Balance Sheet Recessions*

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Abstract

We explore the effects of financial shocks in heterogeneous agent economies (a la Aiyagari) with frictions in goods markets, where demand contributes to productivity. In these economies, households of different wealth and earnings search for goods at different intensities and pay different prices. Increases in savings due to financial shocks trigger a recession completely through the demand channel. In an economy with a single asset and an ad-hoc borrowing limit, a tightening of the borrowing limit generates a mild decline of aggregate output because few households are very badly affected. However, in an extension of the model that includes housing that serves as collateral for borrowing, a tightening of the collateral constraint induces a much more severe recession as many more households are directly affected and as there is a large negative wealth effect due to the reduction in housing prices.

Keywords: Balance Sheet Recession, Endogenous productivity

JEL classifications: E20, E32, F44

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1 Introduction

In this paper we build a model where financial shocks to households generate a recession. Despite a common attempt in the popular press of linking the Great Recession with financial difficulties, there is very little success in building general equilibrium models capable of generating recessions from financial difficulties of households. There are, however, many papers that create a recession from increased financial frictions on the firm side (say, because of Bernanke and Gertler (1989) type of reasons). In this paper, we show that goods market frictions can be an important channel of generating a recession induced by households' financial distress. We also show that a recession can be much larger with the explicit modelization of houses.

In our model the onset of a financial crisis goes like this. After some time of financial bonanza for households, many of them are simultaneously holding little wealth and consuming large amounts. The arrival of a financial shock in the form of a much tighter borrowing constraint requires some households to dramatically reduce their consumption to satisfy the new financial requirement. More importantly, all households are affected in some manner as they find their former financial holdings insufficient to bear the daily vicissitudes of life which in our model take the form of idiosyncratic earnings shocks. Hence all households reduce their consumption and increase their savings. While a new steady state will eventually imply more consumption and more output than the old one due to the fact that households have become richer, the economy experiences a recession in the periods through which it adapts to a higher level of wealth. Standard models do not have this property, instead employment expands immediately after the financial shock and the increased savings.

The gist of our contribution is to pose search frictions in the markets for services. Households must exert search efforts to find services, and the amount of search efforts determine how much potential output can be translated into actual sales. Particularly, we pose a version of the Bai, Ríos-Rull, and Storesletten (2011) model with the additional feature that there is positive marginal need for labor when a match happens. The search frictions imply that when households reduce their consumption of services, they also produce a recession with both decreases in productivity and in labor. Absent search frictions, the drop in the price of services prevents their reduction. With search frictions, consumption of services decreases despite the decline of their prices. Because of the contraction in the service sector, the route to a higher level of wealth required by the tighter financial constraint involves a temporary reduction in output and employment.

While the mechanism is sharp and clear, we find that the recession created is small. Moreover, some households are actually better off. Rich households are barely touched by the financial constraint since their asset position is far from the borrowing constraint. Consequently, their marginal willingness to save is quite minimal. Poor households are much more negatively affected and they reduce their consumption much more dramatically. Because services cannot be used for saving, their relative prices drops sizably which allows rich households to increase their consumption of services and with it their utility. Note that there is a lot of wealth in the economy held by households. A tightening of the financial constraint does not put many households in trouble. For those households who are close to the borrowing constraint and suffering a serious setback, they have low consumption to start with it. Therefore, a further reduction of their consumption does not pose a large dent in the economy.

Therefore, we provide another version of the model with a housing sector susceptible to capital loses. Households borrowing has to be collateralized by housing value and the recession is triggered by a tightening of the collateral constraint. The inclusion of the housing sector serves provides two additional contributions. First, it allows for the financial shock to generate a wealth loss on all households as a consequence of the crisis. The reduction of the maximum loan-to-value (LTV) ratio suppresses the aggregate housing demand and lowers the housing prices. The capital loss induces a further reduction of consumption. Second, the financial shock has much larger effects on the economy. In the model without housing, only a small fraction of households with negative net worth are directly affected by the financial shock. Now all households with a negative financial position (a mortgage) are affected by the negative shock even if they have positive net worth. This happens even when we make the magnitude of the financial shocks comparable across the two economies that we explore.

Our model economies are of the Bewley (1986)-Imrohoroğlu (1989)-Huggett (1993)-Aiyagari (1994) type with many agents and incomplete markets. In these economies, households face uninsurable idiosyncratic risk and they protect themselves from this risk through wealth accumulation and/or elastic labor supply. We extend these models by posing a services market friction that is managed via a directed search protocol. The ability to acquire services in cheap, but inconvenient, markets provides households with another channel for self-insurance. In the steady state, the wealth or income-poor households choose the option to purchase the same services than richer households at a lower price, at the cost of exerting more search efforts, which is in line with the empirical findings of Broda, Leibtag, and Weinstein (2009) and Kaplan and Menzio (2013b). In recessions, most households cut their services consumption and they do so by exerting less search effort. The aggregate economy hence operates at a lower capacity. We modify the utility function used in Bai, Ríos-Rull, and Storesletten (2011) so that the aggregate search efforts move pro-cyclically.

Meanwhile, households also choose to go to markets with lower price, and as a result we observe a decline of the average prices of services. Depending on their asset position, the reactions of households to the financial shock varies quite a bit. We calibrate our model economy to capture the salient features of the U.S. wealth and earnings distribution and we find that the performance of the aggregate economy resembles the behaviour of the wealth poor households, who are the majority of the population.

Related literature This paper is closely related to the literature that attributes the recession to household financial distress. Guerrieri and Lorenzoni (2011) study the effects of a reduction of the borrowing limit in a very similar way than in our baseline economy. Their basic setup is a Huggett (1993) economy where households borrow from each other and aggregate wealth is zero. A tightening of the borrowing constraint induces the poorest households to increase their work effort and their savings. To clear the bond market the interest rate must drop dramatically, because even the richer agents have an incentive to increase work and savings at the old interest rate. The incentives of the rich to save are smaller since they are further away from the borrowing limit. The reduction in the interest rate induces households to delay gratification, it might do it enough so that the rich end up consuming more and working less, while the poor consume less and work more. The overall effect in the economy that Guerrieri and Lorenzoni (2011) parameterize is that output declines due to the reduction of labor of the very high skilled workers. Total working hours, however, increase because most households work more. Clearly, this outcome is not what we have in mind when thinking of the Great Recession and its large reduction of both output and hours. Their paper poses another environment with durable goods produced with a linear technology that can be used as collateral for borrowing. Like in our economy, this permits that a larger fraction of households now have negative financial assets. After a shock to the collateral constraint, the reduction in the interest rate will now be smaller since households can increase their savings via storing durables. As a result, both total output and total hours increase in this case, impeding the outset of a recession.[1].

Another important paper in this literature is by Midrigan and Philippon (2011) who consider an environment with two types of agents rich and poor. Both types are liquidity constrained but only the poor are credit constrained. A shock to the collateral constraint for liquidity significantly reduces aggregate demand if the rich cannot convert credit into liquidity quickly. To prevent

[1]In the economy with durables, a shock to the mark-up from borrowing reduces output. Now the group in the middle, those that are not next to the borrowing constraint but have negative financial wealth, see that consuming durables is now more expensive, and as a result reduce their consumption of durables. The total effect reduces output but not total hours.

households from working harder or moving to a tradable sector capable of accommodating the lack of demand, they assume not only labor reallocation costs, but also wage rigidity . A shock to the collateral constraint for credit has very small effects. This is because the unconstrained households increase consumption substantially. Both of the two papers face substantial difficulty in generating a recession due to the fact that the immediate effect of the financial constraint is to induce households to want to work harder.

Eggertsson and Krugman (2012) consider an environment with sticky prices and a Taylor type monetary policy rule. When borrowers are suddenly forced to reduce their nominal debt, the depressed demand puts downward pressure on the interest rate. To make a recession happen, nominal rigidities have to be present and the zero bound has to be binding. Justiniano, Primiceri, and Tambalotti (2013) incorporate mortgage choices and housing investment sector into an otherwise standard DSGE model. They assume a tightened collateral constraint only apply to new mortgages but not to existing mortgages. Quantitatively, a shock to the collateral constraint has only limited effects on aggregate activities, because most households can maintain their old mortgage plan. Also, savers and borrowers move to the opposite direction, and they wash out in aggregate.

Our paper complements the existing literature in several ways. First, we show that goods market frictions is an important factor contributing to a decline of the aggregate output. Similar to Huo and Ríos-Rull (2013a), a decline of households' demand translates into a decline of productivity in the production side. Second, our results does not rely on nominal rigidities. Despite a large drop of service prices, there remains a loss in output. Third, how a household is affected by a financial shock crucially depend on their balance sheet condition. The effects on aggregate activities are determined by the relative size of different households. Except for Guerrieri and Lorenzoni (2011), most papers assume that there are only two types of households, savers and borrowers. To investigate the effects of financial shock properly, it is crucial that the model produces the right wealth distribution. We calibrate our model to U.S. income and wealth distribution and we show that households are affected very differently by the financial shocks depending on their asset position.

Recently, there has been a growing literature on goods market friction and shopping behaviour. Our approach to modelling the services market frictions builds on Bai, Ríos-Rull, and Storesletten (2011). In addition to posing a model with heterogeneous agents, we modify the utility function used there to allow for search efforts and expenditures to be positively correlated both cross-sectionally and in the business cycles.

Alessandria (2009) and Kaplan and Menzio (2013a) also study the role of goods market frictions in business cycle analysis. Our results resemble theirs in the sense that households buy cheaper goods when they are poor or in a recession. The most crucial difference is that in both Alessandria (2009) and Kaplan and Menzio (2013a), sellers' occupation rate is independent of households' search effort, while it is positively correlated with households' efforts in our model. Michaillat and Saez (2013) consider a similar environment to ours, but they treat the price as an exogenous parameter and the market tightness is the variable responsible for market clearing. Unlike their paper, both the price and the market tightness are determined endogenously in our model, and there are rich implications of the price dispersion.

The rest of the paper is organized as follows. Section 2 and Section 3 describes the baseline model without the housing sector and its calibration. Section 4 presents the quantitative assessment of the baseline model after a shock to the borrowing limit. Section 5 extends the baseline model with housing choice. Section 6 shows the calibration of the model with housing. Section 7 discusses the quantitative performance of housing model and its comparison with the baseline model. Section 8 concludes.

2 The Economy

The economy runs endlessly and in each period there are two types of goods. The first type of good can be used either for consumption or for storage with net return r. For simplicity (to avoid cumbersome but vacuous market clearing conditions in the loan market) we assume that each household can hold negative amounts of this good up to an amount $\underline{a}$. Negative storage holdings can be thought of as loans, and $\underline{a}$ as the credit limit. We use this good as the numeraire and refer to it as such or simply as the good. The second type of good can be easily understood if thought of as services, although we have in mind a much larger class of goods. As such, those goods can only be used for consumption and not for saving. They are traded in decentralized markets and they are subject to additional frictions which we will describe in detail. As in Trejos and Wright (1995), households have to consume the services produced by others but not by themselves. We shall refer to this type of good as the market good because it is subject to market frictions, or, simply, as services.

There is a continuum of households and each household owns a fixed measure of locations. Each location can either be active or not. Every period, a measure y_s of these locations is active. To be operated, an active location requires $\epsilon < 1$ units of labor from the household. If matched with a purchasing shopper, an additional $1-\epsilon$ units of labor is required to produce one unit of the service. If the active location is not matched with a shopper, there is no output. In addition, a household also receives y_c units of the numeraire goods. The endowment $y = \{y_c, y_s\}$ is Markovian with transition Π.

2.1 Directed Search for Services

There are different markets indexed by the price and market tightness (p, q), where the market tightness is defined as the ratio of the measure of locations to the measure of shoppers. By sending a shopper to market (p, q), the household expects to meet a location with probability $\Psi^d(q)$ at price p. Not all markets are active. In fact households understand that there is an equilibrium determined expected revenue for sellers, $\zeta = p\ \Psi^f(q)$, that active markets have to satisfy. Searching is costly for households, and we will use preferences that not only yield a unique choice of market to go to, but also, that wealthy households search in markets with higher price and shorter lines, while poor households are more likely to search in a more crowded market but pay less. This is, we think, the natural case to explore.

Households not only choose where to shop but also where to send its locations to. By sending a location to market (p, q), the household expects to meet a shopper with probability $\Psi^f(q)$ and the expected revenue is $p\,\Psi^f(q)$. In the same fashion that the household is restricted as a shopper by expected revenue ζ, the household is guaranteed as a seller the same amount.

2.2 Preferences and State Variables

Households live forever, discount the future at rate β and are expected utility maximizers. They have preferences over numeraire goods consumption c, market goods or services consumption s and shopping disutility d, represented by a period utility function $u(c, s, d)$.

A household is characterized by (y, a), where a is the household's asset position. Let $x(y, a)$ be the measure over households' types. The total number of active locations that can yield services is

$$T_s = \int y_s \, dx(y, a). \tag{1}$$

The total endowment of numeraire goods is

$$Y_c = \int y_c \, dx(y, a). \tag{2}$$

2.3 Households' Problem

We can write the recursive problem of the household as

$$V(y,a) = \max_{\substack{a',c,s,d,\\ p^*,q^*,t(p,q)}} u(c,s,d) + \beta \sum_{y'} \Pi_{y,y'} V(y',a'), \tag{3}$$

subject to

$$p^* s + c + a' \geq (1+r)\, a + \zeta\, y_s + y_c, \tag{4}$$

$$s = d\, \Psi^d(q^*), \tag{5}$$

$$\zeta \leq p^* \Psi^f(q^*), \tag{6}$$

$$a' \geq \underline{a}, \tag{7}$$

$$y_s \geq \int_{p\,\Psi(q)\leq\zeta} t(dp,dq). \tag{8}$$

Note that in this problem we put a star on the price and market tightness of the market where the household chooses to send its shoppers. The household's budget constraint is (4). Search friction requires that the market goods have to be found, which is constraint (5). To guarantee there are locations sent to market (p^*, q^*), condition (6) has to hold. Condition (7) is an ad-hoc borrowing limit. Finally, condition (8), makes it explicit that the household allocates its measure of locations to active markets. We pose it here because it makes the definition of equilibrium sharper.

The first order conditions can be written as

$$u_s = p^* u_c + \frac{-u_d}{\Psi^d(q^*)}, \tag{9}$$

$$s\, u_c = d \; \frac{\Psi^d_q(q^*)}{\Psi^f_q(q^*) p^*} \; \frac{\Psi^f(q^*)}{\Psi^d(q^*)} \; u_d, \tag{10}$$

$$u_c \geq \beta\,(1+r) \sum_{y'} \Pi_{y,y'} \; u_c'. \tag{11}$$

In Equation (9), the term $\frac{-u_d}{\Psi^d(q)}$ captures the additional search disutility associated with acquiring services. Equation (10) displays the optimality condition associated to the choice of which market to go to. Its left hand side gives the marginal gain of going to a market with a cheaper service, while the right hand side shows the marginal cost of the required extra search that is required taking into account the market determined expected revenue. When the borrowing constraint is not binding, the intertemporal Euler equation (11) holds with equality.

2.4 Equilibrium

A steady state equilibrium is a set of decision rules and values for the households $(s, c, d, p^*, q^*, a', t, V)$ as functions of individual state variables (y, a), aggregate variables for expected revenue of a location ζ, a set of active locations $L = \{(p, q) : \int t(p, q)dx > 0\}$ and a stationary distribution of households x, such that

1. Given aggregate variable ζ, the households solve their problem.
2. Active locations yield expected revenue from locations, $\zeta = p\,\Psi^f(q)$.
3. All active markets fulfill their expected tightness, this is, for all $(p, q) \in L$,

$$q = \frac{\int t(p, q, y, a) \;\; dx(y, a)}{\int d(y, a) \;\; 1_{q^*(y,a)=q} \;\; dx(y, a)}. \tag{12}$$

4. The measure x is stationary and is updated by households' choices and the process for the endowment shocks.

The analysis out of steady state that we will perform consists of an unexpected change to the borrowing limit $\underline{a}$. The associated definition of equilibrium consists of sequences of decision rules and aggregate variables, where the initial condition, x^0 is the steady state of the initial borrowing limit. In this economy, the conditions for convergence to the new unique steady state hold (Hopenhayn and Prescott (1992)) so we will be guaranteed that the computed sequence after the unexpected change is indeed an equilibrium.

3 Calibration

3.1 Functional Forms and Parameters

Preferences The aggregate consumption bundle is valued via an Armington aggregator of goods and services

$$c_A = \left((1-\omega)c^{\frac{\eta-1}{\eta}} + \omega s^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}. \tag{13}$$

where η is the elasticity of substitution between the two types of consumption and ω is the bias towards services. We adopt GHH preferences between consumption and shopping effort, which is sufficient to guarantee that consumption and shopping effort move together

$$u(c, s, d) = \frac{1}{1-\sigma}\left(c_A - \xi_d \frac{d^{1+\gamma}}{1+\gamma}\right)^{1-\sigma}, \tag{14}$$

where σ determines the risk aversion, ξ_d determines average shopping effort, and γ determines how much more effort the household want to exert as they become richer. The other preference parameter is the discount factor β.

Matching A Cobb-Douglas matching function is the most widely used matching function. However, in this matching function the probability of finding a location or a shopper can be greater than 1. Consequently, we use the matching function suggested by Ramey, den Haan, and Watson (2000) that does not have this drawback

$$M(D, T) = \frac{DT}{(D^\mu + T^\mu)^{\frac{1}{\mu}}}. \tag{15}$$

The probabilities of finding a location and a shopper are

$$\Psi^d(q) = (1 + q^{-\mu})^{-\frac{1}{\mu}}, \tag{16}$$

$$\Psi^f(q) = (1 + q^{\mu})^{-\frac{1}{\mu}}. \tag{17}$$

Assets There are two parameters related to households asset holding: the fist one is the return to storage r, and the second is the borrowing limit $\underline{a}$.

3.2 Targets and Values

The model period is a quarter. We separate the parameters into two groups: the parameters in the first group are determined exogenously (they are shown in Table 1) and those in the second group (shown in Table 2 and Table 3) are jointly determined by solving the equilibrium. We set the risk aversion to be 2 and the rate of annul return to storage to be 4%. To determine the elasticity of substitution between market goods and numeraire goods, we follow the trade literature on the elasticity of substitution between nontradable goods and tradable goods. We choose the benchmark value used in Bianchi (2011), 0.83, which is also similar to the estimate in Heathcote and Perri (2002). We choose a curvature of the searching disutility, $\frac{1}{\gamma} = 0.60$, in order to have a value consistent with the Frisch elasticity of labor.

Parameter ϵ has no role whatsoever in shaping the allocation. It only determines the units of the steady state amount of labor which is completely irrelevant. It will play a role, however, down the road when we decompose drops in output into drops in productivity and drops in labor. We can just set it so such decomposition is whatever we want, so in a sense, we learn little (nothing actually) from this parameter. It allows us however to make the case that the structure that we pose is flexible enough to discuss both labor and productivity drops over a recession. We choose it so that changes in output are due in equal measure to changes in productivity and changes in labor.

TABLE 1
Exogenously Determined Parameters of the Baseline Economy

Parameter	Value
Risk aversion, σ	2.0
Return to storage (anual), r	4%
Elasticity of substitution between tradables and nontradables, η	0.83
Frisch Elasticity of Substitution of Search Effort $1/\gamma$	0.60
Fixed labor to keep a location open, ϵ	0.59

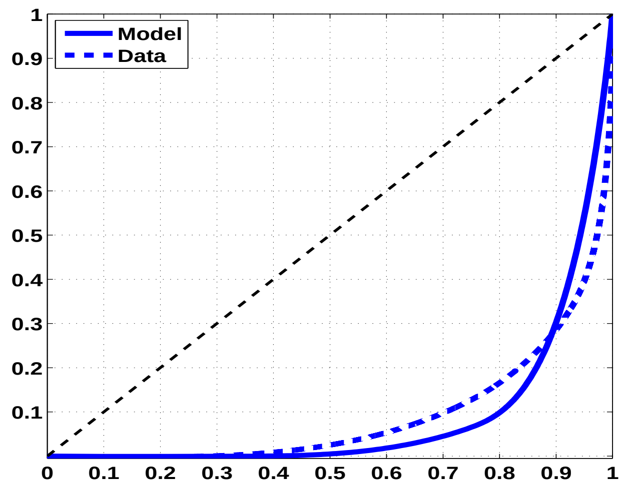
We now turn to the parameters that require solving the model to determine their value (this is they are estimated by an exact method of moments strategy). As is customary, we associate the parameters with the target that provides the most intuition for its value, but all parameters are chosen jointly to determine their values. We choose the discount factor β to target a wealth to income ratio 4.0, the level before the Great Recession. The borrowing limit $\underline{a}$ is such that 15% of households have negative or zero wealth. There are two parameters related to the goods market frictions, they are the units of search costs ξ_d (it could have been posed in the matching function without loss of generality), and the elasticity of the matching function μ. We chose them so that the service occupation rate is 81% and the standard deviation of prices is 10%. According to Kaplan and Menzio (2013a), the standard deviation of prices of the same good ranges from 20% to 30%. Among the dispersion, one third can be attributed to store differences. In our model, in different markets, shoppers exert different efforts to obtain the same good, which we interpreted as only store differences. The average occupancy rate reported by the Federal Reserve Board is 81%. We target a service to total output ratio of 67%, which pin downs ω. We also target that the endowment for numeraire goods accounts for 15% of the total output, which (assuming as we do that both endowments are perfectly correlated) determines the relative units of the two endowments, $y_c = \alpha y_s$.

TABLE 2
Steady-State Targets and Associated Parameters of the Baseline Economy

Parameter	Value	Target	Value	Model
β	0.96	Wealth to output ratio	4.00	4.00
$\underline{a}$	0.12	Fraction of negative wealth	0.15	0.15
μ	2.98	Service occupation ratio	0.81	0.81
ξ_d	0.04	St.d of price dispersion	0.10	0.09
ω	0.89	Services to output ratio	0.67	0.67
α	0.20	Numeraire endowments to output ratio	0.15	0.16

We calibrate the endowment process to capture the earnings and wealth distribution in U.S. We use four discrete endowment levels, i.e., $y_s \in \{y_{s,1}, y_{s,2}, y_{s,3}, y_{s,4}\}$. We interpret the first three endowments as earnings for the majority of households, with type 1 being poor, type 2 being normal and type 3 being rich, and the fourth endowment level is intended to capture the super rich households in the economy as in Castañeda, Díaz-Giménez, and Ríos-Rull (2003) or Díaz, Pijoan-Mas, and Ríos-Rull (2003). The transition probability and the levels of the first three states are calibrated to approximate an AR(1) process using the method by Tauchen (1986). Following Nakajima (2012) and Domeij and Heathcote (2004), we set the persistence for the endowment process to be 0.91, and the standard deviation for the innovation term to be 0.20. We assume the first three types of households have the same probability of becoming the type 4 households who are super rich, $\pi_{enter} = \Pi_{i,4}, i \in \{1,2,3\}$, and that type 4 households return to one of the first three states with the same probability $\pi_{exit} = \Pi_{4,i}, i \in \{1,2,3\}$. We calibrate the rest of the parameters to match the earning Ginis index, 0.64, the wealth Gini index, 0.82, (calculated from 2007 SCF data) and the fact that the top 10% of population own 70% of total wealth. As shown in Figure 1, the model successfully captures the U.S. wealth distribution. The transition probability and endowment levels are shown in Table 3.

FIGURE 1
Wealth Distribution and Lorenz Curve



3.3 Measurement Issues

Define A as the aggregate wealth in the economy

$$A = \int a \, dx(y, a). \tag{18}$$

In the model economy, total output is

$$Y = \int_0^{T_s} p_i \Psi^f(q_i) di + \int y_c \, dx(y, a) + r \int a \, dx(y, a) = \zeta T_s + Y_c + rA. \tag{19}$$

The distribution of prices is clearly changing across periods so we need to set a price index to compare output over time. Let $\mathrm{P}_0 : [0, T_s] \to R_+$ be the function that indicates the price of a location $i \in [0, T_s]$ in the initial steady state, where we rank the locations by their prices in an increasing order, i.e., $\mathrm{P}_0(i) \leq \mathrm{P}_0(j)$ if $i < j$.

We then use the following base year prices to define real output in different periods

$$Y_t = \int_0^{T_s} \mathrm{P}_0(i) \;\; \Psi^f(q_{it}) \;\; di + \int y_c(y, a) \, dx_t(y, a) + r \int a \, dx_t(y, a). \tag{20}$$

TABLE 3

Parameters Related to the Endowment Process in the Baseline Economy

Parameter	Value	Target	Value	Model
$y_{s,4}$	7.385	Wealth held by top 10%	0.70	0.70
$y_{s,1}$	0.155	Total number of locations, T_s	1.00	1.00
$\Pi_{1,4}$	0.001	Income Gini index	0.64	0.64
$\Pi_{4,1}$	0.003	Wealth Gini index	0.82	0.82
$\Pi_{1,1}$	0.965	Persistence, ρ_s	0.91	0.91
$\Pi_{2,2}$	0.976	St.d of innovation, σ_s	0.20	0.20
$\Pi_{3,2}$	0.033	Tauchen (1986) method	—	—
$\Pi_{1,2}$	0.033	$\Pi_{1,2} = \Pi_{3,2}$	—	—
$\Pi_{1,3}$	0.000	$\sum_{i=1}^{3} \Pi_{1,i} = 1 - \Pi_{1,4}$	—	—
$\Pi_{2,1}$	0.011	$\Pi_{2,1} = \Pi_{2,3}$	—	—
$\Pi_{2,3}$	0.011	$\sum_{i=1}^{3} \Pi_{2,i} = 1 - \Pi_{1,4}$	—	—
$\Pi_{3,1}$	0.000	$\Pi_{3,1} = \Pi_{1,3}$	—	—
$\Pi_{3,3}$	0.965	$\sum_{i=1}^{3} \Pi_{3,i} = 1 - \Pi_{1,4}$	—	—
$\Pi_{2,4}$	0.001	$\Pi_{2,4} = \Pi_{1,4}$	—	—
$\Pi_{3,4}$	0.001	$\Pi_{3,4} = \Pi_{1,4}$	—	—
$\Pi_{4,2}$	0.003	$\Pi_{4,2} = \Pi_{4,1}$	—	—
$\Pi_{4,3}$	0.003	$\Pi_{4,3} = \Pi_{4,1}$	—	—
$\Pi_{4,4}$	0.978	$\sum_{i=1}^{4} \Pi_{4,i} = 1$	—	—
$y_{s,2}$	0.388	$\log y_{s,2} = 0.5(\log y_{s,3} + \log y_{s,1})$	—	—
$y_{s,3}$	0.972	$\log y_{s,3} - \log y_{s,1} = 2\sigma_y$	—	—

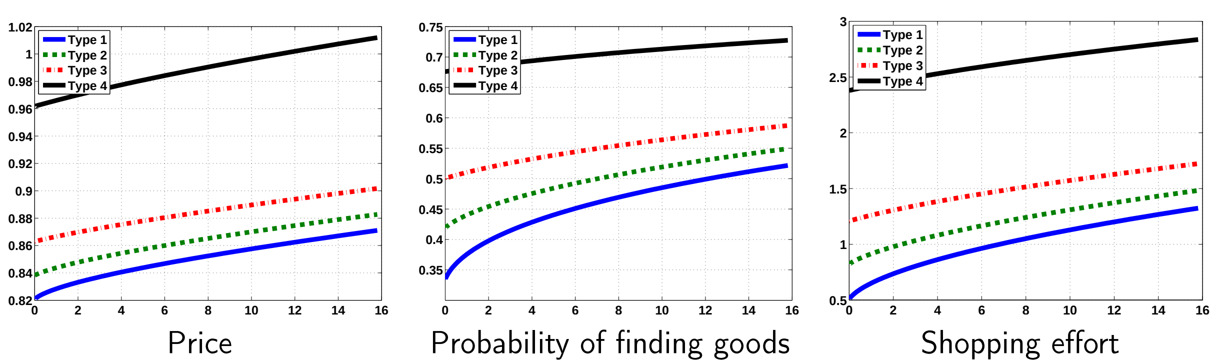
Note that $\Psi^f(q_{it}) = \frac{\zeta_t}{p_{it}}$ is the occupation probability for location i in period t, where the ranking of the locations is according to its price under the new distribution. This definition of output only reflects the change of average occupation rates at a location.

4 Quantitative Results

4.1 Model Properties in the Steady State

To highlight how the market frictions affect households decisions, Figure 2 plots the choice of price and market tightness depending on the wealth level of households for each earnings group. See how households with more wealth or more income choose a market with a higher price and a higher probability to find the locations that deliver services. As shown in Broda, Leibtag, and Weinstein (2009), households with lower income systemically pay a lower price for the same goods. Particularly, households with the highest income in the sample pay 5% more than those with the lowest income (we ignore the few households of type 4, the ultra rich, in this calculation). In our model, the average price paid by the four types are 0.84, 0.85, 0.89 and 1.17. The rich households (type 3) purchase the goods about 5% more expensive than type 1 households. Kaplan and Menzio (2013a) find that households with unemployed working-age members, an indirect measure of earnings, pay 1% to 5% less than those without unemployed members. Based on these findings, we conclude that our model is able to replicate the salient price dispersion features.

FIGURE 2
Market Choice and Shopping Effort as a Function of Wealth



Aguiar and Hurst (2005) and Aguiar and Hurst (2007) document that retired and unemployed people tend to exert more time on shopping. Aguiar, Hurst, and Karabarbounis (2013) show that during recessions, consumers spend 7% more time on shopping on average. At a first glance, this may seem to be contradicting our model prediction, which is that rich households exert more shopping effort than poorer households. In our model, the search effort is the disutility associated with consumption, such as waiting for a restaurant table or booking for hotels on line. It is different from the shopping time spent on finding a cheaper price, such as searching for coupons or sales, which is what Aguiar and Hurst (2005) and Aguiar and Hurst (2007) tend to capture. Whether consumers actually show up in restaurants or theatres affects the occupation rate of the economy, and in recessions, firms operate with a lower capacity. As shown in Aguiar and Hurst (2005), retired and unemployed people do eat outside at a restaurant less frequently. So we conclude that an enhanced interpretation of shopping rather than just bargain hunting makes our model look more like the data. In the baseline economy, about 15% of households hold negative net worth which we can interpret as borrowing from richer households. Of these, 9.4% are actually in the corner, meaning that they are borrowing constrained households.

4.2 A Steady State without Negative Storage

This paper explores the breakdown of borrowing possibilities which can naturally be implemented by setting the lower bound of assets to 0, which carries the interpretation of households being able to save but not to borrow.

In as steady state with a zero assets limit, aggregate wealth is higher due to the strong precautionary saving motive. Table 4 shows that total wealth is 1.05% higher. In such a steady state, households are richer and consequently, they enjoy a higher level of consumption and exert more searching effort, although as Table 4 shows the difference is very small. Accordingly, average search and occupation rate increase a tiny but. It turns out that the price dispersion goes down again only a little bit.

The main feature of the steady states comparison is that households in the economy with a tighter borrowing constraint consume more and the economy operates at a higher occupation rate. This is a standard feature when comparing steady states of economies differing in total wealth. So how can a recession result from the tightening of the borrowing constraint? The answer is that the process of adjusting to higher wealth entails a recession along the transition, during the high saving stages. An analysis of the transition is then required.

4.3 Transition Dynamics

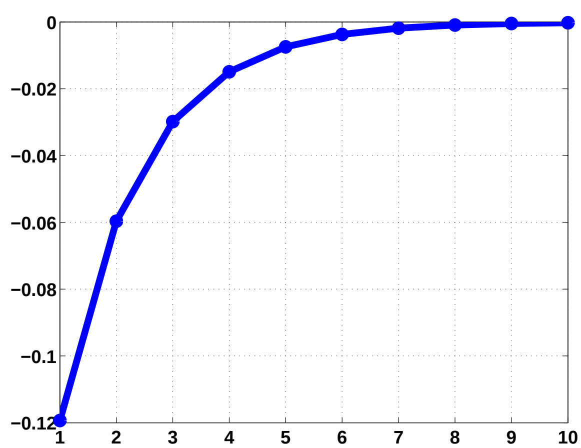
A drastic transition where suddenly all borrowing disappears is the wrong object of study. To the extent that most people borrow long term (and they can also default), we think that a better

TABLE 4
Steady State Comparison

	Percentage change
Output	0.176
Labor	0.009
Productivity	1.165
Service	0.029
Consumption	0.447
Search effort	0.058
Average price	0.631
St.d of price dispersion	-0.123
Wealth	1.050

analysis of how people adjust to increased difficulties in borrowing requires a gradual tightening of the borrowing constraint. Consequently, we assume $\underline{a}$ gradually moves over 6 periods from its value of -.12 at the beginning to 0, as shown in Figure 3, still quite a sharp reduction of borrowing possibilities.

FIGURE 3
Transition of the Borrowing Limit $\underline{a}$



G: The following graph is not quite right, we need to solve for the expected revenue $\zeta = p\psi^f(q)$ for every period to clear the service market.

Note that by virtue of this economy being a storage economy, there are no price effects and computation of the transition is quite a simple endeavour. We just solve the problem of the agents under the new borrowing limit and start with the initial condition of the old borrowing limit. Of course, there is a tiny bit of complication in the first few periods as the borrowing limit changes a bit over a few periods, but this is a small detail.

Figure 4 displays the transitions of the main aggregate variables. Clearly, households start saving as soon as the borrowing constraint tightens. They reduce their consumption of goods (last panel) and increase their wealth in the same amount (second panel). At the beginning of the transition, total output of the numeraire goods is unchanged as consumption and investment are perfectly negatively correlated. If output in the service sector remains the same , nothing would happen to total output. However, in their attempt to increase savings, households also reduce their consumption of services. To do so, they reduce their search for goods, and with it, productivity and labor. In addition, prices of services also change with an initial increase in dispersion that slowly goes down. Average prices also goes down which ameliorates the reduction of consumption of services. As it can be seen, the reduction in goods consumption is much more dramatic than that of services (about three times larger).

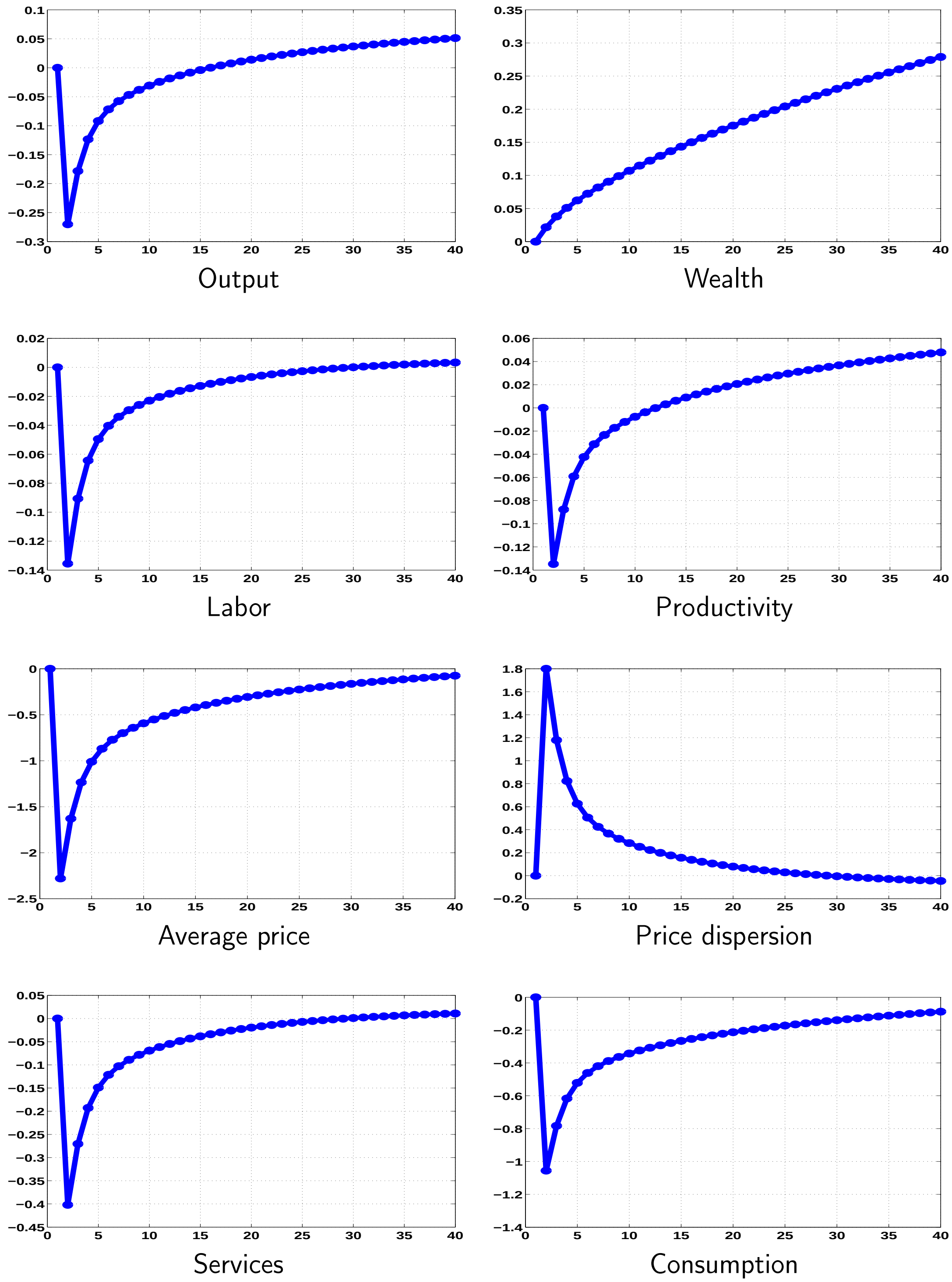
4.4 Heterogeneous Response to the Financial Shock

The reason for the increase in price dispersion throughout the recession gives us some hints of what goes on: poor households who are close to the borrowing limit are the most affected by the tightening of the borrowing constraint and hence they are more willing to bear more searching disutility and choose markets with very low prices. On the other hand, rich households while also wanting to increase savings do not have the same strength of desire to do so as the poor, resulting an increase of price dispersion. Kaplan and Menzio (2013a) document that the price dispersion is larger in areas with higher unemployment rate. Our finding is in line with the empirical finding that worse economic condition enlarges the price dispersion.

To gain a better understanding of the mechanism, it is useful to investigate the cross-sectional response of households. Figures 5 show that the response of households with different earnings and wealth display significant heterogeneity. The poorest earning-households' (type 1) asset position is quite close to the borrowing limit and they are affected by the shock most dramatically. They reduce their consumption of services by 6%, while the other three types of households reduce their consumption of services by no more than 1.5%. This conveys a reduction of the expected revenues

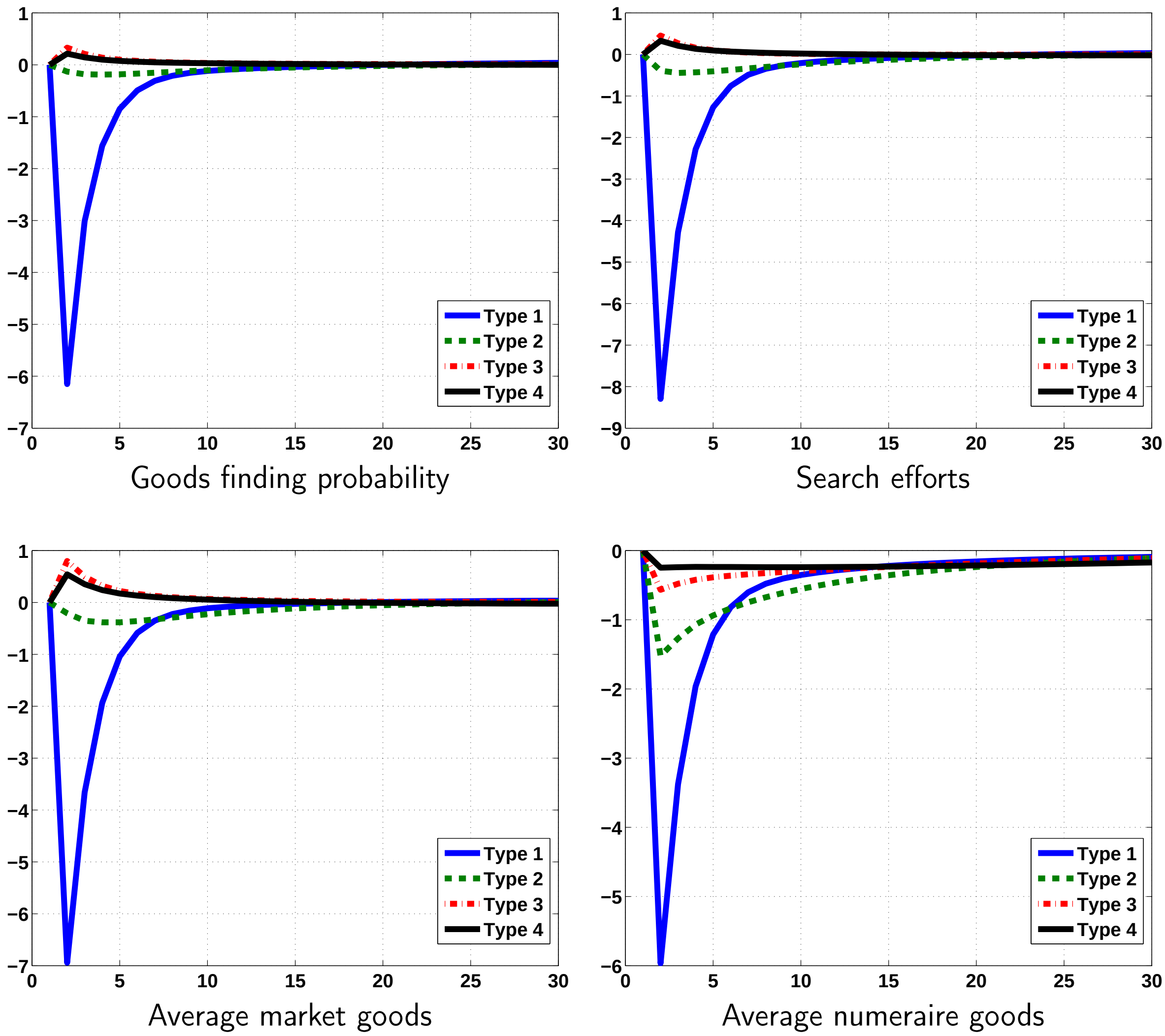
Figure 4

Aggregate Economy Response: Shock to Borrowing Limit



of sellers, ζ, which is accomplished in part by a reduction of prices and in part by a reduction of the occupation rate. According to our assumptions for the production of services, the reduction in quantities is accomplished by a reduction of TFP and of labor that depends on our choice of ϵ.

FIGURE 5
Cross-Sectional Response: Shock to Borrowing Limit



Households are split in how they reduce their expenditures in services. Type 1 and type 2 households reduce both the quantity of services purchased and the price that they pay for them. At the same time, they also reduce their search effort since less goods need to be found now. In contrast, the rich and super rich households (types 3 and 4) reduce their expenditures in services but the lower prices that they face allow them to increase their consumption of services and also increases their search effort, albeit less than proportionally in the sense that they go to less crowded markets which is what accounts for the increase in price and search dispersion. The overall outcome is that the economy as a whole resembles the behavior of the poor households, after all, they are the majority of the population.

In summary, a tightening of the borrowing limit induces a recession due to a weaker aggregate demand. The total output goes down along with total search effort, productivity and labor.

4.5 Assessing the Magnitude of the Recession

When we turn to the size of the recession we see that it is quite mild. Despite a relatively dramatic reduction of borrowing possibilities (they disappear), the reduction in total output about .30% (.35 of services which are 80% of consumption). Moreover, employment, the most popular measure of economic activity only goes down by a fraction ϵ of that.

We do not want to abandon the idea that the lack of credit can be the source of a large recession, but we have to dig deeper to understand why the model yields so little. One possible answer is that the economy adjusts to the attempts to save by reducing the price of services which ameliorates its reduction. A popular strategy to exacerbate economic fluctuations is to prevent the adjustments of prices from happening. This is not the strategy we pursue here. We think that the answer to why the recession is so small relies in the nature of the borrowing constraint, it only affects directly 15% of households, those that are in debt. Moreover, those are the poorest households and their consumption is not that great to start with, so a further reduction will not be that large. What is needed is a much more sweeping financial shock, one that both affects directly a much larger fraction of the population and that in addition triggers a capital loss capable of inducing large negative wealth effects that further reduce consumption. A look at the U.S. Flow of Funds, or out the window for that matter, shows that the large majority of households own a house, hold a mortgage, and suffer a sever capital loss at the onset of the recession.

We now turn to posing our framework with housing susceptible of price changes.

5 Housing Economy

In the baseline economy, households only own one type of asset, which equals their net worth. The single asset structure excludes the possibility that households hold positive assets and debt at the same time. As a consequence, a financial friction only affects the level of net worth and the maximum difficulty for households is to be unable to borrow. The shock to the borrowing limit has direct effects only on the households which are close to the borrowing limit, a minority of the total population. The rest of the households which are far from the borrowing limit also increase their saving level but just slightly, and they are likely to take advantage of the temporarily lowered prices of services. That different households move in different directions results in only mild aggregate effects.

In the U.S., a relatively small fraction (15%) of households have negative net worth, whereas a much larger fraction (75%) of households hold certain kind of debt. Particularly, over 70% of the financial debts are collateralized by residential assets. In the Great Recession, the aggregate net worth of households, total debt, and housing prices all experienced a severe slump. Moreover, county-level data indicate that local economic activity is strongly correlated with housing market conditions. Counties with higher reliance on home equity borrowing reduced their consumption level by significantly more (Mian and Sufi (2012), Mian, Rao, and Sufi (2013)). Motivated by these facts, we extend the model to allow housing to be valued by the households and served as collateral for borrowing.

5.1 Housing Construction Sector

We assume that housing is a perfectly divisible durable good and that the housing stock depreciates at rate δ_h every period. A construction sector transforms goods into residential investment. To get changes in housing prices we just assume a non-linear production possibility frontier, so a decrease in housing construction reduces the value of the stock of houses. Formally, we assume that there are a continuum of firms of measure one that engage in housing investment production with a decreasing returns to scale technology

$$F(m) = z_h \, m^{1-\varphi}, \tag{21}$$

where m is the amount of goods used as intermediate inputs, z_h is a units parameter, and φ determines the degree of decreasing returns. Firms in the construction sector take the price of housing p^h as given and choose their optimal scale of production. The problem of a firm in the housing sector is

$$\max_m \; p^h \, F(m) - m. \tag{22}$$

The optimality condition is

$$p^h = \frac{m^\varphi}{(1-\varphi)z_h}. \tag{23}$$

Equation (23) implies that the housing price is increasing in housing investment and the φ controls the elasticity of the housing price with respect to the change of housing investment. Midrigan and Philippon (2011) also uses a decreasing return to scale technology in the housing sector so that housing demand can play a role in determining the housing price. In Jeske, Krueger, and Mitman (2011) and Corbae and Quintin (2013), a linear production technology leaves the housing price entirely determined by the technology, which corresponds to the special case $\varphi = 0$ in our model. For simplicity we assume that construction firms' profits are distributed lump-sum to households. This reduces the cumbersome process of linking those profits to asset ownership. Since the size of the construction sector is small, these profits constitute a small part of the endowment of households, even the poorest ones.

5.2 Collateral Constraint

This is the crucial step in constructing a financial system vulnerable to shocks. We assume that households may borrow up to a fraction of the value of the amount of houses held by the asset,

$$b \geq -\lambda \, p^h \, h, \tag{24}$$

where b is the total amount of financial assets (or storage plus borrowing) and λ determines the maximum loan to value ratio. Alternatively, $(1-\lambda)$ is the minimum down payment requirement. This collateral constraint can arise in an environment where the debt contract cannot be fully enforced and the lender is only able to recover a fraction λ of the debtor's tangible assets, as in Kiyotaki and Moore (1997). In this setting, households never default on their debt. One can also allow the mortgage rate to depend on households' type, in which case the loan to value ratio is determined endogenously and the mortgage rate reflects the default probability. However, the causes and effects of a rising foreclosure rate for sub-prime mortgages are beyond the scope of the current paper, and the exogenous collateral constraint modelled here is sufficient to make our point. Note that houses do not have any frictions and a tightening of the borrowing constraint can be implemented by reducing housing holdings.

5.3 Preferences, States, and the Problem of Households

We assume that housing has to be owned in order to be enjoyed, and the period utility function is $u(c, s, d, h)$. We abstract from any transaction costs in the resizing of housing, so every period households can buy and sell as much as they want. Consequently we only have to keep track of the households net worth. A household is characterized by its endowment and its net worth, (y, a). To avoid cumbersome record keeping we exclude from the household problem the allocation of locations to markets and just recognize that household earnings depend on their endowment and the equilibrium expected revenue from its active locations, ζ. The household problem is then

$$V(y, a) = \max_{\substack{a', c, s, d, \\ h, p, q, b}} u(c, s, d, h) + \beta \sum_{s'} \Pi_{s,s'} \, V(y', a'), \tag{25}$$

subject to

$$
\begin{aligned}
p\, s + c + p^h\, h + b &\geq a + \zeta y_s + y_c + \pi, && (26)\\
s &= d\, \Psi^d(q), && (27)\\
\zeta &\leq p\, \Psi^f(q), && (28)\\
a' &= p_h'\, h\, (1 - \delta_h) + (1 + r) b, && (29)\\
b &\geq -\lambda\, p^h\, h. && (30)
\end{aligned}
$$

Here π are the profits of housing construction firms, b are the non-housing assets that we interpret as mortgages if negative and as storage or loans if positive. The first order conditions include

$$
\begin{aligned}
u_c &= \beta\, (1 + r) \sum_{s'} \Pi_{s,s'}\, u_c' + \phi, && (31)\\
p^h u_c &= u_h + \beta (1 + r) \sum_{s'} \Pi_{s,s'} p^h (1 - \delta_h) u_c' + \phi \lambda p^h. && (32)
\end{aligned}
$$

where ϕ is the multiplier associated with the collateral constraint. In the case that the collateral constraint is not binding, $\phi = 0$, purchasing an additional unit of housing increases both current utility and helps saving for tomorrow. When the collateral constraint is binding, $\phi > 0$, increasing housing also helps to relax the borrowing limit as it is seen by the presence of the multiplier in condition (32).

5.4 Equilibrium

Equilibrium in this economy is as before except for the addition of market clearing for housing investment . A steady state equilibrium is a set of decision rules and values for the households $(s, c, d, b, p, q, a', t, V)$ as functions of individual state variables (y, a), and an expected revenue of a location ζ, a price for housing p^h, inputs into housing construction m, profits for firms π, a set of active locations $L = \{(p, q) : \int t(p, q)\ dx > 0\}$, and a stationary distribution of households x, such that

1. Firms maximize profits π, and housing investment markets clear.

2. Given aggregate variable ζ, the households solve their problem.

3. Active locations yield expected revenue from locations, $\zeta = p\ \Psi^f(q)$.

4. All active markets fulfill their expected tightness, this is, for all $(p, q) \in L$,

$$q = \frac{\int t(p, q, y, a)\ \ dx(y, a)}{\int d(y, a)\ \ 1_{q(y,a)=q}\ \ dx(y, a)}. \tag{33}$$

5. The housing market clear

$$F(m) = \delta_h \int h(y, a) dx(y, a). \tag{34}$$

6. The measure x is stationary and is updated by households' choices and the process for the endowment shocks.

The analysis out of steady state that we perform consists of an unexpected change of the collateral requirement, λ. The associated definition of equilibrium consists of sequences of decision rules and aggregate variables, where the initial condition, x^0 is the steady state of the initial collateral requirement . In this economy, computation the transition is more involved as we have to ensure that the housing markets clear every period of the transition. Still, it is quite a manageable problem.

6 Calibration of the Housing Economy

The model extended with housing shares a number of parameters and functional forms with the baseline model economy. When encountering a parameter which shows up in both economies, we either set it to be the same or calibrate it to the same target as the baseline. In the discussion below, we focus on the parameters that are unique to the model with housing and we will not repeat those that are already described in Section 3.

TABLE 5
Exogenously Determined Parameters of the Economy with Housing

Parameter	Value
Risk aversion, σ	2.00
Curvature for Low Level of Housing, σ_h^1	2.00
Curvature for High Level of Housing, σ_h^2	10.00
Elasticity of substitution bw tradables and nontradables, η	0.83
Return to storage, r	4%
Frisch Elasticity of Substitution of Search Effort $1/\gamma$	0.60
Fixed labor to keep a location open, ϵ	0.59
Collateral requirement, λ	0.85
Elasticity of housing price w.r.t investment, φ	0.30

We assume that the utility function is separable between housing and non-housing consumption. Furthermore, we assume the following functional form:

$$u(c, s, d, h) = \begin{cases} \frac{1}{1-\sigma}\left(c_A - \xi_d \frac{d^{1+\gamma}}{1+\gamma}\right)^{1-\sigma} + \frac{\xi_h}{1-\sigma_h^1} h^{1-\sigma_h^1}, & \text{if } h < \widehat{h} \\ \frac{1}{1-\sigma}\left(c_A - \xi_d \frac{d^{1+\gamma}}{1+\gamma}\right)^{1-\sigma} + \frac{\xi_h}{1-\sigma_h^2} \left(h + \underline{h}\right)^{1-\sigma_h^2}, & \text{if } h \geq \widehat{h} \end{cases} \tag{35}$$

The first part that involves goods consumption, services consumption, and search effort is the same as in the baseline model. As documented in Díaz-Giménez, Glover, and Ríos-Rull (2011), housing wealth is less concentrated than financial wealth. Thus, to prevent rich households from accumulating too much housing wealth, we assume that if a household holds more than $\widehat{h}$ units of housing, the marginal utility of housing decreases faster, which is achieved by setting $\sigma_h^2 > \sigma_h^1$. Particularly, we choose $\sigma_h^1 = 2$ and $\sigma_h^2 = 10$. The cutoff value $\widehat{h}$ is chosen to target that the top 10% of households own 25% of the total housing wealth. $\underline{h}$ is chosen such that the marginal utility of housing is continuous at the threshold level $\widehat{h}$. We calibrate ξ_h such that the housing value to output ratio is 1.5.

Turning to the housing construction sector, the most important parameter is φ, which controls the degree of decreasing returns to scale. During the Great Recession, residential investment fell about 7 times more than the total output. Motivated by this observation, we choose $\varphi = 0.3$ so that the size of the housing investment reduction relative to the total output is about the same as in the data. The implied profits in the housing construction sector is 1.02% of the total output. We target that the housing investment to output ratio is 3.5%, which determines that depreciation rate of the housing stock. We also choose the technology parameter z_h such that the units of the housing stock is normalized to 1.

TABLE 6
Steady-State Targets and Associated Parameters of the Economy with Housing

Parameter	Value	Target	Value	Model
β	0.96	Wealth to output ratio	4.00	4.20
ξ_h	0.64	Housing value to output ratio	1.50	1.50
μ	2.98	Average occupation ratio	0.81	0.81
ξ_d	0.04	St.d of price dispersion	0.10	0.09
α	0.18	Numeraire endowments to output ratio	0.15	0.14
ω	0.89	Services to output ratio	0.67	0.70
$\widehat{h}$	1.85	Housing held by top 10%	0.25	0.24
$\underline{h}$	-0.71	u_h is continuous at $\widehat{h}$	—	—
δ_h	0.006	Investment to output ratio	0.04	0.04
z_h	0.005	Housing stock	1.00	1.00

The maximum loan-to-value ratio λ is set to 0.85, corresponding to a 15% percent down payment requirement. For the endowment process, we choose the same targets as in the baseline economy. The implied financial debt to output ratio is 55% and the fraction of households with debt is 78%, both of which are in line with data with the debt to output ratio being a little lower than the pre-recession level. Table 6 displays the rest of the parameters of the housing economy.

6.1 Measurement Issues

Output in the housing economy also includes housing investment. We define real output using base year prices as

$$Y_t = \int_0^{T_s} \mathrm{P}_0(i) \;\; \Psi^f(q_{it}) \;\; di + \int y_c(y,a)\, dx_t(y,a) + p_0^h F(m_t) - m_t + r \int b \;\; dx_{t-1}(y,a), \quad (36)$$

where p_0^h is the housing price in the base year, P_0 is the mapping from locations to prices in the base year.

7 Quantitative Results for the Housing Economy

We now hit the economy with a financial shock. This time is not a shock to the borrowing limit itself, but to the maximum loan to value ratio. What makes this different in the economy with housing is that households attempt to satisfy the new limit not only by reducing consumption and increasing saving, but by reducing their housing holdings there is an economy–wide decrease in the price of housing which exacerbates the problem as the original gap in the required ratio due to the change in the collateral requirement is now augmented by the lower value of the house.

The financial shock in the housing economy does not hit directly those with a negative net asset position, but those with a tight loan to value ratio. To compare the financial shock in the two economies we have to make a decision on what are comparable shocks of similar magnitude. Yet the two financial shocks are very different in nature. One affects the absolute level of loans, the other the loan to value ratio. We have chosen to make the two shocks comparable by requiring that the reduction in consumption of a certain group of households is the same (see below in Section 7.2 for details). Before turning to the transition dynamics, we first look at the two steady states with different collateral constraints.

7.1 A Steady State with a lower Loan to Value Ratio

Table 7 reports the changes in the new steady state after the transition is completed. The steady state associated to a tightened collateral requirement has more wealth level due to the stronger precautionary saving motive. The housing stock and housing prices are also higher, but to a much lower extent than total wealth. A higher wealth level naturally boosts housing demand, and the need to sustain its depreciation together with the decreasing returns to the housing technology increases its price. However, housing is a less useful asset for the poorest household, as it requires a lot more wealth to maintain its consumption.

Total output in the new steady state is 1.12% higher, with most of the increase reflected in a higher level of consumption goods, and a mild increase of service consumption of 0.21%. The increase in the former comes as a result of the higher storage, while the increase of the latter requires more search that goes up by 0.41% due to the decreasing returns to scale in the matching function, which implies an increase in productivity of 1.05% and in labor of 0.07%. Prices of services are driven up by a stronger demand resulting from the wealth effect. Price dispersion is lower by almost one percent, -.80%.

TABLE 7
Steady State Comparison

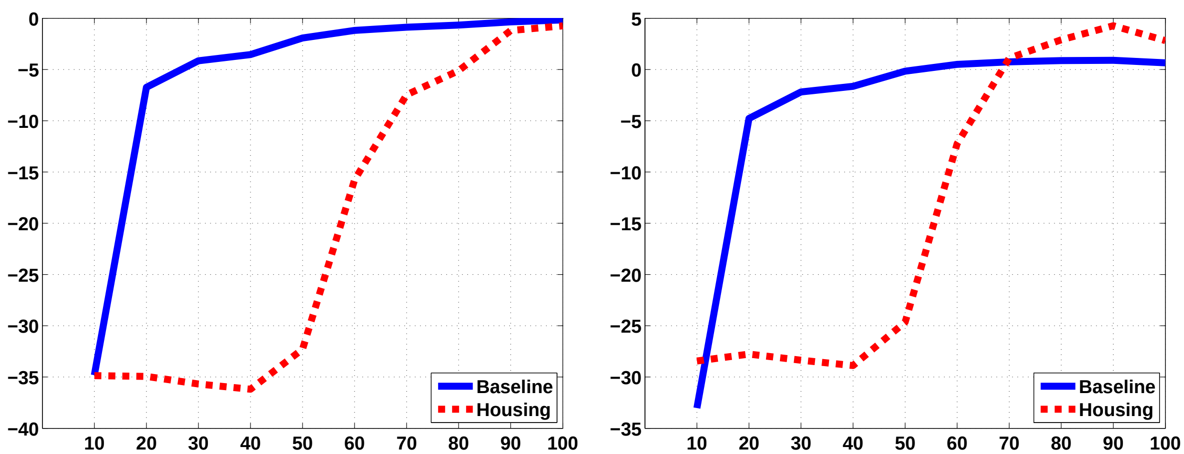
	Percentage change
Output	1.116
Labor	0.071
Productivity	1.050
Service	0.215
Consumption	3.820
Search effort	0.411
Average price	5.529
St.d of price dispersion	-0.801
Housing price	0.109
Housing stock	0.255
Wealth	5.930

7.2 Magnitude of the Recession: Baseline Economy v.s. Housing Economy

We have chosen the size of the financial shock in the housing economy to leave the households in poorest 10th percentile of the economy with a reduction in consumption similar to the baseline economy. By choosing this size we make sure that the force of the financial shocks that hit those households that are relatively weak is the same. Yet we allow the effects of the shock in the housing economy to be larger because it affects not only the poorest but a large group of households in the middle. Recall that in our economy, given the calibration strategy, loans are held by all households and not only the poorest of the poor. Figure 6 and Tables 8 and 9 display the effects of the shock in terms of reduction of consumption on different groups of agents sorted by wealth. As we can see, while the effects are the same for the poorest households, they are much larger for the rest of households (except the top 10%) in the housing economy. Overall the effect is 5 times larger with an overall reduction in consumption of 4% and of 2% of services.

Note that the actual value of the shock is not that large. It is a down payment ratio of 29% relative to a value of 15% before. This is a reduction of 14% of the maximum loan to value ratio. It seems to us that the actual change in the terms of the loans that were available to households before and after the beginning of the Great Recession may have been quite a bit larger.

FIGURE 6
Percentage Decline of Consumption at Different Percentiles



Consumption of Goods

Consumption of Services

Table 8
Goods

	Non-cumulative		Cumulative	
	Baseline	Housing	Baseline	Housing
10	**-34.8**	**-34.8**	-34.8	-34.8
20	-6.7	-34.9	-16.0	-34.9
30	-4.2	-35.7	-11.0	-35.3
40	-3.5	-36.2	-8.7	-35.6
50	-1.9	-32.3	-6.9	-34.7
60	-1.2	-15.8	-5.4	-29.9
70	-0.9	-7.5	-4.3	-24.5
80	-0.7	-5.1	-3.4	-19.8
90	-0.4	-1.2	-2.2	-10.8
100	-0.2	-0.8	-1.1	-4.0

Table 9
Services

	Non-cumulative		Cumulative	
	Baseline	Housing	Baseline	Housing
10	-33.0	-28.4	-33.0	-28.4
20	-4.8	-27.8	-14.4	-28.0
30	-2.2	-28.4	-9.2	-28.2
40	-1.6	-28.9	-7.0	-28.4
50	-0.2	-24.7	-5.2	-27.5
60	0.5	-7.3	-3.8	-22.5
70	0.7	1.1	-2.7	-16.9
80	0.9	2.9	-1.9	-12.4
90	0.9	4.3	-1.1	-6.3
100	0.7	2.8	-0.4	-2.0

7.3 Transition Dynamics

We are now ready to look at the path of the economy after the financial shock. Table 10 shows the direct effect of the financial shock in the main aggregate variables for both the baseline and the housing economies. Output goes down by 2.3% in the housing economy which is 7 times more than in the baseline. Consequently with this, both consumption of goods and services go down, with the latter being smaller more due to its uselessness as an investment good. Productivity and capacity also go down a few times more in the housing economy than in the baseline and the drop in housing investment is 18%, a huge amount. Different from the baseline economy where the total wealth remain constant at the beginning of the recession, households' wealth declines by 2.7% in the housing economy due to the drop of total housing value.

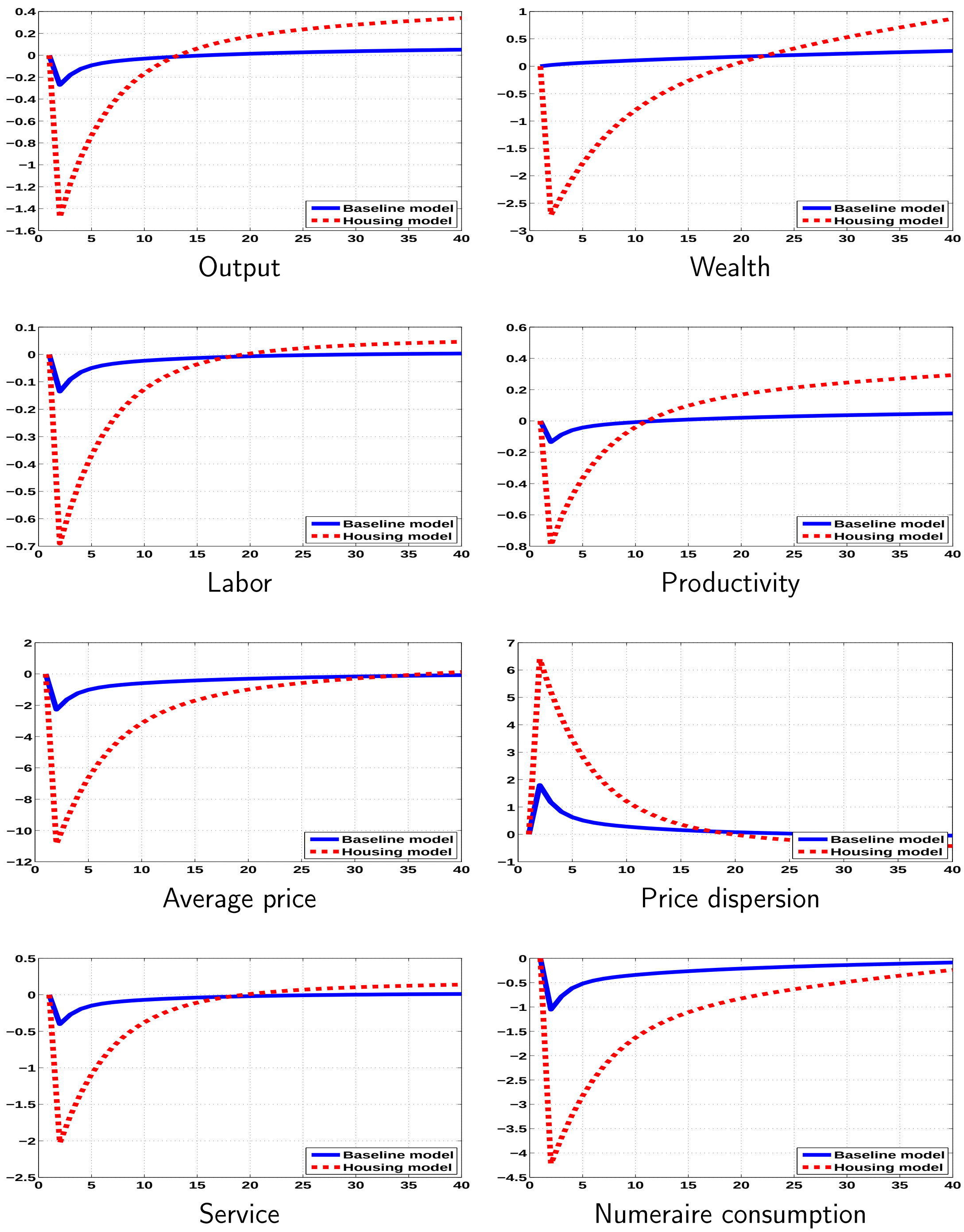
Table 10
Changes in Aggregate Variables
as a Result of the Financial Shock

	Baseline model	Housing model
Total output	-0.27	-1.47
Labor	-0.13	-0.69
Productivity	-0.13	-0.79
Services Consumption	-0.40	-2.03
Goods Consumption	-1.05	-4.22
Average price	-2.27	-10.86
St.d of price dispersion	1.80	6.40
Wealth	0.00	-2.72
Housing price	—	-8.48
Housing investment	—	-18.09

Let's look now at the impulse response of the financial shock in the housing economy. Figure 7 displays the effects of the financial shock in both the baseline (in continuous blue as before) and the housing (in dotted red) economies. We can summarize what happens in the housing economy by saying that we obtain a much larger recession than in the baseline, consistent with what we saw in Table 10.

In addition to the sheer size of the difference in the drop in output, we can see that it takes three years for the housing economy to recover the level of output previous to the crisis. The recovery is also a bit stronger. There is a large drop of wealth due to the loss of value of the houses, something that cannot happen in the baseline economy. It takes the household sector more than four years to recover the original amount of wealth under the new financial situation. The economy ends up rebounding much more strongly than the baseline. Also as we can see, the decomposition of the drop in output shows that it is due to labor and productivity in about the same amount. We also obtain a reduction in the price of services and a large increase in the price dispersion, which indicates how different are the effects of the recession across different groups of households. The poor are much more adversely affected and in consequence they are willing to exert a lot of search effort in exchange for cheaper prices. Consistent with the drop in the price of services we see that

Figure 7
Aggregate Economy Response: Shock to Collateral Constraint



the drop in the consumption of goods is larger implying that households increase their savings by quite a large amount.

Figure 8
Housing Market Response: Shock to Collateral Constraint

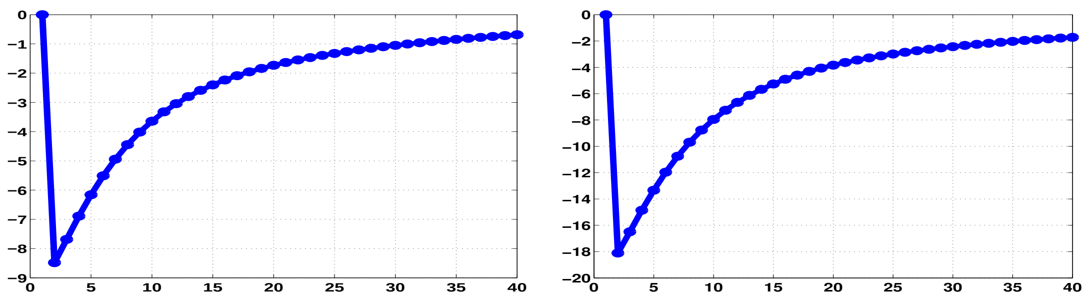


Figure 8 displays the response of the price of houses and of the quantity of new investment. We see that house prices drop by more than 8%, a relatively large amount, yet smaller than that in the U.S. economy. Housing investment, on the other hand also suffers a large drop, 18%. Our Housing economy then has a large drop in total housing wealth. However the model is limited in its ability to experience large loses: there is no land, and the degree of decreasing returns in the construction sector is limited by our willingness to impose a reduction in construction. We specified the decreasing returns to housing by targeting the magnitude of the housing investment drop relative to the output drop. In the transition, the housing investment declines 18%, which is more than 7% than the drop of total output. As Heathcote and Davis (2007) have documented, most of the variation in housing prices is due to changes in the price of land not construction. In Huo and Ríos-Rull (2013b) we explore the implications for the Great Recession in the U.S. of financial shocks over the price of land and the stock markets and we generate numerically plausible values for output contraction and assets' prices reductions.

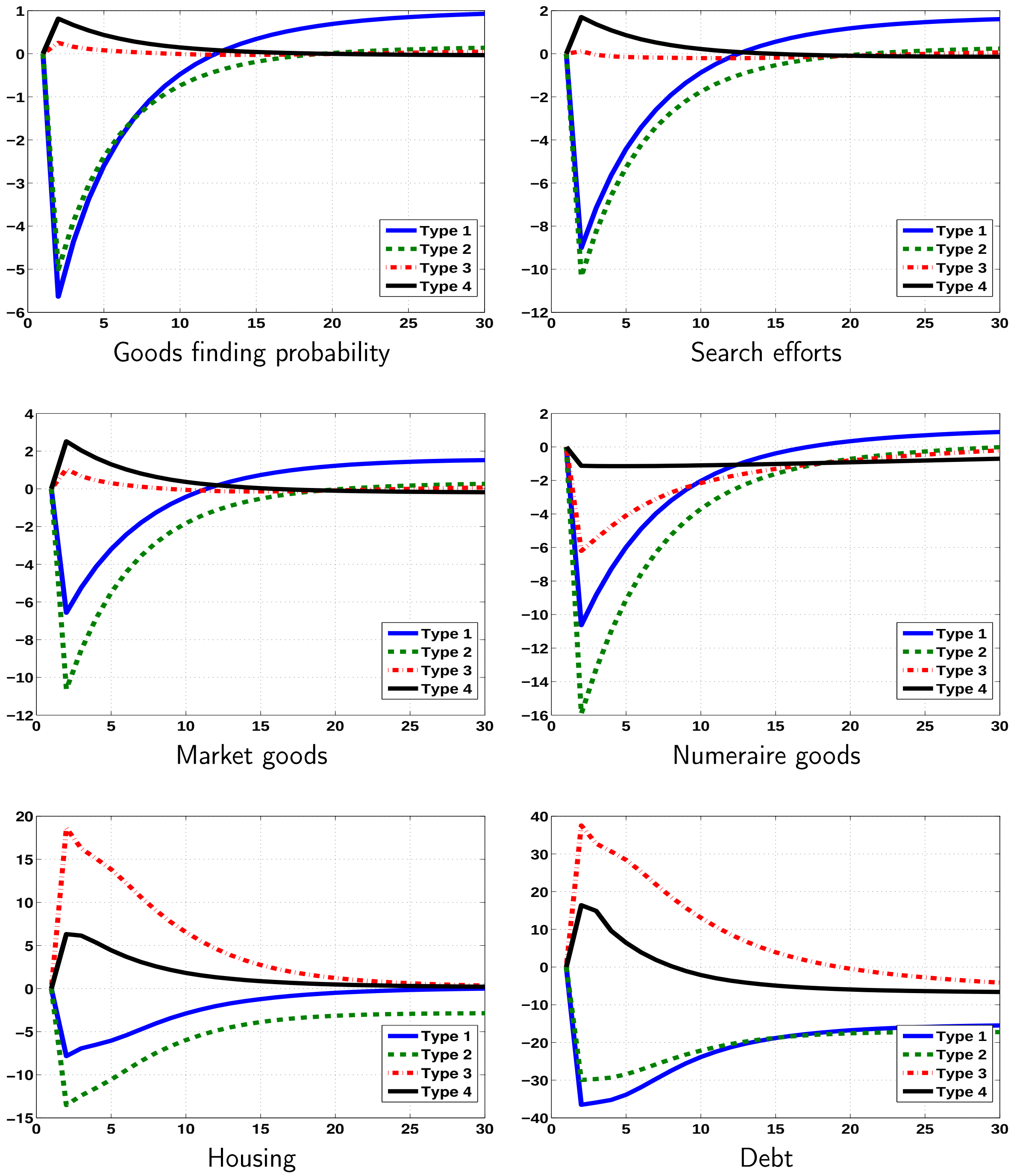
7.4 How different household groups fare

Figure 9 shows the reaction of the different households organized by earnings class and wealth. Recall that type 1 are 18% of the population while type 2 are the majority, 54%; the rich and very rich are 18% and 10% respectively. We see that types 1 and 2 are the ones that suffer the bulk of the recession. While all households reduce their goods consumption and increase their savings, rich households take advantage of the reduced price of services to increase their consumption but poor households also reduce the consumption of services. Interestingly, it is not the poorest of the poor the group that are worse hit, but the second poorest, those that reduce their housing the most. Also interestingly, rich households increase their housing holdings, an artifact of the perfect substitubility of all housing stock in this model. In Huo and Ríos-Rull (2013b) we explore economies where the rich have no appetite to increase their consumption of houses and those housing units have to be held formerly by much poorer people. Hence we eliminate the role of the rich households in maintaining the housing price by picking up the slack.

8 Conclusion

Conclude.

FIGURE 9
Cross-Sectional Response: Shock to Collateral Constraint



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