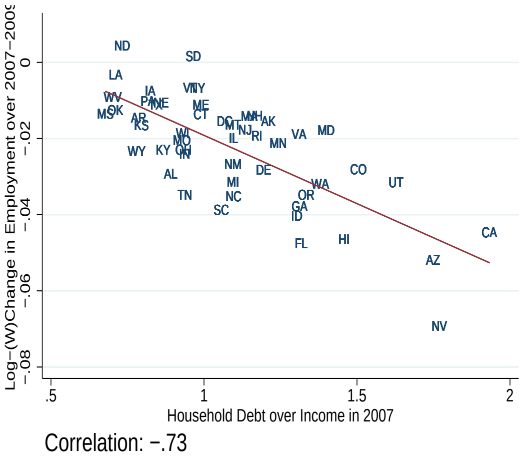
Figure 1: Household debt, employment, and asset prices



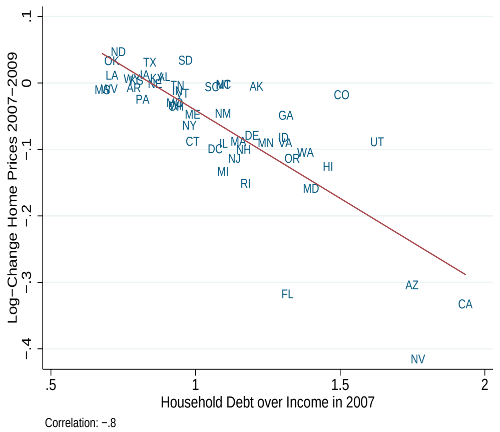
(a) Household debt and interest rates



(b) Net export and current account



(c) Employment and debt



(d) Asset prices and debt

CPI index. To measure house prices we consider three alternative measures. We use either the Case-Shiller price index, the FHFA index or the CoreLogic price index, which correspond to the three different columns in Table 1. To measure the contribution of $X_t \equiv GNP_t - CA_t$ to the fluctuations in q_t we use either its value at t (row one), $X_t + 0.96X_{t+1}$ (row two) or $X_t + 0.96X_{t+1} + 0.96^2X_{t+3}$ (row three). Data are yearly. Overall there is a very strong positive comovement between housing prices and our pricing factor X_t. The correlation is around 90% over the period 2000-2012. Figure 2 shows the strong positive comovement between the pricing factor X_t and the price of housing at the yearly frequency. Each row corresponds to a different price index. Each column refers to each of the three alternative ways of measuring the contribution of the pricing factor X_t to fluctuations in housing prices.

Table 1: Correlations between log-changes of house price and pricing factor X_t (2000-2102)

Correlation with	Case-Shiller	FHFA	CoreLogic
$(X_t \equiv GNP_t - CA_t)$			
$\Delta \ln (X_t)$	0.80	0.85	0.82
$\Delta \ln (X_t + 0.96X_{t+1})$	0.93	0.94	0.93
$\Delta \ln (X_t + 0.96X_{t+1} + 0.96^2X_{t+3})$	0.82	0.84	0.85

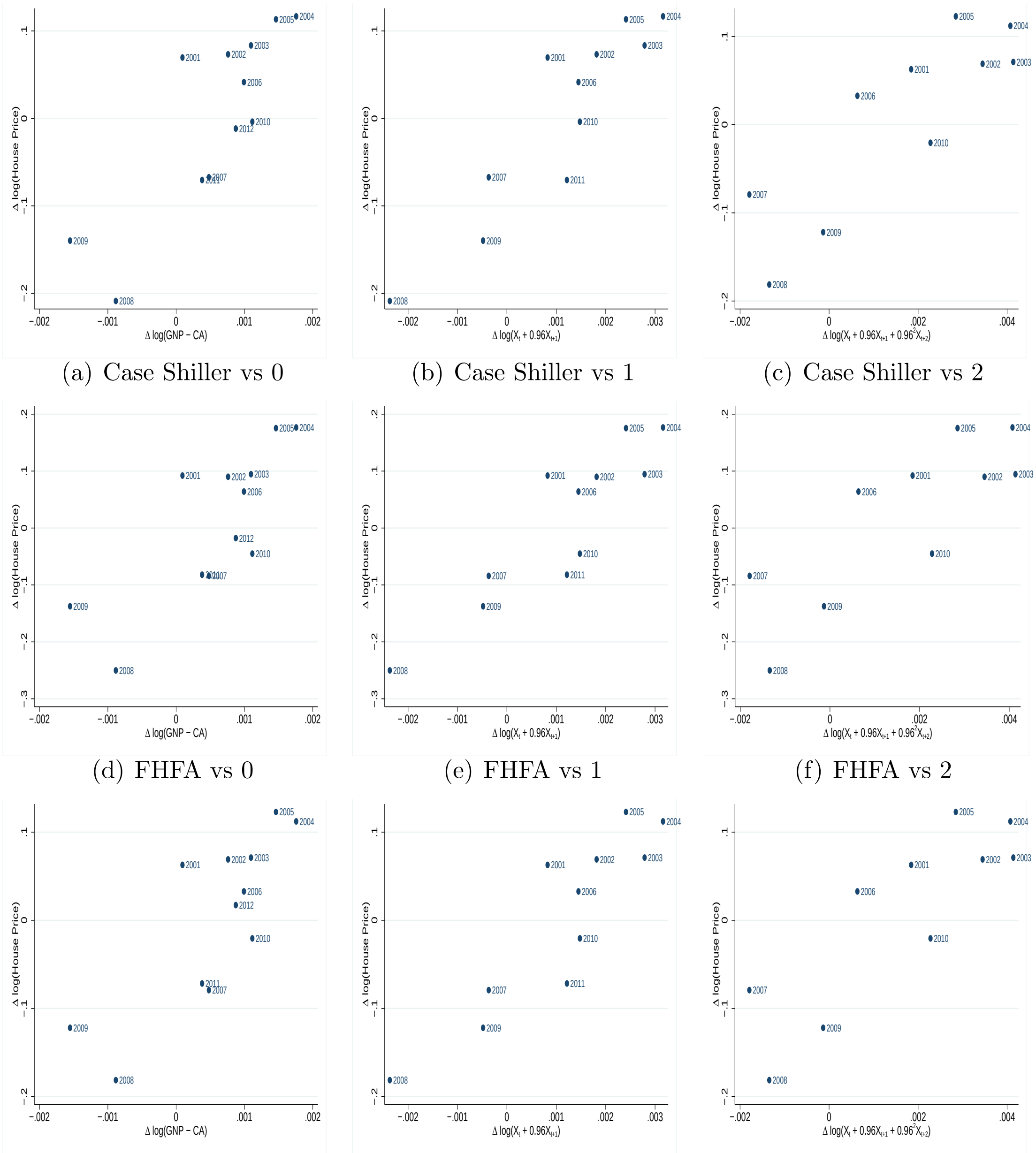
Note: All changes are annual. $X_t \equiv GNP_t - CA_t$

4. *Sharp increase in the amount of business subsidies* Over the current US Great recession, there has been a grand plan to subsidize jobs by the US administration. Using a unique new data set we document an increase in the incidence of business subsidies, see panel (a) and (b) in Figure 3.

We show that in recessions in which households are financially constrained, there is a price externality that justifies subsidizing aggregate employment. The logic is that (i) aggregate employment and output affect the value of all non-tradable assets (real estate and capital) as Fact 3 suggests; (ii) higher households' wealth relaxes households' financial constraint, which helps in sustaining aggregate demand, investment, and job creation (Fact 2) and (iii) private firms take prices as given, so they do not fully internalize the benefits of promoting aggregate employment—which is as in Lorenzoni (2008). This mechanism plays a key role in (severe) recessions and in recoveries, where households are forced to deleverage due to a binding financial constraint, as Fact 1 suggests.

Given this logic there is a rationale for subsidizing businesses and promote aggregate employment. We study the feature of optimal subsidies. We quantify the effects of Make it in America policies and compare effects with those that would have arisen under the optimal subsidy. We evaluate policies to promote employment by estimating a DSGE model with US state panel variation. In our model interventions should be temporary and only when households are financially constrained.

Figure 2: Changes in house prices, q_t and changes in pricing factor $X_t \equiv GNP_t - CA_t$ (Case-Shiller index in first row, FHFA in second row, Corelogic in third row)



(a) Case Shiller vs 0 (b) Case Shiller vs 1 (c) Case Shiller vs 2

(d) FHFA vs 0 (e) FHFA vs 1 (f) FHFA vs 2

(g) CoreLogic vs 0 (h) CoreLogic vs 1 (i) CoreLogic vs 2

Section 2 provides some evidence supporting the importance of our mechanism. Section 3 describes the economy. Section 4 characterizes the properties of business subsidies when the government can commit. Section 5 studies the problem under lack of commitment. Section 6 writes all government problems using the saddle-path representation by Marcet and Marimon (2014), which is needed to solve the government problem at the computer. Section 7 compares the effects of business subsidies with those achieved under alternative government interventions. Section 8 concludes our mechanism.

2 Motivating evidence: Panel VAR

We are interested in analyzing the effects of business subsidies on economic activity, housing prices and households debt. There are at least three issues in identifying the effects of business subsidies: (*i*) there are no official data on business subsidies; (*ii*) business subsidies tend to increase in recessions which leads to reverse causality and endogeneity problems; (*iii*) the effects of business subsidies should be disentangled from those of other expansionary government policies.

To address these issues we construct a new data set which proxies the overall level of business subsidies granted by US states governments over the 2000-2011 period. Shocks to business subsidies are identified using a combination of zero and sign restrictions in a VAR model, as in Mountford and Uhlig (2009) and Rubio-Ramírez, Waggoner, and Zha (2010), who extend the virtues of the pure sign restriction approach developed by Faust (1998), Canova and DeNicoló (2009), and Uhlig (2005). Roughly speaking business subsidies are identified by imposing the restriction that they positively affect employment and that are financed under a balanced government budget—which is always the case in the theoretical analysis of the next section. We are completely agnostic about the response of other macroeconomic variables such as house prices and household debt.

Business subsidy data come from "Subsidy tracker", a data set collected by "Good Jobs First", a non-profit non-partisan national policy resource center founded in 1998 and funded by Ford, Surdna and other major philanthropic foundations. Subsidies are granted from state governments. So federal government subsidies not channeled through state governments are excluded from the data set. Firm subsidies can take many forms: cash grants, tax abatements (property tax abatements, sales tax exemptions, inventory tax abatements, tax credits, employment tax credits), cheap loans, infrastructure assistance, land-price write-downs. There are no official data on business subsidies.[1]

Subsidies are measured at the plant level, so a multi-plant firm can receive several deals from different states. Data are annual and subsidies are attributed to the fiscal year when the deal is signed and the grant is formally awarded. The sample period is 2000-2011 and the sample consists of 137.468 observations with non missing subsidy values. In each year we aggregate the value of subsidies at the state level and convert this value into real terms using the CPI index. The resulting measure is scaled down by the population in the state. See the Data appendix for further details on the construction of the data.

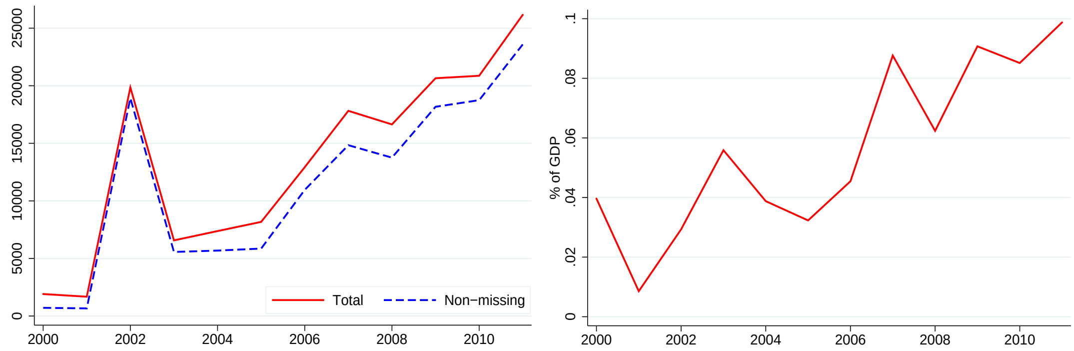
Since data are likely to miss several business subsidies granted by a state in a year, our measure is just a proxy for the overall level of subsidies in the year granted by the state. Our identification strategy just requires that the subsidy measure approximates well the time evolution of subsidies in the state. Given the underreporting of subsidies, the value of the measure has no fundamental meaning. For each state and year we also use data for employment per capita, real household debt per capita, real house prices, and real government debt per capita. All variables are annual, they are expressed in logs and converted into real using the CPI index.

[1]BEA publishes data on production subsidies "amounts payable to business per unit of good or service produced". This is a rather restrictive measure of subsidy.

See Appendix for further details.

Over the current US Great recession, there has been a grand plan to subsidize jobs by the US administration. This is reflected in the time evolution of our proxy which, as documented in Figure 3, exhibits a sharp increase in the incidence (panel (a)) and value (panel (b)) of business subsidies.

Figure 3: Business subsidies in the US (2000-2011)



(a) Number of subsidy deals (b) Value of subsidies over US GDP

Business subsidies were somewhat larger in US states hit harder by the crisis. This is the reverse causality problem discussed above. But business subsidies were sometimes granted for reasons other than countercyclical stabilization policies.[2] This is the source of variation which allows us to identify the macroeconomic effects of business subsidies in our data.

To tackle reverse causality problems we impose structural restrictions in a Panel VAR model. This allows us to exploit cross-sectional variation to identify business subsidy shocks even in the presence of a relatively short time series dimension (11 years). Panel VARs have recently been used by Canova and Pappa (2007) and Calza, Monacelli, and Stracca (2012), see Canova and Ciccarelli (2013) for a survey. Panel VARs have the same structure as VAR models, in the sense that all variables are assumed to be endogenous and interdependent, but a cross sectional dimension is added to the representation. Let

$$y_{it} = \Delta \begin{bmatrix} \ln s_{it} \\ \ln d_{it} \\ \ln e_{it} \\ \ln q_{it} \\ \ln b_{it} \end{bmatrix}$$

[2]This is for example the case of Louisiana, where business subsidies were high over the current recession, despite the fact that the recession was relatively mild compared to other US states. The high value of subsidies in Louisiana was due to important deals granted by the state of Louisiana to Cheniere Energy, IBM and Shintech PVC. The Chenier Energy deal was particularly generous (of the order of 1.69 billion dollar in 2010). The deal was signed to subsidize the Sabine Pass natural gas liquefaction plan and it was unrelated to the macroeconomic conditions of the Louisiana state.

denote the vector of $G = 5$ stationary variables for each state $i = 1....N$ and year $t = 1.....T$. Here s_{it} denotes our proxy for the level of real subsidy per capita in state i at time t, d_{it} is government debt per capita, e_{it} is employment per capita, q_{it} is the relative price of housing, while b_{it} is real household debt per capita. Δ is the first difference operator, which applies to all variables in the vector.

We consider all US states but Hawaii and the District of Columbia, so we have $N = 49$. We checked that results do not change by including them in the analysis. Since our data are annual and cover the period 2001-2011 we have $T = 11$. Our panel VAR is

$$y_{it} = \gamma(i) + \tau(t) + B(L)y_{it-1} + u_{it} \qquad \forall i, t \tag{1}$$

where $\gamma(i)$ is a $G \times 1$ vector of state fixed effects characterizing the (possibly) G state specific trends of the endogenous variables in y_{it}, while $\tau(t)$ is a $G \times 1$ vector of time dummies—common across all states in the panel— which accounts for aggregate shocks in the US economy as well as for spill-overs of state specific shocks to the rest of the US economy. Finally $B(L)$ is a polynomial in the lag operator. In our baseline specification $B(L)$ is a polynomial of degree zero in the lag operator L, that is, we work with a VAR(1). Results are virtually unchanged when allowing estimating a VAR(2) rather than a VAR(1). The vector u_{it} is a $G \times 1$ vector of reduced form state specific Wold innovations, with variance $\Sigma_t = E(u_{it}u_{it}^{'})$, which in principle could vary over time.[3] The vector of reduced form shocks is a linear combination of structural shocks ϵ_{it} so that

$$V_t \epsilon_{it} = u_{it}$$

Notice that in principle we allow the matrix V_t to vary over time. We normalize structural shocks so that they have a unit variance, $I = E(\epsilon_{it}\epsilon_{it}^{'})$. This implies the restriction that $V_t V_t' = \Sigma_t$. After purging the vector of y_{it} for state specific trends as well as for aggregate shocks and/or across states spill-overs we have that

$$\widetilde{y}_{it} \equiv y_{it} - \gamma(i) - \tau(t) = [I - B(L)]^{-1} V_t \epsilon_{it}$$

which fully characterizes the impulse responses of the detrended variables $\widetilde{y}_{it}$ to structural shocks ϵ_{it}.

Since the time dimension of the panel is relatively short, we estimate the matrices in $B(L)$ and the Variance and Covariance Matrices Σ_t of the panel regression model in (1), using the difference GMM panel data estimator by Arellano and Bond (1991) and extended in Arellano and Bover (1995) and Blundell and Bond (1998). This estimator yields consistent estimates even when T is small and, as shown by Alvarez and Arellano (2003), has small efficiency asymptotic losses with respect to the Full Information Maximum Likelihood estimator of the panel model with random state specific effects.

We start focusing on the fully pooled specification where $V_t = V$ and $\Sigma_t = \Sigma$ $\forall t$. We are interested in identifying the specific column of V (say the first), which characterizes the impact effects of an unexpected change in the level of business

[3] In principle this variance could also vary across states. Here we just focus on estimating the average effects of subsidies in US states and we do not exploit the variation of these effects across US states.

subsidies. We use a combination of sign and zero restrictions to identify the effects of this business subsidy shock. In particular we require that (i) the business subsidy has some effect on employment and (ii) it is not financed through government debt:

1. *Business subsidy effectiveness.* The business subsidy shock increases employment on impact and in the following two years. This amounts to impose a positive sign restriction between the impulse response of the level of employment in the state and our proxy for the value of business subsidies.

2. *Government balanced budget restriction.* Business subsidies are financed under a balanced government budget. We impose this restriction by requiring that state government debt varies neither on impact nor in the long run.

Notice that all restrictions are imposed on the level of variables. The sign restriction is imposed not only on impact but also on the two following years, since in our data business subsidies are assigned to the fiscal year when the government subsidy is approved and in practice all subsidy deals involve transfers from the government to the subsidized firm for several years (typically between two and five years).[4] The government balanced budget restriction allows us to separately identify the effects of business subsidies shocks from those of other expansionary fiscal interventions by the local and state governments.

Our implementation of the zero and sign restriction is based on the algorithm developed by Rubio-Ramírez, Waggoner, and Zha (2010) as extended by Arias, Rubio-Ramírez, and Waggoner (2014). The results are based on 500 draws from the posterior distribution of the reduced form parameters $B(L)$ and Σ with 2000 rotations each, which is similar to Kilian and Murphy (2012).[5]

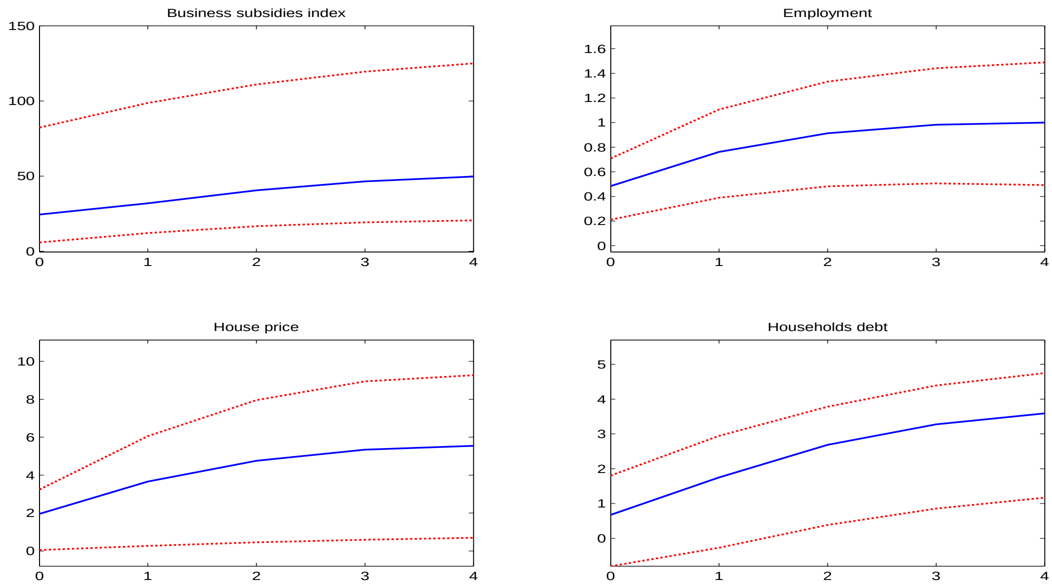
The impulse responses to a business subsidy shock for the full sample are plotted in Figure 4. As common in the literature since Sims and Zha (1999) we plot, as red dotted lines, 68% confidence intervals. To save space we do not report the response of the state government debt, which is always not significant and close to zero, see Figure 6 in Appendix. This follows from our identification restriction. We plot the responses on impact and in the following four years after the shock. The long-run response of employment is normalized to 1 percent. So the impulse responses in the second row measure the elasticities of house prices and household debt to an employment increase driven by business subsidies. An increase of 1 percent in employment roughly leads to a 7 per cent increase in house prices and an increase of 4 percent in household debt. This is evidence in favor of the key externality of the paper.

We are also interested in checking whether the effects of business subsidy shocks have changed over time, and in particular whether the elasticity of household debt to house prices has increased during the Great Recession period, which is when households are expected to be more financially constrained. To test for this hypothesis we allow the matrix V_t and Σ_t to be different in the pre-recession period (2001-2006),$V_{t<07}$ and $\Sigma_{t<07}$, and in the post-recession period (2007-2011) $V_{t\geq 07}$ and

[4]These subsequent transfers are typically conditioned on some requirements in terms of investment and job creation by the subsidized firm.

[5]We thank Fabio Canova and Juan Rubio-Ramírez for making their codes available to us.

Figure 4: Effects of a business subsidy shock



Notes: Blue solid lines are impulse responses to a business subsidy shock. Red dotted are 68% confidence intervals.

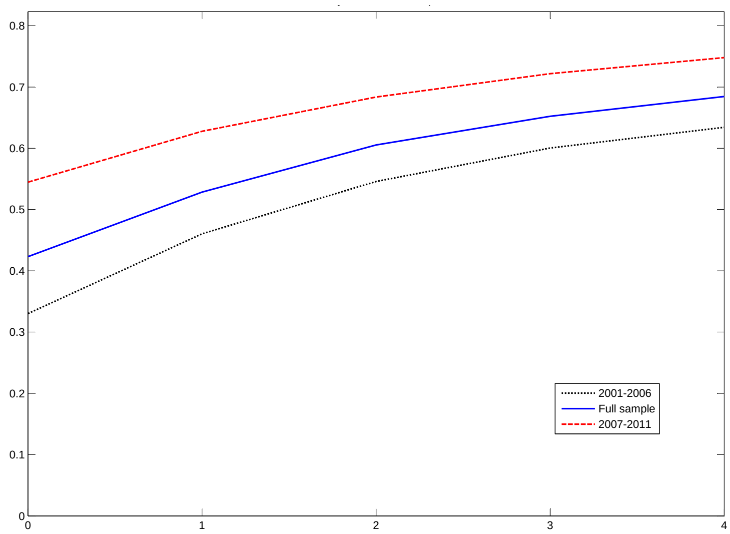
$\Sigma_{t\geq 07}$. To gain degrees of freedom we restrict the matrix in the polynomial $B(L)$ to be constant over the entire sample. This means that the impact effects of shocks can vary over time while their serial correlation has remained relatively stable. Some preliminary evidence suggests that this is the case in the data. Business subsidy shocks are identified by imposing the same restrictions as before. The elasticity of household debt to house prices is measured by the ratio of the impulse response of household debt to the impulse response of house prices. For the full sample it corresponds to the ratio between the blue line in the fourth box in Figure 4 and the blue line in the third box of the same Figure.

The resulting ratio is plotted as a blue solid line in Figure 5 below. The black dotted line corresponds to the elasticity for the pre-recession period (2001-2006). The red dashed line corresponds to the analogous elasticity for the post recession period 2007-2011. Overall there is evidence that this elasticity on impact was two thirds higher during the Great Recession than in the pre-recession period. At a four year horizon after the shock the elasticity of debt to house prices remains higher in the Great Recession period than in the pre-recession period by around 50%. This is coherent with the view that house prices have played a major role in determining the level of household debt during the current recession. This is one of the key channel we are emphasizing in the theoretical model of the next section.

3 Dynamic small open economy

We consider a small open economy that consists of a continuum of measure one of states. All states are identical. We denote by capital letters aggregate quantities for

Figure 5: Elasticity of debt to house prices



Notes: Blue solid line is the elasticity of debt to house prices in the full sample. Black dotted line is the elasticity in the pre-recession period (2001-2006). Red dashed line is the elasticity in the post recession sample (2007-2011).

the aggregate economy and by small letters quantities for a (representative) state. In each state there is a measure one of households characterized by a representative household with utility

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t, e_t\right),$$

with

$$U\left(c_t, e_t\right) = \frac{c_t^{1-\sigma}}{1-\sigma} - \psi \frac{e_t^{1+\nu}}{1+\nu}$$

where c_t is consumption and e_t is the supply of labor earning a wage rate w_t. We assume that labor is immobile across states, which is reasonable in the short run. All markets are perfectly competitive. There are three types of assets. There is one *productive asset* that can be traded only locally (at the state level) at price q_t. There is one *financial asset* that can be freely traded across states in the economy but can not be traded internationally. We model this asset as an investment in the shares of the economy level stock market (say the sum of the NY and NASDAQ stock exchange). Each share of the aggregate stock market pays dividends D_t to the household. These dividends are the sum of all profits generated by all firms in the aggregate economy. Finally the household can purchase *debt* which requires the payment of an an exogenously given interest rate $R-1$, which satisfies $\beta R < 1$. This debt is provided internationally. The exogeneity of R can be reconciled with the assumption of a small open economy.

Household's holdings of the local productive assets are denoted by s_t. The household rents these assets to domestic firms at the rental rate r_t. Domestic productive assets are in fixed supply which is normalized to one. The households also holds shares of the aggregate stock market. These holding are denoted by a_t. The purchase of a stock market share at time t costs P_t units of output. Each share purchased at time $t-1$ yields dividends D_t at time t.

In addition to renting the productive asset to firms, the household provides working capital to local firms at the rental rate r^k_t. We can then write the household's budget constraint as

$$r_t s_t + D_t a_{t-1} + r^k_t k_t + w_t e_t = c_t + k_t + q_t(s_t - s_{t-1}) + P_t\left(a_t - a_{t-1}\right) + Rb_{t-1} - b_t.$$

The left hand side represents household's income. The household obtains income from renting the productive assets, from dividend payments, from renting working capital, and from supplying labor. This income is used to purchase consumption, working capital, to buy new units of the productive assets, to invest in the stock market, and finally to repay debt.

The household borrows inter-temporally for consumption smoothing, b_t, but also for working capital k_t that she provides to firms. The total debt is then $b_t + k_t$. Under the assumption that the debt must be guaranteed by the value of owned assets, the household faces the following borrowing constraint

$$\mu q_t s_t \geq b_t + k_t.$$

The term on the left-hand-side is the liquidation value of household's productive assets, with $\mu < 1$ capturing the fraction of recoverable assets in the event of liquidation. The term on the right-hand-side is is the total liabilities of the household at the end of the period. The debt issued to fund working capital can be interpreted as follows: the household buys goods from firms at the beginning of the period, which then she gives as working capital to other firms. But at the beginning of the period the household does not have resources to pay for the intermediate inputs since she has not received any payment yet. Therefore, she simply promises to pay these inputs at the end of the period, after all payments have been received and the new debt b_t has been issued. But at this point the household could renege on all liabilities, $b_t + k_t$. Anticipating this, lenders impose the above collateral constraint insuring that the borrower does not renegotiate. For simplicity we assume that wealth invested in the stock market cannot be collateralized. This is because this wealth is held anonymously. So external investors can not appropriate this wealth in case of default. No result depends on this assumption. In practice we could assume that $P_t a_t$ increases the collateral available to the household.

The production sector in each state is characterized by a representative firm with production function

$$y_t = z_t \bar{s}^{\alpha}_t k^{\theta}_t e^{\gamma}_t,$$

where z_t is total factor productivity, $\bar{s}_t$ is the input of a productive asset, k_t is working capital and e_t is the input of labor. The problem of the firm is static: the firm rents the fixed asset, working capital and labor from the household at the beginning of the period and pays the rents at the end of the period. Competition implies that the rental prices are equal to the respective marginal productivities, that is,

$$\begin{aligned} r_t &= \alpha z_t k_t^{\theta} e_t^{\gamma} \equiv \alpha y_t & (2) \\ r_t^k &= \theta z_t k_t^{\theta-1} e_t^{\gamma} \equiv \theta \frac{y_t}{k_t} & (3) \\ w_t &= \gamma z_t k_t^{\theta} e_t^{\gamma-1} \equiv \gamma \frac{y_t}{e_t} & (4) \end{aligned}$$

We assume that $\alpha + \theta + \gamma < 1$, which implies that the production sector of each state generates some profits

$$d_t = \max_{\bar{s}_t, k_t, e_t} y_t - r_t \bar{s}_t - w_t e_t - r_t^k k_t$$

which we assume are distributed in the form of dividends. In (symmetric) equilibrium we have

$$D_t = d_t.$$

There are two issues to be discussed:

1. For simplicity, we assumed that there is a rental market for the productive asset. In theory we would like to argue that, due to moral hazard and/or incomplete contracts, *a rental market for the productive asset is not possible*: if an agent wants to use the asset, he has to buy it first and eventually reselling it in the market later. After all, this should be the reason why foreigners cannot buy the asset: since the asset has value only if the agent uses it in production, the asset has zero value to a foreigner, who resides abroad and he cannot use the asset locally in production.[6] This is related to the point by Kilenhong and Townsend (2014), that financial constraints are always due to some missing markets. In practice we assume that the cost of creating this rental market is prohibitively high. After some further refinement, we think this environment can be somewhat justified. It is well known that some rental markets might not work efficiently: after all this is one reason why agents prefer to buy rather than to rent a house, even in the absence of financial frictions. This follows the incomplete contract

[6] A standard justification for why a rental market is not possible is based on moral hazard and/or incomplete contracts. Here we could push the following story. To keep the asset productive (or to make it productive in the following period), the agent has to make some investment in maintenance (or some sunk, production-specific investment). If no investment is made, the agent (say the entrepreneur) obtains private benefits b. If the investment is made, the agent obtains zero benefits but the asset remains productive in the following period. Independently of the investment made, the asset produces αy_t in the period. If no investment is made in a period, the asset will remain unproductive forever. The investment is unobservable (and thereby uncontractible) and after the investment has been made the agent can run away at no cost and there is no way of identifying him again. The end of period productive capacity of the asset is however observable, so that the asset can be traded under a regime of perfect information. The agent is willing to make this investment only if he is the owner (the residual claimant) of the future production flows of the asset. In this case the agent fully internalizes the cost of shirking and he will always invest to keep the asset productive. Also notice, that, since there are no transaction costs, the allocation of the decentralized equilibrium with or without a rental market is identical. This means that private agents have no incentives to privately create a rental market for the asset. The government might have an incentive to do so because the existence of this market would allow the government to introduce the subsidy τ_t^s which would make the financial constraint irrelevant.

literature by Grossman and Hart (1986), Hart and Moore (1994). For further considerations see also the recent review article by Hart and Moore (2007).

2. We have assumed that the wealth invested in the stock market $P_t a_t$ is not collateralizable. This is questionable and it can be easily modified. This assumption does not matter for the results.

3.1 Competitive equilibrium

We characterize first the competitive equilibrium in which all prices are determined in the market without any policy intervention. Let's first characterize the optimization problem of the representative household which is represented by the following Lagrangian

$$\begin{aligned} L &= E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \psi \frac{e_t^{1+\nu}}{1+\nu} \right) \\ &\quad + \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[r_t s_t + D_t a_{t-1} + w_t e_t + r_t^k k_t - c_t - k_t - P_t \Delta a_t - q_t \Delta s_t + b_t - R b_{t-1} \Big] \\ &\quad + \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t s_t - b_t - k_t \Big] \end{aligned}$$

From the Lagrangian we can derive the first order conditions for c_t, e_t, k_t, b_t, s_t, and a_t:

$$\lambda_t = c_t^{-\sigma} \tag{5}$$

$$\lambda_t \gamma \frac{y_t}{e_t} = \psi e_t^{\nu} \tag{6}$$

$$\theta \frac{y_t}{k_t} = 1 + \eta_t \tag{7}$$

$$\lambda_t (1 - \eta_t) = \beta R E_t (\lambda_{t+1}) \tag{8}$$

$$q_t (1 - \mu \eta_t) = \alpha y_t + \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \right). \tag{9}$$

$$P_t = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} (D_{t+1} + P_{t+1}) \right] \tag{10}$$

where we have substituted the equilibrium rental prices derived in (2), (3) and (4).

These conditions characterize the competitive equilibrium of this economy after noticing that the equilibrium holdings of stock market shares satisfy

$$a_t = 1 \tag{11}$$

while aggregate dividend payments are equal to

$$D_{t+1} = (1 - \alpha - \theta - \gamma) Y_{t+1} \tag{12}$$

where Y_t is aggregate output which satisfies

$$Y_t = y_t. \tag{13}$$

4 Planner problem under full commitment

We start with the characterization of the planner's problem of a single local state. We start assuming that the planner commits to future policies (Ramsey allocation). The planner faces the same restrictions individual households face, including the borrowing constraint. Typically, the key difference between the problem solved by the planner and the problem solved by individual households is that in the former we do not need to specify a price system since the planner only cares about allocations. In our problem, however, the planner is also subject to the borrowing limit, which depends on the price of the fixed assets. Therefore, we need some way to determine the price of this asset. We then follow the literature and assume that the price q_t needs to satisfy the equilibrium condition in the private market for productive assets, that is, equation (9). Also notice that (10) says that the stochastic discount factor of households is pinned down by the aggregate return of the stock market that depends on the aggregate price of shares P_t and the aggregate dividend payments D_t. The state planner cannot manipulate these quantities. This means that the stochastic discount factor of households in the state $\frac{\lambda_{t+1}}{\lambda_t}$ is taken as given by the state planner. In practice the stochastic discount of each household in the economy is given by

$$\beta\Lambda_{t,t+1} = \beta\frac{\lambda_{t+1}}{\lambda_t} = \left(\frac{Y_t - K_t + B_t - RB_{t-1}}{Y_{t+1} - K_{t+1} + B_{t+1} - RB_t}\right)^{\sigma} \tag{14}$$

where Y_t, K_t, and B_t denote the aggregate economy level of output, working capital and debt, respectively. All these quantities can not be affected by the decisions of a single state. So the planner takes them a given in solving his Ramsey problem. The numerator in (14) is aggregate consumption at t, the denominator aggregate consumption at $t+1$.

4.1 The Ramsey Problem

We focus on a symmetric equilibrium where all the state planners play a symmetric Nash game. Let's consider the problem of a planner who subsidizes employment and capital and taxes debt in the state to maximize the welfare of the representative household. This means that agents think that each unit of labour yields income

$$(1 + \tau_t^e)\, w_t$$

while each unit of working capital yields income

$$\left(1 + \tau_t^k\right) r_t^k$$

where w_t and r_t^k are the rental prices paid by firms. Finally the cost of repaying debt at time $t+1$ is perceived to be equal to

$$R\left(1 + \tau_{t+1}^b\right)$$

All these taxes and subsidies are financed through lump sum taxes paid by the local households. So the budget constraint of the representative household of each state remains unchanged relative to the decentralized equilibrium. The important assumption here is that the state cannot manipulate the dividend payments of firms. In this sense these are subsidies to the *supply* of labor and working capital, respectively. If he could, the planner would like to tax dividend payments so as to increase the value of the productive asset relative to other financial investments. The FOCs (market clearing conditions) for e_t, k_t and b_t in this decentralized equilibrium will then be as follows

$$U_c(c_t, e_t)(1+\tau_t^e)\gamma y_t = \psi e_t^{1+\nu} \tag{15}$$

$$\left(1+\tau_t^k\right)\theta y_t = (1+\overline{\eta}_t)k_t \tag{16}$$

$$(1-\overline{\eta}_t) = \beta R\left(1+\tau_{t+1}^b\right)\Lambda_{t,t+1} \tag{17}$$

where U_c denotes the marginal utility of consumption, and $\overline{\eta}_t$ is the Lagrange Multipliers in the household problem of the decentralized equilibrium of the household financial constraint. Notice that $\tau_t^e > 0$ and $\tau_t^k > 0$ are a subsidy on employment and capital, respectively, while $\tau_t^b > 0$ is a tax on debt. We will assume that $\forall t$

$$\tau_t^i \in [-1, \infty) \qquad \forall i = e, k, b$$

This means that labor and capital should receive a non negative pay-off, $\tau_t^i \geq -1$ $\forall i = e, k$ and that some minimum amount of debt (say zero) has to be repaid in the following period $\tau_{t+1}^b \geq -1$. In practice we will have $\tau_{t+1}^b \in [-1, \frac{1}{\beta R}]$, $\tau_{t+1}^b \leq \frac{1}{\beta R}$ guarantees that the household holds some debt. After the planner has chosen τ_t^e, τ_t^k, and τ_{t+1}^b, the representative household chooses his asset holding, s_t, consumption c_t, debt b_t, employment e_t, capital k_t, output y_t, and stock market shares a_t This means that in his problem the planner is constrained by the FOCs (equilibrium conditions) about the optimal choices of s_t, c_t, b_t, e_t, k_t, y_t and a_t that emerge in the corresponding decentralized equilibrium. The planner will behave strategically: he will choose τ_t^e, τ_t^k, and τ_{t+1}^b to manipulate the individual choices of agents. The state planner also recognizes that a fraction $1-\alpha-\theta-\gamma$ of state output is transferred to households out of the state. As a result, we can think that the single state planner problem is characterized by the following Lagrangian:

$$\min_{\substack{\{\lambda_t,\phi_t,\eta_t,\pi_t \\ \omega_t^e,\omega_t^k,\omega_t^b,\omega_t^a\}}} \max_{\substack{\{c_t,b_t,e_t,k_t,y_t,q_t, \\ a_t,\overline{\eta}_t,\tau_t^e,\tau_t^k,\tau_{t+1}^b\}}} L^{d1} = \sum_{t=0}^{\infty} \beta^t U\left(c_t, e_t\right) \tag{18}$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \Big[\left(\alpha+\theta+\gamma\right) y_t - c_t - k_t + D_t a_{t-1} - P_t\left(a_t - a_{t-1}\right) + b_t - R b_{t-1} \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t(1-\mu\overline{\eta}_t) \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \omega_t^e \Big[U_c\left(c_t, e_t\right)\left(1+\tau_t^e\right) \gamma y_t - \psi e_t^{1+\nu} \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \omega_t^k \Big[\left(1+\tau_t^k\right) \theta y_t - \left(1+\overline{\eta}_t\right) k_t \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \omega_t^b \Big[\left(1-\overline{\eta}_t\right) - \beta R \left(1+\tau_{t+1}^b\right) \Lambda_{t,t+1} \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \omega_t^a \Big[\beta \Lambda_{t,t+1}\left(D_{t+1} + P_{t+1}\right) - P_t \Big]$$

In symmetric equilibrium we will also have that

$$\Lambda_{t,t+1} = \frac{\lambda_{t+1}}{\lambda_t} \tag{19}$$

$$P_t = \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\alpha-\theta-\gamma) y_{t+1} + P_{t+1}\right] \tag{20}$$

$$D_t a_{t-1} = (1-\alpha-\theta-\gamma) y_t \tag{21}$$

$$a_t = 1 \tag{22}$$

After taking the first order condition for a_t, and after using (14) we see that in a symmetric equilibrium

$$\omega_t^a = 0.$$

This is because in practice we have already used this condition when saying that the state cannot manipulate the stochastic discount factor of households $\Lambda_{t,t+1}$, see (14), and by noticing that in equilibrium (19) holds. The planner has three instruments: τ_t^e, τ_t^k, and τ_{t+1}^b, which will use to make some constraints not binding. As a result some associated Lagrange multipliers will be zero. In theory τ_t^i, $i = e, k, b$ could be positive or negative and unbounded so $\tau_t^i \in (-1, \infty)$. So to have an internal solution for τ_t^e, τ_t^k, and τ_{t+1}^b, it has to be that the corresponding FOCs should hold as an equality. The FOCs for τ_t^e, τ_t^k and τ_{t+1}^b will then read as follows:

$$\begin{aligned} \omega_t^e U_c(c_t, e_t)\gamma y_t &= 0 \\ \omega_t^k \theta y_t &= 0 \\ -\omega_t^b \beta R \Lambda_{t,t+1} &= 0 \end{aligned}$$

We interpret these three conditions as saying that

$$\omega_t^i = 0, \quad \forall i = e, k, b$$

This means that allowing the planner to choose τ_t^e, τ_t^k, and τ_{t+1}^b is equivalent to assuming that the planner is not subject to the decentralized equilibrium optimal conditions for the optimal choice of employment in (15), the optimal choice of capital in (16) and the law of evolution of debt in (17). Given this, the planner problem can be written as follows:

$$\min_{\{\lambda_t,\phi_t,\eta_t,\pi_t\}} \max_{\{c_t,b_t,e_t,k_t,y_t,a_t,q_t,\overline{\eta}_t\}} L^{d2} = \sum_{t=0}^{\infty} \beta^t U(c_t, e_t) \tag{23}$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \Big[(\alpha + \theta + \gamma) y_t - c_t - k_t + D_t a_{t-1} - (a_t - a_{t-1}) + b_t - R b_{t-1} \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^\theta e_t^\gamma - y_t \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t \Big]$$

$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta \Lambda_{t,t+1} q_{t+1} + \alpha y_t - q_t (1 - \mu \overline{\eta}_t) \Big]$$

The planner can freely choose $\overline{\eta}_t$. In practice we know from (17) that $\tau_{t+1}^b \in [-1, \frac{1}{\beta R})$ implies that $\overline{\eta}_t \in [0, 1]$ so maximizing wrt $\overline{\eta}_t$ when $\pi_t > 0$ implies that $\overline{\eta}_t = 1$. So we have that the two following conditions should hold simultaneously

$$\begin{aligned} \overline{\eta}_t &= 1 \\ 1 - \overline{\eta}_t - \beta R \left(1 + \tau_{t+1}^b\right) \Lambda_{t,t+1} &= 0 \end{aligned}$$

which implies that

$$\tau_{t+1}^b = -1 \quad \text{if } \pi_t > 0. \tag{24}$$

This means that the planner wants to fully subsidize debt, so as to make the agents feel that they are fully financially constrained ($\overline{\eta}_t = 1$). This is useful to push up the value of the asset, which is what the planner wants to do when $\pi_t > 0$. This means that in a world where the planner can use either business subsidies or taxes on debt, he will never decide to tax debt. He will try to do the opposite: he will subsidize debt so that agents feel they are more financially constrained and thereby value the asset more. This seems a nice, surprising and unexpected result, which is also present in Bianchi and Mendoza (2012, 2014). This somewhat resembles an expansionary monetary policy. This result follows crucially from the fact that the value of the asset is increasing in the tightness of the financial constraint faced by households (q_t is increasing in $\overline{\eta}_t$). This result might not be robust but follows directly from the properties of our textbook model.

Then we can proceed by assuming that $\overline{\eta}_t = 1$ all the times that $\pi_t > 0$. Based in this assumption, the optimization problem of the state planner is characterized by the following Lagrangian:

$$\min_{\{\lambda_t,\phi_t,\eta_t,\pi_t\}} \max_{\{c_t,b_t,e_t,k_t,y_t,q_t,a_t\}} L^{d3} = \sum_{t=0}^{\infty} \beta^t U(c_t, e_t) \tag{25}$$
$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \Big[(\alpha+\theta+\gamma) y_t - c_t - k_t + D_t a_{t-1} - (a_t - a_{t-1}) + b_t - R b_{t-1} \Big]$$
$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big]$$
$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t \Big]$$
$$+\sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta \Lambda_{t,t+1} q_{t+1} + \alpha y_t - q_t(1-\mu) \Big]$$

The first order conditions for c_t, e_t, k_t, y_t, b_t, q_t and a_t are as follows:

$$\lambda_t = c_t^{-\sigma} \tag{26}$$
$$\lambda_t \phi_t \gamma \frac{y_t}{e_t} = \psi e_t^{\nu} \tag{27}$$
$$\phi_t \theta \frac{y_t}{k_t} = 1 + \eta_t \tag{28}$$
$$\phi_t = (\alpha+\theta+\gamma) + \alpha \pi_t \tag{29}$$
$$1 = \beta R \frac{\lambda_{t+1}}{\lambda_t} + \eta_t \tag{30}$$
$$\mu \eta_t + \pi_{t-1} = (1-\mu)\pi_t \tag{31}$$
$$P_t = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} (D_{t+1} + P_{t+1}) \right] \tag{32}$$

where we used that in symmetric equilibrium (19) holds, and we defined

$$\pi_{-1} = 0.$$

Notice that (31) implies that π_t becomes positive the first time the economy becomes financially constrained and then π_t keeps increasing forever at rate $1/(1-\mu)$. Since $\pi_{-1} = 0$, the asset pricing constraint (equation (9)) becomes binding the first time the borrowing constraint is binding (captured by a positive value of the multiplier η_t). At the same time, we can see from equation (29) that the multiplier ϕ_t increases in π_t which increases when the borrowing constraint is binding, that is, $\eta_t > 0$. This means that increasing output becomes more valuable when the economy faces tight credit. The reason is because the price of the asset depends positively on production. Since the borrowing constraint is relaxed when the asset price increases, it becomes more valuable to increase output when the economy is financially constrained. This price effect, however, is not taken into account by individual agents, which explains the difference between the optimality conditions in the competitive and planner allocations. This can be clearly seen in the first order conditions for labor and working capital (conditions (6) and (7) for the competitive allocation and conditions (27) and for the planner allocation). Remember that in the decentralized equilibrium households choices are governed by $\overline{\eta}_t$ and not η_t, see (15), (16) and (17). After noticing all this, we can conclude that

Proposition 1 *The optimal business subsidies and debt taxes chosen by the planner of each state in a symmetric Nash equilibrium are as follows:*

$$\tau_t^e = \tau_t^b = \tau_{t+1}^b = 0 \qquad \text{if } \pi_t = 0.$$
$$\tau_{t+1}^b = -1 \quad \text{if} \quad \pi_t > 0$$
$$\tau_t^e = \phi_t - 1 \quad \text{if} \quad \pi_t > 0$$
$$\tau_t^k = \frac{2\phi_t}{1+\eta_t} - 1 \quad \text{if} \quad \pi_t > 0$$

where π_t, c_t, χ_t, ϕ_t, and η_t satisfy (26)-(31).

Proof. The last condition is obtained by using (16) and (28) to notice that the optimal subsidy to working capital should satisfy:

$$\frac{1+\tau_t^k}{1+\overline{\eta}_t} = \frac{\phi_t}{1+\eta_t}$$

where $\overline{\eta}_t = 1$ if $\pi_t > 0$. ■

The subsidy ϕ_t in (29) has two components. The first is the constant term $\alpha + \theta + \gamma - 1$ which is negative, so effectively this is a tax. This term derives from the fact that the state planner does not care about households in other states. Then, by reducing the production inputs, the return on the fixed asset declines and with it the incomes earned by households in other states. This component, however, is independent of the financial condition of the state and becomes zero under constant returns to scale. The second component of the subsidies which is time varying, corrects the fact that agents do not internalize that by working harder (and using more working capital) they can relax the borrowing constraint by affecting the price of the asset. The production subsidies make sure that they do so if they are financially constrained. The business subsidy ϕ_t increases over time at rate $1/(1-\mu)$ partly because of the incentive to smooth distortions over time as it is common in the optimal taxation literature. According to conditions (31) and (29), the increase in subsidies is permanent. But this is just part of the story since ϕ_t not only increases permanently but also keeps increasing over time at rate $1/(1-\mu)$. ϕ_t increases over time because increasing output in the future is more valuable than increasing output just today: increasing output at time t relaxes the financial constraint just today, while increasing output at $t' > t$ increases the value of asset and thereby relaxes the financial constraint in all infra-marginal periods between t and t' and not just today.

For this result, however, we need commitment. As we will see, in absence of commitment subsidies will be increased only in the period in which the economy is constrained.

4.2 The problem of the Federal government

We now focus on the problem of a federal government that, as in Section 4.1, chooses a subsidy on employment τ_t^e, a subsidy on working capital τ_t^k and a tax on debt τ_t^b to improve welfare of households in all states in the economy. Subsidies are designed as in Section 4.1. So the FOCs (market clearing conditions) for e_t, k_t and b_t in this decentralized equilibrium are still given by (15), (16) and (17), respectively. The key difference relative to the problem in Section 4.1, is that now the Federal Government chooses its policy in all states simultaneously. This means that now the Federal government recognizes that the discount factor is given in (14) and it is affected by the aggregate output an the aggregate debt in the economy, which can be affected by the Federal government. The Federal government also knows that in symmetric equilibrium $a_t = 1$ and that dividend payments are the equal to the sum of all profits in the economy. As a result, we can think that the Federal Government planner problem is characterized by the following Lagrangian:

$$
\begin{aligned}
\min_{\substack{\{\lambda_t,\phi_t,\eta_t,\pi_t,\\ \omega_t^e,\omega_t^k,\omega_t^b,\chi_t\}}} \; \max_{\substack{\{c_t,b_t,e_t,k_t,y_t,q_t,\overline{\eta}_t,\\ \tau_t^e,\tau_t^k,\tau_{t+1}^b,\Lambda_{t,t+1}\}}} \; L^{f1} &= \sum_{t=0}^{\infty} \beta^t U\left(c_t, e_t\right) \qquad (33) \\
&+ \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[y_t - c_t - k_t + b_t - R b_{t-1} \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta \Lambda_{t,t+1} q_{t+1} + \alpha y_t - q_t (1 - \mu \overline{\eta}_t) \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \omega_t^e \Big[U_c\left(c_t, e_t\right)\left(1 + \tau_t^e\right) \gamma y_t - \psi e_t^{1+\nu} \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \omega_t^k \Big[\left(1 + \tau_t^k\right) \theta y_t - \left(1 + \overline{\eta}_t\right) k_t \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \omega_t^b \Big[\left(1 - \overline{\eta}_t\right) - \beta R \left(1 + \tau_{t+1}^b\right) \Lambda_{t,t+1} \Big] \\
&+ \sum_{t=0}^{\infty} \beta^t \lambda_t \chi_t \Big[\left(\frac{y_t - k_t + b_t - R b_{t-1}}{y_{t+1} - k_{t+1} + b_{t+1} - R b_t} \right)^{\sigma} - \Lambda_{t,t+1} \Big]
\end{aligned}
$$

The last constraint with associated Lagrange multiplier $\lambda_t\chi_t$ incorporates the constraint (14) into the Federal Government planner problem. This is the key difference relative to the Problem in (18). The planner now recognizes that he can increase the value of the productive asset by also manipulating the discount factor of households $\Lambda_{t,t+1}$. We now take the derivative wrt to τ_t^i, $\forall i = e, k, b$. By the same logic as in Section 4.1, we then immediately conclude that $\omega_t^i = 0$ $\forall i = e, k, b$. Moreover by maximizing wrt $\overline{\eta}_t$ when $\pi_t > 0$ we immediately obtain that, as in Section 4.1, it is optimal to have $\overline{\eta}_t = 1$ when $\pi_t > 0$, which means choosing

$$\tau_{t+1}^b = -1 \quad \text{if } \pi_t > 0.$$

This is again exactly as in Section 4.1. After using these results we obtain that the problem in (33) can be simplified to

$$\min_{\{\lambda_t,\phi_t,\eta_t,\pi_t,\chi_t\}} \max_{\substack{\{c_t,b_t,e_t,k_t,\\ y_t,q_t,\Lambda_{t,t+1}\}}} L^{f2} = \sum_{t=0}^{\infty} \beta^t U(c_t, e_t) \tag{34}$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[y_t - c_t - k_t + b_t - Rb_{t-1}\Big]$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^\theta e_t^\gamma - y_t\Big]$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t\Big]$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta \Lambda_{t,t+1} q_{t+1} + \alpha y_t - q_t(1-\mu)\Big]$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_t \chi_t \beta \Big[\left(\frac{y_t - k_t + b_t - Rb_{t-1}}{y_{t+1} - k_{t+1} + b_{t+1} - Rb_t}\right)^\sigma - \Lambda_{t,t+1}\Big]$$

The first order conditions for c_t, $\Lambda_{t,t+1}$, e_t, k_t, y_t, b_t, and q_t are as follows:

$$\lambda_t = c_t^{-\sigma} \tag{35}$$
$$\chi_t = \pi_t q_{t+1} \tag{36}$$
$$\lambda_t \phi_t \gamma \frac{y_t}{e_t} = \psi e_t^\nu \tag{37}$$
$$\phi_t \theta \frac{y_t}{k_t} = 1 + \delta_t + \eta_t \tag{38}$$
$$\phi_t = 1 + \alpha \pi_t + \delta_t \tag{39}$$
$$1 + \delta_t - \eta_t = \beta R \frac{\lambda_{t+1}}{\lambda_t} (1 + \delta_{t+1}) \tag{40}$$
$$\mu \eta_t + \pi_{t-1} = (1-\mu)\pi_t \tag{41}$$

where we used that the fact that (35) implies that in equilibrium we have

$$\left(\frac{y_t - k_t + b_t - Rb_{t-1}}{y_{t+1} - k_{t+1} + b_{t+1} - Rb_t}\right)^\sigma = \Lambda_{t,t+1} = \frac{\lambda_{t+1}}{\lambda_t}$$

and we defined

$$\delta_t \equiv \frac{\sigma}{c_t}\left(\chi_t \beta \Lambda_{t,t+1} - \chi_{t-1}\right).$$

The term δ_t is what makes the conditions in (35)-(41) different from those in (26)-(31). δ_t represents the changes in welfare induced by a change in consumption at time t, c_t, through its effects on the discount factor used by households to price the productive factor. An increase in c_t increases $\Lambda_{t,t+1}$, which increases the price of the asset at time t, q_t. But an increase in c_t also reduces $\Lambda_{t-1,t}$ which reduces the price of the productive asset at time $t-1$, q_{t-1}. Generally δ_t is positive because (36) implies that χ_t is positively related to π_t and q_t, which both increase over time: π_t evolves as in (41) which increases at rate $1/(1-\mu)$, while q_t increases due to the increase in output y_t over time, which is implied by (37) and (38).

An important property of the value of income ϕ_t in (39) in the Federal government problem is that this value is greater than one and it is affected by the presence of the term in δ_t. A marginal increase in output increases the value of the asset directly because of the increase in the rental price of the asset, which corresponds to the second term in the right hand side of (39), and indirectly because higher income means higher consumption which increases the value of the asset thanks to the discount factor effect measured by δ_t. So now income has value also because it allows the planner to manipulate the discount factor used by households to price the productive asset.

We can now characterize the properties of the optimal business subsidies and taxes in the Federal government problem. In the decentralized equilibrium households choices are governed by (15), (16) and (17). After noticing all this, we can conclude that the optimal business in the government planner problem are characterized by the following Proposition

Proposition 2 *The optimal business subsidies and debt taxes chosen by the federal government are as follows:*

$$\begin{aligned}
&\tau_t^e = \tau_t^b = \tau_{t+1}^b = 0 \qquad \textit{if } \pi_t = 0. \\
&\tau_{t+1}^b = -1 \quad \textit{if} \quad \pi_t > 0 \\
&\tau_t^e = \phi_t - 1 \quad \textit{if} \quad \pi_t > 0 \\
&\tau_t^k = \frac{2\phi_t}{1+\delta_t+\eta_t} - 1 \quad \textit{if} \quad \pi_t > 0
\end{aligned}$$

where π_t, c_t, χ_t, ϕ_t, and η_t satisfy (35)-(41).

Proof. The last condition is obtained by using (16) and (38) to notice that the optimal subsidy to working capital should satisfy:

$$\frac{1+\tau_t^k}{1+\overline{\eta}_t} = \frac{\phi_t}{1+\delta_t+\eta_t}$$

where $\overline{\eta}_t = 1$ if $\pi_t > 0$. ■

Relative to Proposition 1, the key difference is that the planner values income more because it also internalize the positive effects of income on the household discount factor. This implies that business subsidies are typically higher than those arising from the state government problem discussed in the previous section.

5 Planner problems without commitment

Although the Ramsey problem with commitment provides important insights about the optimality of policies, the assumption of commitment may not be realistic, especially for very long time horizons. It is then important to look at how the policy prescriptions would change when it is not possible for the planner to commit to future policies. We now study the government problem without commitment. We start with the problem faced by the single state government problem where each state sets his policies independently. We then turn to the study of the Federal government problem.

5.1 State planner problem without commitment

Without commitment, it is more convenient to analyze the problem solved by the state planner recursively using the value function $V_t^d(b_{t-1})$. The state of the economy is summarized by the debt inherited from the previous period (in addition to the exogenous shocks). In solving the problem the planner is also subject to the asset price equation (9) as in the commitment case. However, differently from the case of commitment, the state planner cannot choose the next period price q_{t+1} since this will be chosen by the new planner (new in a conceptual sense). The Lagrangian for the recursive problem is analogous to (25), but when the state government cannot commit, it can be written as

$$\begin{aligned} L_t^{dn}(b_{t-1}) &= \frac{c_t^{1-\sigma}}{1-\sigma} - \psi\frac{e_t^{1+\nu}}{1+\nu} + \beta E_t V_{t+1}^d(b_t) \\ &+ \lambda_t\Big[(\alpha+\theta+\gamma)\,y_t - c_t - k_t + D_t a_{t-1} - (a_t - a_{t-1}) + b_t - Rb_{t-1}\Big] \\ &+ \lambda_t\phi_t[z_t k_t^\theta e_t^\gamma - y_t] \\ &+ \lambda_t\eta_t\Big[\mu q_t - b_t - k_t\Big] \\ &+ \lambda_t\pi_t\Big[\alpha y_t + \beta E_t\left[\tilde{q}_{t+1}^d(b_t)\right] - q_t(1-\mu)\Big] \end{aligned} \tag{42}$$

where we have already set $\overline{\eta}_t = 1$ when $\pi_t > 0$. The last constraint is the price equation that constrains the planner. We have defined the function

$$\tilde{q}_{t+1}^d(b_t) = \Lambda_{t,t+1}q_{t+1}$$

which is the discounted next period price of housing. In constructing this function the discount factor $\Lambda_{t,t+1}$ is taken as given. The planner cannot determine $V_{t+1}^d(b_t)$ and $\tilde{q}_{t+1}^d(b_t)$ directly since it does not have the commitment to choose future variables today. However, it can affect these terms indirectly by choosing b_t and, therefore, changing the state variable in the next period. Therefore, in solving this problem the planner takes as given the function $\tilde{q}_{t+1}^d(b_t)$. This function will be determined in equilibrium by the planner in the next period.

The first order conditions for c_t, e_t, k_t, y_t, b_t, and q_t are

$$\lambda_t = c_t^{-\sigma} \tag{43}$$

$$\lambda_t \phi_t \gamma \tfrac{y_t}{e_t} = \psi e_t^{\nu} \tag{44}$$

$$\phi_t \theta \tfrac{y_t}{k_t} = 1 + \eta_t \tag{45}$$

$$\phi_t = (\alpha + \theta + \gamma) + \alpha \pi_t \tag{46}$$

$$\lambda_t + \beta E_t \left(V_{t+1}^{d\prime} \right) - \lambda_t \eta_t + \beta \lambda_t \pi_t E_t \left(\tilde{q}_{t+1}^{d\prime} \right) = 0 \tag{47}$$

$$\eta_t \mu = \pi_t (1 - \mu) \tag{48}$$

Using the envelope condition $V_{t+1}^{d\prime} = -\lambda_{t+1} R$, the first order condition for the optimal debt b_t can be rewritten as

$$\lambda_t = \beta R E_t \left(\lambda_{t+1} \right) + \lambda_t \eta_t - \beta \lambda_t \pi_t E_t \left(\tilde{q}_{t+1}^{d\prime} \right)$$

The last term differentiates the time-consistency problem from the commitment problem as can be seen by comparing this condition to the analogous condition with commitment, equation (30). This term seems to justify a tax on borrowing (or subsidy if negative) defined as

$$\tau_t = -\beta \pi_t E_t \frac{\tilde{q}_{t+1}^{\prime}}{\lambda_t}$$

However, besides this additional correction, we still have that subsidies to the production inputs are desirable when the borrowing constraint is binding. In fact, using (48) to eliminate π_t in (46) we get

$$\phi_t = (\alpha + \theta + \gamma) + \frac{\alpha \mu \eta_t}{1 - \mu} \tag{49}$$

Abstracting from binding borrowing constraints, the planner finds convenient to tax the inputs k_t and e_t at rate $1 - (\alpha + \theta + \gamma)$. Since dividend transfers are a waste of resources for the state planner, it becomes optimal to reduce the scale of production since part of the output will go to households in other states, and not to local households. The higher the degree of financial integration (lower $(\alpha + \theta + \gamma)$) the higher is the tax. If the borrowing constraint becomes binding, it is optimal to reduce the tax.

5.2 Federal government problem without commitment

We now write the Federal government problem without commitment. To analyze the problem we again write the problem recursively by introducing the value function $V_t^f(b_{t-1})$. As in the problem (42), the state of the economy is summarized by the debt inherited from the previous period (in addition to the exogenous shocks). In solving the problem the planner is also subject to the asset price equation (9) and recognizes that output, investment and debt affect the discount factor used by private agents to price the value of the productive asset. However, differently from the case of commitment, the planner cannot choose the next period price q_{t+1} since this will be chosen by the new planner (new in a conceptual sense). The Lagrangian for the recursive problem analogous to (34), but where the Federal government cannot commit, can be written as

$$\begin{aligned} L_t^{fn}(b_{t-1}) &= \frac{c_t^{1-\sigma}}{1-\sigma} - \psi\frac{e_t^{1+\nu}}{1+\nu} + \beta E_t V_{t+1}(b_t) \\ &+ \lambda_t\Big[y_t - c_t - k_t + b_t - Rb_{t-1}\Big] \\ &+ \lambda_t\phi_t[z_t k_t^{\theta} e_t^{\gamma} - y_t] \\ &+ \lambda_t\eta_t\Big[\mu q_t - b_t - k_t\Big] \\ &+ \lambda_t\pi_t\Big[\alpha y_t + \beta\left(y_t - k_t + b_t - Rb_{t-1}\right)^{\sigma} E_t\left[\tilde{q}_{t+1}^f(b_t)\right] - q_t(1-\mu)\Big] \end{aligned} \quad (50)$$

where we have already set $\overline{\eta}_t = 1$ when $\pi_t > 0$. The last constraint is the price equation that constrains the planner. We have then defined the function

$$\tilde{q}_{t+1}^f(b_t) = \left(\frac{1}{y_{t+1} - k_{t+1} + b_{t+1} - Rb_t}\right)^{\sigma} q_{t+1}$$

which is the next period price of housing expressed in utility units. The planner cannot determine $V_{t+1}^f(b_t)$ and $\tilde{q}_{t+1}^f(b_t)$ directly since it does not have the commitment to choose future variables today. However, it can affect these terms indirectly by choosing b_t and, therefore, changing the state variable in the next period. Hence, in solving this problem the planner takes as given the function $\tilde{q}_{t+1}^f(b_t)$. This function will be determined by the planner in the next period. Notice that now the planner recognizes that he can affect the price of the productive asset also by affecting the discount factor. This explains the term $(y_t - k_t + b_t - Rb_{t-1})^{\sigma}$ in the last row of the problem in (50). The first order conditions for c_t, e_t, k_t, y_t, b_t, and q_t are

$$\lambda_t = c_t^{-\sigma} \quad (51)$$

$$\lambda_t\phi_t\gamma\tfrac{y_t}{e_t} = \psi e_t^{\nu} \quad (52)$$

$$\phi_t\theta\tfrac{y_t}{k_t} = 1 + \eta_t \quad (53)$$

$$\phi_t = 1 + \pi_t\left(\alpha + \tfrac{\beta\sigma}{c_t\lambda_t}E_t\left[\tilde{q}_{t+1}^f(b_t)\right]\right) \quad (54)$$

$$\lambda_t + \beta E_t\left(V_{t+1}'\right) - \lambda_t\eta_t + \beta\pi_t E_t\left(\tilde{q}_{t+1}'\right) + \tfrac{\beta\sigma\pi_t}{c_t}E_t\left(\tilde{q}_{t+1}'\right) = 0 \quad (55)$$

$$\eta_t\mu = \pi_t(1-\mu) \quad (56)$$

We still have that subsidies to the production inputs are desirable when the borrowing constraint is binding. In fact, using (56) to eliminate π_t in (54) we get

$$\phi_t = 1 + \frac{\mu\eta_t}{1-\mu}\left(\alpha + \frac{\beta\sigma}{c_t\lambda_t}E_t\left[\tilde{q}_{t+1}^f(b_t)\right]\right) \quad (57)$$

By comparing with (49) we see that the Federal government will tend to choose

higher subsidies than those set by state governments independently because the Federal government internalizes that higher income affects the value of the productive asset also through the discount factor used by agents to price the asset.

6 Saddle path representation

We now rewrite the problem of the single state government and the problem of the Federal government using the representation by Marcet and Marimon (2014). This is the basis of our computational algorithm.

6.1 State planner problem

The state planner is characterized by the following Lagrangian

$$
\begin{aligned}
L = & \sum_{t=0}^{\infty} \beta^t U\left(c_t, e_t\right) \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[y_t - c_t - k_t + b_t - R b_{t-1} \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\varphi(q_t) - b_t - k_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t (1-\mu) \Big]
\end{aligned} \tag{58}
$$

Let us focus on the last row of the Lagrangian and define

$$
\widetilde{\pi}_t \equiv \lambda_t \pi_t
$$

We rewrite this term in extensive form by placing all terms with the same time subscript on the same row:

$$
\sum_{t=0}^{\infty} \beta_t^t \widetilde{\pi} \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t (1-\mu) \Big] =
$$

$$
\begin{array}{rcl}
[\widetilde{\pi}_{-1} \Lambda_{-1,0} - \widetilde{\pi}_0 (1-\mu)] q_0 & + & \widetilde{\pi}_0 \alpha y_0 + \\
\beta [\widetilde{\pi}_0 \Lambda_{0,1} - \widetilde{\pi}_1 (1-\mu)] q_1 & + & \widetilde{\pi}_1 \alpha y_1 + \\
\beta^2 [\widetilde{\pi}_1 \Lambda_{1,2} - \widetilde{\pi}_2 (1-\mu)] q_2 & + & \widetilde{\pi}_2 \alpha y_2 + \\
\beta^3 [\widetilde{\pi}_2 \Lambda_{2,3} - \widetilde{\pi}_3 (1-\mu)] q_3 & + & \widetilde{\pi}_3 \alpha y_3 + \\
\beta^4 [\widetilde{\pi}_3 \Lambda_{3,4} - \widetilde{\pi}_4 (1-\mu)] q_4 & + & \widetilde{\pi}_4 \alpha y_4 + \\
\dots & & \dots \\
\dots & & \dots
\end{array}
$$

with $\widetilde{\pi}_{-1} = \Lambda_{-1,0} = 0$. We can then write more compactly

$$
\sum_{t=0}^{\infty} \beta_t^t \widetilde{\pi} \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t (1-\mu) \Big] = \sum_{t=0}^{\infty} \beta^t \Big[\widetilde{\pi}_t \alpha y_t + [\widetilde{\pi}_{t-1} \Lambda_{t-1,t} - \widetilde{\pi}_t (1-\mu)] q_t \Big]
$$

This allows us to rewrite the Lagrangian as

$$
\begin{aligned}
L = & \sum_{t=0}^{\infty} \beta^t U\left(c_t, e_t\right) \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[y_t - c_t - k_t + b_t - R b_{t-1} \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \Big[\widetilde{\pi}_t \alpha y_t - \Big(\widetilde{\pi}_t (1-\mu) - \widetilde{\pi}_{t-1} \Lambda_{t-1,t} \Big) q_t \Big]
\end{aligned} \tag{59}
$$

With this formulation we can write the optimization problem recursively as

$$
W_{t-1}(b_{t-1}, \widetilde{\pi}_{t-1}) = \min_{\{\lambda_t, \phi_t, \widetilde{\pi}_t, \eta_t\}} \max_{\{e_t, k_t, y_t, b_t, q_t\}} \Big\{ \Phi_t + \beta W_t(b_t, \widetilde{\pi}_t) \Big\}
$$

where

$$
\begin{aligned}
\Phi_t \quad = \quad & U\left(c_t, e_t\right) + \Big[\widetilde{\pi}_t \alpha y_t - \Big(\widetilde{\pi}_t (1-\mu) - \widetilde{\pi}_{t-1} \Lambda_{t-1,t} \Big) q_t + \lambda_t \eta_t (\mu q_t - b_t - k_t) + \\
& \lambda_t (y_t - c_t - k_t + b_t - R b_{t-1}) + \lambda_t \phi_t (z_t k_t^{\theta} e_t^{\gamma} - y_t) \Big]
\end{aligned}
$$

The subindex t refers to the evolution of the aggregate state variable $\Lambda_{t-1,t}$, which is determined in equilibrium but whose evolution the state planner takes as given.

6.2 Federal government problem

The Federal government problem is characterized by the following Lagrangian

$$
\begin{aligned}
L = & \sum_{t=0}^{\infty} \beta^t U\left(c_t, e_t\right) \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[y_t - c_t - k_t + b_t - R b_{t-1} \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\varphi(q_t) - b_t - k_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t (1-\mu) \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \chi_t \beta \Big[\left(\frac{y_t - k_t + b_t - R b_{t-1}}{y_{t+1} - k_{t+1} + b_{t+1} - R b_t} \right)^{\sigma} - \Lambda_{t,t+1} \Big]
\end{aligned} \tag{60}
$$

Let us focus on the last row of the Lagrangian and define

$$\widetilde{\pi}_t \equiv \lambda_t \pi_t$$

We rewrite this term in extensive form by placing all terms with the same time subscript on the same row:

$$\sum_{t=0}^{\infty} \beta_t^t \widetilde{\pi} \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t(1-\mu) \Big] =$$

$$\begin{array}{rcl}
[\widetilde{\pi}_{-1}\Lambda_{-1,0} - \widetilde{\pi}_0(1-\mu)]q_0 & + & \widetilde{\pi}_0 \alpha y_0 + \\
\beta[\widetilde{\pi}_0\Lambda_{0,1} - \widetilde{\pi}_1(1-\mu)]q_1 & + & \widetilde{\pi}_1 \alpha y_1 + \\
\beta^2[\widetilde{\pi}_1\Lambda_{1,2} - \widetilde{\pi}_2(1-\mu)]q_2 & + & \widetilde{\pi}_2 \alpha y_2 + \\
\beta^3[\widetilde{\pi}_2\Lambda_{2,3} - \widetilde{\pi}_3(1-\mu)]q_3 & + & \widetilde{\pi}_3 \alpha y_3 + \\
\beta^4[\widetilde{\pi}_3\Lambda_{3,4} - \widetilde{\pi}_4(1-\mu)]q_4 & + & \widetilde{\pi}_4 \alpha y_4 + \\
\dots & & \dots \\
\dots & & \dots
\end{array}$$

with $\widetilde{\pi}_{-1} = \Lambda_{-1,0} = 0$. More compactly

$$\sum_{t=0}^{\infty} \beta_t^t \widetilde{\pi} \Big[\beta q_{t+1} \Lambda_{t,t+1} + \alpha y_t - q_t(1-\mu) \Big] = \sum_{t=0}^{\infty} \beta^t \Big[\widetilde{\pi}_t \alpha y_t + [\widetilde{\pi}_{t-1}\Lambda_{t-1,t} - \widetilde{\pi}_t(1-\mu)]q_t \Big]$$

After writing

$$\Lambda_{t-1,t} = \left(\frac{c_{t-1}}{y_t - k_t + b_t - Rb_{t-1}} \right)^{\sigma} \tag{61}$$

We can then write the Lagrangian problem of the Federal government as

$$\begin{aligned}
L = & \sum_{t=0}^{\infty} \beta^t U(c_t, e_t) \qquad (62) \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \Big[y_t - c_t - k_t + b_t - Rb_{t-1} \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \phi_t \Big[z_t k_t^{\theta} e_t^{\gamma} - y_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \lambda_t \eta_t \Big[\mu q_t - b_t - k_t \Big] \\
& + \sum_{t=0}^{\infty} \beta^t \Big[\widetilde{\pi}_t \alpha y_t - \Big(\widetilde{\pi}_t(1-\mu) - \widetilde{\pi}_{t-1} \left(\frac{c_{t-1}}{y_t - k_t + b_t - Rb_{t-1}} \right)^{\sigma} \Big) q_t \Big]
\end{aligned}$$

Notice that the constraint on the pricing factor has disappeared. With this formulation we can write the optimization problem recursive as

$$W(c_{t-1}, b_{t-1}, \widetilde{\pi}_{t-1}) = \min_{\{\lambda_t, \phi_t, \widetilde{\pi}_t, \eta_t\}} \max_{\{c_t, e_t, k_t, y_t, b_t, q_t\}} \Big\{ \Phi_t + \beta W(c_t, b_t, \widetilde{\pi}_t) \Big\}$$

where

$$\Phi_t = U(c_t, e_t) + \Bigg[\widetilde{\pi}_t \alpha y_t - \left(\widetilde{\pi}_t(1-\mu) - \widetilde{\pi}_{t-1}\left(\frac{c_{t-1}}{y_t - k_t + b_t - Rb_{t-1}}\right)^{\sigma}\right) q_t + \lambda_t \eta_t(\mu q_t - b_t - k_t) + \lambda_t(y_t - c_t - k_t + b_t - Rb_{t-1}) + \lambda_t \phi_t (z_t k_t^{\theta} e_t^{\gamma} - y_t)\Bigg]$$

Notice that in this formulation it is no longer true that in equilibrium $\Lambda_{t,t+1} = \frac{\lambda_{t+1}}{\lambda_t}$. This is because, due to re-definition of the pricing factor $\Lambda_{t,t+1}$ in (61), it is no longer true that $\lambda_t = U_c(c_t, e_t)$.

7 Other government interventions

So for we have allowed the planner to use a limited number of instruments (a subsidy on employment, one on capital and one on debt). But in principle there are other instruments that the planner might want to use. We discuss here why these interventions might be either unavailable or ineffective in relaxing the tightness of the financial constraint. We do not want to be too stark here, but we would like to argue that our policy interventions are likely to work better, at least in some dimensions.

1. I1: *Consumption subsidies.* The planner might want to subsidize consumption so that one unit of consumption to the household costs

$$\frac{1}{1+\tau_t^c}$$

units of output to the household where $\tau_t^c \in [-1, \infty)$. It is easy to check that the state planner will never want to use this instrument. This is because this subsidy is irrelevant since the discount factor remains given by (10) which implies that Λ remains determined by P_t and D_t and thereby cannot be manipulated by the state planner. The Federal government might instead want to use consumption subsidies. In practice it is easy to show that once used in combination with the other subsidies a consumption subsidy is enough to make the financial constraint irrelevant. This is because a consumption subsidy allows the planner to manipulate the discount factor of agents Λ freely. By taxing consumption today and using the other instruments to determine consumption, the planner is able to make future income relatively more valuable. The planner can then use this instrument to increase the discount factor Λ and thus the value of the asset, up to the point of making the financial constraint irrelevant. In practice this instrument might not be so effective. Many assets used as a collateral, such as for example housing, produce consumption goods directly. In this case a consumption tax would reduce rather than increase the value of the asset. Moreover in any model where aggregate demand matters for the determination of output, as it is the case for example in sticky prices models, a tax on consumption would reduce aggregate output and thereby could reduce the value of the asset rather than increasing it for the reasons discussed in the previous sections.

2. I2 *Taxing stock market returns.* The state planner would like to tax aggregate dividends. This would again allow the state planner to manipulate the discount factor used by local households to price local assets. There are many reasons why taxing dividends could be ineffective or counterproductive. First the tax on dividend payments will reduce the value of stock market wealth, and this would tighten the financial constraint if stock market wealth is part of the wealth that is collateralizable. Moreover foreigners can invest at least partly in the stock market and this tax can then affect the country ability to borrow from foreigners.

3. I3: *Subsidizing the purchase of the asset.* The planner might want to subsidy at rate τ_t^q the purchase of the asset. This means that the asset is sold at price q_t (the selling price is $q_t^s = q_t$) but the buyer incurs a cost $q_t \left(1 - \tau_t^q\right)$, so that the buying price is $q_t^b = q_t \left(1 - \tau_t^q\right)$. The effect of this subsidy depends on whether the financial constraint depends on the buying or the selling price of the asset, which in our model are equal. If the financial constraint depends on the buying price, this intervention can exacerbate the constraint rather than relaxing it. In practice there are good reasons why the financial constraint could be driven by the minimum between the buying and the selling price $\min(q_t^s, q_t^b)$. In this case this intervention could exacerbate the financial constraint faced by households.

4. I4: *Government purchase of the asset (with or without subsequent use in production).* The government could affect the price of the asset by directly purchasing the asset in the market. This could potentially increase the demand for the asset and thereby increase its market value. There are two cases to be considered. The first is the case where the government purchases the asset and then uses it in production exactly as a private agent would do. In this case, the equilibrium marginal productivity of the asset remains unchanged and so its market value. The second case arises if the government after buying the asset he keeps it idle. This would push up the marginal productivity of the asset and its market value. But at the cost of reducing the amount of collateral s_t available to households in the economy. Due to decreasing marginal productivity of the asset, one can easily see that the second effect would dominate and as a result the financial capacity of the households, given by $q_t s_t$, would fall, despite the increase in the market value of the asset q_t.

5. I5: *Subsidy to the rental of the asset.* The government could subsidize the rental price of the asset, exactly as he subsidizes the rental price of employment and working capital. In this case, a private agent in the economy will then think that by renting one asset unit in the market he obtains a return

$$\left(1 + \tau_t^s\right) \frac{\alpha y_t}{s_t}$$

where $\tau_t^s \in [-1, \infty]$ denotes the subsidy to the rental price of the asset. It is obvious that the same logic that allowed us to conclude that $\omega_t^i = 0$, $\forall i = e, k, b$ would also apply here. So allowing for $\tau_t^s \in [-1, \infty]$ would imply that $\pi_t = 0$. This means that allowing for this subsidy would make the financial constraint completely irrelevant. To see this result formally, one can notice that with this subsidy the asset price would evolve as follows:

$$q_t(1-\mu\eta_t) = (1+\tau_t^s)\,\alpha y_t + \beta E_t\left(\Lambda_{t,t+1}q_{t+1}\right)$$

By incorporating this pricing equation into any of the the social planner problems and then taking the FOC wrt τ_t^i we would immediately obtain the condition

$$\pi_t\alpha y_t = 0$$

which implies that

$$\pi_t = 0$$

This means that allowing for $\tau_t^s \in [-1,\infty]$ makes the financial constraint irrelevant. In many cases, due to moral hazard and/or incomplete contracts, *a rental market for the asset is not available*: if an agent wants to use the asset, he has to buy it first and eventually reselling it in the market later. After all, this should be the reason why foreigners cannot buy the asset: since the asset has value only if the agent uses it in production, the asset has zero value to a foreigner, who resides abroad and he cannot use the asset locally in production. A standard justification for why a rental market is not possible is based on moral hazard and/or incomplete contracts. Here we could push the following story. To keep the asset productive (or to make it productive in the following period), the agent has to make some investment in maintenance (or some sunk, production-specific investment). If no investment is made, the agent (say the entrepreneur) obtains private benefits b. If the investment is made, the agent obtains zero benefits but the asset remains productive in the following period. Independently of the investment made, the asset produces αy_t in the period. If no investment is made in a period, the asset will remain unproductive forever. The investment is unobservable (and thereby uncontractible) and after the investment has been made the agent can run away at no cost and there is no way of identifying him again. The end of period productive capacity of the asset is however observable, so that the asset can be traded under a regime of perfect information. The agent is willing to make this investment only if he is the owner (the residual claimant) of the future production flows of the asset. In this case the agent fully internalizes the cost of shirking and he will always invest to keep the asset productive. Also notice, that, since there are no transaction costs, the allocation of the decentralized equilibrium with or without a rental market is identical. This means that private agents have no incentives to privately create a rental market for the asset. The government might have an incentive to do so because the existence of this market would allow the government to introduce the subsidy τ_t^s which would make the financial constraint irrelevant. It is well known that some rental markets might not work efficiently: after all this is one reason why agents prefer to buy rather than to rent a house, even in the absence of financial frictions. This is also the key selling point of the incomplete contract literature by Grossman and Hart (1986), Hart and Moore (1994); for further considerations see also the recent review article by Hart and Moore (2007).

4. I6: *A subsidy to asset owners.* The government can subsidy owners of the asset: in every period the government transfers an amount τ_t^o to the owner of the asset.

In this case q_t evolves as

$$q_t(1 - \mu\eta_t) = \alpha y_t + \tau_t^o + \beta E_t\left(\Lambda_{t,t+1} q_{t+1}\right)$$

By incorporating this pricing equation into the social planner problem and taking the FOC wrt τ_t^o we would immediately obtain the condition

$$\pi_t = 0$$

which means that this policy intervention would make the financial constraint irrelevant. This is similar to a subsidy to the rental price of the asset. In practice we should argue that this policy intervention would not be feasible (because the private owner would not have the right incentives to properly maintain the asset) or because this intervention is prohibitively expensive. Notice that this subsidy is very expensive: this is not a marginal subsidy that changes either the allocation of resources or some market price. This is really a transfer to each owner of the asset. Any infra-marginal quantity transferred to the owners of the asset will determine the effects of the policy. This means that, to push up the value of the asset, the government should inject a huge amount of money into the program. This makes the program prohibitively expensive, if government money should be raised through some form of distortionary taxation, which is not considered here but it would be in practice.

8 Conclusions

In recessions there is often demand to support economic activity and promote aggregate employment. But the motivation for these interventions is not always clear. In this paper we have emphasized one reason why these interventions might be welfare improving that applies to financially driven recessions where the value of non tradable assets (housing and capital) matters for economic activity. The idea is that in recessions where households are financially constrained, there is a price externality that justifies subsidizing aggregate employment. The logic is that (i) aggregate employment and output affects the value of all non-tradable assets (real estate and capital) , (ii) higher households' wealth relaxes households' financial constraint, which helps in sustaining aggregate demand, investment and job creation and (iii) private firms take prices as given, so they do not fully internalize the benefits of promoting aggregate employment. This mechanism plays a key role in (severe) recessions and in recoveries, where households are forced to deleverage due to a binding financial constraint (Fact 1). In this paper we study the properties of optimal subsidies and we evaluate the effects of 'Make it in America' government policies (*in progress*) aimed at subsidizing businesses in certain states to promote job creation in the US economy.

9 Data Appendix

In the empirical analysis we use the following series:

- *CPI index.* The CPI index is obtained from the Bureau of Labor Statistics (BLS), mnemonic in FRED `CPIAUCSL`. The original series is at monthly frequency and it is converted into annual by taking monthly averages. We normalize its value to one in 2000.

- *Population.* The population data come from BEA and corresponds to the Series "Population (number of persons)" as obtained from table SA1-3.

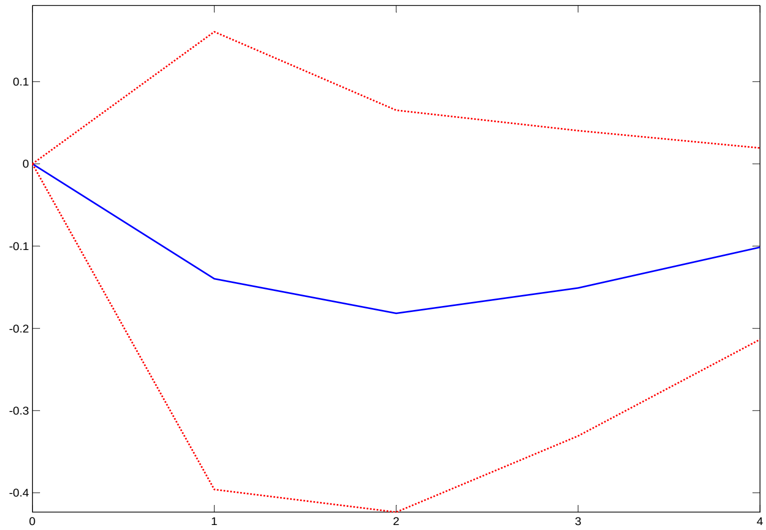
- *Proxy for the value of business subsidy.* Business subsidy data come from "Subsidy tracker" a data set collected by "Good Jobs First" a non-profit non-partisan national policy resource center founded in 1998 and funded by Ford, Surdna and other major philanthropic foundations. It collects information on best practices in state and local job subsidies. Data from "Subsidy tracker" have been featured in the Wall Street Journal, the New York Times, the Washington Post, the Chicago Tribune, the Associated Press, and Reuters. The Data set is the basis of the NY times subsidy database published online. The source of information is well documented and generally come from official sources, government agencies, newspapers (local and national), as well as from direct inquiries. Good Jobs First has been called upon by numerous state commerce agencies to assist them in improving economic development in their states. Subsidies are granted from state governments. So federal Government subsidies not channeled though states are excluded from the data set. Firm subsidies can take many forms: cash grants, tax abatements (property tax abatements, sales tax exemptions, inventory tax abatements, tax credits, employment tax credits), cheap loans, infrastructure assistance, land-price write-downs. There are no official data on business subsidies. BEA publishes data on production subsidies "amounts payable to business per unit of good or service produced". This is a rather restrictive measure of subsidy. Subsidies are measured at the plant level, so a multi-plant firm can receive several deals from different states. Since the data are likely to miss several business subsidies granted by a state in a year, our measure is just a proxy for the overall level of subsidies in the year granted by the state. Data are annual and subsidies are attributed to the fiscal year when the deal is signed and the grant is formally awarded. The sample period is 2000-2011 and the sample consists of 150.440 observations with non-missing subsidy values. In each year we aggregate the value of subsidies at the state level and convert this value in real terms using the CPI index. The resulting measure is scaled down by the population in the state.

- *Employment per capita.* The employment data come from Bureau of Economic Analysis (BEA) and correspond to the series "Total employment (number of jobs)", obtained from Table SA25N. The resulting series is divided by the series population described above.

- *House prices* The data for house prices come from Federal Housing Finance Agency (FHFA) and corresponds to the series "All-Transactions Indexes (Estimated using Sales Prices and Appraisal Data)". We convert the original data to the yearly frequency by taking quarterly averages in the year. House prices are converted into real by dividing by the CPI index.

- *Household debt per capita.* Data on households debt for capita comes from FRBNY Consumer Credit Panel. The data refer to the value of debt in the the fourth quarter of the corresponding year. Household debt per capita is measured as the sum of "Auto Debt Balance per Capita", "Credit Card Debt Balance per Capita" and "Mortgage Debt Balance per Capita".
- *Government debt per capita.* Data come from U.S. Census Bureau, State and Local Government Finances. The series corresponds to "Debt Outstanding" as obtained from Table 1, which reports the State and Local Government Finances by Level of Government and by State. Published figures are at annual frequency. The resulting series is divided by the CPI index and by Population in the state.

Figure 6: Effects of a business subsidy shock on government debt



Notes: Blue solid lines is impulse response of government debt to a business subsidy shock. Red dotted lines are 68% confidence intervals.

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