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# Search and Credit Frictions in the Housing Market

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# Search and Credit Frictions in the Housing Market*

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**Abstract**

This paper develops a model of the housing market with search and credit frictions. The interaction between the two frictions gives rise to a novel channel through which the financial sector affects prices and liquidity in the housing market. Furthermore, an interesting feature of the model is that both frictions combined lead to multiple equilibria. A numerical exercise suggests that credit shocks have a relatively larger impact on mortgage debt and liquidity than on prices.

*JEL Classification*: E2, E32, R21, R31.

*Keywords*: Housing market; Credit Frictions; Search and Matching; Multiple Equilibria; Mortgages.

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# 1. Introduction

A predominant feature of the housing market is that it is subject to search frictions. Empirically, it takes time both to sell a house and find a suitable home. Time-to-sell and time-to-buy display large fluctuations over the business cycle, which is yet further evidence that search frictions are prevalent in the housing market. Another salient feature of the housing market is the presence of credit frictions. The vast majority of households are liquidity constrained and need to finance their home purchase. Furthermore, finding a mortgage lender is a costly and time consuming process.[1]

This paper develops a dynamic general equilibrium model of the housing market with search and credit frictions. In the model, it takes time for buyers to find a suitable home and for sellers to sell a house, so the housing market is subject to search and matching frictions. In addition, buyers are liquidity constrained. They must be pre-approved for a mortgage by a financier before they can purchase a house. Given that this process is costly and time consuming, the credit market is subject to search frictions as well. We show that including credit frictions in an otherwise stylized search model of the housing market leads to multiple equilibria. Furthermore, the frictions give rise to a novel channel through which the financial market can affect prices and liquidity in the housing market. In a numerical exercise, we study the relative contribution of the credit frictions channel to the build-up in housing prices and mortgage debt prior to the 2007 market crash. We find that mortgage debt and time-to-sell are more responsive than prices to shocks associated with this channel.

We allow for free entry of buyers and financiers.[2] If households choose to participate in the market, their first step is to search for a financier, similar to Petrosky-Nadeau and Wasmer (2018) and Wasmer and Weil (2004). Matching between households and financiers is costly and time consuming for both parties. Upon forming a match, they negotiate a mortgage contract and the household begins searching for a suitable home. During this search process the financier must keep funds liquid and readily available in case the buyer finds a home. Hence, both the buyer and financier incur costs during that time. When the buyer finds a home, she pays the

[1] For example, the National Association of Realtors reports that, during 2016, 88% of all buyers financed their homes. Of all buyers, 11% reported that finding a mortgage was the most difficult step of buying a home

[2] As Gabrovski and Ortego-Marti (2018) show, entry of buyers and sellers is important to match the housing market dynamics over the business cycle.

downpayment and begins repaying the mortgage, whereas the financier finances the rest of the purchase.

Given that the financier must incur costs to keep funds liquid while the household searches for houses, we find that equilibrium mortgage repayments are decreasing in the home-finding rate. The intuition is as follows. The match between a household and a financier generates a positive surplus, some of which is extracted by the financier through mortgage repayments. Upon pre-approval, households embark on a costly search for a suitable house. During that time, the financier must keep funds available to finance the purchase once the buyer finds a home. Hence, the financier suffers an opportunity cost of keeping these funds liquid. Since the buyer does not begin repaying the mortgage until after she has purchased a house, a lower home-finding rate increases the expected liquidity costs for the financier and reduces the present value of future repayments. As a result, the financier negotiates a higher mortgage repayments with the household when time-to-sell is high.

The model may exhibit multiple equilibria because, unlike most search models, the buyer's agreement point when she bargains with the seller is decreasing in the time-to-sell, which is determined by the housing market tightness—the ratio of buyers to sellers.[3] After the buyer and the seller agree on the price, the buyer takes on a mortgage from the financier which includes interest payments. This leads to multiple equilibria. There is one equilibrium with high price, high home-finding rate and low interest payments, and one equilibrium with low price, low home-finding rate, and high interest payments. Intuitively, the equilibrium housing price and the housing market tightness are determined by free entry into housing construction and Nash Bargaining over the joint surplus of the seller and the buyer. Both conditions determine a negative relationship between prices and housing market tightness. New vacancies enter the market until the house price covers housing construction and search costs, whereas the price splits the surplus from matching according to Nash Bargaining.[4] Entry of sellers leads to a negative relationship between prices and tightness, as more sellers find it profitable to enter when prices are high, even if that lowers the time-to-sell. When the tightness is high, buyers

[3]As is standard in the search literature, we assume the surplus is shared using generalized Nash Bargaining. The buyer's agreement point is to take on the mortgage, pay the downpayment and move in the house. Her outside option is to keep searching for a home.

[4]In most housing search models, when more sellers enter the market, the market tightness decreases. This increases the home-finding rate for buyers but decreases the vacancy-filling rate for sellers. Thus, sellers expect to stay in the market for a longer time. Since search is costly, this increases their expected search costs.

find suitable homes more slowly, so interest payments are high.[5] This raises mortgage payments and reduces the joint surplus of the buyer and the seller. Given the smaller surplus, buyer and seller negotiate a lower price. As a result, bargaining between the seller and the buyer defines a downward sloping relationship between price and tightness. Overall, bargaining and free entry imply two downward sloping relationships between the price and the housing creation curves, and will in general feature two equilibrium points.[6]

In our model, credit frictions determine the financing fee—higher expected search costs for the financier lead to higher equilibrium fee and as a result higher mortgage payments. This reduces the gains from trade in the housing market and subsequently the prices and time-to-sell. This mechanism represents a novel channel through which the financial sector can impact prices and liquidity in the housing market. We study, in a numerical exercise, the relative contribution of shocks linked to this channel for the build-up in the housing market and the increase in the mortgage debt-to-price ratio prior to the 2007 market crash. To this end, we decompose the empirically observed changes in housing market and financial variables during that period into five fundamental sources. Two of these sources are shocks to housing market variables: i) the utility of home-ownership; ii) the cost of housing construction. The other three are shocks to parameters that affect credit frictions: i) liquidity costs for financiers; ii) credit market search efficiency; iii) financiers' bargaining strength. Our results suggest that, quantitatively, credit frictions did not play a substantial role in the increase of housing prices. However, they were important to keep the housing market "liquid"—time-to-sell in the data remained relatively constant, whereas absent any credit shocks it would have increased 1.7 times. Furthermore, the credit friction had a large contribution to the observed increase in the mortgage debt-to-price ratio. In the data the ratio increased by 16.46%, whereas if there were no credit shocks, it would have decreased by 2.46%.

**Related literature.** Following the seminal work in Wheaton (1990), a large number of papers have used search models à la Diamond-Mortensen-Pissarides to study the housing market. One strand of the literature models the housing market using a matching function as in Pissarides (2000). Papers in this strand include Burnside, Eichenbaum and Rebelo (2016), Diaz

[5]Because our model features free entry of both households and new vacancies, the surplus depends on the market tightness only through the credit frictions channel, i.e. due to the equilibrium interest payments.

[6]There is a knife-edge case where there is a unique equilibrium.

and Jerez (2013), Gabrovski and Ortego-Marti (2018), Genesove and Han (2012), Guren (2018), Head, Lloyd-Ellis and Sun (2014) and (2016), Novy-Marx (2009) and Piazzesi and Schneider (2009). Another strand features changes in the reservation value of houses, rather than changes in the market tightness, to generate changes in the time-to-sell. Krainer (2001), Ngai and Tenreyro (2014), and Ngai and Sheedy (2017) provide examples of such papers.

Additionally, a number of papers employ a search framework to study the housing market in the context of financially constraint households. For example, Guren and McQuade (2018) and Hedlund (2016) study the linkages between housing prices, sales, and foreclosures, whereas Head *et al.* (2016) study the link between the size of the seller's outstanding mortgage, housing prices and time-to-sell on the other.

The work in this paper complements these previous studies by focusing on an environment in which there are search frictions in both the housing and credit markets. We show that the interaction between the two sources of friction leads to the existence of multiple equilibria, each with qualitatively different comparative statics. This is in contrast to the previous literature on search frictions in the housing market, which has not examined these frictions associated with obtaining a mortgage. Furthermore, our framework allows us to study the quantitative importance of credit frictions for housing prices, time-to-sell and mortgage debt.

Our paper proceeds by introducing the environment. Next, we characterize the steady state equilibria, expand on the intuition behind the multiplicity in our model, and discuss existence and properties of the equilibria. Lastly, using a numerical exercise we study the relative contribution of the credit frictions channel to the build-up in housing prices and mortgage debt prior to the 2007 market crash.

# 2. The Economy

Time is continuous. Agents are infinitely lived, risk-neutral, and discount the future at a rate $r$. The economy consists of households, a real estate sector, and financiers. Households are either homeowners, buyers, mortgage applicants, or they can choose not to participate in the market. They are liquidity constrained, so if they wish to purchase a home they must first be pre-approved for a mortgage by a financier. There is free entry into the credit market on both sides of the market, but because of frictions participation is costly and time consuming. Households that match with a financier become "pre-approved" for a mortgage and can begin searching for houses, i.e. they become buyers.

The real estate sector acts as an intermediary in the housing market. It consists of a representative realtor (buyer's side) and a representative investor (seller's side). The investor has the technology to build new homes at a fixed cost. She owns all newly constructed vacant houses and posts each of them as a vacancy on the market. Some of the vacancies are existing homes—household that suffer a separation shock post their home for sale. Houses are identical, so there is no distinction between new and existing homes. There are search frictions associated with selling a home. Buyers must secure the services of a realtor who searches for a suitable home on their behalf. There are no frictions in matching between the realtor and buyers. However, finding a home for the buyer is a costly action, so the realtor charges a fee. To capture depreciation, all houses (including vacancies) are destroyed at a rate $\delta$.

There are search frictions in both the housing market and the credit market. We follow Diaz and Jerez (2013), Gabrovski and Ortego-Marti (2018), Genesove and Han (2012), Head *et al.* (2014), Head *et al.* (2016), Novy-Marx (2009), and Wheaton (1990), among others, and model search frictions in the housing market using the matching function approach in Pissarides (2000). This allows us to capture two key features observed in the data, the simultaneous existence of both buyers looking for homes and vacant houses, and the fact that it takes time for a buyer to find a suitable home and for a seller to find a buyer. Matches form at a rate $M(b, v)$, where $b$ is the measure of buyers and $v$ the measure of vacancies. We impose the standard properties on the matching function—it is concave, increasing in both its arguments, and exhibits constant returns to scale. Thus, the home-finding rate for buyers is given by $m(\theta) \equiv M(b, v)/b = M(1, \theta^{-1})$, and the vacancy-filling rate is $\theta m(\theta) = M(b, v)/v = M(\theta, 1)$, where $\theta \equiv b/v$ is the housing market tightness. For ease of exposition, we also assume that the matching function takes the usual Cobb-Doublas form, i.e. $m(\theta) = \mu\theta^{-\alpha}$. In addition, our model features free entry for both applicants and housing vacancies. As Gabrovski and Ortego-Marti (2018) show, entry on both sides of the housing market is necessary to match the cyclical behavior of prices, sales, vacancies and time-to-sell.

In practice, most households are liquidity constrained so they need to secure financing before buying a home. The process of obtaining a pre-approval for a mortgage is costly and time consuming. We model these credit frictions in the spirit of Petrosky-Nadeau and Wasmer (2018) and Wasmer and Weil (2004). There is free entry for both households looking for a mortgage (applicants) and financiers. Each financier has the funds to finance a single home purchase. Matches between them are formed at a rate $\mathcal{F}(\mathfrak{a}, \mathfrak{f})$, where $\mathfrak{a}$ and $\mathfrak{f}$ are the measures of applicants and financiers respectively. We assume that $\mathcal{F}(\cdot, \cdot)$ is concave, increasing in both arguments, and exhibits constant returns to scale. Applicants meet a financier at a rate $f(\phi) \equiv \mathcal{F}(\mathfrak{a}, \mathfrak{f})/\mathfrak{a} = \mathcal{F}(1, \phi^{-1})$ and financiers meet applicants at a rate $\phi f(\phi) = \mathcal{F}(\mathfrak{a}, \mathfrak{f})/\mathfrak{f} = \mathcal{F}(\phi, 1)$, where $\phi \equiv \mathfrak{a}/\mathfrak{f}$ is the market tightness in the credit market. For simplicity, the matching technology is Cobb-Douglas $f(\phi) = \mu_f \phi^{-\alpha_f}$. Once an applicant and a financier match, they bargain over the mortgage contract. If an agreement is reached, the financier commits to pay a portion $p(1-d)$, where $d$ is the down payment made by the buyer. In exchange, the buyer promises to make repayments $\rho$ after she finds a house. The applicant then becomes pre-approved for a mortgage and can begin searching for a home.

Homeowners are hit with a separation shock at an exogenous rate $s$, at which point they are mismatched with their house.[7] Upon separation, households post their existing home for sale in the housing market. The real estate investor has access to a housing production technology and can built homes at a fixed cost $k$. Given free entry and that houses are identical, the value of existing home vacancies is also $k$ in equilibrium. When a buyer and a seller form a match, the buyer pays the price $p$ to the seller and becomes a homeowner.[8]

## 2.1. The credit market

Let $B_0$ and $F_0$ denote the value functions of being an applicant and a financier *without* a pre-approved buyer, and let $B_1$ and $F_1$ denote be the value of a pre-approved buyer and a financier *with* a pre-approved buyer. There is free entry, but participation for both parties is costly. The applicant and financier suffer flow search costs $c_0$ and $c^F$. Intuitively, $c^F$ is a liquidity cost for the financier, and captures the opportunity costs of keeping funds available—in particular, she cannot invest them in an illiquid risk-free asset which yields dividends. The Bellman equations

[7]For example, they may need to move due to a new job or may need a larger home. For search models of the housing market with an endogenous separation or moving rate, see Ngai and Sheedy (2017).

[8]We follow Diaz and Jerez (2013) and Ngai and Tenreyro (2014), among many others, and do not model the rental market. The treatment of the housing and rental markets as separate is supported by the empirical literature, see for example Glaeser and Gyourko (2007) and Bachmann and Cooper (2014).

for applicants and financiers are given by

$$rB_0 = -c_0 + f(\phi)(B_1 - B_0), \tag{1}$$

$$rF_0 = -c^F + \phi f(\phi)(F_1 - F_0). \tag{2}$$

At a rate $f(\phi)$ the applicant meets a financier. She then negotiates a mortgage contract and enters the housing market, which implies a net gain of $B_1 - B_0$. Similarly, at a rate $\phi f(\phi)$ the financier finds an applicant, which implies a net gain of $F_1 - F_0$.

## 2.2. The housing market

A buyer must hire the services of a realtor in order to buy a house. Since this is a costly action, the representative realtor charges a flow fee of $c^B(b)$, which she takes as given. Hence, the total revenue for the realtor from providing her services is $bc^B(b)$. We assume that there are no frictions associated with hiring the realtor and her cost of servicing a mass $b$ of buyers is $\bar{c}b^{\gamma+1}/(\gamma+1)$. Thus, profit maximization implies $c^B(b) = \bar{c}b^{\gamma}$. Hence, the equilibrium cost of searching is increasing in the number of buyers.[9] The Bellman equation for a pre-approved household is given by

$$rB_1 = -c^B(b) + m(\theta)\left(H - B_1 - dp - \frac{\rho}{r+\delta}\right). \tag{3}$$

When a buyer is matched with a suitable house, she loses the value of being a buyer $B_1$, but gains the value of being a homeowner $H$. In addition she transfers the down payment, $dp$, to the seller and begins the repayments to the financier. She makes the flow repayment $\rho$ until the house is destroyed. Given risk-neutrality and a discount rate of $r$, this is equivalent to transferring the present value $\rho/(r+\delta)$ to the financier at the time of purchase.

The financier suffers flow costs $c^F$ while the buyer is searching for a home. Once the buyer finds a home, the financier finances the purchase by paying $p(1-d)$ to the seller. In addition, she loses the value of being matched with a buyer, $F_1$, but gains the present value of the loan,

[9] As in any model of entry, some cost or price has to increase as more agents enter the market, so that there is an equilibrium entry of buyers. Otherwise the model does not feature entry. If $c^B(b)$ is constant or decreasing, either all agents enter the market or no one does.

$\rho/(r+\delta)$. Thus, the Bellman equation for $F_1$ is given by

$$rF_1 = -c^F + m(\theta)\left(\frac{\rho}{r+\delta} - F_1 - p(1-d)\right). \tag{4}$$

Upon finding a home, the buyer enjoys a utility flow $\varepsilon$ from being a homeowner. The Bellman equation for the homeowner is given by

$$rH = \varepsilon - s(H-V) - \delta H. \tag{5}$$

At a rate of $s$ the homeowner suffers a separation shock, loses the value of being a homeowner $H$, but gains a vacancy which has a value $V$. At a rate $\delta$ the house is destroyed and the household loses $H$.

Lastly, the Bellman equation for a seller is given by

$$rV = -c^S + \theta m(\theta)(p-V) - \delta V. \tag{6}$$

The seller incurs a flow cost of $c^S$ while searching for a buyer. At a rate $\theta m(\theta)$ she finds a buyer and receives the house price $p$, but loses the value of the vacancy $V$. In addition, she may also lose the value of the vacancy due to depreciation at a rate $\delta$.

## 2.3. Bargaining

Forming a match in both the housing and credit market generates a positive surplus that must be split between the negotiating parties. As is standard in the search literature, we assume the surplus is split according to a generalized Nash Bargaining solution as in Nash (1950) and Rubinstein (1982). We follow Wasmer and Weil (2004) and assume sequential bargaining. The buyer and the seller take the mortgage contract as given, but they recognize that the price would affect the value of the loan, and subsequently the repayment made by the buyer. In addition, when the applicant and the financier negotiate their contract, they do not know the exact size of the loan, since they do not know the price of the house. Thus, they bargain over a repayment schedule $\rho(p)$ for any given price.

In the credit market, the surpluses of the applicant and the financier are given by

$$S^A = B_1 - B_0, \tag{7}$$

$$S^F = F_1 - F_0. \tag{8}$$

In the housing market, the surpluses of the buyer and the seller are given by

$$S^B = \left(H - B_1 - dp - \frac{\rho}{r+\delta}\right), \tag{9}$$

$$S^S = (p - V). \tag{10}$$

The repayment, $\rho$, is the solution to the Nash Bargaining problem

$$\rho = \arg\max_{\rho} (S^F)^{\beta}(S^A)^{1-\beta}, \tag{11}$$

and the house price $p$ is the solution to

$$p = \arg\max_{p} (S^S)^{\eta}(S^B)^{1-\eta}, \tag{12}$$

where $\beta$ is the bargaining strength of the financier and $\eta$ is the bargaining strength of the seller. The solution $\rho$ satisfies the first order condition

$$\beta S^A = (1-\beta)S^F. \tag{13}$$

Intuitively, with Nash Bargaining both negotiating parties receive their outside option. In addition, the financier receives a share $\beta$ of the total surplus, whereas the applicant receives a share $1-\beta$. As we will show later, a similar condition holds in the housing market as well.

# 3. Steady State Equilibria

A central feature of our model is the existence of multiple equilibria. In general, there are two equilibria with a positive mass of buyers.[10] Multiple equilibria in our model arise due to

[10] As we show in proposition 2, depending on parameter values the equilibrium may be trivial with no entry of buyers, sellers and financiers. For a knife-edge case of parameter values the equilibrium may be unique.

frictions in the credit market and the fact that buyers must compensate financiers for their liquidity costs while they are searching for a house. An equilibrium is a tuple $(p, \theta, b, \rho, \phi, \mathfrak{a})$ that satisfies six conditions that we characterize below.

Free entry into the credit market requires that $B_0 = F_0 = 0$. Hence, the surpluses of the applicant and financier are given by $S^A = B_1 = c_0/f(\phi)$ and $S_I = F_1 = c^F/(\phi f(\phi))$. Then, Nash Bargaining implies the equilibrium credit market tightness is given by the credit entry equation, (CE),

$$\text{(CE)}: \qquad \phi = \frac{1-\beta}{\beta}\frac{c^F}{c_0} \tag{14}$$

This condition is analogous to that in Wasmer and Weil (2004). The tightness is the ratio of the bargaining powers of the applicant and the financier and their search costs. Combining $F_1 = c^F/(\phi f(\phi))$ with the Bellman equation for the value of a matched financier, (4), yields the repayment equation, (RE), below

$$\text{(RE)}: \qquad \frac{\rho}{r+\delta} = p(1-d) + \frac{r + m(\theta) + \phi f(\phi)}{m(\theta)\phi f(\phi)} c^F. \tag{15}$$

The left hand size of (RE) is the size of the mortgage, $\rho/(r+\delta)$. It is the sum of the principal, $p(1-d)$, and the financing fee. Given free entry, the fee is set such that the financier recovers her expected costs of financing the loan. These expected costs, and in turn the fee, are increasing in the market tightness, $\theta$, for two reasons. First, a tighter market implies a lower house finding rate and subsequently a longer period through which the financier incurs the liquidity costs, $c^F$. Second, a lower matching rate for buyers pushes the repayment period further into the future. Due to discounting, this implies a lower present value of future repayments.[11]

The (RE) condition implies that the buyer's surplus, $S^B$, is linear in the price. Thus, the Nash Bargaining solution for the price satisfies

$$\eta S^B = (1-\eta) S^S. \tag{16}$$

[11]This effect is analogous to the capitalization effect in the standard search models of the labor market with disembodied technological growth, see for example Pissarides (2000), Chapter 3.

Combining (16) with (3) yields the following buyer entry condition

$$\text{(BE)}: \qquad \frac{c^B(b)}{m(\theta)} + \frac{rc_0}{m(\theta)f(\phi)} = \frac{1-\eta}{\eta}(p-k). \tag{17}$$

The right hand sind of (BE) is the buyer's surplus. The left hand side is the cost of searching for a house, $c^B(b)$, plus the flow value of being a buyer, $rc_0/f(\phi)$, times the average time it takes to find a suitable home, $1/m(\theta)$. Intuitively, agents enter the market until the realtor fees, $c^B(b)$, are large enough so that all expected gains are dissipated.

The (BE) imposes a condition on the equilibrium mass of buyers. However, since there is no free entry into the housing market for the buyers, it follows that the (BE) imposes a condition on the mass of applicants: at the steady state $\mathfrak{a}$ must be such that $b$ satisfies (BE). The flow into the pool of buyers is given by the mass of applicants times their mortgage-finding rate, $\mathfrak{a}f(\phi)$, and the flow out by the mass of buyers times the house-finding rate, $bm(\theta)$. At the steady state these two are equated and $\mathfrak{a} = bm(\theta)/f(\phi)$.

The Bellman equation for the value of a vacancy, (6), combined with the free entry condition for housing construction yields the following housing entry condition, (HE),

$$\text{(HE)}: \qquad p = k + \frac{(r+\delta)k + c^S}{\theta m(\theta)}. \tag{18}$$

Due to free entry, houses are constructed up to the point that all profits dissipate. At that point the price is just enough to cover the costs of constructing and servicing a vacancy: the construction cost, $k$, plus the seller's expected search cost, $c^S/(\theta m(\theta))$, and the expected capital loss due to depreciation and discounting, $(r+\delta)k/(\theta m(\theta))$.

Combining the Nash Bargaining solution for the price, the free entry condition for applicants, (RE), and the Bellman equation for a homeowner, (5), yields the price equation (PP)

$$\text{(PP)}: \qquad p = k + \eta\left[\frac{\varepsilon + sk}{r+s+\delta} - \frac{c_0}{f(\phi)} - \frac{r + m(\theta) + \phi f(\phi)}{m(\theta)\phi f(\phi)}c^F - k\right] \tag{19}$$

Intuitively, the price is such that the seller receives her outside option and a fraction $\eta$ of the surplus. The surplus in turn is the buyer's gain in value from being a homeowner net of the cost of financing and the construction cost. The financing cost in turn consists of the average search cost incurred as an applicant and the financing fee charged by the financier. The presence of

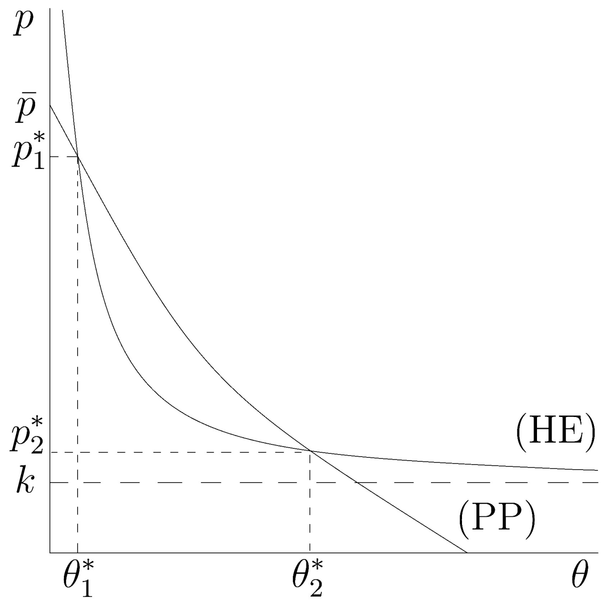
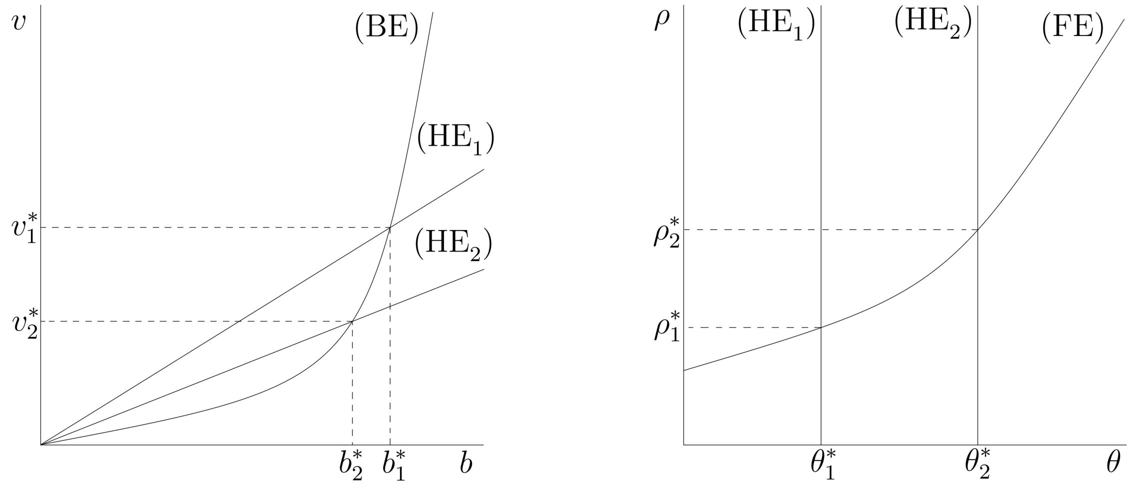



Figure 1: Equilibrium price and housing market tightness

the fee in the price equation is the driving force behind the existence of multiple equilibria.

As is standard in search models, the (HE) curve is downward sloping in $(\theta, p)$ space (Figure 1). Intuitively, a higher market tightness increases the seller's matching rate which decreases the housing price needed to recover her investment and search costs. As $\theta \to \infty$, the price converges to $k$ and as $\theta \to 0$, it diverges to infinity. In our model, the price curve is downward sloping as well.[12] The reason behind this is the following. When the buyer bargains with the seller, her agreement point, $H - dp - \rho/(r + \delta)$, depends negatively on the market tightness, $\theta$. This is so because the applicant and the financier bargain a contract that takes into account the average time it takes a buyer to find a suitable home. When the market is tight, it takes longer to find a suitable home, so the financier expects to both receive the value of the mortgage at a later point in time and to incur higher search costs. As a result, when she negotiates the contract with the applicant she demands to be compensated with a higher fee. This increases the cost of financing and subsequently reduces the surplus of the match between a buyer and the seller which leads to a lower price, $p$. When the tightness is zero, buyers match instantaneously and there is no financing fee. As $\theta$ increases, the fee eventually becomes so large that the (PP) curve crosses the zero line.

[12]This is in contrast to search models in the labor market (see, for example, Pissarides (2000)), where the wage curve is upward sloping in the labor market tightness.




(a) Equilibrium buyers and vacancies

(b) Equilibrium repayment

Figure 2: Equilibrium

Since both curves are downward sloping there will be, in general, two equilibrium points $(\theta_1^*, p_1^*)$ and $(\theta_2^*, p_2^*)$. Intuitively, all parties are indifferent between these two points. At the first equilibrium, the seller finds it harder to fill her vacancy, but is compensated with a higher price. The buyer is matched quicker with a suitable home and is charged a lower fee, but has to pay a higher price. The financier charges a low fee, but does not have to incur large liquidity costs and repayment begins relatively sooner. At the second equilibrium the opposite is true: the seller fills her vacancies quickly, but charges a low price; the buyer pays a high fee and incurs higher search costs but pays a low price; the financier incurs high costs of financing and waits longer for repayments from the buyer to begin, but charges a higher fee.

Figure 2 represents graphically the determination of equilibrium buyers, vacancies, and repayment. The equilibrium size of the housing market is governed by the (BE) and (HE) conditions. The two curves intersect twice. One intersection is at $b = v = 0$. This trivial equilibrium exists for each $\theta$. Since there are two equilibrium market tightnesses, there are two curves (HE$_1$) and (HE$_2$), each corresponding to $\theta_1^*$ and $\theta_2^*$. At the low market tightness the housing creation condition is steeper, which implies a larger market size, i.e. $b_1^*$, $v_1^*$ are larger than $b_2^*$, $v_2^*$. Intuitively, when the tightness is low, the house finding rate is higher. This means that the expected search costs of a buyer are lower, which induces higher entry into the market.

From the (RE) condition, a lower market tightness implies a lower equilibrium repayment $\rho$. A low tightness leads to a high matching rate for buyers, so the financier faces lower liquidity costs and expects to begin receiving the repayments sooner. Thus, she is willing to negotiate a lower repayment. However, it is worth noting that the size of the mortgage at the first equilibrium is smaller even though this equilibrium features a higher price. This implies that the increase in the financing fee from switching to the high tightness equilibrium is large enough to compensate for the decrease in the price.

**Proposition 1.** *The equilibrium with a lower price, $p$, features a larger mortgage size, $\rho/(r+\delta)$.*

A proof is included in the appendix.

Our economy does not always feature two equilibria. If the seller's cost of creating and maintaining a vacancy are too high there will not exist any non-trivial equilibria. For a knife-edge case the equilibrium is unique.

**Proposition 2.** *There exist two distinct equilibria if and only if*

$$\left(\frac{\alpha}{1-\alpha}\right)\left(1+\frac{r}{\phi^* f(\phi^*)}\right)\eta c^F m^{-1}\left(\frac{\left(1+\frac{r}{\phi^* f(\phi^*)}\right)c^F}{(1-\alpha)\left[\frac{\varepsilon+sk}{r+s+\delta}-\frac{c_0}{f(\phi^*)}-\frac{c^F}{\phi^* f(\phi^*)}-k\right]}\right) > (r+\delta)k + c^S \tag{20}$$

*There is a unique equilibrium if the above holds with equality, and if the inequality is reversed there exist no equilibria.*

A proof is included in the appendix.

# 4. Numerical Exercise

Due to the credit frictions in our model, the financial sector affects prices and time-to-sell on the housing market through a mechanism that has not been explored previously in the literature. In this section, we study the quantitative importance of this channel. To this end, we decompose the relative contribution of credit and housing market shocks to the observed build-up in housing prices and mortgage debt and lack of trend in the time-to-sell prior to the 2007 market crash. The three credit shocks are changes to (i) the liquidity costs of the financier, $c^F$; (ii) the matching efficiency in the credit market, $\mu_f$; and (iii) the bargaining power of the financier, $\beta$. The two housing market shocks correspond to changes to (i) the utility from housing, $\varepsilon$; (ii) construction costs, $k$.[13] We focus on these credit shocks because they define the relative size of the financing fee in the model, which is the channel through which the financial sector affects housing prices and the time-to-sell.

In order to back out the implied sizes of these shocks we first calibrate our model to the U.S. economy for the years $1999-2000$. We then pick the changes in $\varepsilon$, $k$, $c^F$, $\mu_f$, $\beta$ that allow the model to match the observed changes in i) prices; ii) time-to-sell; iii) liquidity costs; iv) mortgage debt-to-price ratio; v) mortgage loan originations to applications ratio from their initial values to their average for the years $2006-2007$.

## 4.1. Calibration

The model is calibrated at quarterly frequency. The discount rate, $r$, is 0.012 in order to match an annual discount factor of 0.953. The utility of home-ownership, $\varepsilon$, is normalized to 1. The destruction rate is $\delta = 0.004$ to match an annual housing depreciation rate of 1.6% (Van Nieuwerburgh and Weill (2010)). As in Diaz and Jerez (2013) we target an average tenure in a home of 9 years, hence, $s = 0.024$. We set the elasticity of the house finding rate with respect to the tightness, $\alpha$, as well as the elasticity, $\alpha_f$ to 0.5. The elasticity of $c^B(b)$ with respect to the measure of buyers, $\gamma$, is 2 and we normalize $\bar{c} = 0.1$. We set the down payment, $d$, at 20%.

To calibrate the rest of the parameters we use eight targets. The U.S. Bureau of the Census reports that the average of the Median Number of Months on Sales Market for $1999-2000$ was 4.39 months. Thus, we set the time-to-sell to 1.4625. As in Gabrovski and Ortego-Marti (2018), the average time to buy is set to the average time to sell. We follow Ghent (2012) and set the seller's expected search cost to 5.1% of the price and the buyer's expected search cost to 8% of the housing price. We decompose the buyer's cost into costs associated with search on the credit market (2.5pp) and on the housing market (5.5pp).[14] We interpret $c^F$ as an opportunity cost for the financier—if she does not keep her funds liquid and readily available to finance a mortgage, she can invest them in a risk-free asset. Thus, we set $c^F$ to 0.8213% of the principal, $(1-d)p$, in order to match an average real return for the 3-Month Treasury Bill of 3.326% for

[13]As is common in the housing search literature, for example Diaz and Jerez (2013), Head *et al.* (2014), Ngai and Sheedy (2017) and Novy-Marx (2009), we use both demand and supply shocks to generate movements in prices and time-to-sell.

[14]Woodward (2003) reports average closing costs for mortgage origination of $4,050$ dollars and an average loan amount of $130,000$. Assuming a down payment of 20%, the average cost for the buyer is 2.5% of the price.

the period 1999-2000. We conjecture that applying for a mortgage is relatively easy and that the costly search effort of applicants is associated with "shopping" for mortgages and finding a financier that is willing to extend a line of credit. Thus, we map the mass of applicants, $\mathfrak{a}$, and the flow of mortgage originations, $bm(\theta) = \mathfrak{a}f(\phi)$, to the average number of mortgage applications and mortgage loan originations reported in the Home Mortgage Disclosure Act National Aggregate Report for 1999 and 2000.[15] As a result, we target a mortgage finding rate $f(\phi) = 0.6533$. Lastly, we assume that the household has the same bargaining power in both the credit and housing markets, i.e. $\beta = \eta$. This yields $c^S = 1.5404$, $c_0 = 0.7215$, $k = 40.9631$, $\beta = \eta = 0.5673$, $\mu = 0.6838$, $c^F = 0.2903$, $\mu_f = 0.3618$.

Table 1: Equilibrium

| Variable | Equilibrium Quantity |
|---|---|
| Price | 44.17 |
| Credit Market Tightness | 0.31 |
| Buyers | 4.08 |
| Vacancies | 4.08 |
| Sales | 2.79 |
| Mortgage Size | 37.24 |
| Financing Fee | 5.37% |

Even though our model features two equilibria, only one is consistent with the data targets in our calibration strategy. Hence, we use that equilibrium to study the quantitative importance of the credit frictions channel for the housing price and time-to-sell. The equilibrium quantities of interest are summarized in Table 1.

## 4.2. Shock Sizes

We calibrate the relative size of our five shocks so that the model matches five stylized facts about the changes that occurred in the U.S. housing and credit markets between 1999 and 2007.[16] First, housing prices increased by 51.71%.[17] Second, the time-to-sell increased by 8.74%. Third, the real 3-Month Treasury Bill rate decreased by 50.88%. Fourth, the ratio of mortgage originations to loan applications decreased by 3.97%. Fifth, the mortgage debt-to-

[15] We use data on both conventional, government insured (FHA) and government guaranteed (FSA, RHS, and VA) loans.

[16] We calculate the changes between average values for 1999 − 2000 and 2006 − 2007.

[17] We follow Diaz and Jerez (2013) and calculate the real house price by deflating the Case-Shiller U.S. National Home Price Index by the Consumer Price Index (less shelter).

price ratio increased by 16.46%.[18] The calibrated values of the shocks along with their data targets are summarized in Table 2. The results suggest that all three credit shocks need to be moderately large for the model to be able to explain the observed stylized facts. In particular, their magnitude is similar to that of the utility and construction cost shocks.

Table 2: SHOCKS

| Shock | | Data Target | |
|---|---|---|---|
| Variable | % Change | Variable | % Change |
| $\varepsilon$ | 82.17% | Price | 51.71% |
| $k$ | 53.71% | Time-to-Sell | 8.74% |
| $c^F$ | −25.00% | 3-Month T-Bill Rate | −50.88% |
| $\mu_f$ | −70.14% | Mortgage Originations to Applications Ratio | −3.97% |
| $\beta$ | 60.46% | Mortgage Debt to Price Ratio | 16.46% |

## 4.3. Quantitative Importance of the Credit Frictions Channel

We gauge the quantitative impact of the credit frictions channel through a series of counterfactual exercises reported in Table 3. First, we ask the question "What would the changes in prices, time-to-sell, and debt-to-price be, had the credit frictions channel been absent?" and then repeat the same question for each of the three shocks.

Overall, the credit frictions channel had a relatively small impact on house prices. If it were not present, the price would have increased by 10pp more than it did. By contrast, had there been no credit shocks, the time-to-sell would have increased by 170.26% and debt-to-price would have decreased by 2.48%.

If the liquidity cost $c^F$ were constant, then time-to-sell would have decreased by more than a quarter. Intuitively, if $c^F$ had not decreased, the price would have been relatively lower. Given free entry, this implies that the time-to-sell is lower. Furthermore, financiers charge applicants a fee in order to offset their search costs. If $c^F$ had stayed at its higher initial level, then the search costs faced by financiers would have been higher and as a result the fee and the

[18]We calculate the debt-to-price ratio by dividing the Mortgage Debt Outstanding for One to Four Family Residences reported by the Federal Reserve Board by the Estimates of the Total Housing Inventory (All Housing Units) reported by the U.S. Bureau of the Census. We then divide the resulting ratio by the Case-Shiller National Home Price Index.

Table 3: Impact of Credit Shocks

| No Change in Credit Market Shoks $c^F$, $\mu_f$, $\beta$ | | | |
|---|---|---|---|
| Variable | Price | Time-to-Sell | Debt-to-Price |
| Counter-factual Change | 65.33% | 170.26% | $-2.48\%$ |
| No Change in Liquidity Costs, $c^F$ | | | |
| Variable | Price | Time-to-Sell | Debt-to-Price |
| Counter-factual Change | 48.59% | $-28.23\%$ | 20.97% |
| No Change in Matching Efficiency, $\mu_f$ | | | |
| Variable | Price | Time-to-Sell | Debt-to-Price |
| Counter-factual Change | 63.70% | 150.95% | 0.88% |
| No Change in Bargaining Strength, $\beta$ | | | |
| Variable | Price | Time-to-Sell | Debt-to-Price |
| Counter-factual Change | 59.06% | 95.90% | 2.33% |

debt-to-price ratio would have increased by more.

If the credit market matching technology did not decrease in efficiency, then the time-to-sell would have increased one and a half times, but the debt-to-price ratio would have been constant. Intuitively, when the matching technology is more efficient, then both the mortgage-finding and applicant-finding rates are higher. This reduces the financing fee and consequently the debt-to-price ratio. Furthermore, it would have increased the gains from trade in the housing market. As a result, both the housing price and time-to-sell would have increased.

Our counter-factual exercise suggests that if the bargaining strength, $\beta$, had stayed at its initial level, then the time-to-sell would have almost doubled and the debt-to-price ratio would have increased by only 2.33%. Intuitively, when $\beta$ is lower, financiers receive a lower fraction of the surplus, so they have less of an incentive to enter the market. Hence, the tightness, $\phi$, increases. This leads to lower congestion and as a result lower search costs for the financier, which reduces the financing fee and ultimately the debt-to-price ratio. At the same time, the lower financing fee increases the surplus of the match between the buyer and the seller. Hence, the seller charges a higher price. As a result, construction of new houses is more profitable, which incentivizes entry into the market which increases the time-to-sell.

# 5. Conclusion

This paper develops a dynamic general equilibrium model of the housing market with search and credit frictions. In our model buyers are liquidity constrained. As a result they must be pre-approved for a mortgage by a financier before they can buy a home. Due to credit frictions, this is a costly and time consuming process. Furthermore, search frictions in the housing market imply that finding a home is costly and time consuming as well. The credit frictions generate a novel channel through which the financial sector affects prices and time-to-sell in the housing market. High search costs for the financier induce her to charge a higher financing fee which increases the mortgage payments of the buyer. This reduces the gains from trade in the housing market. As a result prices and liquidity in the market are lower.

We show that the interaction between credit and search frictions may lead to multiplicity of equilibria. This is because the fee that financiers charge buyers for their provision of liquidity increases with housing market tightness. When tightness is high, buyers take longer to find a suitable home and as a result financiers incur higher liquidity costs on average. Hence, the mortgage contract features a higher fee. This positive relationship between tightness and the fee leads to a downward sloping price curve: a higher fee reduces the surplus that is to be split between the buyer and seller, so they negotiate a lower price. Since the housing creation curve is downward sloping as well (as in most standard search models), our economy exhibits, in general, two equilibria.

Our paper gauges the quantitative importance of the credit channel for the determination of housing prices and time-to-sell in the housing market. A numerical exercise suggests that moderately large credit shocks are required to explain the observed changes in the U.S. housing and credit markets prior to the 2007 market crash. A counter-factual analysis suggests credit shocks contributed relatively less to the build-up in prices. However, they were quantitatively important for the observed build-up of mortgage debt and lack of trend in the time-to-sell.

We envision two possible extensions of our work that we believe to be fruitful areas for future work. First, housing construction is a costly endeavor and developers are often liquidity constrained. Hence, it may be worthwhile to examine a model in which there are credit frictions on the seller's side of the market as well. Second, our model features risk-neutral agents and no possibility of mortgage default. A fruitful future research avenue might be for one to analyze an extension of our work with risk-averse agents and endogenous mortgage defaults.

# Technical Appendix

### Proof of Proposition 1

*Proof.* From (15), (19) it follows that

$$\frac{\rho}{r+\delta} = (1-d)\eta\left[\frac{\varepsilon+sk}{r+s+\delta} - \frac{c_0}{f(\phi)}\right] + (1-d)(1-\eta)k + [1-(1-d)\eta]\frac{r+m(\theta)+\phi f(\phi)}{m(\theta)\phi f(\phi)}c^F \tag{A1}$$

Thus, the loan size is increasing in the market tightness, $\theta$. Since the price is decreasing in the tightness, the claim in the proof follows. □

### Proof of Proposition 2

*Proof.* From equations (18) and (19) it follows that in equilibrium

$$\theta m(\theta)\eta\left[\frac{\varepsilon+sk}{r+s+\delta} - \frac{c_0}{f(\phi^*)} - \frac{c^F}{\phi^* f(\phi^*)} - k\right] - \theta\eta\left(1+\frac{r}{\phi^* f(\phi^*)}\right)c^F - (r+\delta)k + c^S = 0 \tag{A2}$$

The left hand side of (A2) is a concave function with a unique maximum. Its maximum is attained at

$$\theta = m^{-1}\left(\frac{\left(1+\frac{r}{\phi^* f(\phi^*)}\right)c^F}{(1-\alpha)\left[\frac{\varepsilon+sk}{r+s+\delta} - \frac{c_0}{f(\phi^*)} - \frac{c^F}{\phi^* f(\phi^*)} - k\right]}\right)$$

If at that point the left hand side of (A2) is positive, then the curve intersects the zero line at two distinct points. If it is zero, then this is the unique equilibrium, and if it is negative then there exist no equilibria. □

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