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Abstract

Increased public spending to combat an economic recession caused by a housing demand shock can significantly harm investment and employment in the housing sector, despite its positive effect on GDP. In terms of the extent of this decoupling between output at the aggregate level and in the housing sector, we find that the easier it is to reallocate employment between production sectors, the lower the reaction of hours worked to wages, and the higher the level of household indebtedness, the more pronounced the decoupling is. Using a Dynamic General Equilibrium model that incorporates a housing construction sector, we find that fiscal stimulus causes an increase in the production of tradable goods that incentivizes the demand for labor and capital, leading to higher wages, which pulls workers out of the construction sector and negatively affects residential investment and total credit. The result is a widespread welfare loss that especially hurts borrowers. Our study offers different possible explanations for the lack of consensus in the empirical evidence on the effects of fiscal policy on the construction sector.

Keywords: Fiscal policy, endogenous housing construction, labor reallocation, two-sector DGSE model, credit constraint households.

JEL classification: E24, E44, E64.

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1 Introduction

In the decade prior to the financial crisis, the weight of the housing sector in the Spanish economy increased substantially. For example, Figure 1 indicates that the share of residential investment in GDP rose steadily from 6 percent to a peak of 12 percent in 2006. Likewise, hours worked in construction as a proportion of total hours increased from 10 percent to a peak of 15 percent in 2007. This pattern contrasts with the relative stability of the weight of the housing sector in the Eurozone as a whole. The economic recession that began in the second half of 2008 was lead by a drop in the importance of residential investment and hours worked in the construction sector.[1] Both variables fell to a third of their peak and more than half, respectively, in just six years.

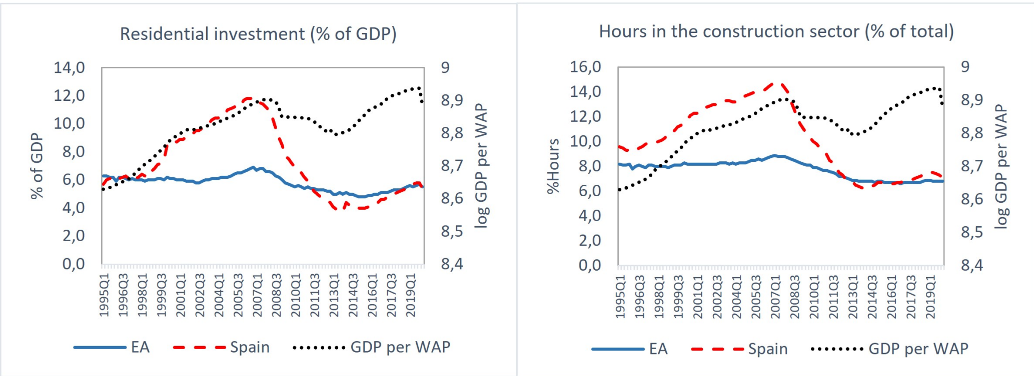

Figure 1: Residential investment and employment in Spain and Euro Area. *Notes*: The graph on the left compares the weight in GDP of residential investment in Spain and in the Euro Area (EA). The graph on the right compares the weight of hours in the construction sector over total hours of work. *Source of data*: EUROSTAT.

At the onset of the crisis, fiscal policy reacted by expanding public consumption to counteract the fall in GDP and the rise in unemployment, but did not prevent the weight of the construction sector from shrinking. Moreover, the two years of significant fiscal stimulus from 2008 onwards coincided with an unprecedented slump in the growth rate of house prices, which did not recover their trend values until ten years later (Figure 2).

The relationship observed between the different variables shown in Figures 1 and 2 from the raw data is anecdotal. There are many factors that could have acted at the same time, so the true effect of government spending on GDP and real estate remains hidden. Would GDP, residential investment

[1] Green (1997), Coulson and Kim (2000) and Leamer (2007), among others, have offered, with different approaches, evidence that residential investment leads the business cycle. Recently, however, Green (2021) finds that housing ability as a leading indicator has weakened since the Great Recession. Figure 1 shows that in Spain, after collapsing, the weight of construction in the economy has not recovered with GDP either.

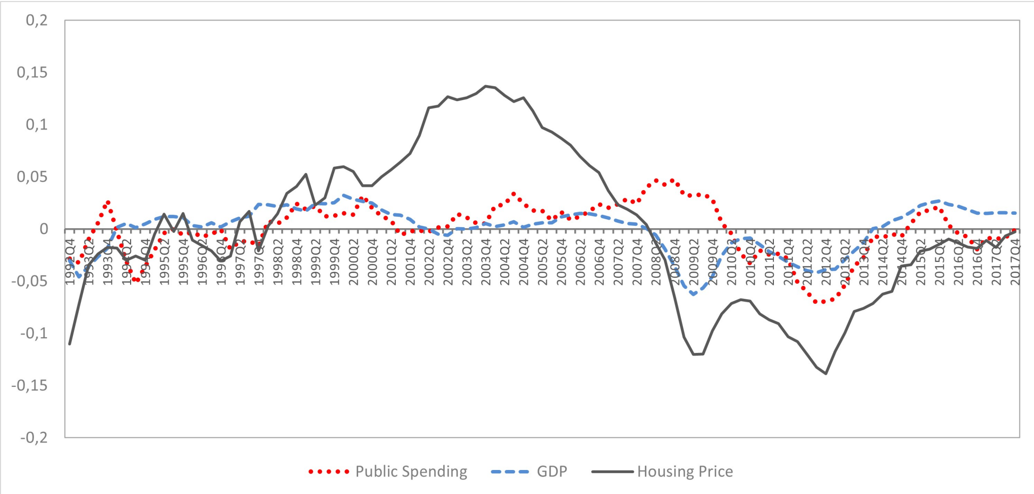

Figure 2: Growth rates of GDP, public spending and housing prices in Spain. *Notes*: Year-on-year growth rates (relative to working-age population for the GDP and government spending) detrended according to the mean of each variable along the period 1992:4 - 2017:4 *Source*: BDREMS.

and housing prices have fallen more or less with exactly the same factors at work except for the fiscal expansion? This is one of the questions we intend to answer in this paper. As a preview of the results, for a benchmark calibration, we find a positive effect of public spending on GDP and residential investment in Spain. We also detect an adverse but mild effect on housing price that, however, is very persistent. However, these effects are not invariant to changes in some key characteristics of the economy. More specifically, we show that the baseline effects on housing investment and prices can be reversed when the reallocation of employment across sectors is easier, when labor supply is more insensitive to wages, or when household debt is high.

There is no empirical consensus on the response of house prices and residential investment to fiscal shocks. Regarding house prices, the results of Agnello and Sousa (2013), Andrés, Boscá and Ferri (2015) and Miles (2021) suggest that increased government spending has negative effects on house prices. In contrast, Afonso and Sousa (2009) and Khan and Reza (2017) find an increase in housing prices, whereas for Afonso and Sousa (2012) house prices rise in some countries (e.g., the United Kingdom), but decrease in others (e.g., Germany). However, for Aye *et al.* (2013) or Ruiz and Vargas-Silva (2016) government spending shocks have no major impact on house prices. Interestingly, Gupta, Jooste and Matlou (2014) detect a time-varying effect, negative for the 1970s and 1980s and positive for the first decade of the 2000s.

The same pattern of mixed empirical evidence holds for residential investment. The seminal empirical analysis of Ramey and Saphiro (1998) shows a substantial drop in residential investment in response to military buildups in the United States. In his comment to the previous article, Eichenbaum (1998) provides additional evidence to a fall in residential investment and wages in the residential sector following an expansion of government spending. The same behaviour are afterwards confirmed by Edelberg, Eichenbaum and Fisher (1999), Mountford and Uhlig (2005), Ruiz and Vargas-Silva (2016) and Miles (2021) On the contrary, in Fatas and Mihov (2001) the increase in public spending produces a significant increase in residential investment, as well as a positive reaction of wages in the housing sector. However, for a variety of identification strategies, Caldara and Kamps (2008) find a small and generally not statistically significant effect on residential investment.

The outline of the literature in the previous two paragraphs shows differences in the results depending on the economy and the particular period studied, the variables and shocks considered in the analysis, and the strategy for identifying fiscal shocks. Leaving aside the identification strategy, the variety of results depending on the period, the country or the variables considered is consistent with the ability of the empirical model to capture some key characteristics of the economy that could be influencing the effect of the fiscal shock on residential activity and prices. In this paper, by perturbing a model economy with an increase in public spending, we show that some features of the economy, such as the ability to reallocate labor across sectors, the responsiveness of labor supply to wages or the ability to increase private sector borrowing, are crucial to understand the quantitative and qualitative effects of public spending on housing prices and residential investment.

The fiscal shock is only part of a more general story, occurring throughout the double-dip recession observed in the Spanish economy, which is highlighted in Figure 2. Thus, our work also explores the effects and economic transmission mechanisms of real estate shocks. To assess the behavior of the economy during this period, we rely on counterfactual exercises using a two-agent, two-sector model of a small open economy within a monetary union. The validity of the model is assessed by its ability to explain the events depicted in Figures 1 and 2.

Our work ties in with the literature that incorporates the housing sector into dynamic stochastic general equilibrium (DSGE) models. After the Great Recession (or, in the words of Christiano, Eichenbaum, and Traband (2018), "after the storm") a stream of work began to analyze the role of financial frictions by introducing the housing market into DSGE models. In these models, housing or land prices influence the ability of households or firms to borrow. Models with this type of financial frictions have been used to study the transmission mechanisms of various shocks, or the macroeconomic effects of certain policies. Thus, for example, the influence of the housing market as a whole on the economy cyclical fluctuations has been studied in Iacoviello and Neri (2010). More specifically, Liu, Wang and Zha (2013) explain macroeconomic fluctuations through the co-movements between land prices and business investment. With a different objective in mind, Liu, Miao and Zha (2016) and Pinter (2019) analyze the links between mortgage-backed credit and the labor market; Rubio and Yao (2020) study the role of macroprudential policies in a low interest rate environment; whereas Rabanal (2018) and Bielecki and Stäler (2020) emphasize the macroeconomic impact of property taxes.

Although the interaction between monetary policy and housing markets has been extensively studied in DSGE models (see, for example, Iacoviello, 2005; Finocchiaro and Von Heideken, 2013; Lambertini, Mendicino and Punzi, 2013; Walentin, 2014; Ng, 2015; Wen and He, 2015; Notarpietro and Siviero, 2015; Quint and Rabanal, 2018; Rubio, 2019; or Bluwstein *et al.*, 2020) consideration of the links between macro-fiscal policy and housing in a general equilibrium framework has been less abundant but still significant. Examples include Roeger, W. and J. in't Veld (2010); Coenen et al (2012); Kollmann, Ratto, and Roeger (2013); Andrés, Boscá and Ferri (2015); Khan and Reza (2017); Liu and Ou (2021); and Hu (2022).

In the case of Spain, DSGE models have also been previously used to shed light on the contribution of fiscal policy to GDP during the financial crisis. Gomez-Gonzalez and Rees (2018) analyze the role of the joint influence of three fiscal shocks during the sovereign debt crisis: a government consumption shock, a government debt shock, and a sovereign risk shock. They find that removing these fiscal shocks would have increased GDP by 1% on average over the period 2010-2014. Similarly, in Boscá *et al.* (2020), they estimate that the fiscal shocks, a mix of government consumption and investment, offset the fall in per capita GDP growth by just under one percentage point between 2008 and 2010, but subtracted an average of almost 1.5 percentage points in 2012.

With respect to the literature, our contribution in this paper is twofold: on the one hand, we focus on the effect of public spending shocks, not only on GDP, but on the residential sector and household welfare; on the other hand, we highlight the importance of labor supply elasticity, labor mobility between the housing sector and the tradable goods sector, and household indebtedness on the variables of interest.

The paper, thus, bridges the gap in the literature between Khan and Raza's (2018) puzzle that 'properly accounting for the empirical evidence on government spending shocks and house prices using a DSGE model remains a significant challenge' and Aspachs-Bracons and Rabanal's (2010) assertion that there is 'very decisive [Bayesian] evidence in favor of the [two-sector] model with costly labor reallocation'.

Indeed, Khan and Raza (2017) find no mechanism that, incorporated in a DSGE model, allows them to reproduce their evidence that house prices rise following an increase in public spending. On the other hand, Aspachs-Bracons and Rabanal (2010) identify, in their model without fiscal policy, a substantial drop in the likelihood of the estimated model when removing barriers to labor mobility between their durable and consumer goods sector.

We identify a set of parameters that help reconcile the empirical evidence, of whatever sign, regarding the effect of public spending shocks on the residential sector: labor supply elasticity, labor mobility between sectors, the intensive and extensive margin of total private indebtedness and the adjustment cost of housing demand. Interestingly, the central role of these parameters has gone virtually unnoticed in this literature, despite representing economic ingredients that are related to specific policies and thus carry a strong normative message (see Kambourov, 2009). In fact, regulations on rental or ownership housing, those affecting the labor market, educational reforms to increase the transferability of human capital, tax reforms, macroprudential policies, etc., are examples of actions that governments can take to influence the value of these parameters. Actually, according to Cardi and Restout (2015) cross-country dispersion of labor mobility between traded and non-traded sectors as captured by the elasticity of substitution, ranges from a low of 0.22 for the Netherlands to a high of 1.80 for the United States. Loan-to-value (LTV) ratios in credit decisions, and the proportion of credit-constrained households can also vary significantly across countries and periods, as can transaction costs in the housing market.

More related to our work, Cardi, Restout and Claeys (2020) study the sectoral effects of public spending shocks in relation to labor mobility. With respect to these authors, the present study differs in some relevant aspects: (a) our interest is on the housing market, which is a particular type of a non-tradable good that accumulates over time, and we focus on housing price and investment reaction; (b) we highlight the role of limited household heterogeneity by introducing lenders and borrowers in our model economy; (c) we reveal the importance of considering explicit import and export functions that explain the long run (absolute and relative) reaction of housing prices to a permanent shock in the tradable good sector productivity.

This document is organized as follows. In section 2, the model is presented. In section 3, we explain the calibration and show the parameter values used to obtain the numerical solution. In section 4 we provide the main results. We begin by analyzing the behavior of the model in the face of a variety of shocks, to show how different the elasticities of residential investment and house prices with respect to GDP can be depending on the nature of the shocks affecting the economy. In relation to the productivity shock, we also study the influence of the price elasticities of imports and exports on the Balassa-Samuelson effect, i.e. the reaction of the relative price of housing with respect to consumer goods. We continue with a validation test by replicating with the model the behavior of the variables observed during the financial crisis. We then turn to the analysis of fiscal policy and the influence of labor market characteristics and household debt in shaping the effect of public spending. We finish the results section with an analysis of welfare. Section 5 offers the main conclusions of the study and cautiously presents some policy implications that could be drawn.

2 The Model

Because of our interest in Spain, we consider a small open economy in a monetary union. There are two production sectors. One sector produces goods for consumption and investment that can be traded with the rest of the union. The other sector produces housing that is not tradable internationally.

The economy is populated by two classes of households depending on their subjective discount rate. Those with the lower discount rate (patient households) become savers. Households with the higher discount rate (impatient households) become borrowers. Both savers and borrowers consume a mix of domestic and foreign consumer goods, demand domestic real estate, and supply labor to the tradables and housing sector. Hours worked are not perfectly substitutable across sectors. The degree of substitutability is captured by a parameter in the model. The higher the substitutability, the lower the cost in terms of utility of switching from one sector to another, and the easier it is to reallocate labor between sectors.

The flow of financial funds from savers to borrowers (the financial market) is subject to lending constraints, as borrowers face a limit on the amount of credit they can take, which is a share of the expected real value of their real estate. The endogenous labor supply response of borrowers and lenders is different. Movements in the housing market directly influence the borrowing capacity and thus the consumption, investment and labor supply of borrowers. On the other hand, changes in the production conditions of tradable goods can influence the relative labor supply of different sectors and create an effect on housing production that feeds back into the quantity of credit.

There is a domestic fiscal authority (government) that affects the economy through the purchase of tradable goods. To keep the results as clean as possible of financing alternatives, we consider that government consumption is financed through a lumpsum tax paid equally in per capita terms by lenders and borrowers.

Monetary policy is conducted by a central bank that sets the nominal reference interest rate for the entire area according to a standard Taylor-type feedback rule that responds to deviations of the monetary union's inflation from its long-term target.

Next, we present the model highlighting the most relevant equations and showing the complete set of model equations in Appendix A.

2.1 Households

As in Iacoviello (2005), there are two representative households types; N_t^l of them are patient (lenders) and N_t^b are impatient (borrowers). Total population is given by $N_t = N_t^l + N_t^b$. We call $1 - \tau^b = \frac{N_t^l}{N_t}$ and $\tau^b = \frac{N_t^b}{N_t}$ the exogenous proportion of lenders and borrowers in the population[2]. In the following two subsections we characterize their choice decisions.

2.1.1 Patient households

Patient households, or lenders, choose consumption, housing and labor to maximize the following schedule (real variables are expressed in per capita terms of the specific type of household).

$$\max_{c_t^l, h_t^l, n_t^l, b_t^l, b_t^{l,eu}, k_t^l} \mathbb{E}_0 \sum_{i=0}^{\infty} (\beta^l)^i \left(\ln c_{t+i}^l + \phi_{j,t}\gamma_h \ln h_{t+i}^l - \frac{(n_{t+i}^l)^{1+\eta}}{1+\eta} \right)$$

subject to the real flow of funds expressed in terms of the consumption price index P_t^c (the *numeraire*) that takes into account the price of imported goods,

$$c_t^l + q_t(h_t^l - (1-\delta^h)h_{t-1}^l) - b_t^l - \frac{b_t^{l,eu}}{\phi_{bt}} + p_t^j(k_t^l - (1-\delta^k)k_{t-1}^l) + \frac{\Phi}{2}(k_t^l - k_{t-1}^l)^2 = w_{ct}n_{ct}^l + w_{ht}n_{ht}^l - \frac{r_{t-1}}{\pi_t^c}b_{t-1}^l + d_t - tr_t - \frac{r_{t-1}^{eu}}{\pi_t^c}b_{t-1}^{l,eu} + r_t^k k_{t-1}^l \quad (1)$$

[2]This differs from other approaches in which the weighting of household types is given by the wage share (e.g., Iacoviello, 2005; Iacoviello and Neri, 2010). We consider that our form of weighting decouples the size of representative households from the wage they receive. Moreover, it allows us to explore, in a natural way, the effect of the extensive margin of indebtedness, τ^b, on the results.

On the utility side, $\beta^l \in (0,1)$ represents the inverse of the patient discount factor, c_t^l is real consumption per capita, h_t^l is lenders' housing tenure, and n_t^l is labor time per person. The parameter γ_h captures housing preference, the inverse of η relates to the elasticity of labor with respect to wages, and $\phi_{j,t}$ is a housing preference driver that changes the preferences for housing. It is initially set to 1.

We assume imperfect substitutability, as in Iacovello and Neri (2010), of labor across sectors, so that n_t^l is a CES composite of lenders' labor supply in the tradable consumption sector n_{ct}^l and in the housing sector n_{ht}^l,

$$n_t^l = [\theta^{\frac{1}{\varepsilon_n}} (n_{ct}^l)^{\frac{1+\varepsilon_n}{\varepsilon_n}} + (1-\theta)^{\frac{1}{\varepsilon_n}} (n_{ht}^l)^{\frac{1+\varepsilon_n}{\varepsilon_n}}]^{\frac{\varepsilon_n}{1+\varepsilon_n}} \tag{2}$$

where $\theta > 0$ is a weight parameter that relates with the disutility of working in the consumption sector relative to the housing sector, and affects the proportion of patient households working hours in each sector. $\varepsilon_n \geq 0$ is the elasticity of substitution between labor supply in the two sectors, capturing the easiness of movement across sectors. When ε_n approaches infinite, then $n_t^l = n_{ct}^l + n_{ht}^l$, and hours worked are perfectly substitutable across sectors. We call it the perfect labor mobility case. If ε_n approaches zero, workers do not change the working hours across sectors no matter what happens with relative wages. We call it the completely immobile labor case. In between there is a continuum of cases[3].

As for the budget constraint, patient households lend in real terms $-b_t^l$ to impatient households (where b_t^l is negative) and $-b_t^{l,eu}$ to the rest of the union. They receive back $-\frac{r_{t-1}}{\pi_t^c} b_{t-1}^l$ and $-\frac{r_{t-1}^{eu}}{\pi_t^c} b_{t-1}^{l,eu}$ from the previous period's loans, where $\frac{r_{t-1}}{\pi_t^c}$ and $\frac{r_{t-1}^{eu}}{\pi_t^c}$ are the gross real interest rate factors. To ensure the stationarity of net foreign assets, we assume a risk premium, ϕ_{bt}, which increases with the country's net foreign debt (see Schmitt-Grohe and Uribe, 2001)

$$\ln \phi_{bt} = \phi_b(\exp(b_t^{eu}) - 1) \tag{3}$$

These households buy houses $(q_t(h_t^l - (1-\delta^h) h_{t-1}^l))$, invest in new productive capital $(p_t^j(k_t^l - (1-\delta^k) k_{t-1}^l))$ and incur capital adjustment costs $(\frac{\Phi}{2}(k_t^l - k_{t-1}^l)^2)$. They receive rents from capital $(r_t^k k_{t-1}^l)$ and labor $(w_{ct} n_{ct}^l + w_{ht} n_{ht}^l)$. They receive profits, d_t, from firms operating in non-competitive markets, and pay lump-sum taxes, tr_t, in terms of consumption goods.

The solution of the above optimization schedule generates the following first order conditions

[3] For a full discussion of this CES function see Cardi and Restout (2015).

$$\lambda_t^l = \frac{1}{c_t^l} \tag{4}$$

$$\frac{\phi_{j,t}\gamma_h}{h_t^l} = \lambda_t^l q_t - \beta^l \mathbb{E}_t(\lambda_{t+1}^l q_{t+1}(1-\delta^h)) \tag{5}$$

$$\frac{w_{ct}}{c_t^l} = (n_t^l)^\eta (\theta \frac{n_{ct}^l}{n_t^l})^{\frac{1}{\varepsilon_n}} \tag{6}$$

$$\frac{w_{ht}}{c_t^l} = (n_t^l)^\eta ((1-\theta) \frac{n_{ht}^l}{n_t^l})^{\frac{1}{\varepsilon_n}} \tag{7}$$

$$\lambda_t^l = \beta^l \mathbb{E}_t \lambda_{t+1}^l \frac{r_t}{\pi_{t+1}^c} \tag{8}$$

$$\lambda_t^l = \phi_{bt} \beta^l \mathbb{E}_t \lambda_{t+1}^l \frac{r_t^{eu}}{\pi_{t+1}^c} \tag{9}$$

$$\lambda_t^l (p_t^j + \Phi(k_t^l - k_{t-1}^l)) = \beta^l \mathbb{E}_t \lambda_{t+1}^l (p_{t+1}^j (1-\delta^k) + r_{t+1}^k + \Phi(k_{t+1}^l - k_t^l)) \tag{10}$$

Equation (5) represents the current demand for housing, which depends positively on housing preferences and the expected value of houses in the future, and negatively on the current price of houses.

Equations (6) and (7) represent the labor supply of patient workers to the tradable goods and housing sectors. The higher the value of $\frac{1}{\eta}$ the more sensitive is the labor supply to both sectors following a change in wages. Likewise, the higher the value of the elasticity of substitution, ε_n, the more likely workers are to shift their labor supply to the sector that has experienced an increase in wages relative to the other.

Combining equations (8) and (9) yields the interest rate parity condition which, in a monetary union, directly relates domestic and foreign interest rates through the risk premium.

$$r_t = \phi_{bt} r_t^{eu} \tag{11}$$

Working with expression (10), gross investment $(k_t^l - k_{t-1}^l)$ can be expressed as a negative function of the adjustment cost, Φ, as well as of current and expected real interest rates, while expected gains from capital asset appreciation, and expected increases in the rental rate of capital push investment upward, which is the basis of Tobin's q theory of investment.

2.1.2 Impatient households

Impatient households are characterized by having a relatively high discount rate, so the inverse of the discount factor $\beta^b < \beta^l$. The impatient household maximizes the following utility function,

$$\max_{c_t^b, h_t^b, n_t^b, b_t^b} \quad \mathbb{E}_0 \sum_{i=0}^{\infty} (\beta^b)^i \left(\ln c_{t+i}^b + \phi_{j,t}\gamma_h \ln h_{t+i}^b - \frac{(n_{t+i}^b)^{1+\eta}}{1+\eta} \right)$$

where c_t^b is borrowers' real consumption, h_t^b denotes borrower's holding of housing, and n_t^b is a composite of labor supply to the consumption sector n_{ct}^b and to the housing sector n_{ht}^b represented by the following CET function,

$$n_t^b = [\theta^{\frac{1}{\varepsilon_n}} (n_{ct}^b)^{\frac{1+\varepsilon_n}{\varepsilon_n}} + (1-\theta)^{\frac{1}{\varepsilon_n}} (n_{ht}^b)^{\frac{1+\varepsilon_n}{\varepsilon_n}}]^{\frac{\varepsilon_n}{1+\varepsilon_n}} \tag{12}$$

Impatient households become borrowers, so in addition to the budget constraint (13), they face a financial constraint on the maximum amount of credit they can obtain. In particular, expression (14) limits the amount of borrowing, b_t^b, to a fraction κ of the expected resale value of housing held by household.

$$c_t^b + q_t(h_t^b - (1-\delta^h)h_{t-1}^b) - b_t^b = w_{ct}n_{ct}^b + w_{ht}n_{ht}^b - \frac{r_{t-1}}{\pi_t^c} b_{t-1}^b - tr_t \tag{13}$$

$$b_t^b \leq \phi_{\kappa,t}\kappa \mathbb{E}_t \frac{q_{t+1}\pi_{t+1}^c h_t^b}{r_t} \tag{14}$$

where κ represents the loan-to value and $\phi_{\kappa,t}$ is a factor to exogenously change the loan-to-value. The first order conditions for the utility maximization problem of the impatient household are the following.

$$\lambda_t^b = \frac{1}{c_t^b} \tag{15}$$

$$\frac{\gamma_h \phi_{j,t}}{h_t^b} = \lambda_t^b q_t - \mathbb{E}_t(\beta^b \lambda_{t+1}^b q_{t+1}(1-\delta^h) + \phi_{\kappa,t}\kappa \mu_t^b q_{t+1}\pi_{t+1}^c) \tag{16}$$

$$\frac{w_{ct}}{c_t^b} = (n_t^b)^\eta \left(\theta \frac{n_{ct}^b}{n_t^b} \right)^{\frac{1}{\varepsilon_n}} \tag{17}$$

$$\frac{w_{ht}}{c_t^b} = (n_t^b)^\eta \left((1-\theta) \frac{n_{ht}^b}{n_t^b} \right)^{\frac{1}{\varepsilon_n}} \tag{18}$$

$$\lambda_t^b = \beta^b \mathbb{E}_t \lambda_{t+1}^b \frac{r_t}{\pi_{t+1}^c} + \mu_t^b r_t \tag{19}$$

where μ_t^b is the Lagrange multiplier on the collateral constraint. Under the assumption that the constraint is binding $\mu_t^b > 0$ is an indicator of the tight of the credit markets for borrowers. This new variable introduces a wedge in the current consumption and housing impatient households demand relative to patient ones.

2.2 Aggregation

Since our economy is composed of two representative households, the value in per capita terms of the aggregate variables may be affected by the weight of each type of household, τ_b. Aggregate per capita values are calculated as follows.

Debt issued by borrowers is fully purchased by patient households

$$(1-\tau^b)b_t^l + \tau^b b_t^b = 0 \tag{20}$$

External debt and private physical capital involve exclusively patient households

$$b_t^{eu} = (1-\tau^b)b_t^{l,eu} \tag{21}$$

$$k_t = (1-\tau^b)k_t^l \tag{22}$$

Net per capita investment is defined as

$$j_t = k_t - (1-\delta^k)k_{t-1} \tag{23}$$

Aggregate per capita consumption and housing stock depends on the borrowers and lenders mix

$$c_t = \tau^b c_t^b + (1-\tau^b)c_t^l \tag{24}$$

$$h_t = \tau^b h_t^b + (1-\tau^b)h_t^l \tag{25}$$

We also consider different measures of working hours. Aggregate hours per worker in the consumption goods sector

$$n_{ct} = \tau^b n_{ct}^b + (1-\tau^b)n_{ct}^l \tag{26}$$

Aggregate hours per worker in the housing sector

$$n_{ht} = \tau^b n_{ht}^b + (1-\tau^b)n_{ht}^l \tag{27}$$

Aggregate hours per worker in the economy

$$n_t = \tau^b(n_{ct}^b + n_{ht}^b) + (1 - \tau^b)(n_{ct}^l + n_{ht}^l) \tag{28}$$

2.3 Producers of tradable goods

There is continuum of firms indexed by $j \in [0, 1]$. Each firm j produces a differentiated good y_{jt} at the nominal price P_{jt} in a monopolistically competitive market. As we will see, this good can be used for consumption or investment. We assume two-level of production. At the top level there is a competitive bundler that mixes the output of these firms y_{jt} at the prices P_{jt} into a single product, y_t, which is sold to households (for consumption and investment) and to the government.

Assuming a constant returns to scale technology *a la* Dixit and Stiglitz (1977) to compose the bundle, the aggregate production, aggregate production price index (PPI), and total demand for each variety are given respectively by

$$y_t = \left(\int_0^1 (y_{jt})^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{29}$$

$$P_t = \left(\int_0^1 (P_{jt})^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}} \tag{30}$$

$$y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} y_t \tag{31}$$

At the bottom level, each variety is produced with the same technology. Specifically, the producer of the variety rents physical capital, k_{jt}, and hires labor, n_{jct}, which are combined according to a Cobb-Douglas production function,

$$y_{jt} = \phi_{c,t} z_t^c (k_{jt-1})^\alpha (n_{jct})^{1-\alpha} \tag{32}$$

where z_t^c is a productivity factor common to all firms and $\phi_{c,t}$ is a driver that change in an exogenous way the productivity of the sector.

Optimal factor demands for production are obtained by solving the cost minimizing problem faced by each variety producer,

$$\begin{aligned} \min_{n_{jct}, k_{jt}} \quad & \sum_{i=0}^{\infty} (w_{ct} n_{jct} + r_t^k k_{jt}) \\ \text{s.t.} \quad & y_{jt} = \phi_{c,t} z_t^c (k_{jt-1})^\alpha (n_{jct})^{1-\alpha} \end{aligned}$$

The solution to production cost minimization yields the labor demand (33) and capital demand for each differentiated product in the tradable sector (34):

$$w_{ct} = mc_{jt}(1-\alpha)\frac{y_{jt}}{n_{jct}} \tag{33}$$

$$r_t^k = mc_{jt}\alpha\frac{y_{jt}}{k_{jt-1}} \tag{34}$$

where mc_{jt} is the Lagrange multiplier for the production constraint, which is interpreted as the increase in production cost after a unit increase in production. Thus, mc_{jt} is real marginal cost.

Combining (33) and (34) we get

$$\frac{r_t^k}{w_{ct}} = \frac{\alpha}{1-\alpha}\frac{n_{jct}}{k_{jt-1}} \tag{35}$$

and the marginal cost takes the following expression

$$mc_{jt} = \frac{1}{\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}}\frac{r_{tk}^{\alpha}w_{ct}^{(1-\alpha)}}{z_t} \tag{36}$$

which says that the marginal cost is common to all firms.

2.3.1 Price setting

Prices of tradable domestic goods are sticky and adjust following Calvo staggered price setting. Each firm optimally resets its price with a $1-\omega$ probability in each period. This probability is independent across firms. Therefore, it can be interpreted as the proportion of firms that each period optimize prices. The proportion ω of firms that do not reprice optimally in t adjust them according to the following indexation rule,

$$P_{jt} = (\bar{\pi})^{1-\zeta}(\pi_{t-1})^{\zeta}P_{jt-1}$$

where ζ stands for the degree of indexation and π_{t-1} is the one-period lag of domestic PPI inflation. According to this rule, among firms that do not optimize, a proportion $1-\zeta$ of firms keep the rate of price growth equal to the steady-state inflation, $\bar{\pi} = 1$, whereas a proportion ζ takes into account lagged PPI inflation.

Firms which are able to choose an optimal price in period t will choose P_t^* that maximizes discount expected profits, taking into account the probability that the price cannot be optimally reset in the future. The problem can be expressed as follows,

$$\max_{p_t^*} \quad \mathbb{E}_t \sum_{i=0}^{\infty} (\beta^l \omega)^i \lambda_{t+i}^l \left(\prod_{r=1}^{i/i>0} \frac{(\bar{\pi})^{1-\zeta} (\pi_{t+r-1})^{\zeta}}{\pi_{t+r}^c} p_t^* y_{jt+i} - mc_{t+i} y_{jt+i} \right)$$

$$\text{s.t.} \quad y_{jt+i} = \left(\prod_{r=1}^{i/i>0} \frac{(\bar{\pi})^{1-\zeta} (\pi_{t+r-1})^{\zeta}}{\pi_{t+r}^c} p_t^* \right)^{-\varepsilon} p_{t+i}^{\varepsilon} y_{t+i}$$

where ${p_t}^*$ is the optimal production price in terms of the numeraire (the consumption price index). The value of the optimal price ${p_t}^*$, which is common to all firms that reoptimize the price, is given by the expression,

$$ {p_t}^* = \frac{\varepsilon}{\varepsilon - 1} \frac{V_t}{F_t} \tag{37}$$

and,

$$V_t = \lambda_t^l mc_t y_t p_t^{\varepsilon} + \mathbb{E}_t \beta^l \omega \left(\frac{(\bar{\pi})^{1-\zeta} (\pi_t)^{\zeta}}{\pi_{t+1}^c} \right)^{-\varepsilon} V_{t+1} \tag{38}$$

$$F_t = \lambda_t^l y_t p_t^{\varepsilon} + \mathbb{E}_t \beta^l \omega \left(\frac{(\bar{\pi})^{1-\zeta} (\pi_t)^{\zeta}}{\pi_{t+1}^c} \right)^{1-\varepsilon} F_{t+1} \tag{39}$$

where $\frac{\varepsilon}{\varepsilon-1}$ represents the steady-state markup, and the optimal price depends on the current and expected future evolution of the real marginal cost.

From expression (30), the value of the aggregate price index P_t in the tradable goods sector can be expressed as a function of the nominal optimal price P_t^* as well as the past nominal production price P_t and inflation,

$$P_t = [\omega(\bar{\pi}^{1-\zeta} \pi_{t-1}^{\zeta} P_{t-1})^{1-\varepsilon} + (1-\omega)(P_t^*)^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$$

therefore, the tradable good price in terms of consumer price (our numeraire) equals,

$$p_t = \left(\frac{1 - \omega \left(\frac{(\bar{\pi})^{1-\zeta} (\pi_{t-1})^{\zeta}}{\pi_t} \right)^{1-\varepsilon}}{1-\omega} \right)^{1-\varepsilon} p_t^* \tag{40}$$

π_t refers to the inflation of domestic produced tradable goods prices. From this, we can calculate the CPI inflation, $\pi_t^c = P_t^c / P_{t-1}^c$, that evolves according to

$$\pi_t^c = \pi_t \frac{p_{t-1}}{p_t} \tag{41}$$

and that will enter the policy rule of the central bank.

Given that all firms use the same technology, production can be aggregated as

$$y_t = \phi_{c,t} z_t^c (k_{t-1})^\alpha (n_{ct})^{1-\alpha} \tag{42}$$

2.4 Housing construction firms

There are many small firms owned by patient households that build identical houses in a perfectly competitive environment. Aspachs-Bracons and Rabanal (2010) find that the prices of durable goods in Spain are more flexible than those of non-durable consumer goods. We assume that the price of housing, q_t, is perfectly flexible, and firms cannot influence it (Iacovello and Neri, 2010). Moreover, since construction and residential investment are relatively labor intensive (Davis and Heathcote, 2005) we also assume for simplicity that residential investment in the economy I_t^h occurs under constant returns to labor according to the production function

$$I_t^h = \phi_{h,t} z_t^h n_{ht} \tag{43}$$

where z_t^h is the steady-state technology factor common to all firms and n_{ht} is the labor hours in the sector. $\phi_{h,t}$ is a technology driver in housing construction that moves the technology out of the initial steady state

The economic objective of the representative firm is to maximize profits subject to the production function

$$\begin{aligned} \max_{n_{ht}} \quad & q_t I_t^h - w_{ht} n_{ht} \\ \text{s.t.} \quad & I_t^h = \phi_{h,t} z_t^h n_{ht} \end{aligned}$$

which yields the labor demand in the construction sector,

$$w_{ht} = q_t \phi_{h,t} z_t^h \tag{44}$$

Considering a constant depreciation rate δ^h for the stock of houses, the total supply of houses h_t evolves according to,

$$h_t = I_t^h + (1 - \delta^h) h_{t-1} \tag{45}$$

2.5 Monetary and Fiscal policy

Monetary policy is managed by the European Central Bank following a Taylor's interest rate rule that respond to deviations of euro-zone inflation π_t^{eu} from its long-run target ($\bar{\pi} = 1$). The rule takes the form:

$$r_t^{eu} = \phi_{r,t}\bar{r}^{1-\rho}(r_{t-1}^{eu})^{\rho}(\pi_t^{eu})^{\psi(1-\rho)} \tag{46}$$

where $\bar{r}$ is the steady state level of the gross interest rate, ρ is a parameter that controls the persistence of the interest rate and ψ represents the weight given by the ECB to inflation targeting and $\phi_{r,t}$ is an exogenous interest rate shifter.

It is assumed that the Spanish economy contributes to euro-area inflation π_t^{eu} according to its economic size.

$$\pi_t^{eu} = (\pi_t^{reu})^{(1-\omega_{Sp})}(\pi_t^c)^{\omega_{Sp}} \tag{47}$$

where ω_{Sp} is the weight of the Spanish economy in the Eurozone, and π_t^{reu} is the average inflation in the rest of the Euro zone.

The real exchange rate between Spain and the rest of the Eurozone is defined as $p_t^{reu} = \frac{P_t^{reu}}{P_t^c}$, where P_t^{reu} is the nominal price of goods produced in the rest of the Eurozone.

The real exchange rate can also be expressed in terms of inflation rates

$$p_t^{reu} = p_{t-1}^{reu}\frac{\pi_t^{reu}}{\pi_t^c} \tag{48}$$

An increase in p_t^{reu} is interpreted as an increase in competitiveness.

As for fiscal policy, to isolate the mechanisms driving our results from the sources of government funding and distortionary taxes, we assume that the government has a balanced budget, where government spending in tradable consumption goods equals total lump-sum transfers to households. Thus, an increase (decrease) in government spending is accompanied by an increase (decrease) in lump-sum taxes of the same magnitude, affecting both patient and impatient households by the same amount on a per capita basis.

$$\phi_{g,t}\bar{g}_t = tr_t \tag{49}$$

Government spending $\bar{g}$ is determined exogenously. $\phi_{g,t}$ is a fiscal shifter that captures the exogenous changes of government consumption in the economy.

2.6 External Sector

The production of tradable goods is used for consumption and investment. The home country trades consumption and investment goods with the rest of the monetary union. Aggregate consumption is a CES composite basket of domestically and foreign-produced consumer goods, given by

$$c_t = ((1-\omega_c)^{\frac{1}{\sigma_c}}(c_{ht})^{\frac{\sigma_c-1}{\sigma_c}} + \omega_c^{\frac{1}{\sigma_c}}(c_{ft})^{\frac{\sigma_c-1}{\sigma_c}})^{\frac{\sigma_c}{\sigma_c-1}} \tag{50}$$

where c_{ht} and c_{ft} are consumption of home-produced goods and foreign goods respectively. σ_c is the elasticity of substitution between domestic and foreign consumption and ω_c is a weight parameter in the CES consumption of non durable goods aggregator. Each period, optimal allocation of consumption between domestic and foreign goods is the result of minimize production costs subject to the technological constraint (50). The first order conditions for the cost minimization problem leads to demand functions of domestic and foreign consumption goods

$$c_{ht} = (1-\omega_c)(p_t)^{-\sigma_c}c_t \tag{51}$$

$$c_{ft} = \omega_c(p_t^{reu})^{-\sigma_c}c_t \tag{52}$$

Analogously, aggregate investment is a CES composite basket of home and foreign produced goods,

$$j_t = ((1-\omega_j)^{\frac{1}{\sigma_j}}(j_{ht})^{\frac{\sigma_j-1}{\sigma_j}} + \omega_j^{\frac{1}{\sigma_j}}(j_{ft})^{\frac{\sigma_j-1}{\sigma_j}})^{\frac{\sigma_j}{\sigma_j-1}}$$

where j_{ht} and j_{ft} represent capital investment using domestic and imported goods respectively, σ_j is the elasticity of substitution between the domestic and foreign investment good and ω_j is the weight parameter in the CES investment aggregator. The demand for home and foreign produced investment goods are

$$j_{ht} = (1-\omega_j)\left(\frac{p_t}{p_t^j}\right)^{-\sigma_j} j_t \tag{53}$$

$$j_{ft} = \omega_j\left(\frac{p_t^{reu}}{p_t^j}\right)^{-\sigma_j} j_t \tag{54}$$

The aggregate nominal cost of investment can be written as $P_t^j j_t = P_t j_{ht} + P_t^{reu} j_{ft}$. And substituting domestic and imported investment goods for their demand functions (53) and (54) yields the expression for the investment price index (in terms of consumption goods),

$$p_t^j = ((1-\omega_j)p_t^{1-\sigma_j} + \omega_j(p_t^{reu})^{1-\sigma_j})^{\frac{1}{1-\sigma_j}} \tag{55}$$

Total imports of the economy are

$$im_t = c_{ft} + j_{ft} \tag{56}$$

We assume an export function that depends on foreign (exogenous) income and relative price elasticity

$$ex_t = s^x \left(\frac{p_t}{p_t^{reu}} \right)^{-\sigma_x} \bar{y}_t^{reu} \tag{57}$$

where s^x is a driver representing changes in foreign preferences or income.

2.7 Total resource constraint and GDP

The aggregation of household budget constraints leads to

$$\begin{aligned} c_t + tr_t + q_t(h_t - (1-\delta^h)h_{t-1}) - \frac{b_t^{eu}}{\phi_{bt}} + p_t^j j_t + \frac{\Phi}{2}\frac{(k_t - k_{t-1})^2}{(1-\tau^b)} = \\ w_{ct}n_{ct} + w_{ht}n_{ht} + (1-\tau^b)d_t - \frac{r_{t-1}^{eu}}{\pi_t^c} b_{t-1}^{eu} + r_t^k k_{t-1} \end{aligned} \tag{58}$$

Using equality between production and income

$$p_t y_t = w_{ct}n_{ct} + (1-\tau^b)d_t + r_t^k k_{t-1} \tag{59}$$

$$q_t I_t^h = w_{ht}n_{ht} \tag{60}$$

Total production of tradable goods is depleted by private consumption and investment in domestic goods, public consumption, exports and the payment of capital adjustment costs

$$y_t = c_{ht} + j_{ht} + \frac{\Phi}{2}(k_t - k_{t-1})^2 + tr_t + ex_t \tag{61}$$

From equations (58) to (61) we can derive the law of motion of the net foreign asset position of the home country,

$$\frac{b_t^{eu}}{\phi_{bt}} = p^{reu} im_t - p_t ex_t + \frac{r_{t-1}^{eu}}{\pi_t^c} b_{t-1}^{eu} \tag{62}$$

where $\frac{b_t^{eu}}{\phi_{bt}}$ is negative when the country is a net lender.

Using (59), (60) and (62) into (58) we obtain another expression for total production of tradable goods in terms of total consumption and investment

$$p_t y_t + q_t I_t^h = c_t + \phi_{g,t}\bar{g}_t + q_t(h_t - (1-\delta^h)h_{t-1}) + \\ p_t^j j_t + \frac{\Phi}{2}\frac{(k_t - k_{t-1})^2}{1-\tau^b} + p_t ex_t - p_t^{reu} im_t \quad (63)$$

Then, gross domestic product in per capita terms is defined as expenditure on tradable goods and new housing,

$$GDP_t = p_t y_t + q_t I_t^h \quad (64)$$

3 Calibration

This section describes the value of the parameters used to obtain the numerical solution of the model. The calibration strategy involves setting the parameters according to previous studies in the literature, mainly referring to the Spanish economy, and setting target values for some steady state equations of the model to obtain the rest of the parameters. By working with the static version of the model we can reduce the whole system to only four central equations and then recursively search for the rest of the solution.

3.1 Parameters recovered from previous studies

Table 1 shows a first set of parameters. We borrow some of the parameters from the Aspachs-Bracons and Rabanal (2010) model estimated for the Spanish economy, in particular, the values of the elasticity of transformation between labor types ε_n, the inverse of the elasticity of labor to wages η, price rigidity ω, and inflation indexation ζ. We set the value of financially constrained households τ^b according to the fraction of financially fragile households in Spain defined by Kaplan et al. (2014). For the loan-to-value parameter κ, we look at the models estimated for Spain by Boscá et al (2020) and int't Veld et al (2014) and consider that constrained households can borrow up to 70% of the value of their home.

The steady-state time preference rate of patient households is set at 0.5% per quarter, which corresponds to an annual interest rate of 2%. Being an impatient household implies a higher discount rate $\frac{1}{\beta^b}$ which we set at approximately 2.5 percentage points quarterly. The depreciation rate of the housing stock δ^h and private capital δ^k follow the usual values in the literature (see Iacovello and Neri (2010), int't Veld et al (2012), int't Veld et al (2014) and Boscá et al (2020)). The adjustment cost of capital is taken from Mendoza (1991). The value of the elasticity of substitution between final

Table 1: Parameters from previous studies

	Description	Value
β^l	Lenders' discount rate	0.995
β^b	Borrower discount rate	0.975
η	Inverse elasticity of labor supply	0.88
ε_n	Elasticity of transformation between types of work	0.78
Φ	Capital adjustment cost	2.9
κ	Loan-to-value	0.7
τ^b	Fraction of borrowers	0.4
ω	Calvo parameter	0.85
ε	Elasticity of substitution in the composite of tradables	6.88
ρ	Interest rate smoothing	0.75
ψ	Interest rate reaction to inflation	1.98
ζ	Inflation indexation	0.52
δ^k	Capital depreciation rate	0.025
δ^h	Housing depreciation rate	0.01
ϕ_b	Risk premium	0.001
s^x	Scale factor in the export function	0.023
σ_c	Elasticity between foreign and domestic consumption	0.857
σ_j	Elasticity between foreign and domestic investment	1.016
σ_x	Price elasticity of exports	0.651
ω_{Sp}	Weight of Spanish economy in the EMU	0.10

goods ε implies a markup of 17% in the steady state according to Boscá et al (2020).

For the foreign sector we have taken from Boscá et al (2020) the values of the elasticity of substitution between domestic and foreign investment σ_j, the elasticity of substitution of consumption between domestic and foreign goods σ_c, the export function factor s^x, the long-run price elasticity of exports σ_x, the risk premium parameter ϕ_b, and the Taylor rule parameters ρ and ψ. These parameters suggest a slightly higher elasticity of substitution between domestic and foreign investment goods compared to consumer goods. The interest rate inertia, ρ, is fairly standard, however, the interest reaction to inflation ψ is higher than in other papers (see Boscá et al (2011), Aspachs-Bracons and Rabanal (2010), in't Veld et al (2014) and in't Veld et al (2012)). The weight of the Spanish economy in the Eurozone ω_{Sp} is set at 10%.

3.2 Parameters recovered from the model solution

The complete system of static equations, i.e., the one obtained by eliminating the time subscript t, reduces to a core subsystem of four equations involving four central variables: total factor productivity in the tradable goods sector, z^c, the ratio of borrowers' to lenders' consumption c^b/c^l, the housing preference parameter in the utility function, γ_h, and the weight parameter in the labor disutility composite, θ. The remaining variables in the complete system can be obtained as a function of these four main variables (see Appendix B for details).

To calibrate the model, we match the model steady state ratios of economic aggregates to GDP with the corresponding average historical ratios for Spain. The ratios are obtained using Eurostat quarterly data for the period 1995Q1- 2020Q1. The steady-state ratios of residential investment and non-residential investment to GDP are 7.3% and 16% respectively. Government spending (that is determined exogenously in our model) in steady state represents 18% of GDP. Also the weight of the labor force working in the residential sector is targeted at 12.8%. For the foreign sector, we take from REMSBD [4] the coefficients of the share of domestically produced goods in consumption and investment, whose values are set at 70.68% and 78.26% respectively. In addition, we normalize to 1 the steady-state value of national GDP, relative prices of production of housing, trabable goods and non-residential investment and producer price index. Table 2 provides information on the target ratios and the normalized variables that the static model solution aims, while table 3 summarizes the nine parameter values (and exogenous variables) that result from this calibration strategy. [5]

4 Results

In this section we show different simulation results with our model. We start by analyzing and comparing the effects produced by four exogenous changes with the potential to affect the residential sector: a productivity shock, a monetary policy shock on the interest rate, a housing preference shock and a loan-to-value shock. Next, we introduce government intervention through

[4] Quarterly data base of the Spanish economy available in BDREMS or at the following url: `http://www.sepg.pap.hacienda.gob.es/sitios/sepg/en-GB/Presupuestos/DocumentacionEstadisticas/Documentacion/Paginas/BasedatosmodeloREMS.aspx`

[5] Both, the core and the complete system are highly nonlinear. We use a Trust Region Reflective algorithm implemented as a solver in Matlab to obtain the solution. All the Matlab codes for calibration and the solution of the static and dynamic version of the model are available to the researchers.

Table 2: Steady State Ratios and endogenous variables normalized

	Description	Model	Data
$\frac{qI^h}{GDP}$	Residential investment/GDP	7.3%	7.3%
$\frac{p^j j}{GDP}$	Non-residential Investment/GDP,	16.0%	16.0%
$\frac{n_h}{n_h+n_c}$	Labor share in the construction industry	12.8%	12.8%
$\frac{pc_h}{c}$	Share of home goods in consumption	70.7%	70.7%
$\frac{pj_h}{p^j j}$	Share of home goods in investment	78.3%	78.3%
GDP	Gross Domestic Product	1	
q	Relative housing price	1	
p	Relative production price	1	
p^j	Relative investment price	1	
π	PPI	1	

Table 3: Parameters and exogenous variables from Steady State

	Description	Value
γ_h	Preference for housing	0.206
θ	Weight parameter in the labor composite	0.145
α	Elasticity of production to capital	0.24
ω_c	Weight parameter in the consumption composite	0.293
ω_j	Weight parameter in the investment composite	0.217
z^c	Productivity in the tradable goods sector	0.254
z^h	Productivity in the housing sector	0.163
y^{reu}	Aggregate consumption in the rest of EU	8.99
π^{reu}	Inflation in the rest of EU	1

public spending at the time of a housing shock. We show how the macroeconomic impact of this fiscal shock on the housing sector interacts with some key features of the labor market. We provide evidence that household heterogeneity reinforces the labor market effects through the extensive and intensive margin of indebtedness. We conclude with a welfare analysis that highlights the main drivers of welfare effects.

4.1 Shocks leading to a decline in housing prices

In this section we shock the economy with an unanticipated and permanent change in: (a) the productivity of the tradable goods sector, relative to the housing sector ($\phi_{c,t}$-$\phi_{h,t}$); (b) the Eurozone interest rate ($\phi_{r,t}$); (c) the housing demand preferences ($\phi_{j,t}$); (d) the loan-to-value ratio ($\phi_{\kappa,t}$). We hold constant

$\phi_{h,t}$ at the initial value of 1, and thus the change in $\phi_{c,t}$-$\phi_{h,t}$ is completely driven by $\phi_{c,t}$.

In terms of comparison, we use the long-run percentage decline in house prices as a metric, so that all shocks produce the same drop in this variable. Table 4 shows the long-term responses of some variables. The first row represents the percentage change from the value of 1 in each of the four shifters. The interest rate shock is equivalent to a permanent annual decrease of 30 basis points in the ECB interest rate. We also represent the long-run effects on residential investment, on hours worked in the tradable goods sector, on hours worked in the housing sector and, finally, the effect on GDP.

The long-run effects of a preference shock and loan-to-value ratio are quite similar. To produce a 1 percent reduction in housing prices, both reduce residential investment by more than 0.80% which translates into an equivalent decrease in hours worked in this sector. However, the effect of hours worked in the tradable goods sector is negligible. Overall, GDP declines moderately, by about -0.15%. This implies a high elasticities of housing prices and residential investment to GDP of more than 6.7 and 5.6 respectively, conditional on these shocks.

A technology shock and a monetary shock produce long-term responses in the variables considered that go in the same direction. A monetary shock, however, causes a greater redistribution of labor in favor of the tradables sector. On the other hand, the shock that increases the total productivity of the tradable goods sector is the one that is most detrimental to aggregate output. Conditional on this shock, the long-run elasticity of housing price to GDP is only 1.3, one-fifth of the elasticity conditional on preference or LTV shocks, whereas the residential investment elasticity to GDP is virtually zero.

Hence, the long run elasticities of housing prices and residential investment to GDP change dramatically depending of the type of shock that affects the economy.

The picture of the macroeconomic effects of the shocks described above changes dramatically when we look at the dynamics depicted in Figure 3. In fact, unlike in the long run, house prices and GDP increase immediately after the productivity shock and the monetary shock. Also residential investment suffers a negative U-shaped effect that is more pronounced and persistent for the case of the monetary shock.

The equivalence that we detect in the long run between the effects caused by preferences and LTV shocks are not observed in the short run, a fact that is especially evident for residential investment. While an LTV shock causes a short-term increase in housing production and hours worked, a preference shock reduces residential investment from the very moment of the initial impact.

Table 4: Long-term responses (in %) to different shocks
that reduce the price of housing by 1%

Description	$\phi_{c,t}$	$\phi_{r,t}$	$\phi_{j,t}$	$\phi_{\kappa,t}$
Shock size	-1.60	-0.02	-1.80	-10.4
Housing price	**-1.00**	**-1.00**	**-1.00**	**-1.00**
Residential investment	0.02	0.03	-0.80	-0.84
Hours tradable good sector	0.12	0.29	-0.02	-0.04
Hours housing sector	0.02	0.03	-0.80	-0.84
GDP	-0.77	-0.41	-0.14	-0.15
Long-run elasticity (price)	1.3	2.4	7.1	6.7
Long-run elasticity (investment)	-0.0	-0.1	5.7	5.6

Our reference economy delivers rigid prices, which may affect the short-term dynamics of the variables. Figure 4 shows the transition dynamics in the first quarters under a flexible pricing scenario. The shift to a price flexibility regime in the tradable goods sector smoothes the positive impact of a negative productivity shock in that sector. This is a well-known result. When prices are rigid and productivity falls, firms need more workers to supply a demand that does not fall much in the short run. Price flexibility changes this outcome. Firms face lower demand due to rising prices and adjust hours to cope with the new environment. The effect of a productivity shock on GDP is unambiguously negative from the outset.

However, the most interesting result from the graph is that greater price flexibility in the production of tradable goods also affects the short-term dynamics of the housing sector. Thus, the positive short-term impact of a productivity shock in the tradable sector on investment and price in the housing sector, unlike in the case of price rigidity, becomes negative. The analysis of the different mechanisms underlying the linkages between the effects on tradable goods and on the housing sector will be the focus of the next sections.

4.1.1 Import and export elasticities and the Balassa-Samuelson effect

The Balassa-Samuelson model predicts that, in an economy with a tradable and a non-tradable sector that use the factors of production with the same intensity, and in which wages are equalized between the sectors due to perfect mobility of labor, a 1% increase in the productivity of the tradable sector with respect to the non-tradable sector will increase the price of the non-tradable good with respect to that of the tradable sector good by 1%.

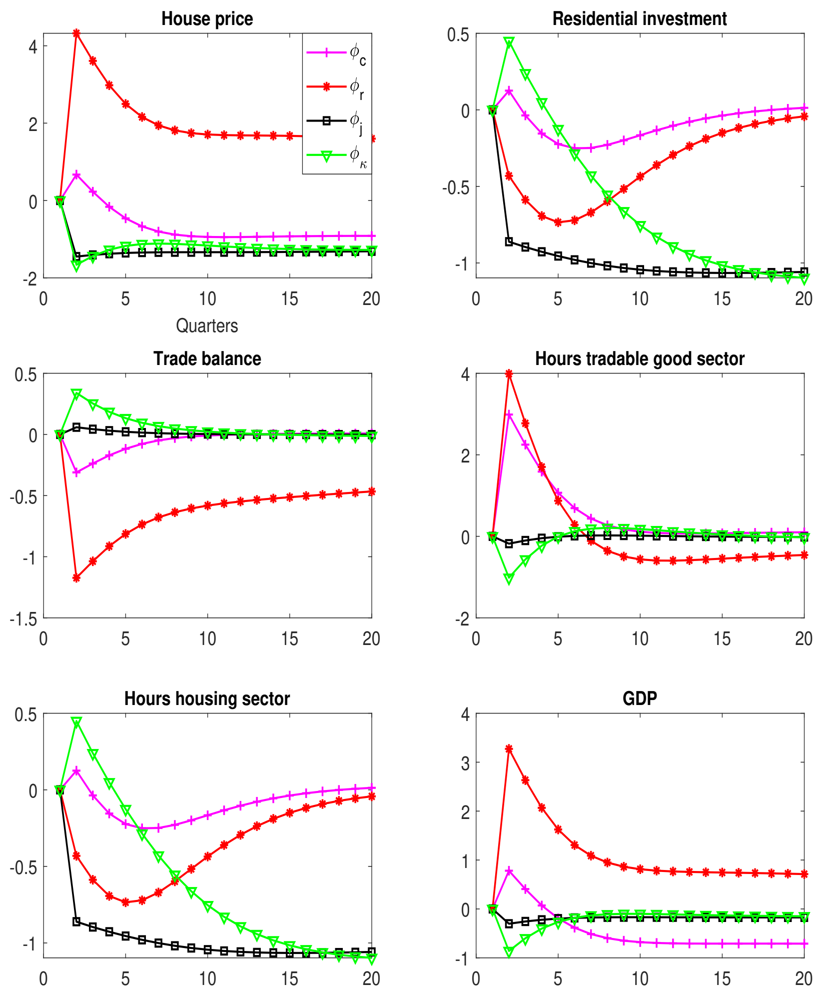

Figure 3: Transitional dynamics after permanent shocks: (a) tradable goods productivity ($\phi_{c,t}$); (b) interest rate ($\phi_{r,t}$); (c) preferences for housing ($\phi_{j,t}$); (d) Loan-to-value ($\phi_{\kappa,t}$). Sticky prices case ($\omega = 0.85$).

Cardi and Restout (2015) question both empirically and theoretically the standard Balassa-Samuelson result. Indeed, when the labor factor is not perfectly mobile between the two sectors, the relative price increase of the non-tradable good with respect to the tradable one may be less than one after the productivity shock.

Cardi and Restout (2015) do not model an explicit import or export func-

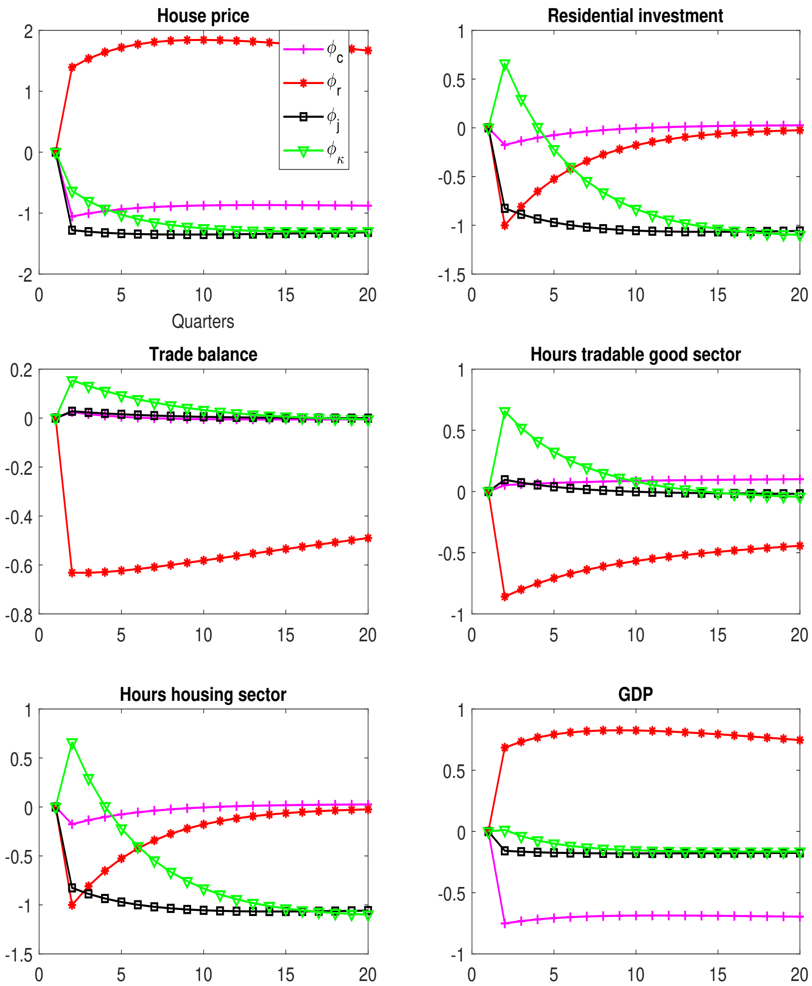

Figure 4: Transitional dynamics after permanent shocks: (a) tradable goods productivity ($\phi_{c,t}$); (b) interest rate ($\phi_{r,t}$); (c) preferences for housing ($\phi_{j,t}$); (d) Loan-to-value ($\phi_{\kappa,t}$). Flexible prices case ($\omega = 0$)

tion. Bergin, Glick and Taylor (2006) do. However, these authors focus on endogenous tradability over a continuum of goods differentiated by productivity to explain the Balassa-Samuelson effect, and do not analyze the role played by the price elasticity of international trade. In this subsection we address the influence of the price elasticity of imports and exports.

Figure 5 presents the long-run effect on housing prices (as percentage deviation from the initial steady state) of a permanent 1 percent increase in the productivity of the tradable sector (holding constant that of the housing sector). We shift the price elasticities of exports, σ_x, and imports, σ_c and σ_j, into a range that includes the model's benchmark elasticities, although we assume that the price elasticities of imports of consumer and investment goods are the same and move equally.

The simulation results point to a less (more) positive (negative) effect on housing prices when the price elasticities of imports and investment goods are lower. Both elasticities interact and lead to nonlinear effects that are strengthened for the lowest values of the elasticities.

The intuition is as follows. Equations (51) and (53) show that the lower the elasticity of substitution between domestic and imported goods, the less price-elastic is the demand for domestically produced goods, since it is more difficult to substitute domestic production for imported production. A productivity shock in the tradable sector causes in this case a greater fall in the price of domestically produced goods, and a greater fall in the price of goods that are part of the consumption basket. The terms of trade are reduced with a lower elasticity of imports, which, in turn, reduces imports and increases exports. The productivity shock facing a more inelatic demand increases less the production of tradables, which requires less labor factor, with respect to the scenario of a higher elasticity of substitution. In any case, the higher demand for labor after the shock leads to an increase in the wage, although lower than in the case of a higher elasticity of substitution. Worker mobility between sectors tends to relocate workers from the construction sector to the tradables sector, although this relocation is smaller than with a higher elasticity of substitution. Investment in the residential sector falls less, and the increase in wage costs is smaller, so housing prices rise less than when the elasticity of substitution is higher.

Exports capture the part of the production that is sold abroad. When the price elasticity of exports is lower, cetereis paribus, exports are less reactive to what happens to the terms of trade and aggregate demand is more price inelastic. After the productivity shock, the price of domestic production has to fall to a greater extent, and the terms of trade deteriorate. Domestic output increases less than in the case of a higher price elasticity of exports, and the volume of exports does not change significantly, as a fall in the terms of trade is compensated by a lower price elasticity of exports. Lower output growth and falling prices keep wage growth moderate in both the tradable and housing sectors, and house prices rise less.

The reaction of housing prices to the productivity shock has its reflection in the relative (to the tradable good) price of housing, as shown in Figure 6. For the range of elasticities considered, the relative price increase varies

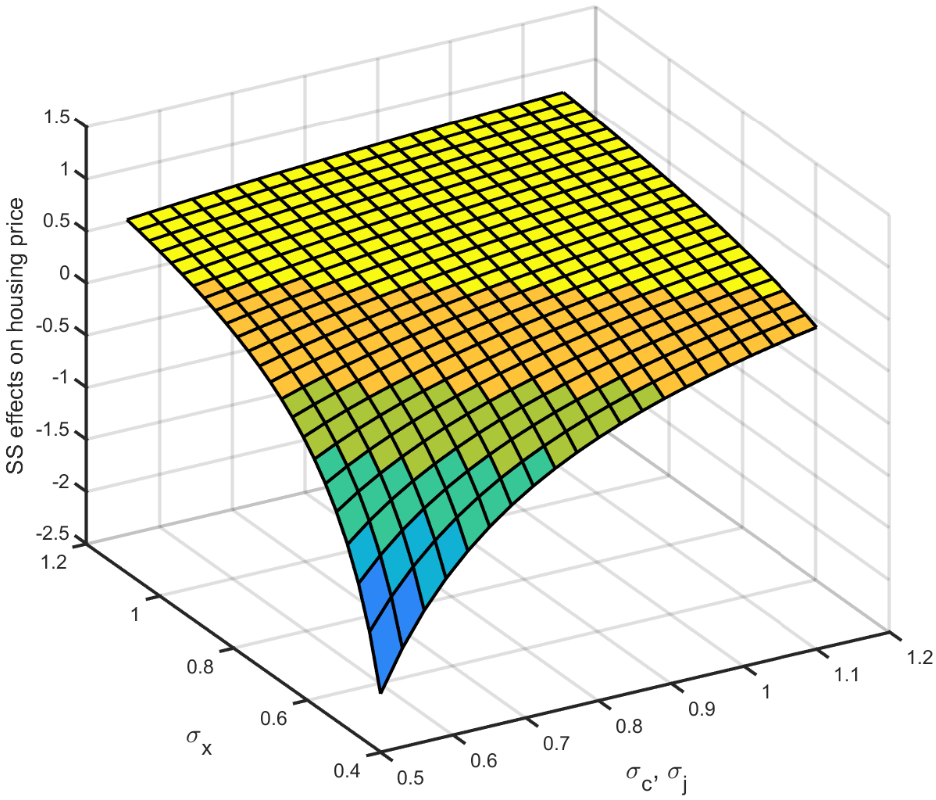

Figure 5: Permanent productivity shock. Effect on housing price

between 1.3 and 0.4, highlighting the important role that international trade elasticities can play in tempering the Balassa-Samuelson effect.

4.2 Housing demand shocks and fiscal policy

The housing sector played an important role during the financial crisis in Spain. As shown in Figure 2 in the Introduction, house price growth rates began to fall sharply below trend in the second quarter of 2008 until reaching a trough in 2009:3 where the annual growth rate was 12% below trend. This house price movement coincided in time with a fall in the GDP growth rate below its long-term growth rate to a trough of -6%, and a fall in the weight of residential investment in GDP of about 2 percentage points between the second quarter of 2008 and the third quarter of 2010, as shown in Figure 1. Meanwhile, the growth rate of public spending increased at historic rates.

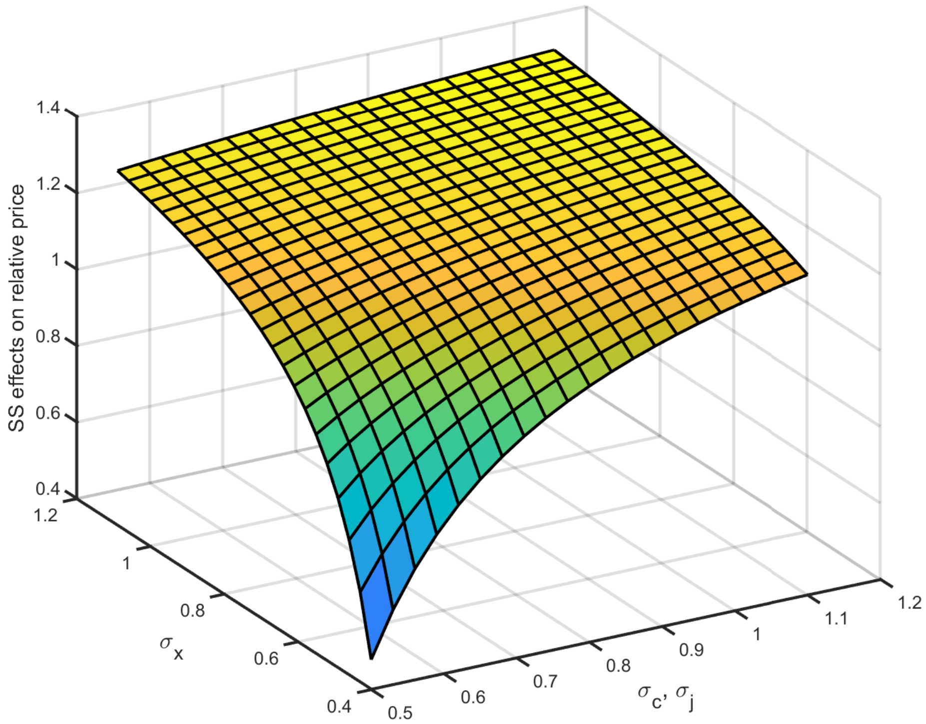

Figure 6: Productivity shock. Effect on the relative price of housing to tradable goods

4.2.1 The burst of the housing bubble

To study the behavior of the model with respect to the observed variables, we apply to the synthetic economy a sequence of unexpected negative shocks on housing preferences of nine quarters duration, coinciding with the period covering the first recession in Spain, between 2008:2 and 2010:3, after the global financial contagion and before the sovereign debt crisis. In this case, we include a persistence parameter to the dynamics of $\phi_{j,t}$, so that we consider[6]

$$\phi_{j,t} = \rho_j \phi_{j,t-1} + \epsilon_{j,t} \tag{65}$$

Results are shown in Figure 7. The upper panel of the figure represents the percentage annual growth rates of GDP and house prices, which can be directly compared with those in Figure 2. The second panel represents the

[6] We take from Boscá et al. (2020) their estimate of the coefficient of persistence $\rho_j = 0.9994$ for a housing preference shock in the Spanish economy.

results in terms of percentage deviations of the levels from their steady states. The bottom panel shows the response of the percentage weight of housing investment over GDP, which is directly comparable to the same measure in Figure 1. It shows that the single shock considered in the Figure can largely explain the movements observed during the second quarter of 2008 and the third quarter of 2010 in house prices, residential investment and GDP[7].

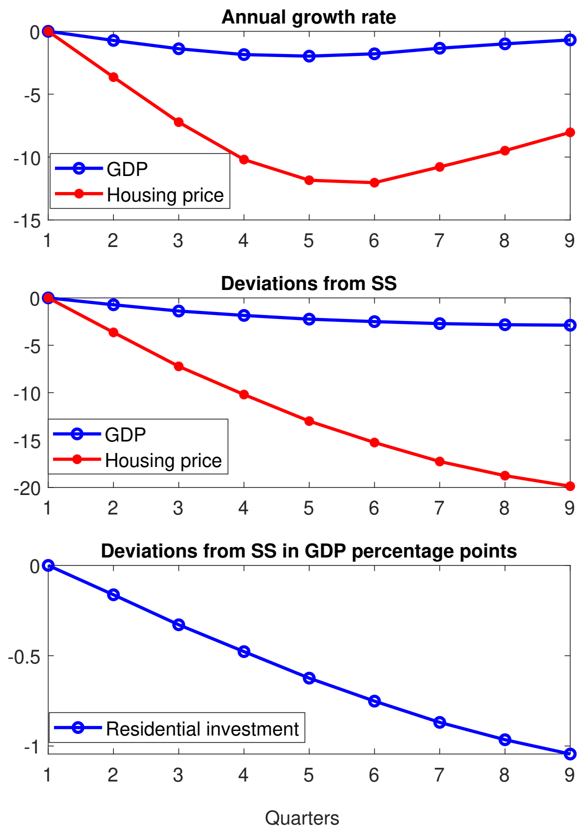

Figure 7: Reaction of GDP, house prices and residential investment to a sequence of unexpected negative housing preference shocks

Figure 8 offers a broader picture of the general equilibrium effects of a transitory negative shock affecting housing demand as a consequence of the reduction in the marginal utility of owning houses. Now we impose a one-shot unanticipated change in $\epsilon_{j,t}$, so that the model-implied contraction in the

[7]Replacing a housing preference shock with a negative LTV shock would improve the simulation of GDP, which would fall further for the same fall in house prices, but would worsen residential investment performance.

preferences for housing results in an immediate price decline of 6.6%. This drop in housing prices coincides with that observed in the fourth quarter of 2008. We chose this particular quarter because it corresponds to the peak of the increase in public spending at the onset of the financial crisis. Therefore, this point represents a good reference to study the effect of a fiscal policy to combat the housing demand shock.

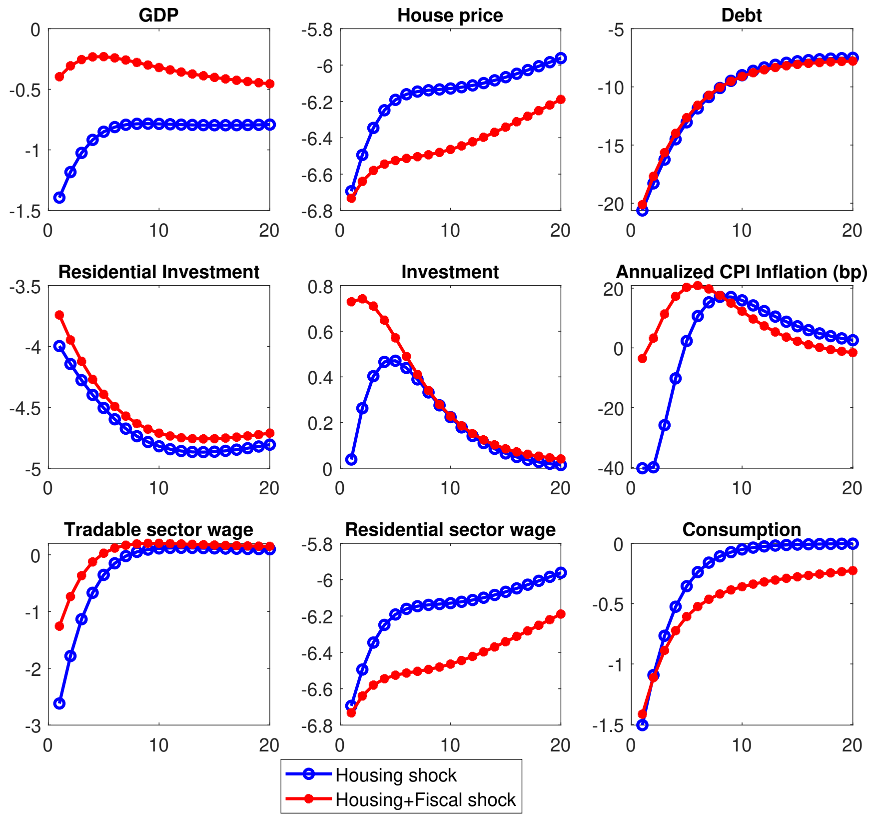

Figure 8: Impulse Response to a housing shock and countercyclical fiscal policy.

Similar to what was observed in the aftermath of the crisis the model predicts a sizeable reduction in residential investment and GDP after a sharp drop in house prices (big-dotted blue line). The housing preference shock causes a fall in housing demand leading to a persistent decline in housing prices. Housing production reacts endogenously and thus residential investment falls. In addition, the decline in house prices and housing production has relevant consequences for other macro variables.

The fall in housing production negatively affects employment demand in the housing sector. Housing production is labor intensive (actually, in the model houses are produced using only labor), so the reactions of production and employment in the housing sector are equivalent. The decline in demand for labor in the housing sector causes a reduction in wages and generates a reallocation of labor from the construction sector to the tradable sector. The labor and capital factors are complementary, so capital investment increases in the tradable goods sector.

The model includes heterogeneous households. Impatient households use home equity as collateral to obtain loans that they use to spend on consumer goods or buy houses. When the price and stock of housing decreases due to the real estate shock, so does their ability to obtain credit against their collateral. As a result, credit falls by about 20% on impact. As credit is a fundamental aspect of their consumption, borrowers' consumption deteriorates. However, lenders take advantage of lower prices and having to extend less credit to borrowers to increase consumption and home purchases. Overall, however, consumption declines.

The lower demand for consumption, together with the increase in labor supply in the tradable sector resulting from the improvement in relative wages compared to the housing sector, contributes to the fall in wages. Thus, a shock that initially starts at the housing level is transmitted through the general equilibrium mechanism to other sectors of the economy, causing a generalized fall in the level of activity, employment and wages. These indirect effects do not exist in Aspach-Bracons and Rabanal (2010), who do not consider financial frictions. In their model, the housing preference shock produces a positive co-movement between house prices and residential investment but, as they point out, the spillover effects to the rest of the economy are not significant.

4.2.2 An expansionary fiscal policy at the time of a housing shock

In this section we analyze the economic consequences of applying an expansionary fiscal policy to alleviate the adverse effects of a negative real estate shock. In our model, this policy is implemented through an increase in government spending on consumer goods. Since the government is assumed to run a balanced budget, an increase in government spending is accompanied by a lump-sum tax increase of the same magnitude, which affects patient and impatient households alike[8].

We assume that the shift of public spending shows persistence so that

[8]The analysis of letting the government run deficits and accumulate debt, or the consequences of a different transfer distribution scheme are beyond the scope of this paper.

$$\phi_{g,t} = \rho_g \phi_{g,t-1} + \epsilon_{g,t} \tag{66}$$

where $\rho_g = 0.967$ is set according to the estimation of Boscá et al (2020) for the Spanish economy[9] .

We exogenously provide a one-shot increase in $\epsilon_{g,t}$ for public consumption to rise by 4.8% on impact from its steady-state level. This value coincides with the observed increase in Spain (after subtracting the year-on-year growth rate) in per capita public spending in the fourth quarter of 2008. Therefore, we simultaneously introduce in the model the above negative housing demand shock together with the positive public spending shock which represents 0.864% of GDP. Results are display in the small-dotted red lines of Figure 8.

The expansionary fiscal policy eases the decline in GDP. In particular, it alleviates the initial drop in GDP on impact by 1%, an amount slightly greater than the share of GDP equivalent to the initial boost to government consumption.

The improvement in GDP is mainly due to the positive effect of government spending on tradable consumer goods. Expansionary fiscal policy creates the expectation of an increase in the return on capital among producers of tradable goods. Patient households, who are the owners of firms, decide to invest more in physical capital. Since capital and labor are cooperating factors, the increase in the capital stock improves labor productivity and induces higher demand for labor in the tradable goods sector. The increased demand for labor contributes to push wages up in the tradable sector.

The expansionary fiscal policy also raises consumer prices and domestic interest rates, which punishes the real value of assets (including the relative price of housing) but also alleviates the real cost of liabilities. As Figure 9 shows, patient households reduce their demand for consumer goods and housing due to a negative wealth effect caused by the expectation of lower asset prices and higher taxes to finance public spending. Instead, the wealth of borrowers increases due to a Fisher effect (more inflation reducing the real debt burden). In addition, the fiscal shock has a positive income effect due to higher wages in the non-durable sector. Impatient households quickly pass on these positive income and wealth effects to current consumption and housing. On aggregate, higher borrower demand for housing and more persistent wage declines push up residential investment after the fiscal shock.

[9] For the sake of comparability with the steady-state results in the Table 4, if we assume that $\rho_g = 1$ (a permanent and unanticipated increase in government spending) the long-run elasticity of housing prices to GDP is -0.61 and that of residential investment to GDP is 0.15, conditional to a government spending shock

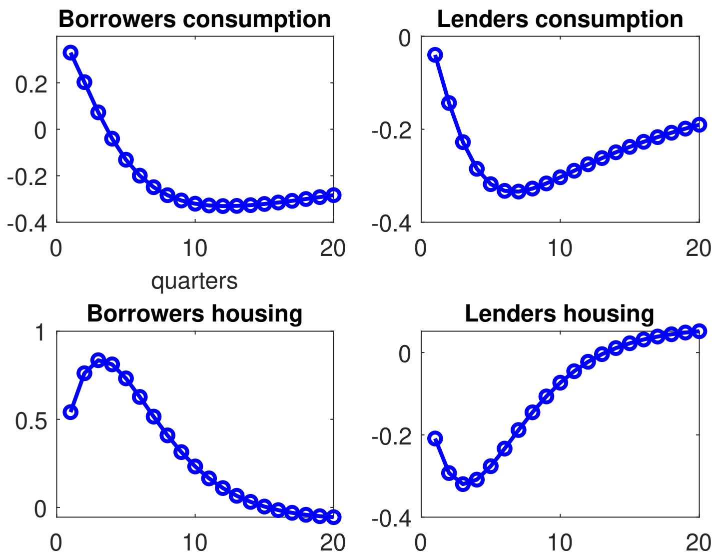

Figure 9: Impulse-response of households purchasing of goods and housing to a government spending shock.

Thus, in our baseline model-economy, the expansionary fiscal shock stimulates not only the tradable goods sector, but also the construction sector, although house prices fall more. However, the modest impact movements we find in residential investment and house prices depend on some features of the labor market, as well as on the resulting changes in the purchasing power of indebted owner households, which is highly dependent on credit conditions. We study these factors in the following subsections.

4.3 Fiscal policy: the role of the labor market

How would the results on fiscal policy have changed with a different characterization of the labor market? In this section, we focus on two parameters that relate to the willingness to work when wages change (η) and the degree to which labor substitutes between the trade and homebuilding sectors (ε_n).

The results are presented in Figure 10. We focus on residential investment, house prices, and GDP, and plot for a range of values of the parameters of interest the impact reaction (the effect at the very moment the shock occurs) to an expansionary fiscal expansion of 1 percent of GDP in Equation (66).

Labor market characteristics are crucial in explaining the size and sign of

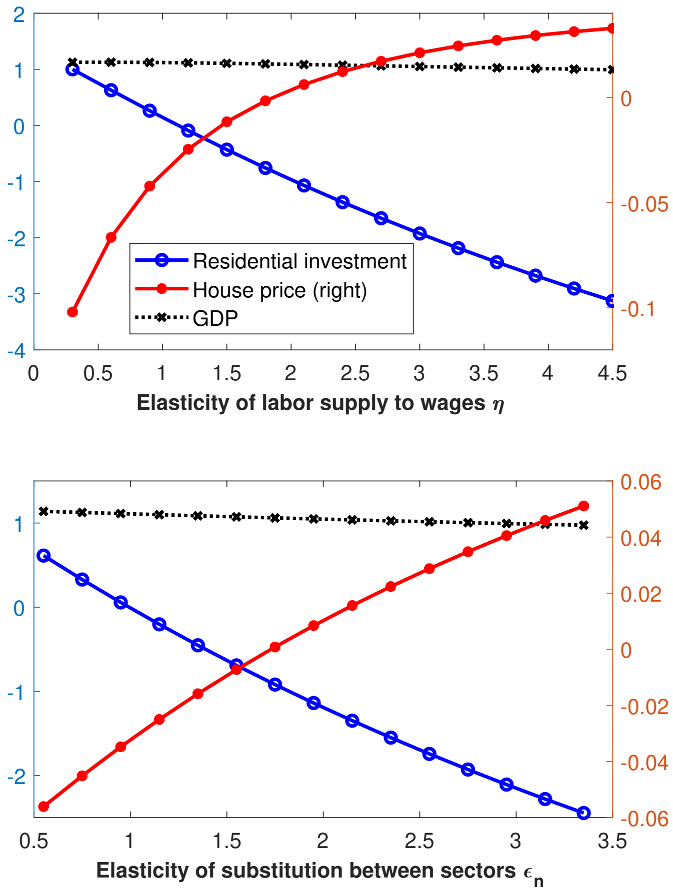

Figure 10: Impact responses (in %) to a public spending shock of 1% of GDP for different labor market parameters

residential investment and housing prices in response to the fiscal shock. In particular, higher values of ε_n and η worsen investment in the housing sector. Residential investment decreases when workers' mobility between sectors increases (higher values of the elasticity of substitution between sectors, ε_n) and when working hours are less reactive to wage changes (higher values of the inverse Frisch elasticity of labor supply, η). Not surprisingly, house prices (right axis) react in opposite ways to movements in housing supply, moving from a slight negative reaction when housing production rises to a positive response when residential investment falls the most.

In general, from our simulations we find three possible combinations: for low values of ε_n and η, residential investment and housing supply increase,

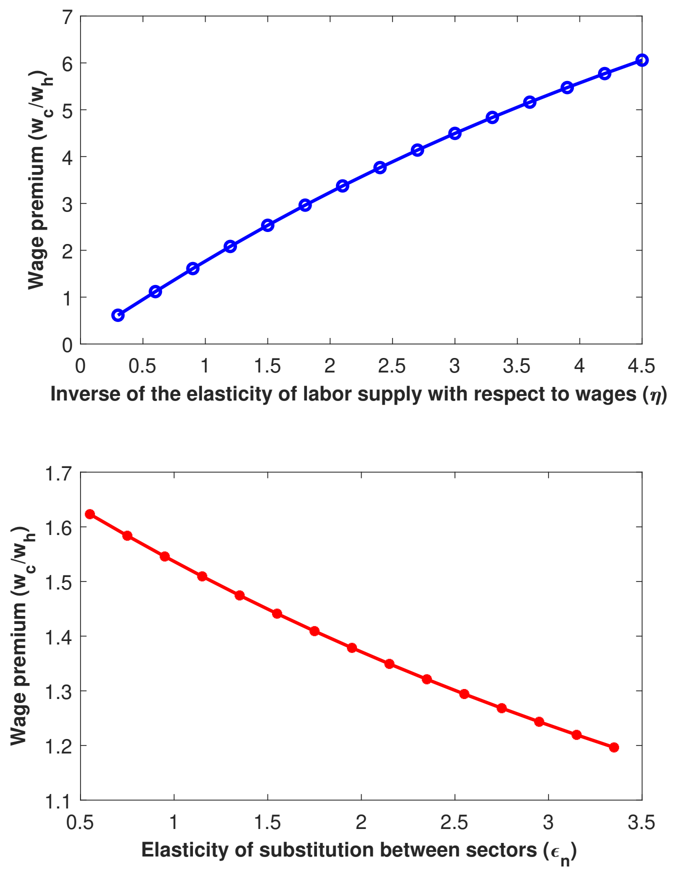

Figure 11: Impact responses (in %) to a public spending shock of 1% of GDP for different values of the inverse of Frisch elasticity of labor supply.

while housing prices fall; for intermediate values of these parameters, both residential investment and housing fall; and for high values of the parameters residential investment falls while prices rise.

The negative effect on residential investment not only affects housing production, but also greatly affects housing employment, since residential investment is a labor-intensive industry. Therefore, a fiscal policy of increasing government consumption can be particularly detrimental to housing production and employment under certain conditions. However, this does not significantly affect GDP, as a further decline in residential investment is offset by a further increase in consumption (for the case of η) or in investment for the tradable sector (for the case of ε_n).

4.3.1 Elasticity of labor supply to wages

The top panel of the Figure 10 shows how the government spending shock impacts more negatively (less positively) on residential investment the larger the value of η, the inverse of the elasticity of labor supply to wages. In fact, real state investment is strongly affected by this feature of labor supply.

The increase in aggregate demand caused by the increase in government spending encourages the production of tradable goods and favors the demand for labor in the tradable sector. The higher the η parameter the less prone workers are to increase working hours. Therefore, producers of non-durable goods have to offer higher wages. As a result, production costs rise and investment falls relative to the baseline scenario.

The differential of wages in the tradable sector with respect to the residential sector soars (see Figure 11). The flow of workers from the housing sector into the tradable goods sector, attracted by higher wages, disincentivizes employment for residential construction and causes residential investment to fall.

4.3.2 Elasticity of substitution between labor types

The bottom panel of the Figure 10 shows the consequences of a variation in labor mobility between production sectors. For low values of the elasticity of substitution, ε_n (low labor mobility across sectors) the fiscal shock encourages residential investment. As ε_n increases, the response of residential investment declines sharply. More specifically, housing production starts to fall for elasticities that exceed the vicinity of 1 (our benchmark is set at 0.78). However, GDP is hardly affected.

The response mechanism of the variables is as follows. The expansion of government spending boosts the demand for consumer goods, which has a positive effect on firms' output and increases the demand for labor and wages in the tradable goods sector. When the elasticity of substitution between types of labor, ε_n, is low few workers move from the housing sector to the tradable goods sector. Relative wages remain high, and housing construction takes advantage of the higher demand for housing due to higher labor income. However, when ε_n is large, workers move massively from the housing sector to the tradable goods sector, where they are better paid. Firms in the tradable sector react to this increase in labor supply by increasing output. The movement of workers from the residential sector to the tradable goods production sector causes a fall in employment in the housing sector and in the production of new housing. Unlike in the case of labor supply elasticity, the impact on relative wages fall as there is a greater reallocation of workers

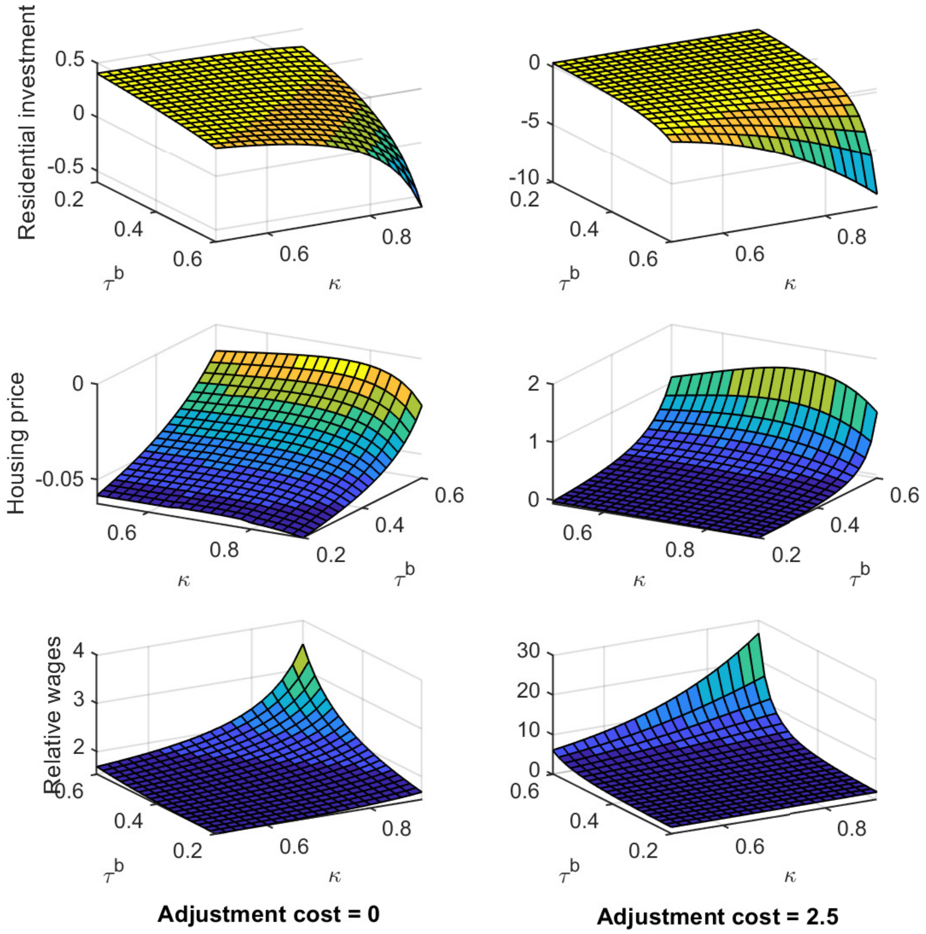

Figure 12: Impact responses (in %) to a public spending shock of 1% of GDP as a function of the share of borrowers, τ^b, and the LTV, κ

between sectors and wages tend to equalize (Figure 11) [10].

4.4 Fiscal policy: the role of household debt

Debt accumulation in the model depends on an intensive and an extensive margin. The intensive margin is given by the ability of households to transform home equity into loans, and is controlled by the parameter κ. The extensive margin is related to the number of borrowers, whose share over total households is captured by the parameter τ^b.

[10] In the limit, when ε_n tends to infinity, the relative wage is 1

We simulate the response to the impact of a government spending shock of 1 percent of GDP as a function of the intensive and extensive margin. The results can be found in Figure 12. The left column refers to the benchmark parameterization, while in the right column we include adjustment costs on housing demand. The results show that both increasing the intensive and extensive margin lead to a smaller (larger) positive (negative) impact on residential investment. Both margins reinforce each other, so that the effect is nonlinear and increases substantially for high values of κ and τ^b.

The intuition for understanding the effect of debt on housing construction is based on the Equations (19) and (24). After the government spending shock, the variable μ_t^b decreases, meaning that the borrowing constraint becomes less tight, causing the marginal propensity to consume to fall and increasing borrowers' consumption of tradable goods (contrary to the effect of government spending on lenders' consumption). Interestingly, the fall in μ_t^b is more pronounced the higher the LTV, as government spending eases the constraint to a greater extent for those households that can borrow more at the margin of home equity.

In addition, a higher value of τ^b gives more weight to borrowers' consumption in aggregate consumption. Thus, the effect of the shock on aggregate consumption increases with a higher value of τ^b. As aggregate consumption increases, so does the demand for workers in the tradable sector and the wage premium, which incentivizes the movement of workers from the housing sector to the tradable sector, decreases home construction, and increases housing prices.

The second column shows the importance of considering housing demand adjustment costs in determining the magnitude of the impact of public spending on housing sector variables. These adjustment costs involve including in the budget constraint given by the Equations (1) and (13) an additional cost of changing the housing stock which, following Iacoviello (2005), is written as $\varepsilon_{h,t}^a = \phi_h(\Delta h_t^a / h_{t-1}^a)^2 q_t h_{t-1}^a / 2$ (where $a = l,\ b$ stands for lenders and borrowers), and where ϕ_h is set to 2.5, coinciding with the parameter for adjustment costs of productive capital[11]. With the same direction, housing adjustment costs significantly increase the effect that household debt has on the effect of government spending.

[11] Iacoviello (2005) and Iacoviello and Neri (2012) set the value of ϕ_h to 0, as we do in the benchmark calibration. They state that preliminary attempts to estimate this parameter take the value to zero, although they note some difficulties in estimating the parameter and some theoretical support for expecting it to be different from 0. Indeed, Flavin and Nakawaga (2008) show that housing adjustment costs are extremely important for the dynamics of nondurable consumption.

4.4.1 Interactions between household debt and the labor market

The previous sections have highlighted the role of both labor market characteristics (worker mobility across sectors and wage elasticity of labor supply) and household indebtedness (intensive and extensive margin) in the magnitude of the effects of fiscal shocks on the housing market. In this subsection we study the interactions between household debt and the labor market.

Figure 13 shows the response of residential investment to an increase in government spending for three values of the inverse of the Frisch elasticity (first column) and of the elasticity of substitution of labor supply across sectors (second column). Changes in the LTV ratio are plotted in the first row and changes in the proportion of borrowers in the second row. The rest of the parameters that do not appear in the different graphs are fixed at their reference values.

The lines shift downward as η and ϵ_n increase, in line with what we discussed in the section 4.3. More interestingly, the lines all curve downward as the intensive and extensive margins of household borrowing increase, and the curve is steeper the greater the mobility of workers between sectors and the lower the elasticity of labor with respect to wages. This means that household debt interacts with the two labor market characteristics, reinforcing the negative impact on residential investment, especially above a threshold.

4.5 Housing demand shocks and fiscal policy: a welfare analysis

The equilibrium levels of consumption flows and housing stocks may differ considerably across household types, and the consequences of a housing shock and a fiscal expansion may lead to interesting distributional outcomes in terms of welfare. In this section we evaluate the effect of these two shocks on both aggregate welfare and the welfare of each household type.

We rely on utility-based welfare calculations, so household welfare a is the discounted sum of utilities derived over infinite periods. In our model, household utility is additive in private consumption, housing and labor. Thus, we can define the expected welfare of household a at time t as.

$$W_t^a = \mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^a)^t \left(\ln c_t^a + \gamma_h \ln h_t^a - \frac{(n_t^a)^{1+\eta}}{1+\eta} \right) \quad (67)$$

Notice that Equation (67) can be represented recursively as

$$W_t^a = U_t^a + \beta^a \mathbb{E}_0 W_{t+1}^a$$

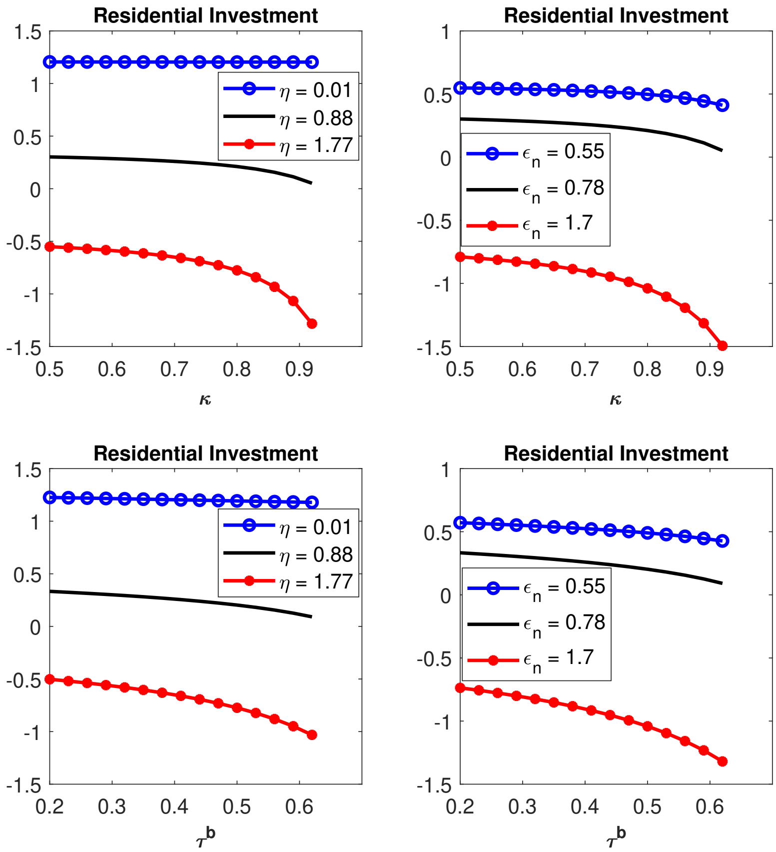

Figure 13: Impact responses (in %) to a public spending shock of 1% of GDP. Residential investment.

We define social welfare as a weighted sum of individual welfare for different types of households. The weight of household utilities is represented by Ω_a, for which we choose the values defined by Mendicino and Pescatori (2007), i.e., Ω_a equals $(1-\beta^l)$ for lenders and $(1-\beta^b)$ for borrowers. Therefore, we express social welfare in period t as

$$W_t^s = \mathbb{E}_0 \sum_{a=l,b} \Omega_a \sum_{t=0}^{\infty} (\beta^a)^t \left(\ln c_t^a + \gamma_h \ln h_t^a - \frac{(n_t^a)^{1+\eta}}{1+\eta} \right) \tag{68}$$

or in a more compact way as,

$$W_t^s = (1-\beta^l)W_t^l + (1-\beta^b)W_t^b$$

Under the assumption of perfect foresight, Figure 14 shows the percentage change in welfare over time with respect to the steady state in the presence of the same temporary housing shock and the expansionary fiscal shock that we introduced in Figure 8. More specifically, Figure 14 presents the welfare response for each agent in the economy and for the aggregate, as well as the differential contribution of consumption, housing and employment to welfare. The results reveal some interesting patterns.

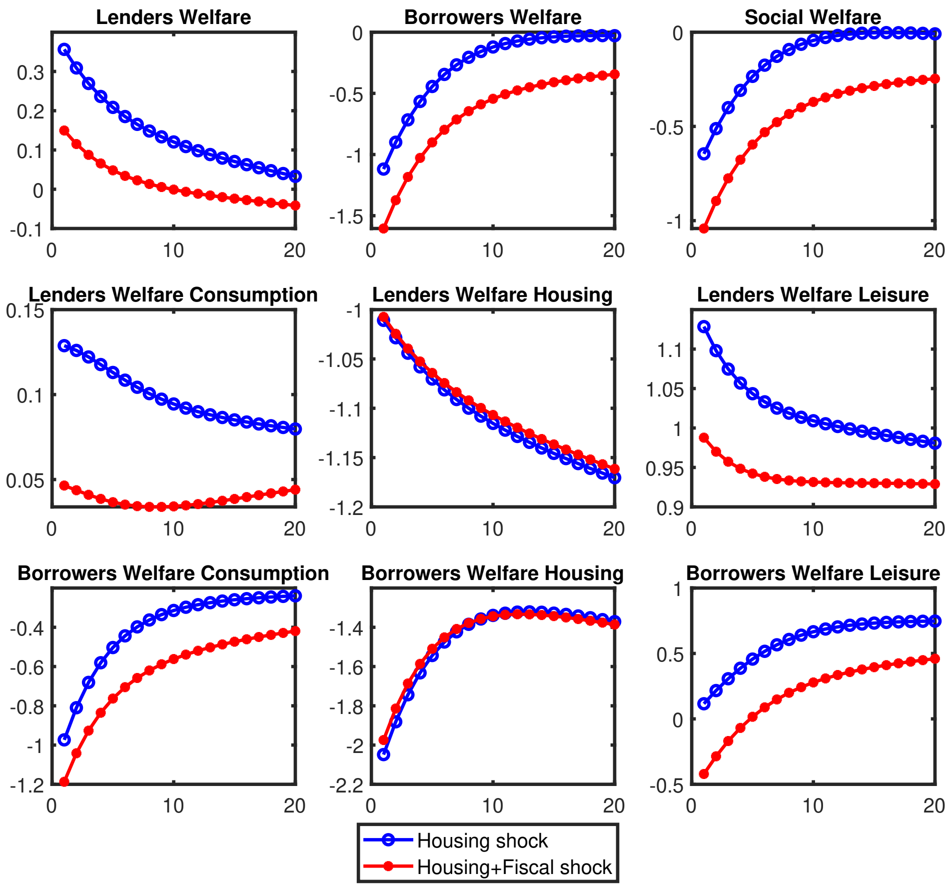

Figure 14: Welfare response to a real estate shock and countercyclical fiscal policy.

First, the negative shock on housing demand negatively affects (unsurprisingly) social welfare. However, borrowers suffer much more than lenders in terms of welfare during the early periods. As time passes, the welfare of lenders deteriorates and that of borrowers improves. Credit-constrained households are less likely to smooth consumption, and when house prices fall they are less able to cushion the loss of wealth. After the shock, both house prices and residential investment fall, and borrowers' ability to obtain credit deteriorates, affecting their consumption and demand for housing. Lenders also suffer from falling house prices, which reduce the value of their durable assets. However, as they are not credit constrained and lending falls, they even increase consumption.

Second, and related to the previous point, housing variation has the largest negative effect on welfare, especially for borrowers. In fact, it is the only component that reduces the welfare of lenders, while consumption also reduces the welfare of borrowers. On the other hand, the housing shock leads to a reduction in working hours, so that the effects of leisure offset, at some extent, the negative welfare effects from other components.

Third, the implementation of an expansionary public spending policy in a situation of depressed housing demand deteriorates welfare for both types of households. Interestingly, most of the negative welfare difference created by the policy is due to variation in consumption[12] and leisure, with virtually no effect coming from housing tenure. These results are consistent with Sims and Wolff (2018), who obtain that, despite producing a positive effect on aggregate output, the welfare multiplier of government consumption is negative on average.

5 Concluding remarks

This paper represents a step forward in understanding the effects of expansionary fiscal policies on the housing sector, and especially on residential investment and house prices. The empirical literature reveals opposing results on the response of residential investment and house prices following increases in government spending. A two-sector dynamic general equilibrium model with financial and labor frictions that produces tradable consumer and investment goods, as well as housing, is able to predict different signs in the reaction of residential investment and house prices.

The model presents a small open economy with endogenous imports and exports. Housing is produced using labor and, in addition to providing utility, can also be used as collateral by a portion of households to obtain credit that is used to finance their consumption of tradables and housing. Fiscal policy is characterized by government consumption and a balanced budget without distortionary taxes. The model is calibrated to reproduce some key aspects of the Spanish economy and its real estate sector. We use the synthetic economy to uncover some results.

[12] Even if borrowers' consumption increases for a few periods after the fiscal shock, welfare takes into account the lifetime flow of consumption

First, unlike other drivers of the economy, a permanent change in public spending produces a negative long-run elasticity of housing prices to GDP.

Second, the short-term responses of the residential sector to permanent changes in exogenous variables differ greatly from long-term responses. In addition, price rigidities in the production of tradable goods also affect the short-term dynamics of the housing sector.

Third, import and export elasticities play an important role in attenuating the Balassa-Samuelson effect. The long-run response of the relative price of housing to tradables, to an increase in productivity in the tradable sector, is attenuated when elasticities are reduced.

Fourth, the model largely reproduces the effect of the 2008 Spanish crisis on GDP and the housing sector (investment and prices), simply through a shock in housing preferences or, equivalently, a shock in the LTV ratio.

Fifth, following a fiscal shock, the model shows how increased government spending can alleviate the negative effects of the fall in housing demand. However, unlike aggregate output, the response of residential investment and prices to the fiscal shock may be significantly affected depending on the characteristics of the labor market. In particular, the fiscal shock would lead to a reduction in housing production the easier it is to reallocate employment between productive sectors, and the more inelastic labor supply is to wages. The impact of an increase in public spending on relative wages plays a key role in the results.

Sixth, household indebtedness, both at the intensive and extensive margin, helps explain the effect of public consumption on the housing sector. The higher the household indebtedness, the more (less) negative the impact of public consumption on housing construction (house prices). The existence of adjustment costs in housing demand contributes to greatly amplify the effect of private indebtedness. In addition, household indebtedness interacts in a non-linear way with labor market characteristics, reinforcing the negative impact on residential investment above a threshold of labor reallocation intensity between sectors and labor elasticity to wages.

Seventh, the welfare analysis reveals that the expansion of government spending could worsen the adverse welfare effect of a housing shock. Although the welfare consequences of a housing shock act mainly through the change in housing demand, the unfavorable effect of fiscal policy is mainly due to movements in consumption and working hours.

Some normative analysis could be derived from the above points, with sufficient caution. For example, when the economy suffers a shock that particularly hurts the construction sector and spreads through the economy via a credit crunch, using public consumption as an antidote could be counterproductive. The negative effect caused in the housing sector may deepen the problems associated with the credit crunch and further damage the economy. This effect is not fully captured in our model, but could be better rationalized in an environment with a banking system whose assets are overly concentrated in the housing sector and with the possibility of credit default. On the other hand, in a period of rapid credit indebtedness and expanding housing construction, the use of fiscal policy can help correct financial imbalances without harming economic activity, playing the role of a macroprudential policy.

The direction and magnitude of the likely effects on the real estate sector of the use of fiscal policy must be carefully calibrated using as a proxy particular aspects of the economy such as the ability to change jobs, the responsiveness of working hours to wages, the ease of obtaining credit, the total amount of private debt, or the range of costs associated with buying a home.

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A The complete Model

A.1 Equations of the model

The following equations define the model:

Lender's labor supply:

$$n_t^l = [\theta^{\frac{1}{\varepsilon_n}}(n_{ct}^l)^{\frac{1+\varepsilon_n}{\varepsilon_n}} + (1-\theta)^{\frac{1}{\varepsilon_n}}(n_{ht}^l)^{\frac{1+\varepsilon_n}{\varepsilon_n}}]^{\frac{\varepsilon_n}{1+\varepsilon_n}}$$

Risk premium function:

$$\ln \phi_{bt} = \phi_b(\exp(b_t^{eu}) - 1)$$

Lender's marginal utility of consumption:

$$\lambda_t^l = \frac{1}{c_t^l}$$

Lender's demand for housing:

$$\frac{\gamma_h}{h_t^l} = \lambda_t^l q_t - \beta^l \mathbb{E}_t(\lambda_{t+1}^l q_{t+1}(1-\delta^h))$$

Lender's labor supply in consumption goods sector:

$$\frac{w_{ct}}{c_t^l} = (n_t^l)^\eta (\theta \frac{n_{ct}^l}{n_t^l})^{\frac{1}{\varepsilon_n}}$$

Lender's labor supply in housing sector:

$$\frac{w_{ht}}{c_t^l} = (n_t^l)^\eta ((1-\theta) \frac{n_{ht}^l}{n_t^l})^{\frac{1}{\varepsilon_n}}$$

Lender's Euler condition for consumption:

$$\lambda_t^l = \beta^l \mathbb{E}_t \lambda_{t+1}^l \frac{r_t}{\pi_{t+1}^c}$$

Lender's investment-consumption decision:

$$\lambda_t^l(p_t^j + \Phi(k_t^l - k_{t-1}^l)) = \beta^l \mathbb{E}_t \lambda_{t+1}^l (p_{t+1}^j(1-\delta^k) + r_{t+1}^k + \Phi(k_{t+1}^l - k_t^l))$$

Interest parity condition:

$$r_t = \phi_{bt} r_t^{eu}$$

Borrower's total labor supply:

$$n_t^b = [\theta^{\frac{1}{\varepsilon_n}}(n_{ct}^b)^{\frac{1+\varepsilon_n}{\varepsilon_n}} + (1-\theta)^{\frac{1}{\varepsilon_n}}(n_{ht}^b)^{\frac{1+\varepsilon_n}{\varepsilon_n}}]^{\frac{\varepsilon_n}{1+\varepsilon_n}}$$

Borrower's budget constraint:

$$c_t^b + q_t(h_t^b - (1-\delta^h)h_{t-1}^b) - b_t^b = w_{ct}n_{ct}^b + w_{ht}n_{ht}^b - \frac{r_{t-1}}{\pi_t^c}b_{t-1}^b - tr_t$$

Borrowing constraint:

$$b_t^b = \kappa \mathbb{E}_t \frac{q_{t+1}\pi_{t+1}^c h_t^b}{r_t}$$

Borrower's marginal utility of consumption:

$$\lambda_t^b = \frac{1}{c_t^b}$$

Borrower's demand for housing:

$$\frac{\gamma_h}{h_t^b} = \lambda_t^b q_t - \mathbb{E}_t(\beta^b \lambda_{t+1}^b q_{t+1}(1-\delta^h) + \kappa \mu_t^b q_{t+1}\pi_{t+1}^c)$$

Borrower's labor supply in consumption goods sector:

$$\frac{w_{ct}}{c_t^b} = (n_t^b)^\eta \left(\theta \frac{n_{ct}^b}{n_t^b}\right)^{\frac{1}{\varepsilon_n}}$$

Borrower's labor supply in housing sector:

$$\frac{w_{ht}}{c_t^b} = (n_t^b)^\eta \left((1-\theta)\frac{n_{ht}^b}{n_t^b}\right)^{\frac{1}{\varepsilon_n}}$$

Borrower's Euler condition for consumption:

$$\lambda_t^b = \beta^b \mathbb{E}_t \lambda_{t+1}^b \frac{r_t}{\pi_{t+1}^c} + \mu_t^b r_t$$

Aggregate debt:

$$(1-\tau^b)b_t^l + \tau^b b_t^b = 0$$

Aggregate housing:

$$h_t = \tau^b h_t^b + (1-\tau^b)h_t^l$$

Aggregate consumption:

$$c_t = \tau^b c_t^b + (1-\tau^b)c_t^l$$

Aggregate labor supply in consumption goods sector:

$$n_{ct} = \tau^b n_{ct}^b + (1-\tau^b)n_{ct}^l$$

Aggregate labor supply in housing sector:

$$n_{ht} = \tau^b n_{ht}^b + (1-\tau^b)n_{ht}^l$$

Aggregate labor supply:

$$n_t = \tau^b(n_{ct}^b + n_{ht}^b) + (1-\tau^b)(n_{ct}^l + n_{ht}^l)$$

Aggregate foreign debt:

$$b_t^{eu} = (1-\tau^b)b_t^{l,eu}$$

Aggregate capital:

$$k_t = (1-\tau^b)k_t^l$$

Total investment:

$$j_t = k_t - (1-\delta^k)k_{t-1}$$

Aggregate production function of consumption goods:

$$y_t = z_t^c(k_{t-1})^\alpha(n_{ct})^{1-\alpha}$$

Labor demand in consumption goods sector:

$$w_{ct} = mc_t(1-\alpha)\frac{y_t}{n_{ct}}$$

Capital demand in consumption goods sector:

$$r_t^k = mc_t\alpha\frac{y_t}{k_{t-1}}$$

Price determination:

$$p_t^* = \frac{\varepsilon}{\varepsilon-1}\frac{V_t}{F_t}$$

Present utility of discounted expected costs:

$$V_t = \lambda_t^l y_t mc_t(p_t)^\varepsilon + \beta^l\omega\mathbb{E}_t\left(\frac{\bar{\pi}^{1-\zeta}\pi_t^\zeta}{\pi_{t+1}^c}\right)^{-\varepsilon}V_{t+1}$$

Present utility of discounted expected revenues:

$$F_t = \lambda_t^l y_t (p_t)^{\varepsilon} + \beta^l \omega \mathbb{E}_t \left(\frac{\bar{\pi}^{1-\zeta} \pi_t^{\zeta}}{\pi_{t+1}^c} \right)^{-\varepsilon} F_{t+1}$$

Aggregate inflation:

$$p_t^* = p_t \left(\frac{1 - \omega (\frac{\bar{\pi}^{1-\zeta} \pi_{t-1}^{\zeta}}{\pi_t})^{1-\varepsilon}}{1-\omega} \right)^{\frac{1}{1-\varepsilon}}$$

Production function of houses

$$I_t^h = z_t^h n_{ht}$$

Labor demand in housing sector:

$$w_{ht} = q_t z_t^h$$

Total supply of houses:

$$h_t = I_t^h + (1 - \delta^h) h_{t-1}$$

Balanced budget constraint:

$$\bar{g_t} = tr_t$$

Taylor's interest rate rule:

$$r_t^{eu} = \bar{r}^{1-\rho} (r_{t-1}^{eu})^{\rho} (\pi_t^{eu})^{\psi(1-\rho)}$$

Euro zone inflation:

$$\pi_t^{eu} = (\pi_t^{reu})^{(1-\omega_{Sp})} (\pi_t^c)^{\omega_{Sp}}$$

Real exchange rate:

$$p_t^{reu} = p_{t-1}^{reu} \frac{\pi_t^{reu}}{\pi_t^c}$$

Consumption composite basket of home and foreign produced good:

$$c_t = ((1 - \omega_c)^{\frac{1}{\sigma_c}} (c_{ht})^{\frac{\sigma_c - 1}{\sigma_c}} + \omega_c^{\frac{1}{\sigma_c}} (c_{ft})^{\frac{\sigma_c - 1}{\sigma_c}})^{\frac{\sigma_c}{\sigma_c - 1}}$$

Consumption demand for home consumption goods:

$$c_{ht} = (1 - \omega_c)(p_t)^{-\sigma_c} c_t$$

Consumption demand for foreign consumption goods:

$$c_{ft} = \omega_c (p_t^{reu})^{-\sigma_c} c_t$$

Investment demand for home consumption goods:

$$j_{ht} = (1-\omega_j)\left(\frac{p_t}{p_t^j}\right)^{-\sigma_j} j_t$$

Investment demand for foreign consumption goods:

$$j_{ft} = \omega_j \left(\frac{p_t^{reu}}{p_t^j}\right)^{-\sigma_j} j_t$$

Investment price:

$$p_t^j = ((1-\omega_j)p_t^{1-\sigma_j} + \omega_j (p_t^{reu})^{1-\sigma_j})^{\frac{1}{1-\sigma_j}}$$

Ratio of Consumer Price Index (CPI) to Producer Price Index (PPI):

$$\pi_t^c = \pi_t \frac{p_{t-1}}{p_t}$$

Exports:

$$ex_t = s^x \left(\frac{p_t}{p_t^{reu}}\right)^{-\sigma_x} \bar{y}_t^{reu}$$

Imports:

$$im_t = c_{ft} + j_{ft}$$

Total resource constraint of the economy:

$$p_t y_t + q_t I_t^h = c_t + \phi_{g,t}\bar{g}_t + q_t(h_t - (1-\delta^h)h_{t-1}) + \\ p_t^j j_t + \frac{\Phi}{2}\frac{(k_t - k_{t-1})^2}{1-\tau^b} + p_t ex_t - p_t^{reu} im_t$$

Net foreign asset position:

$$\frac{b_t^{eu}}{\phi_{bt}} = p^{reu} im_t - p_t ex_t + \frac{r_{t-1}^{eu}}{\pi_t^c} b_{t-1}^{eu}$$

Nominal gross domestic product:

$$GDP_t = p_t y_t + q_t I_t^h$$

A.2 List of endogenous variables

Variable	Description
c_t^l	Lenders' consumption
h_t^l	Lenders' housing holding
n_t^l	Lenders' supply of labor
n_{ct}^l	Lenders' supply of labor in consumption goods sector
n_{ht}^l	Lenders' supply of labor in housing sector
λ_t^l	Lagrange multiplier on lenders' budget constrait
b_t^l	Domestic real debt held by lenders
$b_t^{l,eu}$	Foreign real debt held by lenders
k_t^l	Lenders' private physical capital
c_t^b	Borrowers' consumption
h_t^b	Borrowers' housing holding
n_t^b	Borrowers's supply of labor
n_{ct}^b	Borrower's supply of labor in consumption goods sector
n_{ht}^b	Borrower's supply of labor in housing sector
λ_t^b	Lagrange multiplier on borrowers' budget constrait
b_t^b	Borrower's domestic real debt
μ_t^b	Lagrange multiplier on borrowers' collateral constrait
w_{ct}	Real wage in cosumption goods sector
w_{ht}	Real wage in housing sector
n_{ct}	Labor supply to the consumption goods sector
n_{ht}	Labor supply to the housing sector
n_t	Labor supply
c_t	Consumption
h_t	Total supply of houses
k_t	Aggregate private physical capital
b_t^{eu}	Aggregate foreign real debt
j_t	Investment
y_t	Domestic output
GDP_t	Gross domestic product
mc_t	Marginal cost
F_t	Expected revenues
V_t	Expected costs
I_t^h	Residential investment
q_t	Real housing price
p_t^*	Real optimal price
p_t	Real production price

p_t^j	Real investment price
p_t^{reu}	Real foreign price
π_t	Domestic PPI inflation
π_t^c	Domestic CPI inflation
π_t^{eu}	EU gross inflation rate
r_t	Nominal interest rate on domestic bonds
r_t^k	Real rental rate of physical capital
r_t^{eu}	Nominal ECB interest rate
ϕ_{bt}	Risk premium
ex_t	Exports
im_t	Imports
c_{ht}	Home-produced consumption goods
c_{ft}	Foreign-imported consumption goods
j_{ht}	Home-produced investment goods
j_{ft}	Foreign-imported investment goods
tr_t	Lump sum transfers

A.3 List of exogenous variables

Variable	Description
z_t^c	Productivity(technological) shock in consumption goods sector
z_t^h	Productivity(technological) shock in housing sector
g_t	Government spending
π_t^{reu}	PPI and CPI in the rest of the European Union
y_t^{reu}	Aggregate consumption in the rest of the EU

A.4 List of parameters

Parameter	Description
β^l	Lenders' discount rate
β^b	Borrowers' discount rate
η	Inverse elasticity of labor supply
γ_h	Weight of utility from housing
θ	Weight parameter in labor services aggregator
ε_n	Elasticity of substitution between labor types
κ	Loan-to-value ratio
ε	Elasticity of substitution among final goods

Parameter	Description
τ^b	Fraction of borrowers
ω	Calvo parameter
ρ	Coeffcient on lagged nominal interest rate in Taylor rule
ψ	Taylor rule reaction to inflation
ζ	Indexation
δ^h	Depreciation rate of housing stock
δ^k	Depreciation rate of capital
ϕ_b	Premium risk parameter
α	Elasticity of substitution between labor and capital
ω_{Sp}	Weight of Spanish economy in UE
ω_c	Weight parameter in consumption aggregator
σ_c	Consumption elasticity of substitution domestic and foreign goods
s^x	Foreign preference
ω_j	Weight parameter in investment aggregator
σ_j	Elasticity of substitution domestic and foreign investment
σ_x	Log-run price elasticity of exports
Φ	Capital adjustment-cost parameter

B Steady State

B.1 Key sub-vector of variables

$$\mathbf{X} = (z^c, \theta, \frac{c^b}{c^l}, \gamma_h)$$

B.2 Steady state values imposed

Endogenous variables	Exogenous variables	Ratios
$GDP = 1$	$\frac{g}{GDP} = 0.18$	$\frac{qI^h}{GDP} = 0.073$
$q = 1$		$\frac{p^j j}{GDP} = 0.16$
$p = 1$		$\frac{n_h}{n_h+n_c} = 0.128$
$p^j = 1$		$\frac{c_h}{c} = 0.7068$
$\pi = 1$		$\frac{j_h}{j} = 0.7826$

B.3 Steady state values which follows straightforwardly

$$p^{reu} = \left(\frac{(p^j)^{1-\sigma_j} - (1-\omega_j)p^{1-\sigma_j}}{\omega_j} \right)^{\frac{1}{1-\sigma_j}}$$

$$\pi^c = \pi$$

$$\pi^{reu} = \pi^c$$

$$\pi^{eu} = \pi^{reu}$$

$$r = \frac{\pi^c}{\beta^l}$$

$$r^{eu} = r$$

$$\phi_b = \frac{r}{r^{eu}}$$

$$b^{eu} = 0$$

$$b^{l,eu} = \frac{b^{eu}}{1-\tau^b}$$

$$y = GDP - qI^h$$

$$h = \frac{I^h}{\delta^h}$$

$$c = GDP - g - qI^h - p^j j$$

$$k = \frac{j}{\delta^k}$$

$$k^l = \frac{k}{1-\tau^b}$$

$$r^k = \frac{1}{\beta^l} + \delta^k - 1$$

$$mc = \frac{\varepsilon - 1}{\varepsilon}$$

$$p^* = p$$

$$tr = g$$

$$c_h = c(1-\omega_c)(p)^{-\sigma_c}$$

$$c_f = c\omega_c(p^{reu})^{-\sigma_c}$$

$$j_h = j(1-\omega_j)\left(\frac{p}{p^j}\right)^{-\sigma_j}$$

$$j_f = j\omega_j\left(\frac{p^{reu}}{p^j}\right)^{-\sigma_j}$$

$$im = c_f + j_f$$

$$ex = \frac{p^{reu} im}{p}$$

$$y^{reu} = \frac{ex}{s^x}\left(\frac{p}{p^{reu}}\right)^{\sigma_x}$$

B.4 Steady state values which are function of X

$$c^l = \frac{c}{\tau^b(1-(1-\frac{c^b}{c^l}))} \equiv \mathbf{c^l}(\mathbf{x})$$

$$c^b = \frac{c^b}{c^l}\mathbf{c^l}(\mathbf{x}) \equiv \mathbf{c^b}(\mathbf{x})$$

$$\lambda^l = \frac{1}{\mathbf{c^l}(\mathbf{x})} \equiv \lambda^{\mathbf{l}}(\mathbf{x})$$

$$\lambda^b = \frac{1}{\mathbf{c^b}(\mathbf{x})} \equiv \lambda^{\mathbf{b}}(\mathbf{x})$$

$$\mu = \lambda^{\mathbf{b}}(\mathbf{x})(\frac{1}{r} - \beta^b) \equiv \mu(\mathbf{x})$$

$$n_c = \left(\frac{y}{z^c k^\alpha}\right)^{\frac{1}{1-\alpha}} \equiv \mathbf{n_c}(\mathbf{x})$$

$$w_c = \frac{mc(1-\alpha)y}{\mathbf{n_c}(\mathbf{x})} \equiv \mathbf{w_c}(\mathbf{x})$$

$$n_h = \frac{0.138}{1-0.138}\mathbf{n_c}(\mathbf{x}) \equiv \mathbf{n_h}(\mathbf{x})$$

$$z^h = \frac{I^h}{\mathbf{n_h}(\mathbf{x})} \equiv \mathbf{z^h}(\mathbf{x})$$

$$w_h = q\mathbf{z^h}(\mathbf{x}) \equiv \mathbf{w_h}(\mathbf{x})$$

$$n^l = \Big(\frac{1}{\theta}\Big(\frac{\mathbf{w_c}(\mathbf{x})}{\mathbf{c^l}(\mathbf{x})}\Big)^{1+\varepsilon_n} + \frac{1}{1-\theta}\Big(\frac{\mathbf{w_h}(\mathbf{x})}{\mathbf{c^l}(\mathbf{x})}\Big)^{1+\varepsilon_n}\Big)^{\frac{1}{\eta(1+\varepsilon_n)}} \equiv \mathbf{n^l}(\mathbf{x})$$

$$n_c^l = \Big(\frac{\mathbf{w_c}(\mathbf{x})(\mathbf{n^l}(\mathbf{x}))^{\frac{1}{\varepsilon_n}-\eta}}{\mathbf{c^l}(\mathbf{x})\theta^{\frac{1}{\varepsilon_n}}}\Big)^{\varepsilon_n} \equiv \mathbf{n_c^l}(\mathbf{x})$$

$$n_h^l = \Big(\frac{\mathbf{w_h}(\mathbf{x})(\mathbf{n^l}(\mathbf{x}))^{\frac{1}{\varepsilon_n}-\eta}}{\mathbf{c^l}(\mathbf{x})(1-\theta)^{\frac{1}{\varepsilon_n}}}\Big)^{\varepsilon_n} \equiv \mathbf{n_h^l}(\mathbf{x})$$

$$n^b = \Big(\frac{1}{\theta}\Big(\frac{\mathbf{w_c}(\mathbf{x})}{\mathbf{c^b}(\mathbf{x})}\Big)^{1+\varepsilon_n} + \frac{1}{1-\theta}\Big(\frac{\mathbf{w_h}(\mathbf{x})}{\mathbf{c^b}(\mathbf{x})}\Big)^{1+\varepsilon_n}\Big)^{\frac{1}{\eta(1+\varepsilon_n)}} \equiv \mathbf{n^b}(\mathbf{x})$$

$$n_c^b = \Big(\frac{\mathbf{w_c}(\mathbf{x})(\mathbf{n^b}(\mathbf{x}))^{\frac{1}{\varepsilon_n}-\eta}}{\mathbf{c^b}(\mathbf{x})\theta^{\frac{1}{\varepsilon_n}}}\Big)^{\varepsilon_n} \equiv \mathbf{n_c^b}(\mathbf{x})$$

$$n_h^b = \Big(\frac{\mathbf{w_h}(\mathbf{x})(\mathbf{n^b}(\mathbf{x}))^{\frac{1}{\varepsilon_n}-\eta}}{\mathbf{c^b}(\mathbf{x})(1-\theta)^{\frac{1}{\varepsilon_n}}}\Big)^{\varepsilon_n} \equiv \mathbf{n_h^b}(\mathbf{x})$$

$$n_c = \tau^b\mathbf{n_c^b}(\mathbf{x}) + (1-\tau^b)\mathbf{n_c^l}(\mathbf{x}) \equiv \mathbf{n_c}(\mathbf{x})$$

$$n_h = \tau^b\mathbf{n_h^b}(\mathbf{x}) + (1-\tau^b)\mathbf{n_h^l}(\mathbf{x}) \equiv \mathbf{n_h}(\mathbf{x})$$

$$h^b = \frac{\gamma^h}{q\lambda^{\mathbf{b}}(\mathbf{x})(1-\beta^b(1-\delta^h)) - q\kappa\mu(\mathbf{x})} \equiv \mathbf{h^b}(\mathbf{x})$$

$$h^l = \frac{\gamma^h}{q\lambda^{\mathbf{l}}(\mathbf{x})(1-\beta^b(1-\delta^h))} \equiv \mathbf{h^l}(\mathbf{x})$$

$$h = \tau^b\mathbf{h^b}(\mathbf{x}) + (1-\tau^b)\mathbf{h^l}(\mathbf{x}) \equiv \mathbf{h}(\mathbf{x})$$

$$b^b = \kappa\frac{q\mathbf{h^b}(\mathbf{x})}{r} \equiv \mathbf{b^b}(\mathbf{x})$$

$$b^b = \frac{\mathbf{c^b(x)} + q\delta^h \mathbf{h^b(x)} + tr - \mathbf{w_c(x)n_c^b(x)} - \mathbf{w_h(x)n_h^b(x)}}{1-r} \equiv \mathbf{b^b(x)}$$

B.5 Non-linear sub-system for the steady state value of X

The steady state value of $\mathbf{X} = (z^c, \theta, \frac{c^b}{c^l}, \gamma_h)$ is the solution to the following four-equations non-linear sub-system:

$$\left(\frac{y}{z^c k^\alpha}\right)^{\frac{1}{1-\alpha}} - (\tau^b \mathbf{n_c^b(x)} + (1-\tau^b)\mathbf{n_c^l(x)}) = 0$$

$$\frac{0.138}{1-0.138}\mathbf{n_c(x)} - (\tau^b \mathbf{n_h^b(x)} + (1-\tau^b)\mathbf{n_h^l(x)}) = 0$$

$$\frac{I^h}{\delta^h} - (\tau^b \mathbf{h^b(x)} + (1-\tau^b)\mathbf{h^l(x)}) = 0$$

$$\kappa\frac{q\mathbf{h^b(x)}}{r} - \left(\frac{\mathbf{c^b(x)} + q\delta^h \mathbf{h^b(x)} + tr - \mathbf{w_c(x)n_c^b(x)} - \mathbf{w_h(x)n_h^b(x)}}{1-r}\right) = 0$$

B.6 Rest of steady state

Given the steady state values computed so far the rest of them follows straightforwardly. Namely,

$$V = \frac{y\lambda^l mc}{1-\omega\beta^l}$$

$$F = \frac{y\lambda^l}{1-\omega\beta^l}$$

$$n = \tau^b(n_h^b + n_c^b) + (1-\tau^b)(n_h^l + n_h^l)$$

$$b^l = -b^b\frac{\tau^b}{1-\tau^b}$$