Fiscal consolidation in heavily indebted economies*

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Abstract

In this paper, I build a general equilibrium model to study the macroeconomic effects of alternative fiscal consolidation strategies when the private sector is heavily indebted. I model fiscal consolidation as a permanent decrease in the targeted debt-to-GDP ratio by means of government spending cuts or tax hikes. I show that in the long run, fiscal consolidation entails output benefits that are dampened when private debt is high. This effect occurs independently of the instrument used to stabilize debt. In the short-run, I find that a fiscal policy that rises labour or capital tax rates induces deleveraging in the private sector, which amplifies temporary output losses due to fiscal consolidation. By contrast, fiscal consolidation achieved by government spending cuts or consumption tax hikes ease private debt repayment, thereby mitigating the negative output effect associated with a public debt reduction. Finally, regarding social welfare I find that a fiscal consolidation brings welfare gains when government spending and consumption tax rates adjust. However, it entails a social welfare loss when capital or labour tax rates adjust that is amplified in an environment of high private debt.

Keywords: Great recession, public debt, private debt, fiscal consolidation, borrowing constraints.

JEL classification numbers: E44, E61, E62, H63.

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1 Introduction

In many advanced countries the Great Recession of 2008-09 leaves a legacy of high and growing public debt-to-GDP ratios, as governments have implemented discretionary fiscal stimulus and provided support to the financial system whereas tax revenues have sharply declined. As a result, these economies need to design a fiscal consolidation plan over the medium term to reduce public debt and recover the role of fiscal policy as a tool for stabilizing the economy. In addition to high public debt ratios, most of these countries also feature high private sector debt-to-GDP ratios (i.e., debt of households and non-financial corporations)[1], meaning that fiscal consolidation will occur in an unprecedented environment of high private debt.

In this paper, I shed light on how effective are different fiscal consolidation strategies when private debt is high, considering both household and corporate debt, by addressing the following question: what are the effects of different fiscal consolidation strategies in a heavily indebted economy? Answers to this question can help policymakers to better understand the effects of private indebtedness on the transmission mechanism of different fiscal consolidation strategies as well as its effects on welfare. In the paper, I focus on consolidation plans that implement one fiscal instrument at a time to reduce public debt-to-GDP to meet a particular public debt target, while holding the other instruments constant. The purpose of this exercise is to differentiate between the macroeconomic effects of different fiscal consolidation instruments. In particular, I consider as fiscal instruments an increase in taxes on consumption, labor income and capital income, and cuts in government spending.

In order to address the previous questions, I build a dynamic general equilibrium (DGE) model of a closed economy in the spirit of Kiyotaki and Moore (1997) and Iacoviello (2005). The model is enriched with a detailed fiscal sector and government debt. Households exhibit a heterogeneous desire to save which generates borrowing and lending among them, and hence a role for household debt. In addition to household borrowers, firms can also borrow from household savers. Household borrowers and firms are financially constrained; they can borrow up to a limit given by a fraction of the expected nominal value of their housing and commercial real state holdings, respectively. As a consequence, housing prices and inflation play a crucial role in the dynamics of private debt through its impact on collateral values. Fiscal consolidation strategies will change households' and firms' ability to borrow through its impact on asset prices and inflation, and hence on consumption and investment decisions.

To explore how the interaction between fiscal consolidation and private debt levels, shapes the trans-

[1] Private sector debt is defined as the sum of indebtedness of both sectors, households and non-financial corporations.

mission mechanism of different fiscal policy instruments, I calibrate the model for the United States, an economy characterized by high public and private debt ratios. In the paper, I model fiscal consolidation as a permanent reduction in the government debt-to-GDP ratio from its value of 76% in 2016 to the average pre-crisis value of 60%, and analyze both expenditure and revenue based consolidation strategies and then compare the results with an economy in which private debt is lower. I find three key results. First, I find that fiscal consolidation has positive long run effects on key macroeconomic variables such as output regardless of the fiscal policy instrument used to reduce public debt. However, the long run output benefits associated with fiscal consolidation are reduced in an environment of high private debt. Second, I show that fiscal consolidation has negative short run effects on output for all fiscal consolidation strategies considered. Moreover, I find an asymmetric effect of fiscal consolidation on private debt dynamics depending on the fiscal instrument used. While instruments defined on labor or capital tax rates induce to a private deleveraging, amplifying the output losses associated with a fiscal consolidation process, government spending or consumption tax rates help private debt repayment, postponing the deleveraging in the private sector, and therefore mitigating the output losses. Third, and finally, I find that private debt amplifies the welfare losses associated with a consolidation based on labor and capital tax rates, but it also amplifies the welfare gains associated with a consolidation based on consumption and government spending. To sump up, my findings suggest that private debt plays an important role in the effectiveness of fiscal consolidation and the results depend crucially on the fiscal instrument used to stabilize the public debt ratio.

This paper brings together two branches of the literature: one that has focused on the macroeconomic effects of fiscal consolidation and another on the relation between private debt and the transmission mechanism of fiscal policy. My results corroborate previous findings in the fiscal consolidation literature, which suggest that fiscal consolidations are associated with short-term output losses and long-term output gains (see, e.g Coenen, Mohr, and Straub (2008); Guajardo, Leigh, and Pescatori (2014)). However, a strand of the literature, including Forni, Gerali, and Pisani (2010) and Cogan, Taylor, Wieland, and Wolters (2013), indicates that fiscal consolidation plans might even be expansionary in the short run. All these papers analyze a mix of policy instruments to achieve the desired fiscal consolidation. In contrast, I consider fiscal instruments separately to disentangle the short and the long run effect on output and welfare.

The recent literature analyzing the effectiveness of fiscal policy has focus on the length of a binding zero lower bound (ZLB) on interest rates (see, e.g. Christiano, Eichenbaum, and Rebelo (2011); Eggertsson (2011); Erceg and Lindé (2013)). However, the last crisis leaves a heavily leveraged private sector. Thus, study the impact of private debt levels on the transmission of fiscal consolidation has become an issue of

policy relevance. To the best of my knowledge, this is the first theoretical study investigating the role of household and corporate debt on the effects of fiscal consolidation.

Recent contributions show that the effectiveness of fiscal stimuli depends on the levels of private debt (Eggertsson and Krugman (2012); Kaplan and Violante (2014); Andrés, Boscá, and Ferri (2016)). I depart from this literature in two dimensions. First, I analyze the consequences of implementing fiscal consolidation measures to reduce the public debt-to-GDP ratio through permanent changes in the different fiscal instruments. It would be misleading to assume that the effects of fiscal consolidation are just the mirror image of fiscal stimulus because a fiscal stimulus is a temporary policy change that leads to a return to the initial steady state in the long run. Second, I investigate how the transmission of fiscal policy changes with the level of private debt considering the dynamics of households and corporate debt.

The rest of the paper is organized as follows. Section 2 provides a detailed description of the model. Section 3 explains the calibration procedure. Section 4 shows the quantitative results of the model, where section 4.1 and 4.2 presents the long-run and the short-run effects of a fiscal consolidation when private debt is high, and section 4.3 presents the welfare effects. Section 5 concludes.

2 The model

In this section, I present the theoretical model used in the quantitative exercises of the paper. I build a closed-economy general equilibrium model featuring financial frictions in the form of collateral constraints in the spirit of Kiyotaki and Moore (1997) and Iacoviello (2005). I extend their framework by incorporating fiscal policy and government debt.

The economy is populated by three types of consumers, patient households, impatient households and entrepreneurs, who differ by the rate at which they discount the future. Patient households have a higher propensity to save, meaning that in equilibrium, they are the ones saving and lending in the economy. Patient households and impatient households are inn measures χ_s and χ_b , respectively.[2] Patient households work, consume, buy houses, invest in private bonds and in government bond holdings. Impatient households work, consume, buy houses and borrow subject to a collateral constraint.[3] Entrepreneurs also borrow subject to a collateral constraint, produce an intermediate good combining household labour, commercial real estate and capital and sell it to a sector of retailers that operate in a monopolistically competitive market. The economy

[2]The proportion of borrowers and lenders in the economy are assumed to be constant over time.

[3]The only asset that serves as collateral is real estate properties. This feature is motivated by the fact that mortgages are the main component of U.S. household liabilities. In the case of non-financial corporations, around 55% of credit liabilities are secured by collateral (see Azariadis (2018)).

is also populated by a government that collects a mix of lump-sum and distortionary taxes on consumption, capital and labour income, and finances its fiscal deficit by issuing government debt. Monetary policy is implemented by a central bank that follows a Taylor-type interest rate rule, while fiscal policy follows a rule to meet the government's debt target. In the next subsections, I describe the decision problems of agents. Appendix A contains all the equilibrium conditions and provide more details on the model.

2.1 Households

Households supply labour and derive utility from consumption, $c_{i,t}$ and housing services, $h_{i,t}$. They maximize a lifetime utility function given by:

$$E_0 \sum_{t=0}^{\infty} \beta_i^t \left\{ \ln(c_{i,t} - \theta c_{i,t-1}) + j \ln(h_{i,t}) - \varphi \frac{(l_{i,t})^{1+\eta}}{1+\eta} \right\}, \tag{1}$$

where $i = \{s, b\}$ denotes the household's type. Patient and impatient households are denoted by s and b, respectively.[4] Impatient households' discount factor is $\beta_b < \beta_s$, where β_s is the discount factor of the patient households. The parameter η measures the elasticity of labour with respect to the real wage, and j is the housing weight in the utility.[5] I consider external habit formation, as in Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007). The parameter $\theta \in (0, 1)$ is the degree of habit adjustment, which is last period consumption. All the variables are in per-capita terms.

2.1.1 Patient households (savers)

Patient households accumulate residential housing, $h_{s,t}$, invest in private bonds, b_t^p and in government bonds, b_t^g. They also pay taxes on private consumption, τ_t^c, earned labour income, τ_t^w, and lump-sum taxes, $\tau_{s,t}^l$. They maximize their expected utility given by function (1) for $i = s$ subject to the following budget constraint in real terms:

$$(1+\tau_t^c)c_{s,t} + p_t^h(h_{s,t} - h_{s,t-1}) + b_t^p + b_t^g = (1-\tau_t^w)w_{s,t}l_{s,t} + \frac{R_{t-1}}{\Pi_t}(b_{t-1}^p + b_{t-1}^g) - \tau_{s,t}^l, \tag{2}$$

where p_t^h is the relative price of housing, $\Pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate, and $w_{s,t}$ is the real wage. R_{t-1} is the nominal return on private and public bond holdings between $t-1$ and t. As in Iacoviello (2005),

[4] The utility function of households is standard with the exception that goods are separable between non durable and durable goods (see Bernanke (1984)).

[5] As in the literature, housing services are assumed to be a fraction of the housing stock owned by households. See Iacoviello (2005) and Iacoviello and Neri (2010).

the gross inflation rate in the term $\frac{R_{t-1}}{\Pi_t}(b^p_{t-1} + b^g_{t-1})$ reflects the assumption that debt contracts are set in nominal terms, meaning that price swings between $t-1$ and t can affect the realized real interest rate.[6]

2.1.2 Impatient households (borrowers)

Impatient households maximize their expected utility given by function (1) for $i = b$ subject to:

$$(1+\tau^c_t)c_{b,t} + p^h_t(h_{b,t} - h_{b,t-1}) + \frac{R_{t-1}}{\Pi_t}b_{b,t-1} = (1-\tau^w_t)w_{b,t}l_{b,t} + b_{b,t} - \tau^l_{b,t}, \tag{3}$$

$$b_{b,t} \leq \rho_c \frac{b_{b,t-1}}{\Pi_t} + (1-\rho_c)\ m_b E_t\left[\frac{p^h_{t+1}\Pi_{t+1}h_{b,t}}{R_t}\right], \tag{4}$$

where equation (3) and (4) denotes the budget constraint and the borrowing constraint respectively. The borrowing constraint is specific for impatient households. As in Kiyotaki and Moore (1997) and Iacoviello (2005), borrowing is limited to a fraction of the value of the borrowers' housing stock. Thus, outstanding debt $b_{b,t}$ cannot exceed a fraction m_b of the expected discounted value of the household's residential stock. The parameter m_b can be interpreted as the loan-to-value (LTV) ratio. The term ρ_c allows for a slow adjustment over time of the borrowing constraint.[7] The assumption that $\beta_b < \beta_s$ guarantees that the borrowing constraint holds with equality.[8]

2.2 Production

In the production sector, entrepreneurs produce an intermediate good using a Cobb-Douglas constant returns-to-scale technology that uses household labour, capital and collateralizable real estate as input.[9] Retailers purchase the intermediate good from entrepreneurs in a competitive flexible price market and transform it into a composite final good.

[6] This assumption is based on the empirical evidence that, in low-inflation countries, the vast majority of debt contracts are set in nominal terms (see Iacoviello (2005)).

[7] This formulation is to capture the idea that in practice lenders do not readjust borrowing limits every quarter, as in Iacoviello (2015).

[8] As shown in Iacoviello (2005), without uncertainty it is possible to show that, in the present framework, impatient households and entrepreneurs borrow up to the maximum in the neighborhood of the deterministic steady state. Consider for instance the Euler equation of the impatient household evaluated at the deterministic steady state $\mu_b = \frac{\beta_s - \beta_b}{(1+\tau^c)(1-\theta)c_b(1-\rho_c\beta_b)} > 0$, where μ_b is the Lagrange multiplier associated with the borrowing constraint of impatient households. An analogous proof holds for entrepreneurs.

[9] Commercial real estate plays a dual role for entrepreneurs. It is an input of the production function and it also serves as collateral in the entrepreneurs' loan contracts.

2.2.1 Entrepreneurs

Entrepreneurs produce an homogenous intermediate good that is sold under perfect competition to retailers at price mc_t. The entrepreneur maximizes their lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \ln(c_{e,t} - \theta c_{e,t-1}), \tag{5}$$

where $\beta_e < \beta_s$, subject to the following budget constraint:

$$\begin{aligned}(1+\tau_t^c)c_{e,t} + I_t + p_t^h(h_{e,t} - h_{e,t-1}) + \frac{R_{t-1}}{\Pi_t} b_{e,t-1} =& (1-\tau_t^k)(mc_t Y_t - w_{s,t}L_{s,t} - w_{b,t}L_{b,t}) + b_{e,t} \\ &+ \tau_t^k \delta^k K_{t-1} + (1-\tau_t^k)\Pi_t^r - \xi_{k,t},\end{aligned} \tag{6}$$

where $Y_t = K_{t-1}^{\mu}(h_{e,t-1})^{\nu} {L_{s,t}}^{\alpha(1-\mu-\nu)} L_{b,t}^{(1-\alpha)(1-\mu-\nu)}$ is output of the intermediate good, K_{t-1} is capital (that depreciates at rate δ^k), $h_{e,t-1}$ is commercial real estate, $L_{s,t}$ and $L_{b,t}$ are aggregate labour from patient and impatient households respectively, $b_{e,t}$ is the real value of entrepreneurial debt outstanding at the end of period t and Π_t^r are real profits from the retail sector. I consider that capital installation entails a costs $\xi_{k,t} = \frac{\psi_K}{2\delta^k}\left(\frac{I_t}{K_{t-1}} - \delta^k\right)^2 K_{t-1}$, where $I_t = K_t - (1-\delta^k)K_{t-1}$ is investment in capital goods.[10] Entrepreneurs need to pay taxes on consumption τ_t^c and capital income τ_t^k. Capital income taxes are levied on capital income net-of-depreciation.

Entrepreneurs also face a limit on their obligations:

$$b_{e,t} \leq \rho_c \frac{b_{e,t-1}}{\Pi_t} + (1-\rho_c)\ m_e E_t\left[\frac{p_{t+1}^h \Pi_{t+1} h_{e,t}}{R_t}\right]. \tag{7}$$

2.2.2 Retailers

There exist a measure-one continuum of retailers that purchase the intermediate good from entrepreneurs and transform it one-for-one into differentiated final good varieties at no cost. For these firms, the real price of the intermediate good, mc_t, represents the real marginal cost. Cost minimization by consumers implies that each final good producer $z \in [0,1]$ faces the following demand curve for its product variety:

$$Y_t(z) = \left(\frac{P_t(z)}{P_t}\right)^{-\varepsilon} Y_t^d, \tag{8}$$

[10] The specific functional form for capital adjustment costs ensures that the costs are zero in steady state.

where $P_t(z)$ is the firm's nominal price, $\epsilon > 1$ is the elasticity of substitution between final good varieties and Y_t^d is the aggregate demand for final goods. I assume staggered nominal price adjustment à la Calvo (1983). Letting θ_p denote the constant probability of not adjusting the price, the optimal price decision of price-setting firms is given by:

$$\sum_{k=0}^{\infty} \theta_p^k E_t \left\{ \Lambda_{t,k} \left(\frac{P_t^*(z)}{P_{t+k}} - \frac{\epsilon}{\epsilon - 1} mc_{t+k} \right) Y_{t+k}^*(z) \right\} = 0, \tag{9}$$

where $\Lambda_{t.k} = \beta^k((c_{e,t}(1+\tau_t^c)/(c_{e,t+k}(1+\tau_{t+k}^c))$ is the entrepreneurs relevant discount factor. This condition tells that P_t^* equates expected discounted marginal revenue to expected discounted marginal cost. As a fraction θ_p of prices stays unchanged, the aggregate price level evolution is

$$P_t = (\theta_p P_{t-1}^{1-\epsilon} + (1-\theta_p)(P_t^*)^{1-\varepsilon})^{1/(1-\varepsilon)}. \tag{10}$$

Combining the above optimality condition and the aggregate price level evolution and linearizing yields a forward-looking Phillips curve.

2.3 Monetary policy

The central bank implements a simple Taylor-type interest-rate rule

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_R} \left[\left(\frac{\Pi_t}{\Pi} \right)^{\rho_\Pi} \right]^{1-\rho_R}, \tag{11}$$

where R and Π are steady-state levels of output and inflation, respectively. In this specification, the nominal interest rate is adjusted in response to deviations of inflation from its target and the rule allows for interest rate inertia.[11]

2.4 Fiscal policy

The government finances its expenditures, G_t, by levying taxes on consumption, τ_t^c, labor income, τ_t^w, and capital income, τ_t^k, and by issuing government bonds, b_t^g. The government budget constraint in real terms

[11] In this Taylor interest-rate rule, monetary policy does not react to output deviations. As shown in Iacoviello (2005), a monetary policy that only reacts to inflation amplifies the financial accelerator.

is given by:

$$\begin{aligned} B_t^g =& \frac{R_{t-1}}{\Pi_t} B_{t-1}^g + G_t - \tau_t^l - \tau_t^c C_t - \tau_t^w \left(w_{s,t} L_{s,t} + w_{b,t} L_{b,t}\right) \\ & - \tau_t^k \left(mc_t Y_t - w_{s,t} L_{s,t} - w_{b,t} L_{b,t} - \delta K_{t-1} + \Pi_t^r\right), \end{aligned} \tag{12}$$

where C_t is aggregate private consumption.

I assume that the government adjust spending or taxes to keep the government debt-to-GDP ratio close to a target path. If government spending is the fiscal instrument, I assume that spending adjusts endogenously according to the following linear rule:[12]

$$\bar{G}_t = \rho_f \ \bar{G}_{t-1} - (1-\rho_f)\Big[\phi_1^g \Big(B_{t-1}^{gy} - B^{gy^*}\Big) + \phi_2^g \Big(B_t^{gy} - B_{t-1}^{gy}\Big)\Big]. \tag{13}$$

In this equation, $\bar{G}_t$ is the deviation of government spending from its steady state level, B_t^{gy} is the government debt-to-GDP ratio and B^{gy^*} is the government debt-to-GDP target. If the government follows this rule, the other fiscal instruments are assumed to be constant at their steady state values. Alternatively, if distortionary taxes are used as fiscal instruments, the fiscal rules takes the following form:

$$\bar{\tau}_t^x = \rho_f \bar{\tau}_{t-1}^x + (1-\rho_f)\Big[\phi_1^{\tau^x} \Big(B_{t-1}^{gy} - B^{gy^*}\Big) + \phi_2^{\tau^x} \Big(B_t^{gy} - B_{t-1}^{gy}\Big)\Big], \tag{14}$$

where $\bar{\tau}_t^x = \{\bar{\tau}_t^c, \bar{\tau}_t^w, \bar{\tau}_t^k\}$ are the deviations of taxes from its steady state level. When the government adopts as fiscal instrument one tax, government spending as well as the other taxes that are not used to stabilize government debt remain constant at their steady state level. Under either fiscal rule, lump-sum transfers, τ_t^l, are also held constant at steady state.

2.5 Market clearing conditions

The goods market, the loans market and the housing market clear. This is summarized by the following equilibrium conditions:

$$Y_t = C_{s,t} + C_{b,t} + C_{e,t} + I_t + G_t + \xi_{k,t}, \tag{15}$$

$$B_t^p = B_{b,t} + B_{e,t}, \tag{16}$$

[12] This type of fiscal rule specification is similar to the one proposed by Erceg and Linde (2013).

$$1 = H_{e,t} + H_{s,t} + H_{b,t}, \tag{17}$$

where uppercase letters denote aggregate variables for agents. For example, $C_{s,t}$ is aggregate consumption for patient households. The last condition implies that real estate is fixed in supply and normalize to one.

3 Calibration of the model

I calibrate the model to the U.S. economy matching some key statistics for 2016, a period characterized by high public and private debt. Consequently, the model's steady state should be interpreted as the starting initial conditions to analyze the effects of a public debt reduction when private debt is high. The time period in the model is a quarter.

Parameter values and their descriptions are shown in Table 1. I describe first the set of parameters calibrated using steady state targets. The discount factor for patient households, β_s, is set to 0.99, which is a standard value for quarterly data and implies an annual real interest rate of 4%.

The loan-to-value ratio for impatient households, m_b, and the housing weight in the utility, j, are jointly calibrated to match two targets. The first target is household real estate value to annual GDP, which I compute from Flow of Funds (FF) and NIPA data as the ratio between the market value of real estate of households and nonprofit organizations and GDP (136.76%). The second target is the household debt to real estate ratio, for which I use FF data on home mortgages from the balance sheet of U.S. households and nonprofit organizations and the market value of real estate of households and nonprofit organizations (38.06%).[13] Under this parametrization, the model is able to replicate a ratio of household mortgages to annual GDP of 52.04% as in the data.

The elasticity of output to entrepreneurial real estate, ν, is calibrated to match commercial real estate over annual output, which I compute as the ratio between the market value of commercial real estate from the balance sheet of U.S. non-financial corporate business and GDP (63%). The loan-to-value ratio for entrepreneurs m_e is set to 0.89, as in Iacoviello (2005). Under this parametrization, the model is able to replicate a ratio of credit liabilities of non-financial corporations to annual GDP of 55.6%, which corresponds to the fraction of secured liabilities, as estimated by Azariadis (2018).[14]

Tax rates and government spending are key fiscal policy parameters in the paper. I estimate the con-

[13] The data source are the Board of Governors of the Federal Reserve System and the Bureau of Economic Analysis (BEA).
[14] In 2016, total credit liabilities of non-financial corporations as percent of GDP was 101.25%.

sumption tax, τ^c, labor income tax, τ^w, and capital income tax, τ^k, following the methodology of Mendoza, Razin, and Tesar (1994), and using data from the OECD for 2016. According to the estimates, the consumption tax rate is set to 5%, the labor tax rate to 26% and the capital tax rate to 29.5%. The estimates are in line with those found by Trabandt and Uhlig (2011). I set G to target a ratio of government expenditure to output equal to 14.7%, to match U.S. data in 2016.[15] I set the initial target of government debt to quarterly GDP, B^{gy*}=4×76%, to match the publicly held debt-to-GDP ratio in the U.S. economy.[16] The steady-state value of the lump-sum tax, τ^l, is treated as a residual to calibrate government debt at a desired steady-state level.

I borrow the remaining parameters from the existing literature. In particular, I borrow from Iacoviello (2005) the discount factors for impatient households and entrepreneurs, β_b and β_e, which are set to 0.98, the adjustment cost parameter, ψ_k, which is set to 2 and the Taylor rule parameters, ρ_Π=0.27 and ρ_R=0.73. Since the labor disutility parameter, φ, only affects the scale of the economy, I normalize it to one. The parameter η is set to 2 such that the Frisch elasticity of labor supply equals 1. I set ϵ equals to 6, in order to target an initial net markup equals to 20 percent, and the Calvo parameter, θ_p, is set to 0.75. I set the capital share in production, α, equal to 0.30 and the depreciation of productive capital, δ_k to 0.025. The patient household wage share, α, is set to 0.5. In the fiscal rules, the parameter ρ_f is set to 0.5 to allow for a small degree of inertia, as in Erceg and Lindé (2013). The habit in consumption coefficient, θ, and the inertia parameter in the borrowing constraints, ρ_c, are set to 0.46 and 0.5, respectively in line with Iacoviello (2005) estimates. The proportion of impatient households, χ, is set to 0.8. This value is slightly larger than the number used in Justiniano, Primiceri, and Tambalotti (2015) since I consider a period of relative high private indebtedness.

4 The macroeconomic effects of fiscal consolidation plans

In this section, I asses the effects of alternative fiscal consolidation strategies when private debt is high. First, I define how I model fiscal consolidation. Second, I describe the quantitative exercise aiming to shed light on how the presence of private debt can change the transmission mechanism of fiscal consolidation strategies.

I model fiscal consolidation as a permanent decrease in the initial target of government debt-to-GDP

[15] I define government spending as government consumption expenditure, government gross investment, and government net purchases of non-produced assets, minus government consumption of fixed capital. The data is from the Bureau of Economic Analysis (BEA)

[16] Total public debt over GDP in 2015 was 101.7%. In the paper, I use the publicly held debt-to GDP because it is the measure of debt used by the Congressional Budget Office to examine the future path of budget deficits and debt under different tax policies. As an alternative, I also use the gross debt to GDP ratio but none of the results change noticiable.

ratio (76%), through an expenditure reduction or an increase in fiscal revenues, by means of the fiscal rules. I analyze four different consolidation strategies, one for each fiscal instrument. I implement one at a time i.e., when one fiscal rule in equation (13) or (14) is active the other fiscal instruments remain constant at steady state. To achieve the desired public debt reduction, I decrease the target to 60% which is the average government debt-to-GDP ratio from 1995 to 2007.

The best way to assess how the transmission mechanism of fiscal consolidation changes in an environment of high private debt is to set up a counterfactual experiment, such that we can compare two economies that are identical to each other and differ only with respect their level of private indebtedness. To accomplish this exercise, I simulate a public debt reduction in the calibrated model for the U.S. economy, which features high private debt, and compare the macroeconomic effects of alternative fiscal consolidation strategies with an economy in which private indebtedness is lower. This allows us to evaluate the effectiveness of fiscal consolidation when private debt is high in the long run, the short-run, as well as implement social welfare comparisons.

4.1 What are the long-run effects of reducing public debt?

In this section, I analyse the long-run effects of a permanent reduction in the government debt-to-GDP ratio. First, I introduce some key steady state equations to understand the long run effects in the presence of private debt. Next, I compare the results for the calibrated model to the U.S. economy, which I refer to as "heavily indebted economy" (HIE), with an economy in which I set the LTV ratio for household's borrowers and entrepreneurs to zero, and maintain the proportion of borrowers. I refer to this economy, in which there is no credit, as " no indebted economy" (NIE).

4.1.1 Key Steady State Equations

Although the focus of this paper is on the short-run dynamics of reducing public debt when the private sector is heavily indebted, it is also relevant to study the key mechanism at work in the long run. To do so, I rewrite the steady state budget constraint of the different agents to examine how total spending capacity depends on public and private indebtedness. For patient households (savers), the total spending capacity depends on after-tax labor income, lump-sum taxes and net income from the repayment of government bonds and private bonds holdings:

$$(1+\tau^c)c_s = (1-\tau^w)w_s l_s - tr_s^l + (R-1)(b^g + b^p) \quad \text{with} \quad b^p = b_e + \chi b_b \tag{18}$$

For impatient households (borrowers), the total spending capacity depends on after-tax labor income, lump-sum taxes and net cost from private debt issued:

$$(1+\tau^c)c_b = (1-\tau^w)w_b l_b - tr_b^l - (R-1)b_b \quad \text{with} \quad b_b = \beta m_b p^h h_b \tag{19}$$

Finally, for entrepreneurs (borrowers), their total spending capacity depends on after-tax profits and net cost from issuing private debt[17]:

$$(1+\tau^c)c_e + I = (1-\tau^k)\Pi_e - (R-1)b_e \quad \text{with} \quad b_s = \beta m_e p^h h_e \tag{20}$$

In the steady state, when the evolution of interest rates and inflation does not matter for the steady state results, private debt benefits patient households, but it entails a cost for impatient households and entrepreneurs. Consequently, in the long run when the economy converges to a new steady state, if the fiscal consolidation strategy involves a private debt increase respect to the initial steady state, borrowers will lose spending capacity against savers reducing consumption, investment and aggregate demand.

4.1.2 Long-run transmission of fiscal consolidation measures

In Table 2, I show the long-run effects for different consolidation strategies in both indebtedness scenarios. All effects are shown as percentage changes relative to the initial steady state, except for tax instruments, which are reported as percentage-point changes.

In the long run, the economy converges to a new steady state with a smaller government debt-to-GDP ratio. The fall in the ratio implies lower interest rate payments for the government, which creates an additional fiscal space that leads to an increase in government spending or a decrease in the distortionary tax rates compared to the initial steady state. These steady state changes in fiscal instruments are the causes that generate long run benefits of fiscal consolidation policies in terms of output. This result is in line with Coenen et al. (2008) and Cogan et al. (2013), who analyze the impact of different consolidation strategies in the Euro area and United States, respectively. However, I find that, if the fiscal consolidation is implemented in a private debt overhang the output benefits are shift downward due to a private debt increase. If private debt increases, the spending capacity of borrowers is lowered as shown by equations (19) and (20), decreasing aggregate consumption and investment compared with a NIE scenario. Consequently, this dampens the long run benefits in terms of output. This amplification mechanism occurs for all consolidation strategies

[17] In equation (20), I define steady state investment as $I = \delta(1-\tau^k)k$ and entrepreneurial profits as $\Pi_e = mcY - w_s l_s - w_b l_b + \Pi^r$

considered, and the strength depends on the LTV ratios and the share of household borrowers.

Now, I analyze the long run effects for the different fiscal consolidation strategies highlighting the role of private debt in shifting the steady state results. I begin by analyzing the long-run effects of fiscal consolidation when government spending is used as instrument. This strategy has a direct positive long-run impact on aggregate demand, as the improvement in the fiscal position results in an increase in government spending, which directly affects the resource constraint. The increase in government spending absorbs part of the economy's resources, without providing utility to agents generating a negative wealth effect on part of them, leading to a crowding-out of aggregate consumption and residential housing and higher labor supply. As result, housing prices decrease and hours worked rises in equilibrium. The latter leads to an increase in the marginal product of capital, which implies an increase in factor inputs, capital and commercial real estate. Consequently, higher labor and factor inputs lead to an increase in output. The crowding-out of aggregate consumption and residential housing is solely caused by patient households. The reason is that the lower government debt-to-GDP ratio leads to lower interest income from holding government bonds so that their consumption and residential housing are reduced. For impatient households labor income increases and so does consumption and residential housing. The increase in commercial and residential real estate implies a rise in non-financial corporations debt and household debt. This leads to smaller aggregate consumption and investment in the HIE scenario compared with NIE scenario, which implies a smaller increase in output[18].

When consumption or labor income taxes are used as instrument, I find qualitatively similar results. A long run decrease of consumption or labor income taxes makes leisure relative to consumption more expensive and hence households increase their labor supply. Aggregate consumption increases under both strategies, despite the fall in consumption of patient households when consumption tax is used as fiscal instrument. In this case, the decrease of the consumption tax rate does not fully compensate patient households for the lower interest income from holding government bonds. For impatient households, labor income increases and so does residential housing increasing household debt. The factor inputs, capital and commercial real estate, increase to satisfy the increase in demand and this implies an increase in output. As before, the increase in commercial real estate and residential housing implies a rise in private debt leading to smaller aggregate consumption and investment in the HIE scenario compared with NIE scenario, which implies a smaller increase in output.

[18]Note that, although in the HIE scenario, the fall in consumption for patient households is smaller compared with a NIE, due to the fact that the lower interest income from holding government bonds is partly compensated with higher income from holding private debt, aggregate consumption decreases more because impatient borrowers represent a higher proportion in the economy.

Finally, a decrease in the capital tax rates leads to an increase of capital in production and a higher after-tax profits to entrepreneurs. This increases the marginal product of capital. Entrepreneurs increase factor inputs and the marginal product of labor increases rising aggregate wages. Then output, consumption, investment and hours worked increase. Housing prices experiment a high increase due to the increase in housing demand for entrepreneurs. This, implies a private debt increase that reduces the long-run gains of fiscal consolidation.

The long-run analysis suggests that fiscal consolidation would have been more effective in a much less leveraged economy. In a recent paper, Mian, Sufi, and Verner (2015) using an empirical analysis show that an increase in private debt tends to lower growth in the long run[19]. Therefore, my results corroborate their findings since fiscal consolidation strategies entail a rise in private debt that reduces output benefits. This effect occurs independently of the instrument used to stabilize debt. However, this amplification mechanism is only at work in the long run. In the next section, I compute the transitional dynamics between the initial and the final steady state for alternative indebtedness scenarios. The aim is to determine how the short run transmission of fiscal consolidation changes with the presence of private debt.

4.2 What are the short-run effects of reducing public debt?

While in the long run a fiscal consolidation generates additional fiscal space that can be used to increase government spending or decrease taxes, in the short run, a fiscal consolidation requires a government spending cut or significant tax hikes generating costs in terms of output.

To offer a quantitative representation of the adjustment in the output dynamics when the public debt reduction is produced in an environment of high private debt, I compute the cumulated output losses as the cumulative percentage changes in output relative to the initial steady state for the different fiscal consolidation strategies, aimed at reducing public debt from 76% to 60% in 10 years. I compare the HIE outcomes with an alternative indebtedness scenario, in which I set the proportion of household borrowers in the economy and also the LTV ratio for household borrowers and entrepreneurs to lower values. I refer to this economy as the "low indebted economy" (LIE). In particular, I set the proportion of borrowers, χ, as in Justiniano et al. (2015), who estimates an average precrisis share of U.S. household borrowers equal to 61%, and the LTV ratio for impatient households and entrepreneurs is reduced by 50%.

Figure 1 reveals that the presence of high private indebtedness shift the cumulated output losses for

[19]This result only holds for increases in household debt, while for rises in corporate debt the authors do not find significant future output effects.

the different fiscal instruments in two ways. When the fiscal consolidation is carried out through labor or capital income tax rates, the cumulative output losses are always much higher in a HIE. However, when government spending or consumption tax rate adjust to stabilize debt, the output losses are higher in a less indebted economy. Thereby, the results suggest that government spending and consumption tax rate are more effective in reducing public debt when private debt is high.

4.2.1 Amplification mechanism

To facilitate the understanding of the previous result, I provide a short description of the main economic mechanisms that shift the effects of fiscal consolidation strategies when private debt is high. A more detailed discussion then follows in the next two sections.

In table 3, I compute the cumulative percentage change, after 8 quarters from the beginning of the fiscal consolidation, for output, aggregate consumption, investment and private debt. I find an asymmetric effect of fiscal consolidation strategies on the evolution of private debt. If government spending or consumption tax rate adjust to stabilize debt around the new target, private debt increases which allows borrowers to mitigate the short run cost of fiscal consolidation since they can consume and invest more. However, If labor or capital income tax rates are used as fiscal instruments, the public debt deleveraging has associated a private debt deleveraging, forcing borrowers to a rapid debt repayment. Thus, lowering consumption and investment more intensively in a HIE.

Private debt dynamics depend on how interest rates, inflation and house prices evolve. First, fiscal consolidation strategies that generate an increase in interest rates affect borrowers by higher interest payments and lower collateral values, tightening the borrowing constraint. Second, fiscal consolidation strategies that generate an increase in inflation decreases borrowers' cost of private debt financing and increases the expected value of the collateral, facilitating the access to credit. Finally, fiscal consolidation strategies that generate a rise in house prices increase borrowers' collateral values relaxing the borrowing constraints. As a result, the effectiveness of fiscal consolidation strategies depends on how it indirectly affects private debt dynamics, through changes in the previous macroeconomic variables.

4.2.2 Government spending and consumption tax based consolidation

In Figure 2, I report the adjustment dynamics of a government spending (first column) and a consumption tax based consolidation (second column) across both indebtedness scenarios.

Fig. 2 shows that the crowding in (crowding out) consumption and in investment is stronger (weaker) in an scenario of high private debt for both fiscal instruments. Thus, in this case the response of private consumption and investment are the reasons why the output losses are smaller in a high indebted economy. Next, I analyze in detail a government spending based consolidation since the amplification mechanism at work is similar to a consumption tax based consolidation.

Considering the adjustment dynamics of a government spending based consolidation, I find a persistent fall in output across both indebtedness scenarios. This fall in output is less pronounced in a high private debt scenario and is caused by the responses of aggregate consumption and investment. Patient and impatient households rise consumption as government spending decreases due to a wealth effect, as they want to smooth their consumption path. The wealth effect also decreases hours worked for both types of agents lowering labor income. Patient households anticipate an income increase because of the inflow of funds stemming from the repayment of government debt holdings. They use debt repayment that they do not use for consumption to buy residential real estate. The increase in their housing stock produces a rise in housing prices which leads to a direct housing wealth effect for impatient households and entrepreneurs through an increase in the value of the residential ($p_t^h h_{b,t-1}$) and commercial real estate ($p_t^h h_{e,t-1}$). The rise in housing prices also increases the expected value of the collateral for impatient households ($E_t p_{t+1}^h h_{b,t}$) and entrepreneurs ($E_t p_{t+1}^h h_{e,t}$)increasing their access to new credit (increase in private debt, b_t^p) despite the rise in real interest rates (R_t/Π_{t+1}). The increase in the value of housing combined with an increase in the access to new credit allow borrowers to increase consumption and investment. This effect is stronger in an economy where the LTV ratios and the proportion of household borrowers are higher and led to higher consumption and investment in an scenario of high private debt. Note that because of private debt increases, patient households, instead, consume less in an scenario of high private debt, but the decline in patient households' consumption does not fully offset the rise in borrowers' consumption, and aggregate consumption rises.

4.2.3 Labor income and capital income tax based consolidation

In Figure 3, I report the adjustment dynamics of a labor income tax based consolidation (first column) and a capital income tax based consolidation (second column) across both indebtedness scenarios.

Fig. 3 shows that the crowding out in consumption and in investment is stronger in an scenario of high private debt for both fiscal instruments. Thus, in this case the response of private consumption and investment are the reasons why the output losses are higher in a high indebted economy. Next, I analyze in detail a labor tax based consolidation since the amplification mechanism at work is similar to a capital tax

based consolidation.

When using the labour income tax as fiscal instrument, the initial increase in the tax rate on labour income leads to a consumption fall and a decline in investment. The negative response of both consumption and investment translate into a persistent negative response of output. Comparing the output response in both indebtedness scenarios, I find that the output fall is amplified in an scenario of high private debt through a more persistent drop in consumption and investment. The increase in labor income taxes reduce households' labor supply. Households' labor income decreases because of the higher labor tax rate and the reduction in hours worked. This implies a reduction in consumption and residential housing for both types of households lowering housing prices. The increase in labor tax rates generates a rise in the real wage because households want to be partly compensated for the implied reduction in the after tax real wage. The rise in real wages increases the marginal cost. As a result of higher marginal cost, inflation and nominal interest rate rises. The fall in output and the rise in real wages decrease entrepreneurial profits and consequently entrepreneurs' consumption, commercial real estate and investment. In an scenario of high private debt, the fiscal consolidation induces to a longer a deeper recession. The amplification mechanism works through the reduction in the availability of new credit and the deterioration in the net financial wealth defined as housing wealth ($p_t^h h_{x,t-1}$) net of private debt ($R_{t-1}/\Pi_t b_{x,t-1}$, $x = \{e, b\}$). The fall in housing prices decreases the expected value of the collateral for impatient households ($E_t p_{t+1}^h h_{b,t}$) and entrepreneurs ($E_t p_{t+1}^h h_{e,t}$) decreasing their access to new credit (decrease in private debt, b_t^p) despite the fall in real interest rates (R_t/Π_{t+1}). Thus, the spending capacity of borrowers decrease lowering consumption and investment. The net financial wealth for borrowers is also reduced due to the fall in housing prices. Note that the rise in Π_t decreases the cost of debt repayment, but the net effect is negative, decreasing more the spending capacity of borrowers and hence reducing even further consumption and investment. In a high indebted scenario, in which the LTV ratios are higher and also the proportion of borrowers, the negative effects are amplified.

4.3 Who are the winners and losers of reducing public debt?

In this section, I analyze how private indebtedness changes the welfare effects for different fiscal consolidation strategies. First, I compute the gains and losses incurred by patient and impatient households and entrepreneurs to asses the impact of the alternative fiscal consolidation strategies on welfare. Next, I compare welfare across both indebtedness scenarios.

Welfare for patient households, $V_{s,t}$, impatient households, $V_{b,t}$, and entrepreneurs, $V_{e,t}$, is given by their discounted lifetime utility functions. Aggregate welfare V_t is defined as the weighted sum of households'

welfare for the two types of households and entrepreneurs' welfare:

$$V_{i,t} = \sum_{t=0}^{\infty} \beta_i^t \left\{ ln(c_{i,t} - \theta c_{i,t-1}) + j \ ln(h_{i,t}) - \varphi \frac{(l_{i,t})}{1+\eta}^{1+\eta} \right\} \tag{21}$$

$$V_{e,t} = \sum_{t=0}^{\infty} \beta_e^t \left\{ ln(c_{e,t} - \theta c_{e,t-1}) \right\} \tag{22}$$

$$V_t = (1-\chi)V_{s,t} + \chi V_{b,t} + V_{e,t} \tag{23}$$

where $i = \{s, b\}$ denotes the two types of households. I compute welfare of fiscal consolidation as the permanent change in consumption that would be necessary to achieve the same change in welfare as through the impact of fiscal consolidation.

Table 4 shows the welfare effects of alternative fiscal consolidation strategies in consumption equivalence units for an scenario of low and high private debt.

There are important differences in terms of welfare effects depending on which instrument is used to reduce public debt. A government spending based consolidation is associated with a social welfare gain which is more intense in a high indebted economy. The low indebted scenario leads to a 1.35 percent increase in welfare, whereas the high indebted scenario leads to a 1.56 percent increase. The main reason for the welfare differences across both indebtedness scenarios is the higher increase in private debt in the high indebted scenario which leads to a higher response of consumption and housing for impatient households and entrepreneurs which are the borrowers in the economy. A consumption tax based consolidation is associated with a positive social welfare which is also amplified in a high indebted economy. The higher welfare increase is due to the higher increase in private debt which reduces the drop in consumption and housing.

A labor income tax based consolidation or a capital income tax based consolidation is associated with a social welfare loss which is more intense in a high indebted economy. The reduction in welfare ranges from -2.94 percent for labor taxes to -4.17 percent to capital taxes. The reason for the amplification in the decrease in welfare for both fiscal instruments is the private debt deleveraging which is more intense in a much leveraged economy. A stronger decrease in private debt leads to a stronger decrease in consumption and housing for impatient households and entrepreneurs so that the welfare losses are amplified.

It is worthwhile to look at the different welfare effects of patient households. For patient households the welfare impact is positive for all fiscal consolidation strategies. However, the positive effects on welfare are

reduced when the fiscal consolidation is implemented in a high indebted economy. Thus, they always lose from reducing public debt in an environment of high private debt while borrowers could gain if the fiscal consolidation is carried out through a government spending cut or a consumption tax hike.

5 Concluding Remarks

I have analyzed the influence of private debt on the effectiveness of fiscal consolidation strategies in a dynamic general equilibrium model calibrated to the U.S. economy.

In the paper, I simulate a fiscal consolidation as a permanent decrease in the targeted government debt-to-GDP ratio by means of government spending cuts or tax hikes. I find that in the long run, fiscal consolidation entails output benefits that are dampened when private debt is high. This effect occurs independently of the instrument used to stabilize debt and is especially important when distortionary taxation is used to reduce public debt. In the short run, my findings gives rise to the interpretation that effectiveness of fiscal consolidation in an environment of high private debt depends on which fiscal instruments adjust to stabilize debt. Fiscal policies that rise labour or capital tax rates induce to a private sector deleveraging. The simultaneous private and public sector deleveraging amplifies temporary output losses due to fiscal consolidation. Hence, in an economy characterized by a high level of private indebtedness the negative effects of a fiscal consolidation process are amplified. By contrast, fiscal consolidation achieved by government spending cuts or consumption tax hikes ease private debt repayment, thereby mitigating the negative output effect associated with a public debt reduction.

Regarding social welfare, I find that a fiscal consolidation produces a social welfare gain when government spending or consumption tax rates are used as fiscal instruments to stabilize debt. This effect is amplified in an environment of high private debt through the increase in private debt, which allows agents to consume more and increase their housing units. However, it entails a social welfare loss when capital or labour tax rates adjust that is amplified in a heavily indebted economy due to the private sector deleveraging.

Finally, I also analyze the influence of the type of private debt, i.e. household debt or corporate debt, on the transmission of fiscal consolidation. I find that household debt always amplifies the effects of a fiscal shock whereas corporate debt only when labour or capital tax rates adjust. When government spending or consumption tax rates are used as instrument, the size of the multiplier diminishes when I include corporate debt.

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Table 1: Baseline Calibration

Description	Parameter	Value
Patient Households discount factor	β_s	0.99
Impatient Households discount factor	β_b	0.98
Entrepreneurs discount factor	β_e	0.98
Weight on housing services	j	0.19
Habits in consumption	θ	0.46
Labor supply elasticity	η	2.00
Labor preference parameter	φ	1.00
Share of Household borrowers	χ	0.80
Capital share	μ	0.30
Housing share	ν	0.05
Patient households' wage share	α	0.50
Capital adjustment cost	ψ_k	2.00
Capital depreciation rate	δ	0.025
Elasticity of substitution in goods	ϵ	6.00
Probability of non-adjusting prices	θ_p	0.75
LTV for household-borrower	m_b	0.89
LTV for entrepreneurs	m_e	0.89
Response to past inflation	ρ_Π	0.27
Response to past interest rate	ρ_R	0.73
Tax rate on consumption	τ^c	0.05
Tax rate on labor income	τ^w	0.26
Tax rate on capital income	τ^k	0.295
Government spending-to-GDP ratio	G/Y	0.147
Government debt-to-GDP ratio	$B^G/4Y$	0.76
Inertia in fiscal instruments	ρ_f	0.50
Inertia in borrowing constraints	ρ_c	0.50

Table 2: Long-run effects for different fiscal consolidation strategies

	G		τ^c		τ^w		τ^k	
	NIE	HIE	NIE	HIE	NIE	HIE	NIE	HIE
Output	0.77	0.64	0.77	0.64	0.93	0.85	2.16	1.82
Consumption	−0.18	−0.29	0.92	0.77	1.11	1.02	2.16	1.83
Patient households	−1.89	−1.62	−0.81	−0.59	0.03	0.14	−0.64	−0.24
Impatient households	0.55	0.46	1.65	1.51	2.24	2.15	1.54	1.30
Entrepreneurs	0.77	0.64	1.87	1.70	0.93	0.85	5.95	5.25
Investment	0.77	0.64	0.77	0.64	0.93	0.85	4.61	4.09
After-tax labor income	0.77	0.64	0.77	0.64	3.14	3.02	2.16	1.82
Housing prices	−0.55	−0.27	−0.55	−0.27	0.85	1.00	1.87	2.24
Real estate								
Patient households	−1.34	−1.34	−1.34	−1.34	−0.82	−0.81	−2.46	−2.43
Impatient households	1.11	0.74	1.11	0.74	1.38	1.17	−0.32	−0.92
Entrepreneurs	1.33	0.93	1.33	0.93	0.08	−0.12	4.86	3.81
Private debt		0.54		0.54		1.47		3.79
Fiscal Instrument	5.47	4.59	−1.13	−1.09	−1.62	−1.59	−3.21	−2.98

Note: NIE refers to a non indebted economy and HIE refers to high indebted economy. All variables are denoted in percentage changes from initial steady state, except for tax instruments, which are denoted in percentage points.

Table 3: Cumulative change in response of a Fiscal Consolidation after 8 quarters

	G		τ^c		τ^w		τ^k	
	LIE	HIE	LIE	HIE	LIE	HIE	LIE	HIE
Output	−19.03	−13.99	−20.80	−16.73	−45.74	−61.09	−30.26	−58.63
Consumption	24.88	28.75	−29.42	−24.21	−56.64	−75.47	−31.70	−61.92
Investment	7.54	9.34	7.57	9.52	−35.98	−50.22	−63.95	−130.89
Private debt	21.78	107.29	20.96	112.45	−19.25	−47.82	−26.22	−49.60

Note: LIE refers to a low indebted economy and HIE refers to a high indebted economy. All variables are denoted in cumulative percentage changes from initial steady state.

Table 4: Welfare effects for different fiscal consolidation strategies

	G		τ^c		τ^w		τ^k	
	LIE	HIE	LIE	HIE	LIE	HIE	LIE	HIE
Social Welfare	1.35	1.56	0.33	0.60	−1.56	−2.94	−2.52	−4.17
Patient households	1.94	0.03	2.04	0.15	3.05	1.50	2.17	0.39
Impatient households	0.05	0.88	−0.63	0.27	−1.83	−2.25	−0.71	−0.57
Entrepreneurs	0.57	0.85	−0.08	0.35	−1.63	−1.45	−2.93	−3.79

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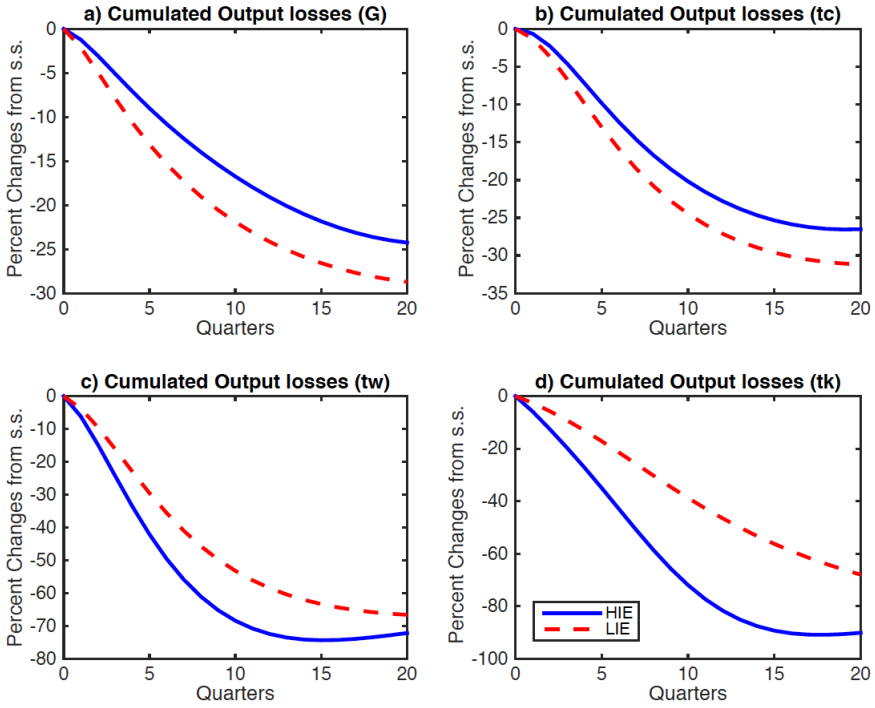

Figure 1: Cumulated Output losses for different fiscal consolidation strategies

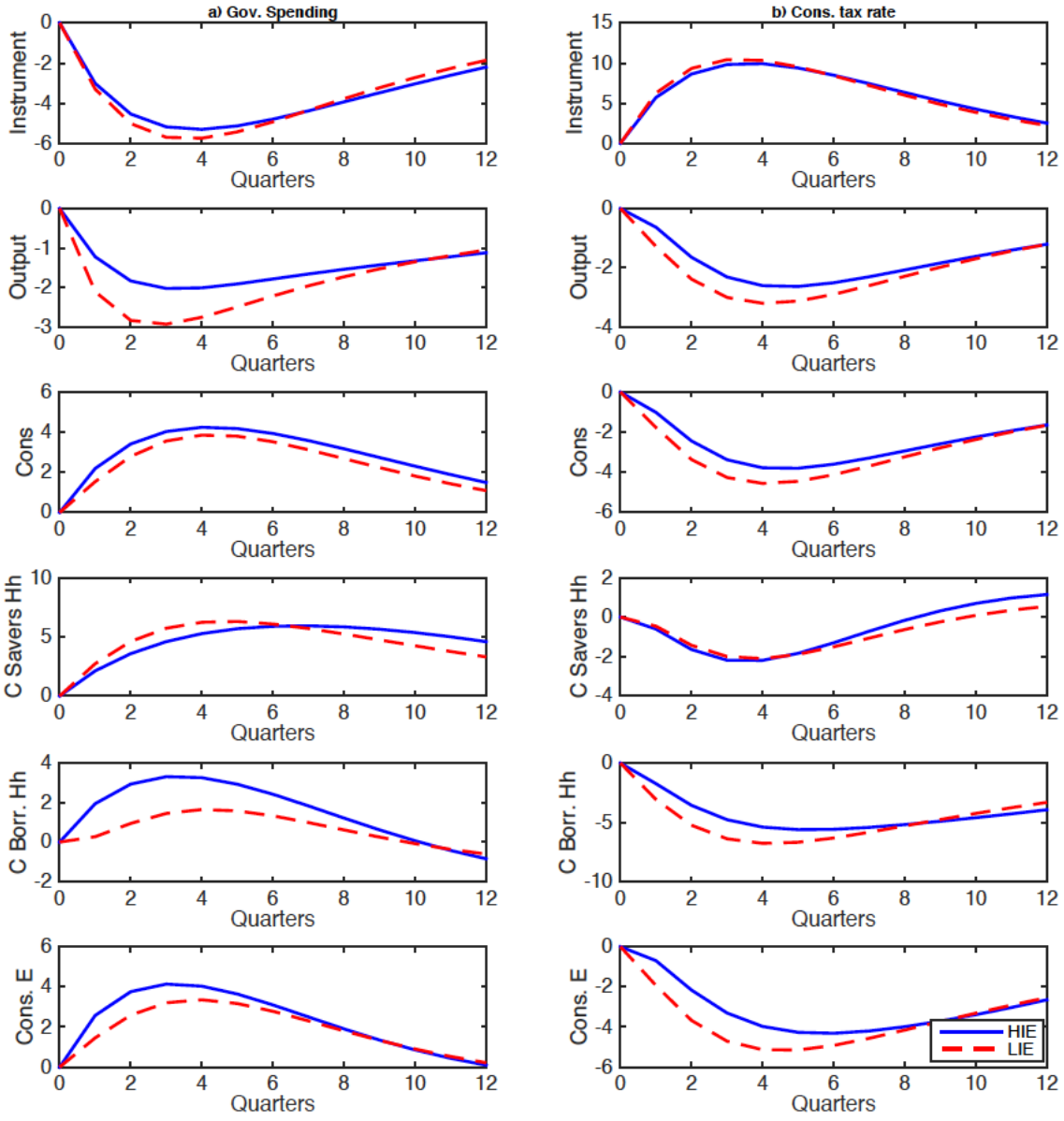

Figure 2: Transitional dynamics of Government spending and consumption tax based consolidation

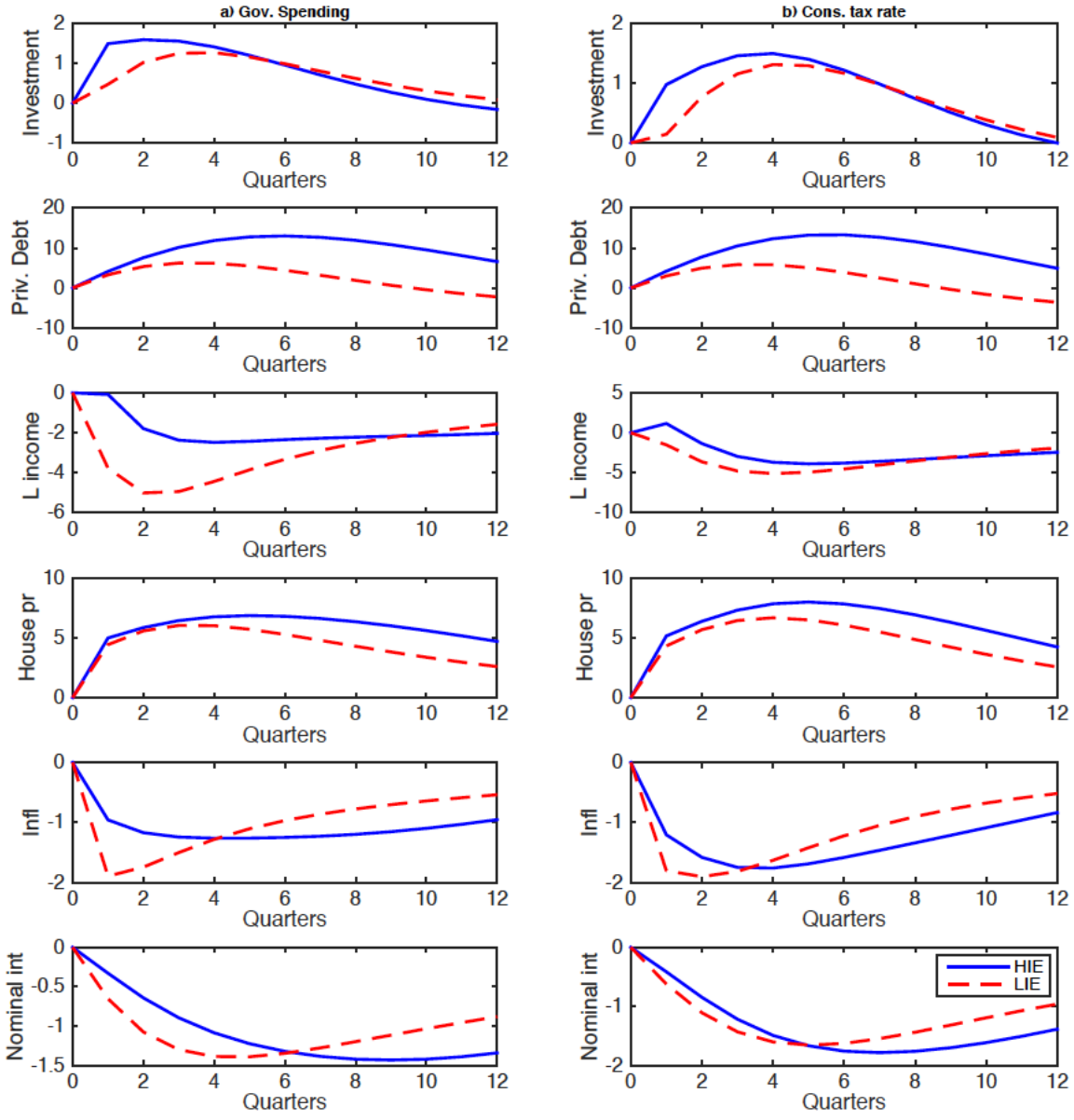

Figure 2 (Cont.): Transitional dynamics of Government spending and consumption tax based consolidation

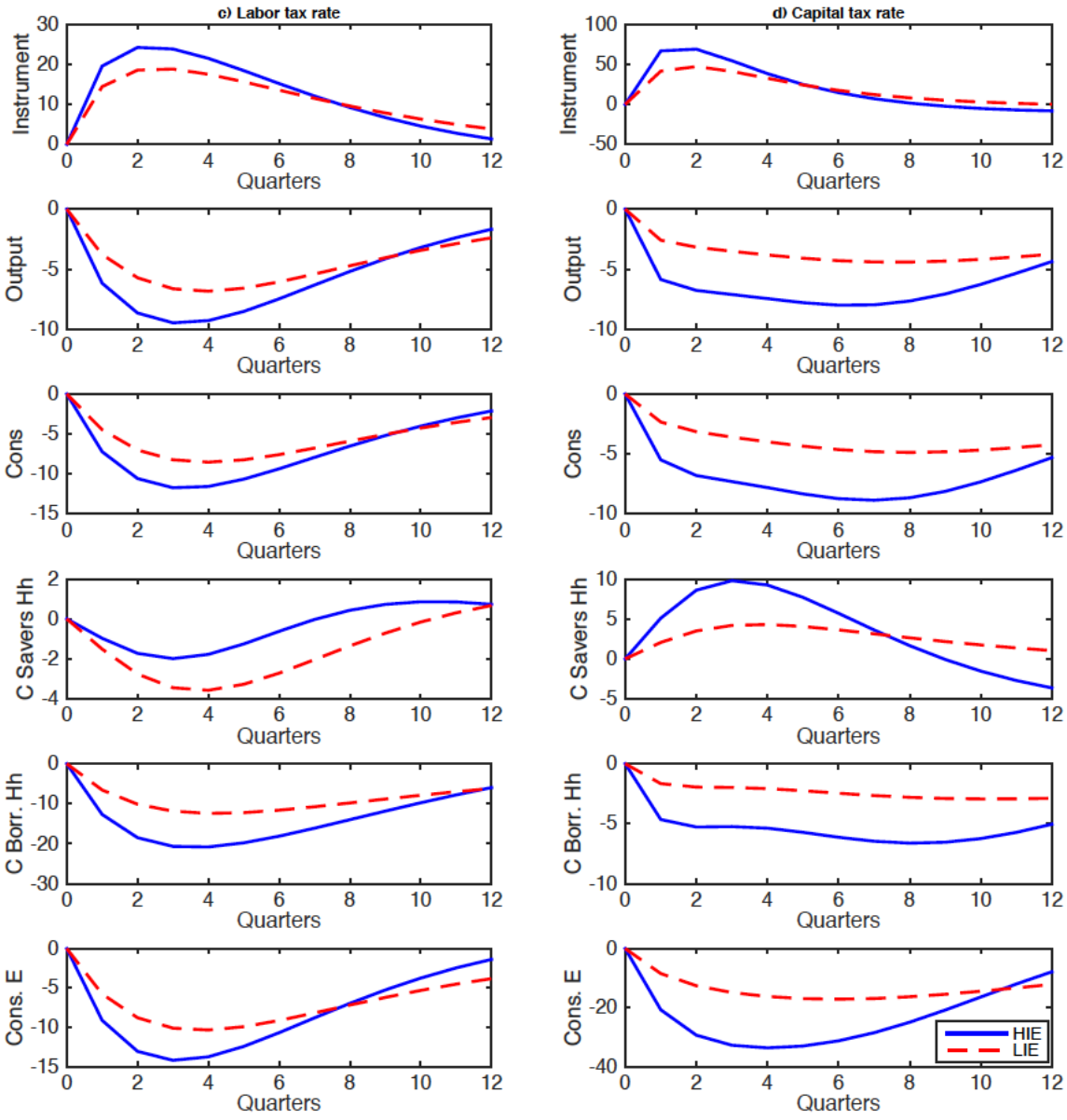

Figure 3: Transitional dynamics of Labor and Capital tax based consolidation

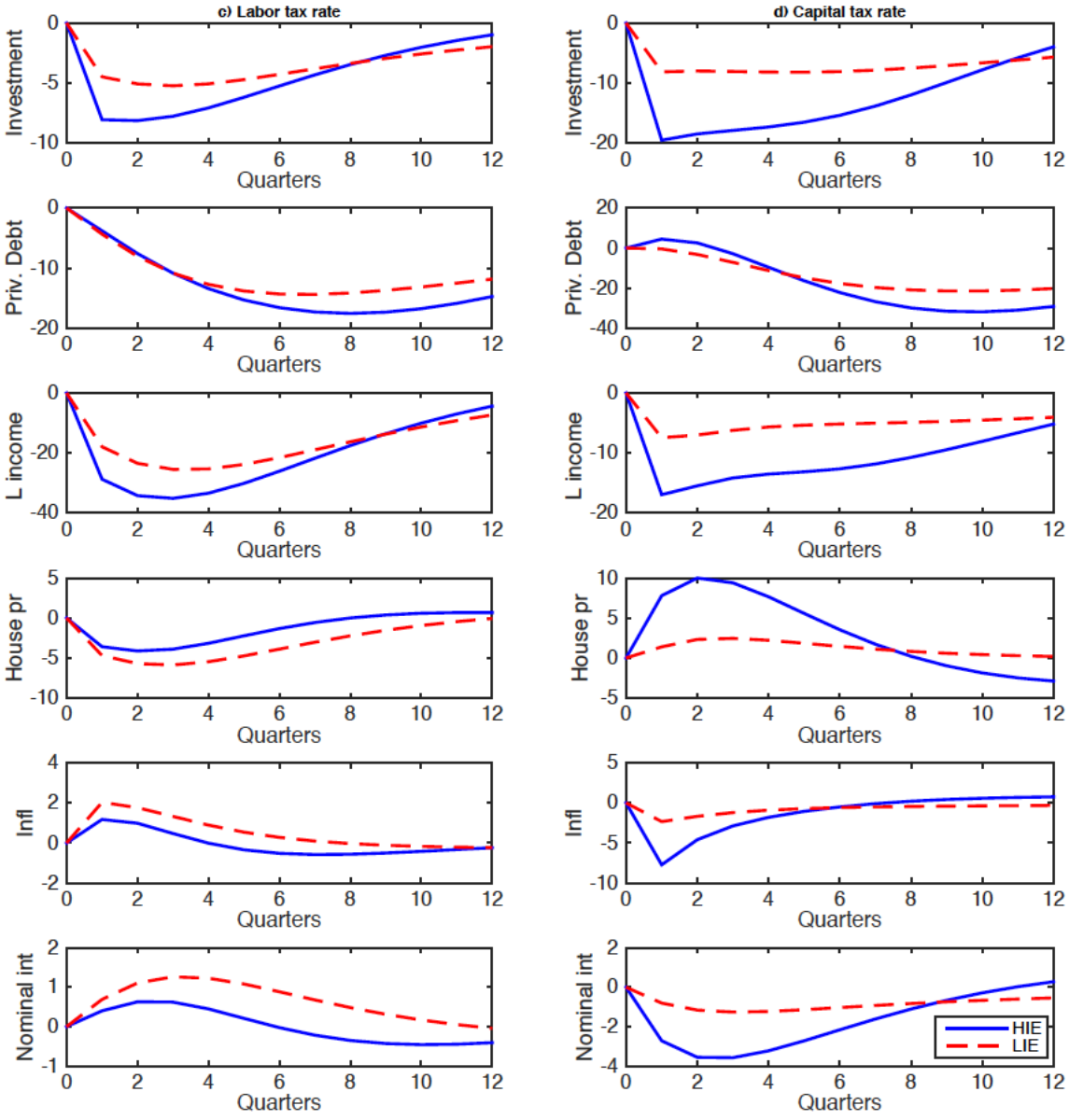

Figure 3 (Cont.): Transitional dynamics of Labor and Capital tax based consolidation

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Appendix

A Solving the model

In this appendix, I provide a detailed description of the model developed in section 2.

A.1 Patient households (savers)

$$\max_{c_{s,t},h_{s,t},l_{s,t},b_t^p,b_t^g} \; E_0 \sum_{t=0}^{\infty} \beta_s^t \left\{ \ln(c_{s,t} - \theta c_{s,t-1}) + j \ln(h_{s,t}) - \varphi \frac{(l_{s,t})}{1+\eta}^{1+\eta} \right\}, \tag{24}$$

subject to:

$$(1+\tau_t^c)c_{s,t} + p_t^h(h_{s,t} - h_{s,t-1}) + b_t^p + b_t^g = (1-\tau_t^w)w_{s,t}l_{s,t} + \frac{R_{t-1}}{\Pi_t}(b_{t-1}^p + b_{t-1}^g) - \tau_{s,t}^l. \tag{25}$$

Intertemporal maximization yields the following first-order conditions for consumption, debt, housing holdings and labour supply:

$$\lambda_{s,t} = \frac{1}{x_{s,t}(1+\tau_t^c)}, \tag{26}$$

$$\frac{1}{x_{s,t}(1+\tau_t^c)} = \beta_s E_t \left[\frac{R_t}{x_{s,t+1}(1+\tau_{t+1}^c)\Pi_{t+1}} \right], \tag{27}$$

$$\frac{p_t^h}{x_{s,t}(1+\tau_t^c)} = \frac{j_t}{h_{s,t}} + \beta_s E_t \left[\frac{p_{t+1}^h}{x_{s,t+1}(1+\tau_{t+1}^c)} \right], \tag{28}$$

$$w_{s,t} = \varphi(l_{s,t})^{\eta} \frac{(1+\tau_t^c)}{(1-\tau_t^w)} x_{s,t}, \tag{29}$$

where $\lambda_{s,t}$ is the Lagrange multiplier associated with equation (25), which is the budget constraint of patient households, $\Pi_t = p_t/p_{t-1}$ represents the gross inflation rate and $x_{s,t} = c_{s,t} - \theta c_{s,t-1}$. Equation (26) states that the current marginal utility of consumption is the inverse of actual consumption. Equation (27) is the Euler equation for patient households. Equation (28) determines the housing demand. Finally, equation (29) is the first order condition for labour supply. This condition pins down hours of work as a function of the wage.

A.2 Impatient households (borrowers)

$$\max_{c_{b,t},h_{b,t},l_{b,t},b_{b,t}} \quad E_0 \sum_{t=0}^{\infty} \beta_b^t \left\{ \ln(c_{b,t} - \theta c_{b,t-1}) + j \ln(h_{b,t}) - \varphi \frac{(l_{b,t})^{1+\eta}}{1+\eta} \right\}, \tag{30}$$

subject to:

$$(1+\tau_t^c)c_{b,t} + p_t^h(h_{b,t} - h_{b,t-1}) + \frac{R_{t-1}}{\Pi_t} b_{b,t-1} = (1-\tau_t^w) w_{b,t} l_{b,t} + b_{b,t} - \tau_{b,t}^l, \tag{31}$$

$$b_{b,t} \leq \rho_c \frac{b_{b,t-1}}{\Pi_t} + (1-\rho_c)\, m_b E_t \left[\frac{p_{t+1}^h \Pi_{t+1} h_{b,t}}{R_t} \right]. \tag{32}$$

Intertemporal maximization yields the following first-order conditions for consumption, loans, housing holdings and labour supply:

$$\lambda_{b,t} = \frac{1}{x_{b,t}(1+\tau_t^c)}, \tag{33}$$

$$\frac{1}{x_{b,t}(1+\tau_t^c)} = \beta_b E_t \left[\frac{R_t}{x_{b,t+1}(1+\tau_{t+1}^c)\Pi_{t+1}} \right] - \beta_b E_t \left[\rho_c \frac{\mu_{b,t+1} R_{t+1}}{\Pi_{t+1}} \right] + \mu_{b,t} R_t \tag{34}$$

$$\frac{p_t^h}{x_{b,t}(1+\tau_t^c)} = \frac{j_t}{h_{b,t}} + E_t \left[\frac{\beta_b p_{t+1}^h}{x_{b,t+1}(1+\tau_{t+1}^c)} + (1-\rho_c)\mu_{b,t} m_b p_{t+1}^h \Pi_{t+1} \right], \tag{35}$$

$$w_{b,t} = \varphi (l_{b,t})^{\eta} \frac{(1+\tau_t^c)}{(1-\tau_t^w)} x_{b,t}, \tag{36}$$

where $\lambda_{b,t}$ is the Lagrange multiplier associated with equation (31) the budget constraint of impatient households, $\mu_{b,t}$ is the Lagrange multiplier associated with equation (32) the borrowing constraint and $x_{b,t} = c_{b,t} - \theta c_{b,t-1}$. Equation (33) and equation (36) are identical to the first-order condition for the patient households. Equation (35) is identical to the housing demand equation for the patient households except for the term $(1-\rho_c)\mu_{b,t} m_b p_{t+1}^h \Pi_{t+1}$. This term captures that when impatient households increase their housing stock it also relaxes their budget constraint and allows them to borrow more against the value of their houses. The Euler equation (34) differs from the Euler equation of patient households in the term $\mu_{b,t} R_t$, which is included because increasing consumption incurs an extra cost by tightening the collateral constraint and also in the term $\beta_b E_t \left[\rho_c \mu_{b,t+1} R_{t+1} \right]$.

A.3 Entrepreneurs (borrowers)

$$\max_{c_{e,t},b_{e,t},I_t,K_t,h_{e,t},L_{s,t},L_{b,t}} \quad E_0 \sum_{t=0}^{\infty} \beta_e^t \ln(c_{e,t} - \theta c_{e,t-1}) \tag{37}$$

subject to:

$$Y_t = K_{t-1}^{\mu}(h_{e,t-1})^{\nu} {L_{s,t}}^{\alpha(1-\mu-\nu)} L_{b,t}^{(1-\alpha)(1-\mu-\nu)} \tag{38}$$

$$\begin{aligned}(1+\tau_t^c)c_{e,t} + I_t + p_t^h(h_{e,t} - h_{e,t-1}) + \frac{R_{t-1}}{\Pi_t} b_{e,t-1} =& (1-\tau_t^k)(mc_t Y_t - w_{s,t}L_{s,t} - w_{b,t}L_{b,t}) + b_{e,t} \\ &+ \tau_t^k \delta^k K_{t-1} + (1-\tau_t^k)\Pi_t^r - \xi_{k,t}\end{aligned} \tag{39}$$

$$b_{e,t} \leq \rho_c \frac{b_{e,t-1}}{\Pi_t} + (1-\rho_c)\ m_e E_t \left[\frac{p_{t+1}^h \Pi_{t+1} h_{e,t}}{R_t} \right] \tag{40}$$

$$I_t = K_t - (1-\delta^k)K_{t-1} \tag{41}$$

The adjustment cost function is:

$$\xi_{k,t} = \frac{\psi_K}{2\delta^k} \left(\frac{I_t}{K_{t-1}} - \delta^k \right)^2 K_{t-1}. \tag{42}$$

Intertemporal maximization yields the following first-order conditions for consumption, loans, investment, capital, commercial real estate and labour:

$$\lambda_{e,t} = \frac{1}{x_{e,t}(1+\tau_t^c)}, \tag{43}$$

$$\frac{1}{x_{e,t}(1+\tau_t^c)} = \beta_e E_t \left[\frac{R_t}{x_{e,t+1}(1+\tau_{t+1}^c)\Pi_{t+1}} \right] - \beta_e E_t \left[\rho_c \frac{\mu_{e,t+1} R_{t+1}}{\Pi_{t+1}} \right] + \mu_{e,t} R_t. \tag{44}$$

$$u_t = \frac{1}{x_{e,t}(1+\tau_t^c)} \left[1 + \frac{\psi_K}{\delta^k} \left(\frac{I_t}{K_{t-1}} - \delta^k \right) \right], \tag{45}$$

$$u_t = \beta_e E_t\left[\frac{1}{x_{e,t+1}(1+\tau^c_{t+1})}\left(\frac{\psi_K}{\delta^k}\left(\frac{I_{t+1}}{K_t}-\delta^k\right)\frac{I_{t+1}}{K_t}-\frac{\psi_K}{2\delta^k}\left(\frac{I_{t+1}}{K_t}-\delta^k\right)^2\right)\right]+$$
$$\beta_e E_t\left[\frac{1}{x_{e,t+1}(1+\tau^c_{t+1})}\left((1-\tau^k_{t+1})\mu\frac{mc_{t+1}Y_{t+1}}{K_t}\right)+u_{t+1}\left(1-\delta^k(1-\tau^k_{t+1})\right)\right], \tag{46}$$

$$\frac{p^h_t}{x_{e,t}(1+\tau^c_t)} = E_t\left[\frac{\beta_e}{x_{e,t+1}(1+\tau^c_{t+1})}\left((1-\tau^k_{t+1})\nu\frac{mc_{t+1}Y_{t+1}}{h_{e,t}}+p^h_{t+1}\right)+(1-\rho_c)\mu_{e,t}m_e p^h_{t+1}\Pi_{t+1}\right], \tag{47}$$

$$w_{s,t} = mc_t\frac{\alpha(1-\mu-\nu)Y_t}{L_{s,t}}, \tag{48}$$

$$w_{b,t} = mc_t\frac{(1-\alpha)(1-\mu-\nu)Y_t}{L_{b,t}}, \tag{49}$$

where $\lambda_{e,t}$ is the Lagrange multiplier associated with equation (39) the budget constraint, $\mu_{e,t}$ is the Lagrange multiplier associated with equation (40) the collateral constraint, u_t is the Tobin's Q and $x_{e,t} = c_{e,t} - \theta c_{e,t-1}$. Equation (44) is the Euler equation, equation (45) and (46) are the investment decisions and equation (47) is the housing demand equation. Finally, equation (48) and (49) determines labour demand.

A.4 Retailers

The retailers' problem is:

$$\max_{P^*_t} \; E_0\sum_{k=0}^{\infty}(\beta\theta_p)^k\,\Lambda_{t+k}\left[\left(\frac{P^*_t(z)}{P_{t+k}}-mc_{t+k}\right)Y_{t+k}(z)\right] \tag{50}$$

subject to:

$$Y_{t+k}(z) = \left(\frac{P_t(z)}{P_{t+k}}\right)^{-\epsilon}Y^d_{t+k}. \tag{51}$$

The first order condition of this problem is:

$$\sum_{k=0}^{\infty}\theta^k_p E_t\left\{\Lambda_{t+k}\left(\frac{1}{P_{t+k}}Y_{t+k}-\epsilon\frac{1}{P_{t+k}}Y_{t+k}+\epsilon\frac{mc_{t+k}}{P^*_t}Y_{t+k}\right)\right\} = 0. \tag{52}$$

After some algebra, I derive equation (9).

A.5 Aggregation

Aggregate consumption for patient households and impatient households is given by:

$$C_{s,t} = \chi_s c_{s,t},$$

$$C_{b,t} = \chi_b c_{b,t},$$

Aggregate consumption in the economy is computed as the sum of entrepreneurs' consumption and households' consumption:

$$C_t = C_{e,t} + C_{s,t} + C_{b,t},$$

Aggregate labour for patient and impatient households are given by:

$$L_{s,t} = \chi_s l_{s,t},$$

$$L_{b,t} = \chi_b l_{b,t},$$

Aggregate private debt is given by:

$$B_t^p = \chi_s b_t^p,$$

$$B_{b,t} = \chi_b b_{b,t},$$

Aggregate housing is given by:

$$H_{s,t} = \chi_s h_{s,t},$$

$$H_{b,t} = \chi_b h_{b,t},$$

Finally, aggregate lump-sum transfers are given by:

$$\tau_t^l = \chi_s \tau_{s,t}^l + \chi_b \tau_{b,t}^l.$$