A Note on the Efficiency in the Housing Market with Search Frictions*

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Abstract

This paper studies efficiency in the housing market in the presence of search frictions and endogenous entry of buyers and sellers. These two features are essential to explain the housing market stylized facts and to generate an upward-sloping Beveridge Curve in the housing market. Search frictions and endogenous entry create two externalities in the market. First, there is a congestion externality common to markets with search frictions. Sellers do not internalize the effect of listing a house for sale on other sellers' probability of finding a buyer. Second, the endogenous entry of buyers leads to a participation externality, as new entrants in the market raise search costs for all buyers. The equilibrium is inefficient even when the Hosios-Mortensen-Pissarides condition holds. Using a calibration to the US housing market, we quantify the size of these externalities and how far the housing market is from the optimal allocation. The optimal vacancy rate and time-to-sell are about half their equilibrium counterparts, whereas the optimal number of buyers and homeowners are above their decentralized equilibrium values. Finally, we investigate how housing market policies restore efficiency in the housing market.

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1 Introduction

Any model attempting to describe the housing market must include two essential features: search and matching frictions and entry of both buyers and sellers. Search frictions are necessary to capture that it takes time for buyers to find a suitable house and for sellers to find a buyer, i.e. that search is a costly and time-consuming process. The large fluctuations in time to sell, the co-movement between houses for sale and time-to-sell, and the large dispersion in prices even after controlling for housing observables (Kotova and Zhang, 2020) are all clear indications of the presence of search frictions in the housing market. Less known is the fact that entry of both buyers and sellers is essential to account for the key stylized facts in the housing market: prices are positively correlated with sales and vacancies (i.e. houses for sale), but negatively correlated with time-to-sell. In other words, when house prices are high many houses are listed for sale, there is a high volume of sale transactions, and houses sell fast. As Gabrovski and Ortego-Marti (2019) and Gabrovski and Ortego-Marti (2024) show, these stylized facts imply that the Beveridge Curve (i.e. the correlation between buyers and vacancies) in the housing market is upward sloping.[1] Search models of the housing market without an endogenous entry of both buyers and sellers generate a counterfactual downward sloping Beveridge Curve and are unable to match the sign of the correlations between prices, sales, time-to-sell and vacancies (Gabrovski and Ortego-Marti, 2019).

These two essential characteristics of the housing market, search and matching frictions and the endogenous entry of buyers, lead to two externalities. The first externality encapsulates both congestion and market thickness externalities that arise in markets with search frictions (Hosios, 1990; Pissarides, 2000). When a seller posts a vacancy, she does not internalize that by doing so she is making it harder for other sellers to find a buyer (congestion externality) while making it easier for buyers to find a home (thick market externality).[2] Absent the endogenous entry of buyers, the efficient allocation is restored if the Hosios-Mortensen-Pissarides (HMP) condition holds, i.e. if the bargaining power of buyers equals the elasticity of the matching rate. Under this condition, the congestion and thick market externalities fully offset each other. However, the equilibrium is not efficient even under the HMP condition because the endogenous entry of buyers leads to an

[1]More specifically, Gabrovski and Ortego-Marti (2019) show that, within the context of a search model, these three correlations must imply a positive relationship between buyers and vacancies; whereas Gabrovski and Ortego-Marti (2024) use data on vacancies and time-to-sell to back out a series for buyers, which they show is positively correlated with vacancies.

[2]We borrow the terms “congestion externality" and “thick market externality" from the labor search literature. In that literature, the market thickness/tightness is traditionally defined as the ratio of vacancies to unemployed workers. Consequently, when a firm posts a vacancy the market thickness increases, which makes it easier for workers to find jobs, i.e. a thick market externality. In our setting, the market thickness/tightness is defined as the ratio of buyers to sellers. Thus, when a seller posts a vacancy the market thickness decreases, which makes it easier for buyers to find a house. Although the effect on the market tightness is opposite to the effect in the labor market, this is simply due to our definition of the tightness. The economics behind the mechanism are the same, so we use the same terminology.

additional participation externality.

This paper studies efficiency in the housing market in the presence of both congestion and participation externalities. In addition, using empirical evidence on the housing market we ask the following question: how far is the housing market from the optimal allocation? To answer these questions, we develop a search and matching model of the housing market with an endogenous entry of both buyers and sellers similar to Gabrovski and Ortego-Marti (2019), in which entry is driven by rising search costs as more buyers enter the market. The additional participation externality arises because buyers do not internalize that by entering the market they raise other buyers' costs.

We begin by characterizing the decentralized equilibrium. We then study the social planner's problem and find the optimal allocation. A comparison of both allocations reveals that the decentralized equilibrium is inefficient even if the HMP condition holds, because the planner lacks a tool with which to regulate the entry of buyers. Intuitively, in the decentralized economy households only evaluate if, given their utility of owning a home, it is worthwhile to enter the market. They do not, however, internalize their effect on other buyers' search costs. By contrast, the planner internalizes the effect that an additional buyer has on other buyers' costs.[3]

We calibrate the model to the U.S. economy to assess how far the decentralized equilibrium is from the efficient allocation. Given that the housing market is inefficient, a natural follow up question is whether housing market policies can restore efficiency. This exercise gives us an alternative method to gauge the size of the externalities. We consider four housing policies: (*i*) taxes on new construction; (*ii*) taxes on profits from housing sales; (*iii*) transfer fees to the buyer; (*iv*) property taxes. We study these policies because they affect the entry decision of buyers and sellers and how the trade surplus is split. We find that the optimal vacancy rate and time-to-sell are about half their values in the decentralized economy, and the optimal number of vacancies about 80% of its counterpart in the decentralized economy. By contrast, the optimal number of buyers and homeowners are both above the value in the decentralized economy. Intuitively, the planner finds it optimal to increase homeownership. However, she chooses not to achieve this through a faster matching rate for buyers because new home construction is costly. Instead, the planner decreases the number of available housing units for sale and raises the number of buyers. This ensures high homeownership rates while keeping houses for sale low. We then turn to whether policies can implement the planner's allocation. Since the model features two externalities, two policy tools are required to restore efficiency. We show that a combination of taxes on profits from housing sales and a subsidy to housing construction can implement the constrained-efficient allocation. To provide an alternative measure of the size of the two externalities, we calculate the quantitative magnitude of the policies required to restore efficiency.

[3]In separate derivations not included in this paper (available upon request) we show that the equilibrium is also inefficient when search is directed. The intuition is similar, the planner lacks an additional tool with which to regulate the measure of buyers to its efficient level.

Related literature. Since the seminal work in Arnott (1989) and Wheaton (1990), the literature has extensively used search and matching models à la Diamond-Mortensen-Pissarides to study the housing market. This large literature includes Albrecht *et al.* (2007), Anenberg (2016), Arefeva (2020), Arefeva *et al.* (2024), Burnside *et al.* (2016), Diaz and Jerez (2013), Gabrovski *et al.* (2024), Gabrovski and Ortego-Marti (2019, 2021a, 2022), Garriga and Hedlund (2020), Genesove and Han (2012), Guren (2018); Guren and McQuade (2018), Han *et al.* (2021), Head *et al.* (2014, 2016), Hedlund (2016) Kotova and Zhang (2020), Krainer (2001), Ngai and Tenreyro (2014), Ngai and Sheedy (2020, 2024), Novy-Marx (2009), Piazzesi and Schneider (2009), Piazzesi *et al.* (2020), Smith (2020) and Smith *et al.* (2022). Han and Strange (2015) provide an extensive review of this literature. Compared to these papers, we study efficiency in the housing market in a framework with search frictions and and an endogenous entry of buyers and sellers mechanism that delivers the observed positive correlation between buyers and vacancies, i.e. an upward-sloping Beveridge Curve. In addition, we characterize the congestion and participation externalities in the housing market and quantify how far the observed equilibrium is from the optimal allocation.

To a lesser extent, our paper is also related to papers that study efficiency in labor markets with search frictions and compositional effects that arise from labor force participation (Albrecht *et al.*, 2010; Griffy and Masters, 2021; Julien and Mangin, 2017; Masters, 2015). Although in search models with labor market participation the Beveridge Curve is downward-sloping and consistent with the labor market stylized facts, empirically the Beveridge Curve in the housing market is upward-sloping (Gabrovski and Ortego-Marti, 2019, 2024). Relative to the above papers in the labor literature, we study efficiency in a framework with a different entry mechanism that is consistent with an upward-sloping Beveridge Curve in the housing market.[4]

2 The housing market with endogenous buyer entry

This section studies efficiency with an endogenous entry mechanism similar to Gabrovski and Ortego-Marti (2019) in which buyers' search costs increase as more buyers enter the market. We begin with a description of the decentralized economy. The main ingredients of the model are: there are search and matching frictions, which capture that it takes time for buyers to find a house and for sellers to find a buyer for their listed property, there is free entry of both buyers and sellers, and prices are determined by bargaining.

Next, we derive the efficient allocation. The planner faces two externalities. First, search frictions give rise to the usual congestion and thick market externalities. When sellers list a house for sale, they do not internalize that by posting a house for sale they increase buyers' chances of finding a home (thick market externality). At the same time, they also make it more difficult

[4]The technical appendix studies an alternative environment in which entry of buyers is driven by heterogeneity, as in this labor literature. However, as we show in a previous version of this paper (Gabrovski and Ortego-Marti, 2021b), quantitatively such a model generates a counterfactual downward-sloping Beveridge Curve.

for other sellers to find a buyer (congestion externality). To simplify the exposition, we refer to both thick market and congestion externalities as *congestion externalities*. The second externality arises because buyers do not internalize that by entering the market they raise search costs for other buyers. We denote this externality a *participation externality*. As we show in this section, because of this additional externality, the HMP condition does not restore efficiency. Intuitively, the social planner needs an additional tool to first fix the entry of buyers to its efficient level.

2.1 Environment

Time is continuous. Agents are risk-neutral, infinitely lived and discount the future at a rate r. There are three types of agents: households, developers and realtors. Households either own a home, search for a house (i.e. they are buyers), or choose not to participate in the market. Developers may enter the housing market and build a new home at a cost k if not enough existing houses are listed for sale by households through separations. Upon building a house, developers post a vacancy and search for buyers. Houses are identical, regardless of whether they are old or newly built. To capture depreciation in a tractable way, houses are destroyed at an exogenous rate δ.

It takes time for buyers to find a house and for sellers to sell their home. We capture these search frictions in the housing market by assuming a matching function $M(b, v)$, where b is the measure of buyers and v the measure of vacancies or houses for sale—we use both terms interchangeably. The matching function satisfies the usual properties: it is increasing in each of its terms, concave and displays constant returns to scale. Let $\theta \equiv b/v$ denote the housing market tightness. The matching function implies that buyers find homes at a rate $m(\theta) \equiv M(b, v)/b = M(1, \theta^{-1})$ and that sellers find buyers at a rate $\theta m(\theta) = M(b, v)/v = M(\theta, 1)$. As market tightness increases, the home-finding rate for buyers $m(\theta)$ decreases and the finding rate for sellers $\theta m(\theta)$ increases. Intuitively, an increase in market tightness implies that vacancies are relatively more scarce, so it becomes harder for buyers to find a house, but easier for a seller to find a buyer. In addition to these flows, some homeowners become separated from their house at an exogenous rate s. This separation shock captures that the household may need to relocate because of their job, need to move to a different type of home or area, and so on. Once a separation shock occurs, households list their house for sale.

There is free entry of both buyers and sellers. Given free entry of buyers, households keep entering the market until the value of becoming a buyer equals zero, the value of their outside option.[5] Similarly, free entry of sellers implies that sellers enter the market until the value of a vacancy equals the construction cost k, regardless of whether the house is newly built or existing (all houses are identical). As is common in markets with search frictions, there are rents from

[5]In particular, there is a large measure of households who may chose to enter the market. This assumption is analogous to the assumption that there is a large meausre of potential firms, which can enter the labor market in the Diamond-Mortensen-Pissarides type models of the labor market.

matching. We assume that prices are determined by Nash Bargaining (Nash, 1950; Rubinstein, 1982), where β denotes the seller's bargaining strength.[6] Once a buyer and a seller are matched, the buyer pays the price p to the seller and begins enjoying a utility flow ε from owning a house.

Households must secure the services of a realtor to start searching for a house. Searching for houses is costly for the realtor. Her cost of servicing b buyers is given by $\bar{c}b^{\gamma+1}/(\gamma+1)$, which is consistent with many findings in the real estate literature (Sirmans and Turnbull, 1997). In exchange for her services, the realtor charges a fee c^B, so her revenue is bc^B. Assuming a competitive market, the realtor's problem is to maximize her net present value of profits, $\int_t^\infty e^{-r(v-t)}[b(v)c^B(v) - \bar{c}b(v)^{\gamma+1}/(\gamma+1)]dv$, with respect to $b(v)$, the measure of buyers she provides the service to. Absent shocks, the realtor's problem of maximizing the net present value of all future profits reduces to a static problem of maximizing profits per unit of time. Thus, profit maximization implies that the fee is given by $c^B(b) = \bar{c}b^\gamma$, which is increasing in the number of buyers.[7] Intuitively, $c^B(b)$ captures search costs such as arranging and scheduling viewings, driving to view houses or locating properties that match buyers' preferences. In reality, buyers incur some of these costs themselves, but for simplicity of the exposition we assume that the realtor bears all the costs and then charges a fee $c^B(b)$. Assuming instead that buyers incur all costs themselves, and that costs are increasing in the number of buyers due to congestion, gives the exact same results. This endogenous entry mechanism generates an upward-sloping Beveridge Curve, and accounts for the housing market stylized facts qualitatively and quantitatively (Gabrovski and Ortego-Marti, 2019). Finally, sellers incur search flow cost c^S until they find a buyer.[8]

2.2 Decentralized equilibrium

Let H, B and V denote the value functions of a homeowner, a buyer and a vacancy. They satisfy the Bellman equations

$$rB = \max\{0, -c^B(b) + m(\theta)(H - B - p))\}, \tag{1}$$

$$rH = \varepsilon - s(H - V - B) - \delta(H - B). \tag{2}$$

[6] There is ample of evidence of bargaining in housing markets, more so than in labor markets. See the review by Han and Strange (2015) and the references therein.

[7] The functional form enters only one equation in equilibrium, the one that determines buyers given equilibrium market tightness, and only affects the equilibrium number of buyers. Qualitatively, results remain unchanged with alternative cost functions as long as $c^B(\cdot)$ is increasing in the measure of buyers.

[8] Similar to many papers in the literature, we do not model the rental market and treat it as a separate market, see for example Diaz and Jerez (2013) and Ngai and Tenreyro (2014), among others. This assumption is well supported empirically by Glaeser and Gyourko (2007), who find that rental and owner occupied homes have very different characteristics, and that there is no arbitrage between both types of homes. In addition, Bachmann and Cooper (2014) find that most flows are within each rental/owner category. In addition, flows from the owner to rental segment are acyclical, and turnover is unrelated to vacancies in the rental market.

Intuitively, buyers can choose whether to enter the housing market. When they search for a house, they incur flow costs $c^B(b)$. At a rate $m(\theta)$, they find a house, pay the house price p and become a homeowner, which carries a net gain $H - B - p$. A homeowner derives a utility ε from owning a house. At a rate s a separation shock occurs, and the household lists her house for sale, which has a value V, and decides whether to become a buyer. At a rate δ the house is destroyed, which implies a net loss of $H - B$. Similarly, the seller's Bellman equation is given by

$$rV = -c^S + \theta m(\theta)(p - V) - \delta V. \tag{3}$$

Sellers incur flow costs c^S while they search. At a rate $\theta m(\theta)$, they meet a buyer and enjoy net capital gains $p - V$. The vacancy is also subject to a destruction shock at a rate δ.

Because of the frictional nature of the housing market, a match between a buyer and seller generates a positive surplus. We assume that the two parties split this surplus according to Nash Bargaining. Let $S^B \equiv H - B - p$ and $S^S \equiv p - V$ denote the surpluses of the buyer and seller, and let $S \equiv S^B + S^S$ denote the total surplus. Prices solve the following Nash Bargaining problem

$$p = \arg\max_p \left(S^B\right)^{1-\beta} \left(S^S\right)^{\beta}. \tag{4}$$

The first order condition to the above problem yields $(1 - \beta)S^S = \beta S^B$. In particular, the above sharing rule implies that the buyer extracts a fraction $1 - \beta$ of the surplus and the seller a fraction β, i.e. $S^B = (1 - \beta)S$ and $S^S = \beta S$. As a consequence both the buyer and seller agree on when the trade is beneficial, i.e. $S^B \geq 0$ if and only if $S^S \geq 0$ if and only if $S \geq 0$.

Free entry implies that sellers enter the market until the value of a vacancy covers the construction costs k, i.e. $V = k$. On the buyer's side, households participate in the market until the value of being a buyer B equals the value of their outside option, which we normalize to 0, i.e. $B = 0$. Combining the Bellman equations for the buyer and seller (1) and (2) with the free entry condition for sellers implies

$$S^B = \frac{\varepsilon + sk}{r + s + \delta} - p, \tag{5}$$

$$S^S = p - k. \tag{6}$$

Combining the above surpluses with the Nash bargaining rule gives the equilibrium price (PP) condition

$$\text{(PP):} \qquad p = k + \beta\left(\frac{\varepsilon + sk}{r + s + \delta} - k\right). \tag{7}$$

Intuitively, due to Nash Bargaining sellers are compensated for their outside option, k, and receive a share β of the surplus.[9]

Free entry of sellers, together with the Bellman equation for a vacancy (3) gives the Housing Entry (HE) condition

$$\text{(HE):} \qquad \frac{(r+\delta)k + c^S}{\theta m(\theta)} = p - k. \tag{8}$$

The left hand-side of the above equation captures the seller's expected cost from searching for a buyer: the search cost c^S and the user cost $(r+\delta)k$ for the expected duration of the vacancy $1/(\theta m(\theta))$. The right-hand side corresponds to the seller's surplus. The HE condition reflects that developers keep entering the market until the profits from selling the house are just enough to cover the expected cost of finding a buyer. Thus the (HE) condition governs entry of sellers in equilibrium.

Free entry of buyers gives the Buyer's Entry (BE) condition

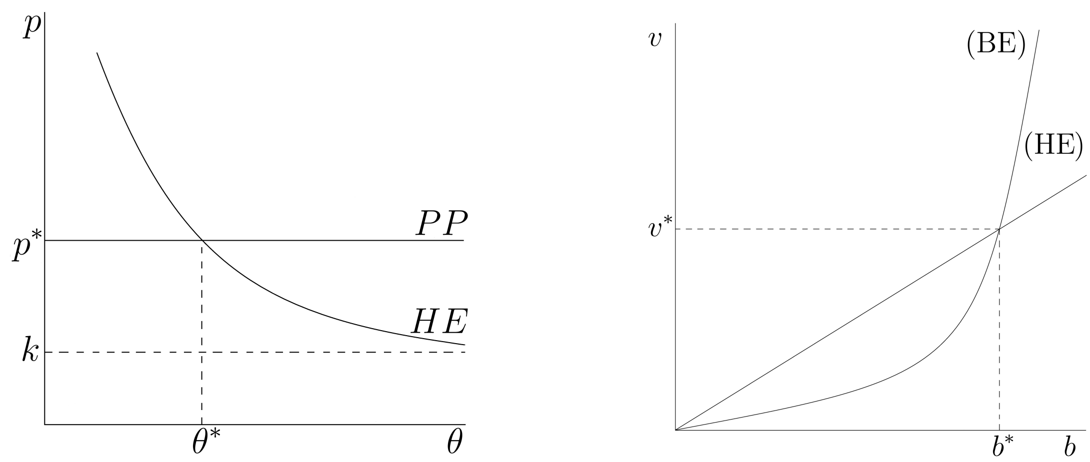
$$\text{(BE):} \qquad \frac{c^B(b)}{m(\theta)} = (1-\beta)\left(\frac{\varepsilon + (r+\delta)k}{r+\delta+s}\right). \tag{9}$$

Intuitively, buyers keep entering the market until the marginal buyer's expected cost of finding a home equals the buyer's surplus of being a homeowner, which equals the present discounted value of the return ε net of the user cost $(r+\delta)k$, using the effective discount is $r+s+\delta$.

The PP and HE conditions determine the equilibrium market tightness θ. Given the equilibrium θ, the BE condition yields the equilibrium measure of buyers b. It is straightforward to verify that the equilibrium exists and is unique. This environment yields an upward-sloping Beveridge Curve, which corresponds to the BE curve. Intuitively, as more sellers enter the market, buyers find it more desirable to enter because they can find houses more quickly. Hence, buyers and vacancies are positively correlated and the BE curve is upward-sloping.

The equilibrium is depicted graphically in figures 1a and 1b. Figure 1a depicts the HE condition and the price relationship PP given by (7) and (8). The HE condition captures that as house prices increase it becomes more profitable to post a vacancy. This leads to more entry of sellers and a lower market tightness. The PP condition comes from Nash Bargaining between buyers and sellers. The equilibrium price p^* and market tightness θ^* are given by the intersection of both curves. The equilibrium market tightness θ^* in figure 1a describes a straight line in the vacancies-buyers space in figure 1b, which we denote as the HE condition. The BE curve in figure 1b corresponds to the BE condition (9). The BE curve captures that as the ratio of vacancies to buyers increases buyers find houses faster, which leads to an increase in the entry of buyers.

[9] The price is independent of market tightness because with free entry of buyers the outside option for buyers is pinned down by a free entry condition and, therefore, does not depend on market tightness (Gabrovski and Ortego-Marti, 2019).



(a) Equilibrium price p^* and tightness θ^* (b) Equilibrium buyers b^* and vacancies v^*

Figure 1: **Equilibrium in the housing market**

2.3 The social planner's allocation

The social planner faces two externalities. In addition to the usual *congestion* externality in markets with search frictions, the decentralized equilibrium is inefficient because buyers do not internalize the effect their entry has on other buyers' search costs. We refer to this additional externality as the *participation* externality. Let $\tilde{h}$ and c denote the number of homeowners and construction (the number of newly built houses). The planner's problem is given by

$$\max_{\theta,c} \int_0^\infty e^{-rt} \left[\varepsilon\tilde{h} - v\theta c^B(v\theta) - vc^S - ck\right] dt, \tag{10}$$

subject to

$$\dot{v} = c + sh - \delta v - v\theta m(\theta), \tag{11}$$

$$\dot{\tilde{h}} = v\theta m(\theta) - (s+\delta)\tilde{h}. \tag{12}$$

Setting up the Hamiltonian and using the first order conditions gives the following solution for the planner' allocation at steady state

$$\frac{(r+\delta)k + c^S}{\theta m(\theta)} = \alpha \left(\frac{\varepsilon + sk}{r+s+\delta} - k\right), \tag{13}$$

$$\frac{c^B(b)}{m(\theta)} = \left(\frac{1-\alpha}{1+\gamma}\right) \left(\frac{\varepsilon + sk}{r+s+\delta} - k\right), \tag{14}$$

where $\alpha \equiv -m'(\theta)\theta/m(\theta)$ denotes the elasticity of the matching rate. The appendix provides the derivations and shows that the above conditions are necessary and sufficient. Equations (13) and (14) are the counterpart of the equilibrium conditions (8) and (9) in the decentralized economy.

Comparing the decentralized allocation with the optimal one shows that the HMP condition does not restore efficiency. More specifically, restoring efficiency in the decentralized equilibrium requires

$$\beta = \alpha \quad \text{and} \quad 1 - \beta = \frac{1-\alpha}{1+\gamma}. \tag{15}$$

The first condition $\beta = \alpha$ corresponds to the standard HMP condition. If HMP holds, the decentralized equilibrium is efficient if and only if $\gamma = 0$, i.e. there is no entry of buyers. As soon as there is free entry of buyers, the equilibrium is inefficient because the endogenous entry of buyers generates a participation externality.[10] Intuitively, when there is no buyer entry the only externality is the congestion externality, which can be internalized if the two parties share the surplus in the appropriate fractions, i.e. the seller receives a share α and the buyer receives the rest. With endogenous entry of buyers, however, the participation externality manifests itself through increased search costs for buyers. As a result, the planner finds it optimal to disincentivize entry by giving buyers only a share $(1-\alpha)/(1+\gamma)$ of the surplus and leaving the remaining $\gamma(1-\alpha)/(1+\gamma)$ fraction of the surplus "on the table". Thus, at least two housing market policies are required to eliminate the two externalities and restore efficiency: one policy to set the fraction of surplus that is left "on the table" (i.e. eliminate the participation externality), and one to set the sharing rule for the remainder of the surplus (i.e. eliminate the congestion externality).[11]

3 Quantifying inefficiency in the housing market

In this section we quantify the inefficiency in the housing market implied by the congestion and participation externalities. In other words, we ask: how far is the decentralized equilibrium from the efficient allocation? To this end, we calibrate a version of our model which includes housing market policies. Consequently, we can study what policies implement the socially efficient allocation in the decentralized economy. Upon calibrating the model to the U.S. housing market, we measure the distance between the decentralized equilibrium allocation and the planner's efficient allocation in terms of liquidity, for which we use tree measures: time-to-sell, the vacancy rate, and the listing rate. In a second exercise, we examine the housing policies required to restore efficiency.

3.1 The model with housing policies

We consider four policies. First, homeowners pay property taxes τ_p on their home. Second, buyers pay taxes τ_b when they purchase a house. Third, sellers pay a tax τ_s upon selling the house, which

[10] A similar result holds when search is directed, efficiency in the decentralized equilibrium is only restored if there is no entry of buyers. A proof for the environment with directed search is available upon request.

[11] In particular, even a generalized HMP rule such as the one in Mangin and Julien (2021) cannot restore efficiency on its own.

we assume applies to the capital gains $p - V$. Finally, construction may be taxed or subsidized at a rate τ_k, where $\tau_k > 0$ corresponds to a tax on construction and $\tau_k < 0$ to a subsidy. The Bellman equations are given by

$$rB = \max\{0, -c^B(b) + m(\theta)\left[H - B - (1+\tau_b)p\right]\}, \tag{16}$$

$$rH = \varepsilon - \tau_p p - s\,(H - V) - \delta H, \tag{17}$$

$$rV = -\,c^S + \theta m(\theta)(1-\tau_s)\,(p - V) - \delta V. \tag{18}$$

The intuition for the above Bellman equations is similar to the intuition for (1)-(3). House prices are determined in a similar way by Nash Bargaining, except that the surplus S is now given by $S = H - B - (1+\tau_b)p + (1-\tau_s)\,(p - V)$, where $S^B = H - B - (1+\tau_b)p$ is the buyer surplus and $S^S = (1-\tau_s)\,(p-V)$ is the seller's surplus. Nash Bargaining implies the following first order conditions: $S^S = \tilde{\beta} S$ and $S^B = (1-\tilde{\beta})S$, where $\tilde{\beta} \equiv \beta(1-\tau_s)/[\beta(1-\tau_s) + (1-\beta)(1+\tilde{\tau}_b)]$ and $\tilde{\tau}_b \equiv \tau_b + \tau_p/(r+s+\delta)$.[12]

Following the same steps as in section 2.2, we find the following equilibrium conditions

$$p = \frac{\tilde{\beta}}{\tilde{\beta}(1+\tilde{\tau}_b) + (1-\tilde{\beta})(1-\tau_s)}\left[\frac{\varepsilon - (r+\delta)(1+\tau_k)k}{r+s+\delta} - \tilde{\tau}_b(1+\tau_k)k\right] + (1+\tau_k)k, \tag{19}$$

$$\frac{(r+\delta)(1+\tau_k)k + c^S}{\theta m(\theta)} = \tilde{\beta}\left[1 + (1-\beta)\tilde{\tau}_b - \beta\tau_s\right]\left[\frac{\varepsilon + s(1+\tau_k)k}{(r+s+\delta)(1+\tilde{\tau}_b)} - (1+\tau_k)k\right], \tag{20}$$

$$\frac{c^B(b)}{m(\theta)} = (1-\tilde{\beta})\left[1 + (1-\beta)\tilde{\tau}_b - \beta\tau_s\right]\left[\frac{\varepsilon + s(1+\tau_k)k}{(r+s+\delta)(1+\tilde{\tau}_b)} - (1+\tau_k)k\right], \tag{21}$$

which correspond to the PP, HE and BE conditions without policies (7), (8) and (9). We use these conditions to calibrate the model and derive the optimal policies in our numerical exercise below.[13]

3.2 Calibration

Following Gabrovski and Ortego-Marti (2021a), let $r = 0.012$ to match an annual discount factor of 0.953. We set $\delta = 0.004$ to match an annual housing depreciation rate of 1.6% (Van Nieuwerburgh and Weill, 2010). The matching function is assumed to be Cobb-Douglas with $m(\theta) = \mu\theta^{-\alpha}$. The elasticity of the matching function α is equal to 0.16, following the empirical evidence in Genesove

[12] This is a notable difference compared to the equilibrium without policies. Intuitively, $\tilde{\beta}$ is the effective bargaining weight. Consider for example property taxes. If the buyer pays a higher price, part of the surplus is lost because the homeowner pays higher property taxes. The Nash Bargaining solution takes into account the effect of a change in the price on the surplus, given the housing market policies. The effective weights in the solution capture the effect of the tax rates on the surplus. A similar result emerges with labor market policies (Lagos, 2006; Ortego-Marti, 2020; Pissarides, 2000).

[13] Specifically, we plug in for the socially optimal b and θ from the planner's solution and then solve for the set of τ_k, τ_s, and $\tilde{\tau}_b$ implied by equations (20) and (21).

and Han (2012). The flow utility of owning a house ε is normalized to 10.883. This implies a steady state price of 491.2, which is the average empirically observed price (in thousands of dollars) in Kotova and Zhang (2020). We set a profit tax rate for sellers of 3.65%, which corresponds to the average effective tax rate for the Real Estate Developer firms for the years 2014-2019 as reported by Aswath Damodaran.[14] The Tax Foundation in its "Facts and Figures 2018" reports an effective annual property tax rate for the United States of 1.13%. The median real estate transfer tax rate reported by the National Association of Realtors is 0.16%. Following Gabrovski and Ortego-Marti (2019), we assume that $c^B(b) = \bar{c}b^\gamma$. We normalize $\bar{c} = 1$, which yields $b = 96.29$.

To obtain the rest of the model parameters we target six moments from the data. The time-to-sell is set to 1.76 quarters which is the average of the Median Number of Months on Sales Market reported by the U.S. Bureau of Census for the period of 1987:1–2017:4. We also set the time-to-buy to be equal to the time to sell following Gabrovski and Ortego-Marti (2019, 2021a) based on the evidence in Genesove and Han (2012). These two targets yield $\mu = 0.5682$, $k = 451.98$. Ngai and Sheedy (2020) calculate a listing rate, given by the number of new listings on the market divided by the stock of owner-occupied houses not already for sale, equal to 1.667%. This target implies a separation rate $s = 0.0126$. To calibrate c^S, we target expected costs for the seller equal to 5.1% of the average house price, following Ghent (2012). Following the same reference we also target an average cost for the buyer of 8%. These two moments yield $c^S = 14.233$ and $\beta = 0.5234$. Lastly, to calibrate γ we use monthly data on vacancies and sales from the New Residential Sales Release reported by the U.S. Bureau of Census for the period January 1963–December 2019.[15] Given that in our model sales$= bm(\theta)$, the information on sales and vacancies allows us to back out a series for the number of buyers using $b = v[\text{sales}/(\mu v)]^{1/(1-\alpha)}$. Next, we regress the cyclical component of the series for buyers on the cyclical component of the series for vacancies and a constant to arrive at an elasticity of 0.19.[16] Plugging this estimate into equation (14) in Gabrovski and Ortego-Marti (2019) results in $\gamma = 0.68$. Table 1 summarizes the calibration.

3.3 Results

Our calibrated model matches the housing market data well. In particular, vacancy and construction rates, which are not targeted in the calibration, are close to their empirical counterparts. These moments are of particular relevance in our context: the vacancy rate captures liquidity in the housing market, whereas the construction rate captures the importance of the entry channel, which is at the core of our paper. In the model, the vacancy rate is measured as the ratio of vacancies to the total stock of homes and equals 2.83% in the steady state. In the data, the

[14]The data can be found at `http://people.stern.nyu.edu/adamodar/New_Home_Page/dataarchived.html`. We exclude 2018 for which there is no data on taxes paid.

[15]The series we use for vacancies is Houses for Sale and the series for sales is Houses Sold.

[16]We obtain the cyclical components of the series by first taking natural logs and then detrending using an HP filter with a smoothing parameter of 129,600. The standard error of the estimated coefficient is 0.08.

vacancy rate is 1.9% and is measured as the average of the Homeowner Vacancy Rate reported by the United States Census Bureau for the period 1987:1—2017:4. The model also does a relatively good job at matching the construction rate. In the model, this construction rate is measured by the number of homes built divided by the total housing stock, and is equal to 0.4%. In the data, the average of this ratio for the period 1987:1—2017:4 is 0.27%.[17]

We gauge the distance of the decentralized equilibrium to the planner's social optimum by focusing on three important measures of liquidity in the housing market: the vacancy rate, the listing rate, and the time-to-sell. The values of these liquidity measures at the steady state equilibrium and at the planner's optimum are summarized in Table 2. In general, the planner finds it optimal to reduce the relative amount of vacancies in the market and to have houses match with buyers faster. Intuitively, this is due to the congestion externality. In equilibrium sellers extract too much of the surplus which induces an inefficient over-entry into the market. This leads to higher than optimal expected search and construction costs for sellers.

Finally, we quantify the size of the housing policies required to restore efficiency. Table 3 reports the optimal tax rates implied by the model and the dollar amount of these policies, in thousands of dollars. The efficient allocation requires fewer houses for sale and more buyers than the decentralized equilibrium. This can be achieved through a combination of taxes on sellers and a subsidy to housing construction.[18] From the HE condition (20), a lower τ_k and a higher τ_s both raise the market tightness, which lowers time-to-sell. From the BE condition, the combination of a lower market tightness, a lower τ_k and a higher τ_s raises the measure of buyers. Quantitatively, raising the profit tax from 3.65% to 69.8% and subsidizing construction at a rate 17.31% brings the housing market to its efficient level. In dollar amounts, these policies correspond to \$44,540 and \$78,250 respectively. To put the dollar amount in perspective, our calibration is such that house prices are $\$491,000$ on average, as in the data.

4 Conclusion

This paper studies efficiency in the housing market with search frictions and endogenous entry of both buyers and sellers. These two features are fundamental to account for the stylized facts of the housing market, in particular to generate a positive correlation between buyers and vacancies, i.e. an upward sloping Beveridge Curve. We show that in this environment two externalities arise: congestion and participation externalities. We characterize the efficient allocation and show that

[17] The data on new construction is taken from the New Privately-Owned Housing Units Completed series by U.S. Census Bureau and U.S. Department of Housing and Urban Development and the data on the stock of homes is from the All Housing Units series reported in the Housing Vacancy Survey of the U.S. Census Bureau.

[18] An examination of equations (21) and (20) reveals that a tax/subsidy on construction is necessary to implement the efficient allocation. The other policy tool the planner can use is either τ_s or $\tilde{\tau}_b$. We focus on the former as this delivers a cleaner comparison with the results in the model in which participation is driven by heterogeneity in Gabrovski and Ortego-Marti (2021b).

the decentralized equilibrium is inefficient even when the HMP condition holds. In particular, the decentralized economy features inefficiently low levels of homeownership and inefficiently high vacancy rate and time-to-sell. Finally, this paper studies housing market policies and how they can restore efficiency in the housing market.

Technical Appendix

1. Social planner's solution in the model with homogeneous buyers

The Hamiltonian for the social planner's problem is given by

$$H = e^{-rt}\{\varepsilon\tilde{h} - vc^S - ck - v\theta c^B(v\theta) + \lambda_{\tilde{h}}[v\theta m(\theta) - (s+\delta)\tilde{h}] \tag{A1}$$

$$+ \lambda_v[c + s\tilde{h} - \delta v - v\theta m(\theta)]\}. \tag{A2}$$

The first-order conditions are given by

$$\frac{\partial H}{\partial c} = 0 \Rightarrow \lambda_v = k, \tag{A3}$$

$$\frac{\partial H}{\partial \theta} = 0 \Rightarrow (1+\gamma)c^B(b) = (1-\alpha)m(\theta)(\lambda_{\tilde{h}} - \lambda_v), \tag{A4}$$

$$\frac{\partial H}{\partial \tilde{h}} = -\dot{\lambda}_{\tilde{h}} + r\lambda_{\tilde{h}} = \varepsilon - (s+\delta)\lambda_{\tilde{h}} + s\lambda_v, \tag{A5}$$

$$\frac{\partial H}{\partial v} = -\dot{\lambda}_v + r\lambda_v = -(1+\gamma)\theta c^B(b) - c^S + \lambda_{\tilde{h}}\theta m(\theta) - (\delta + \theta m(\theta))\lambda_v. \tag{A6}$$

Combining the above first-order conditions and observing that at steady state $\dot{\lambda h} = \dot{\lambda}_v = 0$ yields the planner's allocation (13) and (14).

To show that the solution to (13) and (14) is indeed the global maximum, re-write the Hamiltonian

$$\hat{H}(v,b,c,h) = \varepsilon\tilde{h} - vc^S - ck - bc^B(b) + \lambda_{\tilde{h}}[M(b,v) - (s+\delta)\tilde{h}] \tag{A7}$$

$$+ \lambda_v[c + s\tilde{h} - \delta v - M(b,v)] \tag{A8}$$

$$= \varepsilon\tilde{h} - vc^S - ck - bc^B(b) - \lambda_{\tilde{h}}(s+\delta)\tilde{h} + \lambda_v(c + s\tilde{h} - \delta v) \tag{A9}$$

$$+ (\lambda_{\tilde{h}} - \lambda_v)M(b,v). \tag{A10}$$

Since $bc^B(b)$ is convex, $M(b,v)$ is concave, and for any admissible tuple $\lambda_{\tilde{h}} - \lambda_v = (\varepsilon - (r+\delta)k)/(r+s+\delta)$, it follows that $\hat{H}(v,b,c,h)$ is concave. Thus, the solution is a global maximum.

A Efficiency with heterogeneity and endogenous participation

In this section we study efficiency in an environment with an alternative entry mechanism. The main departure relative to the framework in section 2 is our assumption that households are heterogenous in how much they value owning a house. The advantage with this mechanism is that we can use data on price dispersion to calibrate the distribution of households' heterogeneity. The main disadvantage, however, is that the framework with heterogeneity generates a counterfactual Beveridge Curve, as we prove below. Despite this shortcoming, the results on efficiency remain remarkably similar to the environment with rising search costs.

Let ε denote the household's individual utility from owning a home, and let x denote the utility from homeownership that is common to all households.[19] Overall, households derive a utility εx from owning a home. Assume that ε follows a known distribution $F(\varepsilon)$. Relative to the model of section 2, buyers now incur a flow of constant costs c^B while searching for a house. Given free entry of buyers, households keep entering the market until the value of becoming a buyer equals zero, the value of their outside option. Intuitively, this free entry condition for buyers pins down the utility of the marginal buyer and determines the endogenous measure of buyers. Given that the value function for buyers is strictly increasing in ε, there exists a unique reservation value ε_R such that only households with $\varepsilon \geq \varepsilon_R$ enter the market.[20]

Let $B(\varepsilon)$ and $H(\varepsilon)$ denote the value functions of a buyer and homeowner with utility ε, and V denote the value function of a vacancy. The value functions satisfy the following Bellman equations

$$rB(\varepsilon) = \max\{0, -c^B + m(\theta)[H(\varepsilon) - B(\varepsilon) - p(\varepsilon)]\}, \tag{A11}$$

$$rH(\varepsilon) = \varepsilon x - s[H(\varepsilon) - V - B(\varepsilon)] - \delta[H(\varepsilon) - B(\varepsilon)], \tag{A12}$$

$$rV = -c^s + \theta m(\theta) \int_{\varepsilon_R}^{\infty} (p(\varepsilon) - V) \frac{dF(\varepsilon)}{1 - F(\varepsilon_R)} - \delta V. \tag{A13}$$

Prices solve the following Nash Bargaining problem

$$p(\varepsilon) = \arg\max_{p(\varepsilon)} \left(S^B(\varepsilon)\right)^{1-\beta} \left(S^S(\varepsilon)\right)^{\beta}, \text{ for all } \varepsilon. \tag{A14}$$

Free entry of sellers and buyers imply $V = k$ and $B(\varepsilon_R) = 0$. Intuitively, given a utility of the marginal buyer ε_R, free entry of sellers pins down the market tightness. Given the equilibrium

[19] The common component of the utility flow, x, plays no role in our analysis and can, without loss of generality, be normalized to 1. Although beyond the scope of this paper, including it allows one to study the effects of aggregate demand shocks.

[20] Observe that from the assumption of Nash Bargaining, both the buyer and seller agree on the value of ε_R, i.e. $S^B(\varepsilon) \geq 0$ if and only if $S^S(\varepsilon) \geq 0$. We assume that x is large enough, so that all matches yield a positive surplus, akin to search models with endogenous labor market participation.

market tightness, free entry of buyers pins down the marginal buyer ε_R and, therefore, the measure of buyers. Solving the model in a similar way as in the baseline model gives the equilibrium[21]

$$\text{(HE):} \qquad \frac{(r+\delta)k + c^S}{\theta m(\theta)} = (1-\beta)\left[\frac{\bar{\varepsilon}x + c^B - (r+\delta)k}{r+s+\delta+\beta m(\theta)}\right] \tag{A15}$$

$$\text{(BE):} \qquad \frac{c^B}{m(\theta)} = (1-\beta)\left[\frac{\varepsilon_R x - (r+\delta)k}{r+s+\delta}\right]. \tag{A16}$$

$$\text{(PP):} \qquad p(\varepsilon) = k + \beta\left(\frac{\varepsilon x + c^B + sk + \beta m(\theta)k}{r+s+\delta+\beta m(\theta)} - k\right), \tag{A17}$$

We should note that in the pricing equation for the model in the main text, (7), does not include the market tightness, whereas equation (A17) does. The reason is that in the homogeneous case the outside option for the buyer in the bargaining game, B, equals 0 due to free entry. In the heterogeneous case, however, this is only true for the marginal buyer. For any buyer with a preference for housing $\varepsilon > \varepsilon_R$ the outside option in the bargaining game $B(\varepsilon)$ is strictly positive and depends on how soon the buyer expects to match with another seller.

1. The social planner's allocation

Similar to the benchmark model with homogeneous buyers, the social planner faces two externalities. With heterogeneous buyers, however, the participation externality is driven by compositional effects. The marginal households participating in the market are the households who value housing the least. As a result, the average utility of homeownership declines as more buyers enter the market. This leads to a participation externality because buyers do not internalize how their participation affects the distribution of match surpluses. When the planner internalizes both externalities, the HMP condition is again insufficient to restore the efficient allocation. Intuitively, this condition controls for the congestion externality, but again an additional policy is required to restore entry of buyers to the efficient level.

As before c denotes new construction, $\tilde{h}$ denotes the number of homeowners and N is a large measure of the population (such that there is never a corner solution to the buyer's entry decision).

[21] A main disadvantage of a model with heterogeneity in utility flows and participation is that it generates a downward-sloping Beveridge Curve. The reason is the following. The slope of the BE curve depends on two opposite effects. On the one hand, more vacancies imply a lower market tightness, which makes it easier for buyers to find a house and induces entry of buyers. On the other hand, as buyers find homes more quickly the stock of buyers depletes. This is the usual mechanism in search models of housing without buyer entry, and leads to a counterfactual downward-sloping Beveridge Curve. Whether the BE Curve is upward-sloping depends on which effect dominates. It turns out that, given a standard calibration, the second effect dominates and the BE curve is downward-sloping, as in search models of the labor market with labor force participation. See a previous version of this paper for full derivations (Gabrovski and Ortego-Marti, 2021b)

We express buyers as a function of the total measure of homeowners $\tilde{h}$ instead of using the fraction of market participants who are homeowners h, as it simplifies the derivations. The planner maximizes

$$\max_{\tilde{h},v,\theta,\varepsilon_R,c} \int_0^\infty e^{-rt} \left\{ \left(\int_{\varepsilon_R}^\infty \varepsilon x \frac{dF(\varepsilon)}{1-F(\varepsilon_R)} \right) \tilde{h} - [N(1-F(\varepsilon_R)) - \tilde{h}]c^B - vc^S - ck \right\} dt \tag{A18}$$

subject to

$$\dot{\tilde{h}} = v\theta m(\theta) - (s+\delta)\tilde{h}, \tag{A19}$$

$$\dot{v} = e + s\tilde{h} - \delta v - v\theta m(\theta), \tag{A20}$$

$$N(1-F(\varepsilon_R)) - \tilde{h} = \theta v. \tag{A21}$$

Solving for the optimal allocation $\{\theta, \varepsilon_R\}$ in steady state yields the two equation system below

$$\frac{(r+\delta)k + c^S}{\theta m(\theta)} = \alpha \left\{ \frac{[(1-h)\bar{\varepsilon} + h\varepsilon_R]x - (r+\delta)k}{r+s+\delta} \right\}, \tag{A22}$$

$$\frac{c^B}{m(\theta)} = \left(\frac{1-\alpha}{\alpha} \right) \frac{(r+\delta)k + c^S}{\theta m(\theta)} - \frac{xh(\bar{\varepsilon} - \varepsilon_R)}{m(\theta)}. \tag{A23}$$

Comparing the planner's first-order conditions with the corresponding HE and BE conditions in the decentralized economy (A15) and (A16) shows that the HMP condition does not restore efficiency. The optimal allocation reflects that the planner does not only care about the marginal buyer, she is also concerned about the average composition of buyers. By contrast, in the decentralized equilibrium only the marginal buyer matters for entry.

2. Quantifying inefficiency in the housing market

We keep our calibration strategy as close as possible to the strategy in section 3 to make the quantitative predictions of the two models comparable. In particular, the only moments that are different in the calibration are those that pin down the parameters of the utility distribution $F(\varepsilon)$.[22] Kotova and Zhang (2020) report housing price dispersion of 16.84%. The authors further attribute 14.67% of the overall dispersion to buyer heterogeneity. Using these estimates we back out an implied mean-min ratio for prices equal to 1.0884. This yields $\tilde{\alpha} = 1.2698$. It turns out that one can normalize ε_R as it acts as a scaling variable. Accordingly we set $\varepsilon_R = 9.934$ so that the average equilibrium price is 491.2, the average price in thousands of dollars reported in Kotova and Zhang (2020). This normalization, together with the buyer entry condition allows us to back out $\beta = 0.2994$. Lastly, the normalization $N = 10,000$ yields an equilibrium number of buyers $b = 0.8038$.

[22] We also drop the moment which pins down γ in the homogeneous case, as this parameter is absent in the heterogeneous buyers model.

Given the model's calibration we compute the benchmark equilibrium and the planner's socially optimal allocation. The benchmark equilibrium features a vacancy rate of 2.83%. This is very close to the empirically observed vacancy rate for the U.S. of 1.9%. This version of the model also matches relatively well the data on construction: the construction rate in our model is 0.4% whereas the one in the data is 0.27%. Turning our attention to the efficient allocation, the planner finds it optimal to reduce the time-to-sell by almost half. This is achieved by increasing the number of buyers by 13.65% and reducing the number of vacancies by 41.51%. Intuitively, from the planner's perspective the congestion externality induces an over-creation of vacancies in equilibrium. At the same time, the participation externality leads to a sub-optimally low homeownership rate in equilibrium. Therefore, the planner instructs a higher number of households to enter the market. The resulting optimal vacancy rate is 1.64%.

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Preferences/Technology	Parameter	Value	Source/Target
Discount rate	r	0.012	Annual discount factor= 0.953
Utility	ε	10.883	Normalization
Elasticity of Matching Function	α	0.16	Genesove and Han (2012)
Destruction rate	δ	0.004	Van Nieuwerburgh and Weill (2010)
Separation Rate	s	0.0126	Listing rate = 1.67%
Efficiency of Matching Function	μ	0.5682	TTB= 1.76 quarters
Seller cost	c^S	14.233	Average seller cost= 5.1% of price
Bargaining power	β	0.5234	Average buyer cost= 8% of price
Construction cost	k	451.98	TTS= 1.76 quarters
Buyer cost parameter	$\bar{c}$	1	Normalization
Profit tax rate	τ_s	0.0365	Effective tax rate, real estate firms
Property tax rate	τ_p	0.0028	Tax Foundation Facts and Figures 2018
Transfer rate	τ_b	0.0016	National Association of Realtors
Construction tax	τ_k	0	

Table 1: Baseline Model: Calibration

Moment	Calibrated Benchmark	Optimal
Vacancy rate	2.83	1.55
Listing rate	1.67	1.66
TTS	1.76	0.95
Buyers	96.29	165.95
Vacancies	96.29	79.98
Homeowners	3,305.52	5,069.06

Table 2: Baseline Model: Moments

Taxes	Calibrated Benchmark	Optimal
τ_s	3.65%	69.8%
	(\$1.43)	(\$44.54)
τ_k	0%	−17.31%
	(\$0)	(−\$78.25)

Table 3: Baseline Model: Optimal Policies