Housing Market Congestion and Internal Migration In Major European Cities *

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Abstract

Housing plays a crucial role in influencing inter-regional relocations. Employing a parsimonious spatial search and matching model, this research reveals that congestion faced by renters could lead to out-migration—a phenomenon distinct from the well-documented "lock-in" and cost-related channels. Moreover, the correlation between congestion and inter-regional relocation is likely state-dependent, wherein migration flow directions may vary based on the tightness of the market. The central mechanism is the trade-off between the thick-market effect and congestion externality. If the latter dominates, an increase in congestion leads to reduced housing consumption, incentivising out-migration. Conversely, if the former dominates, such an increase could result in in-migration. Leveraging a proprietary micro-dataset obtained from a prominent property consulting company, I construct a congestion measure aligned with the theoretical framework for 34 major European cities spanning 2009-2021. Subsequently, I demonstrate a positive overall correlation between congestion and out-migration, while emphasising the state-dependent nature of this relationship, thereby validating the model's insights. These novel empirical patterns are the first to unveil the association between congestion and inter-regional relocation. Policy analysis utilising the theoretical framework underscores potential adverse implications of imposing rent subsidies in cities with tight housing markets. In contrast, expanding the housing stock could be welfare-enhancing. The essence of these policy implications lies in the search and matching frictions; outcomes would be different if the housing market were Walrasian.

JEL Classifications: E22, R21, R23, R31

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1 Introduction

Housing is an important driver of regional relocation, contributing to 41.6% of internal migration in 2022 (U.S. Census Bureau (2023a)). The recent surge in departures from major European cities [1] aligns with a prevalent housing crisis within these areas, sparking a renewed exploration of how the housing market influences migration decisions.

Previous studies on the relationship between housing market and internal migration have primarily focused on two key pathways. The first, referred to as the "lock-in" channel (Ferreira et al. (2010); Head and Lloyd-Ellis (2012); Sterk (2015)), suggests that homeowners are less likely to relocate compared to renters. However, these studies are primarily conducted in the U.S., where home ownership rates are high [2]. Conversely, the "lock-in" channel could be inadequate in explaining internal migration patterns in major European cities, where homeownership rates remain low.

The second pathway concerns expenses associated with housing. High housing costs, encompassing both purchasing prices and rents, would deter inter-regional immigrants (Ganong and Shoag (2017); Cannari et al. (2000); Muellbauer and Cameron (1998)) and prompts current residents to outmigrate (Nenov (2015); Stawarz et al. (2021)).

This paper offers a fresh perspective on the interplay between housing market and internal migration, focusing on the influence of congestion. In recent decades, major European cities have experienced a notable surge in population without a corresponding increase in housing stock. Figure (1) illustrates this phenomenon, where annual changes in population, depicted in red bars, generally exceed annual changes in housing stock, depicted in in blue bars. Consequently, time and effort invested on house hunting has increased significantly. Data from Rightmove reveals a threefold increase in enquiries for each rental property in London over the past five years (BBC (2023)). These findings highlight the prevalence of congestion among buyers and renters in the housing market.

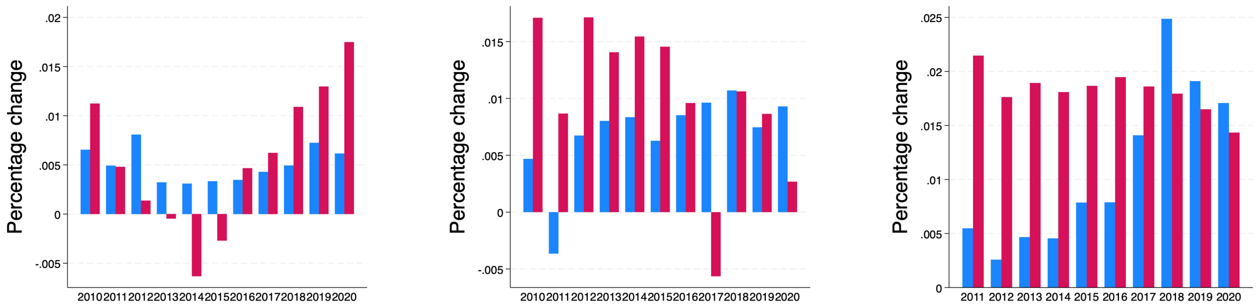
The influence of housing market congestion on migration is evident both in theory and in practice. The housing market, characterised by its frictional nature, would clear through price and time (Han and Strange (2015)). The existing literature extensively examines the impact of housing prices and rents on migration decisions. In a similar vein, congestion, which increases buyer and renter's time in the housing market, could have comparable effects. On an empirical note, evidence from a recent randomised controlled trial conducted by Bergman et al. (Forthcoming) identifies search frictions as the predominant barrier to migration, implying that congestion could play a deterrent role for potential immigrants. This research aims to provide a theoretical framework as well as empirical evidence to study how congestion would affect the housing market, and subsequently influence regional relocation.

[1] Domestic emigration has been consistently higher than immigration in major European cities, such as London (Greater London Authority (2023)) and Vienna (City of Vienna (2023)), for the past decade.

[2] The United States has a home ownership rate of 66% in Q3 2023 (U.S. Census Bureau (2023b)). In contrast, Germany's average home ownership rate is 46.7% in 2022 (Statista (2023)), while London's rate is 44.6% (Office for National Statistics (2021)).

Figure 1: Population and Housing Stock Growth

(a) Madrid (b) Munich (c) Copenhagen



Notes: Figure 1 plots population growth rates, which proxies housing demand growth rates, and housing stock growth rates. The blue bars depict annual changes in housing stock. The red bars depict annual changes in population. Figure 1a is for Madrid. Figure 1b is for Munich and Figure 1c is for Copenhagen.

The search and matching literature, spanning various contexts, underscores that congestion can give rise to two contrasting effects. On one hand, the congestion experienced by buyers and renters can have positive implications for match creation. This is the well-known "thick-market effect" (Ngai and Tenreyro (2014); Brancaccio et al. (2023)), as sellers and landlords are able to sell or lease their properties faster. Conversely, this congestion can present challenges for buyers and renters in finding matches, creating a negative externality.

The balance between these effects becomes pivotal, underscored by the renowned Hosios condition (Hosios (1990)). If the "thick-market effect" prevails over the congestion externality, an increase in congestion among buyers and renters could lead to more transactions in the housing market. This is because the enhanced probability of successful selling or leasing surpass the heightened search costs. Such an outcome is beneficial as it contributes to an increased level of housing consumption. Conversely, if the congestion externality dominates, an increase in congestion would have adverse effects, as the challenges faced by buyers and renters in finding matches outweigh the positive effect associated with market thickness. Moreover, considering that out-migration tends to occur during deteriorating housing market conditions, while in-migration takes place when conditions improve—a premise consistent with the Rosen-Roback model (Rosen (1979) and Roback (1982))—migration decisions in the face of elevated congestion depend on the trade-offs between match creation and congestion externality.

To formalise the potential state-dependent impact of congestion on the housing market and migration decisions, I utilise a spatial adaptation of Michaillat and Saez (2015)'s framework. I illustrate that in a city where the housing market is initially tight, heightened congestion among buyers and renters leads to a reduction in housing consumption, thereby encouraging out-migration. Conversely, in a city with an initially loose housing market, an increase in congestion faced by buyers and renters enhances housing consumption and fosters in-migration.

I validate the model's predictions utilising a proprietary dataset obtained from a prominent property consulting company. This dataset spans comprehensive housing market information for 34 major European cities from 1990 to 2023. Leveraging this dataset, I create a measure of housing market congestion that aligns with the theoretical framework on a one-to-one basis. I also incorporate rental prices to account for the housing cost-related channel of internal migration. However, the sample period introduces two potential complications that could challenge the interpretation of housing market congestion attributed to internal migration. Firstly, the onset of the work-from-home (WFH) trend during COVID-19 led to a shift as individuals relocated to suburban towns in pursuit of larger houses. Secondly, the surge in mortgage rates after February 2022 compelled some people to sell their properties and move due to difficulties in meeting mortgage repayment obligations. To mitigate these complications, I address them by excluding observations recorded after 2021 from the sample.

I complement the housing market data by incorporating local internal migration and economic conditions data sourced from official statistical agencies. The former is utilised in constructing the dependent variable, while the latter serves as additional controls. Two novel empirical patterns emerge. Firstly, the congestion experienced by buyers and renters is positively correlated with the out-migration rate across the entire sample. This aligns with the model's predictions, considering these major cities represent some of the tightest housing markets in Europe. Additionally, the association between congestion and out-migration is state-dependent, as outlined in the model. Despite the overall positive correlation, the relationship between out-migration and congestion is negative for cities characterised by relatively loose housing markets, while the opposite holds true for cities with relatively tight housing markets. In essence, the empirical findings substantiate the outcomes projected by the model.

As the theoretical framework successfully replicates empirical patterns, I employ the model to assess the implications of two prevalent place-based policies when implemented in cities with tight housing markets, contributing to the long standing "subsidy/production" debate (Apgar Jr (1990); Galster (1997); Yates and Whitehead (1998)). I underscore the potential negative welfare effects associated with rent subsidies, as they exacerbate already high search costs. Conversely, an increase in housing stock could be welfare-enhancing, as it mitigates congestion among buyers and renters. Furthermore, I highlight the crucial influence of search and matching frictions in shaping the outcomes of housing policies. In the absence of these frictions, a rent subsidy might prove beneficial to recipients by increasing their endowment. In scenarios where price adjustment is sluggish, this could result in an increase in their housing consumption.

Related literature. This research aligns with several established bodies of literature. Firstly, it contributes to the understanding of the relationship between the housing market and internal migration. In conventional studies, as summarised in Jia et al. (2022), two primary channels of interaction between the housing market and internal migration are explored. The first emphasises the role of home ownership and the associated "lock-in" effect (Ferreira et al. (2010); Head and Lloyd-Ellis (2012);

Sterk (2015)), while the second underscores housing costs (Ganong and Shoag (2017); Plantinga et al. (2013); Jeanty et al. (2010); Cannari et al. (2000); Cameron et al. (2005); Muellbauer and Cameron (1998); Nenov (2015); Stawarz et al. (2021)). Recent studies, such as the randomised controlled trial conducted by Bergman et al. (Forthcoming), have brought attention to search frictions as a significant barrier to internal migration. This research contributes to the evolving literature by presenting a framework that illustrates how housing market congestion could impact inter-regional relocation. Additionally, it validates the model's findings by empirically revealing a positive overall but state-dependent correlation between housing market congestion and out-migration.

Second, this paper contributes to the application of search and matching models in housing markets. Given its inherent frictions (Han and Strange (2015)), various iterations of search and matching models are extensively employed to model the microstructures of the housing market (Stein (1995); Genesove and Han (2012); Ngai and Tenreyro (2014); Ngai and Sheedy (2020a); Ngai and Sheedy (2020b); Novy-Marx (2009); Diaz and Jerez (2013)). Nonetheless, fundamentally, these theoretical frameworks all represent various adaptations of the textbook Diamond-Mortensen-Pissarides (DMP) model, as evidenced in Mortensen and Pissarides (1994) and Pissarides (2000). In contrast, I employ Michaillat and Saez (2015)'s framework for two reasons. First, housing market congestion in Michaillat and Saez (2015) does not require knowledge of listed properties, for which I lack data. Instead, it can be derived from housing stock, for which I have access to the data. Second, search cost is explicitly modelled as a cost associated with every home visit, capturing the reality of the housing market more accurately. The model-implied relationships between housing market congestion and internal migration hold empirically.

Third, this paper contributes to the design of housing market policy, particularly in the "subsidy/production" debate, a central focus in various conventional studies (Apgar Jr (1990); Galster (1997); Yates and Whitehead (1998)). I demonstrate that policy implications are state-dependent. Specifically, rental subsidies would be ineffective in tight markets, as substantial proportions of the subsidies would be utilised to cover search and matching costs. This formalises Weicher (1990)'s argument that *"subsidies do not work when the housing market is tight"*.

Road map. The rest of the paper is organised as follows. Section 2 presents the model. Section 3 shows and validates the proprietary data used in this research. Section 4 highlights the novel empirical patterns. Section 5 studies the implications of place-based housing policies, and Section 6 concludes.

2 Model

This section outlines a model that analyses how housing market congestion influences migration. The model focuses on the trade-off between thick market and congestion externality. If congestion externality dominates after an increase in congestion, aggregate housing consumption decreases, encouraging out-migration as the outside option becomes more attractive. Conversely, if thick market dominates post-congestion increase, housing consumption improves, attracting immigrants.

2.1 Set-up and Primitives

The model integrates the static version of Michaillat and Saez (2015)'s model with endogenous migration decisions. The economy consists of two cities, denoted as T and L. Each city comprises N_i identical households, where $i \in (T, L)$. These cities fundamentally differ in terms of endowment, housing preference, and housing stock. Consequently, the housing demand and supply exhibit variations between city T and city L.

The housing market of interest in the rental market, which neglects the home capital aspect of residential structures (Piazzesi and Schneider (2016)). However, housing rental market highlights low home ownership rates in major European cities. For consistency, "buying" and "renting" are used interchangeably in the theoretical framework, specifically denoting the acquisition of rental services. Similarly, within this context, the terms "selling" and "leasing" are also used interchangeably, both signifying the action of renting out houses.

Households lease housing services in a frictional housing rental market in each city. Housing services are produced by households, however, they cannot consume their own services. Therefore, households also rent housing services from other households from the same city. Hence, households act as both buyers and sellers of housing services, which is a unique feature of the housing market as highlighted in Han and Strange (2015). One can rationalise this feature by viewing households as real estate agents. Lastly, I consider a symmetric equilibrium in each city's housing market.

Finally, households engage in migration both into and out of the city until per household housing consumption equalises across locations, an adaptation of the Rosen (1979) and Roback (1982) framework.

2.2 Matching Function

Each household in city i visits V_i other households to purchase housing services, and therefore, aggregate numbers of visits is $V_i N_i$. Moreover, each city is endowed with a fixed $\bar{K}_i$ housing stock; that is, households in each city can produce up to $\bar{K}_i$ housing services. Aggregate housing services produced in city i are given by the following matching function:

$$Y_i = [(V_i N_i)^{-\gamma} + (\bar{K}_i)^{-\gamma}]^{-\frac{1}{\gamma}}, i \in (T, L). \tag{1}$$

Define the housing market tightness X_i as aggregate numbers of visits over aggregate housing stock $X_i = \frac{V_i N_i}{\bar{K}_i}$. Therefore, in each city, one housing service is sold with probability:

$$f(X_i) = \frac{Y_i}{\bar{K}_i} = (1 + X_i^{-\gamma})^{-\frac{1}{\gamma}}, \tag{2}$$

and one visit yields a purchase with probability

$$q(X_i) = \frac{Y_i}{V_i N_i} = (1 + X_i^{\gamma})^{-\frac{1}{\gamma}}. \tag{3}$$

The function f is strictly increasing on [0, +∞], whereas the function q is strictly decreasing on [0, +∞]. These two properties imply that when the housing market becomes tighter, it is easier to lease out a house but harder to rent a house. [3] Therefore, housing market tightness essentially captures the congestion renters face in the housing market.

2.3 Households and Aggregate Housing Demand

Households face a search and matching cost ρ of housing service during every visit. Therefore, a household in city i desires to consume housing service C_i and pays V_i visits is required to buy $C_i + \rho V_i$ units of housing services in total. Hence, since there are N_i identical households in city i, the aggregate housing service purchased is characterised as

$$Y_i = (C_i + \rho V_i) N_i. \tag{4}$$

Substituting the (3) into the left hand side of (4), numbers of visits required to purchase C_i housing services are endogenously determined as $V_i = \frac{C_i}{q(X_i) - \rho}$. Therefore, to buy one unit of housing service, a household in city i is required to pay $\frac{1}{q(X_i)-\rho}$ visits and purchase $1 + \frac{\rho}{q(X_i)-\rho}$ housing services in total. Let $\frac{\rho}{q(X_i)-\rho} \equiv \tau(X_i)$, a household is required to purchase $1 + \tau(X_i)$ total housing services in order to consume one unit of housing service.

The function τ captures the severity of search and matching cost faced by buyers in the housing market. This cost strictly increases with housing market tightness X_i until X_i reaches X_i^m, where X_i^m satisfies $q(X_i^m) = \rho$. Intuitively, when housing market becomes tighter from the buyer's perspective, they would face higher search frictions.

Households derive utility from housing consumption and holding real money balances. Formally, a household living in city i's utility is given by

$$\text{Max}_{C_i, \frac{M_i}{P_i}} [\chi_i C_i^{\frac{\epsilon-1}{\epsilon}} + (\frac{M_i}{P_i})^{\frac{\epsilon-1}{\epsilon}}], \tag{5}$$

where the parameter χ_i captures the taste for housing consumption relative to money in city i, and the parameter $\epsilon < 1$ governs the elasticity of substitution. Households are also subject to a nominal budget constraint,

$$M_i + C_i[1 + \tau(X_i)]P_i = \bar{\mu}_i + P_i f(X_i) \frac{\bar{K}_i}{N_i}. \tag{6}$$

The left hand side of (6) shows that a household would allocate their nominal income between

[3] These features match the stylised facts documented in Diaz and Jerez (2013).

holding money balance M_i and consuming housing services C_i. Moreover, as explained above, to consume C_i housing service, one is required to purchase $C_i[1+\tau(X_i)]$ housing service in total due to the search costs. From the buying household's perspective, it is as if they would purchase C_i housing service at a unit price $P_i(1+\tau(X_i))$, where the search and matching costs incurred during visits become a price wedge.

The right hand side of (6) shows that a household would generate their nominal income from receiving a endowment $\bar{\mu}_i$, as well as providing $f(X_i)\frac{\bar{K}_i}{N_i}$ housing services using $\frac{\bar{K}_i}{N_i}$ units of endowed housing stock. The $f(X_i)$ term highlights that not all housing services that a household are able provide will be sold, which stems from the matching function.

After taking money market clearing in each city, that is $N_i M_i = N_i \mu_i$, into account, the solution to a household's utility-maximisation problem gives

$$(\frac{\bar{\mu}_i}{P_i})^{-\frac{1}{\epsilon}} = \frac{\chi_i}{1+\tau(X_i)} C_i^{-\frac{1}{\epsilon}} \tag{7}$$

Following Michaillat and Saez (2015), I define aggregate housing demand in city i as the utility-maximisation level of aggregate housing consumption at a given housing market tightness and price. Formally,

$$\mathcal{C}^D(X_i, P_i) = (\frac{\chi_i}{1+\tau(X_i)})^{\epsilon} \frac{\bar{\mu}_i}{P_i} \times N_i, \tag{8}$$

where $\mathcal{C}^D$ is strictly decreasing in X_i and P_i. These two properties of aggregate housing demand reflect that when housing consumption becomes relatively more expensive either due to increased price, or due to higher search and matching cost associated with increased market tightness, housing consumption would become less attractive.

2.4 Aggregate Housing Supply

As per Michaillat and Saez (2015), I define aggregate housing supply in city i as the total consumable housing services produced in that city. Formally, the aggregate supply takes the following form

$$\mathcal{C}^S(X_i) = \frac{f(X_i)\bar{K}_i}{1+\tau(X_i)}. \tag{9}$$

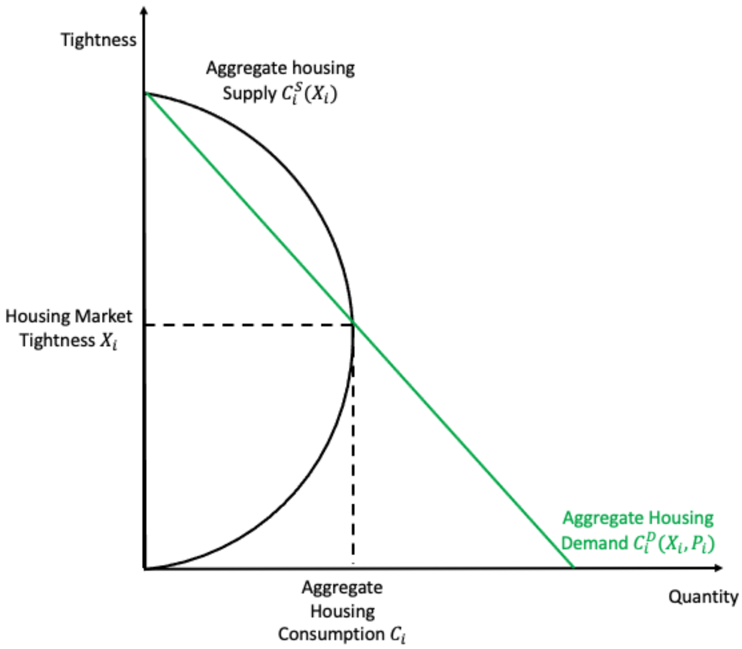
The numerator of (9) characterises total housing services produced in city i, which is a fraction of production capacity $\bar{K}_i$. This arises from the matching function, which implies that that not all housing services within households' production capacity will be sold. Moreover, only $\frac{1}{1+\tau(X_i)}$ fraction of the housing services produced is not spent on the cost of search and matching, and could be consumed by households.

Using the definition of $\tau(X_i)$ and substituting $X_i = \frac{f(X_i)}{q(X_i)}$, (9) can be expressed as

$$\mathcal{C}^S(X_i) = (f(X_i) - \rho X_i)\bar{K}_i. \tag{10}$$

Define a level of tightness X_i^* by $f'(X_i^*) = \rho$ for city i. Therefore, the first order condition of (10) suggests that aggregate supply is strictly increasing on $[0, X_i^*]$, and strictly decreasing on $[X_i^*, X_i^m]$. Moreover, X_i^* would be the level of tightness that maximises housing consumption. Figure

Figure 2: Aggregate Housing Demand and Supply



Notes: Figure 2 illustrates aggregate housing demand and supply. The former is in black, and the latter is in green. Their intersection, as section 2.5 would explain, denotes housing market equilibrium.

2.5 Housing Market Equilibrium

The definition of a competitive equilibrium, which mirrors that in Michaillat and Saez (2015), implies that aggregate housing demand equals to aggregate housing supply in a symmetric equilibrium in city i, that is, $\mathcal{C}_i^S(X_i) = \mathcal{C}_i^D(X_i, P_i)$. This property can be formally demonstrated as outlined below.

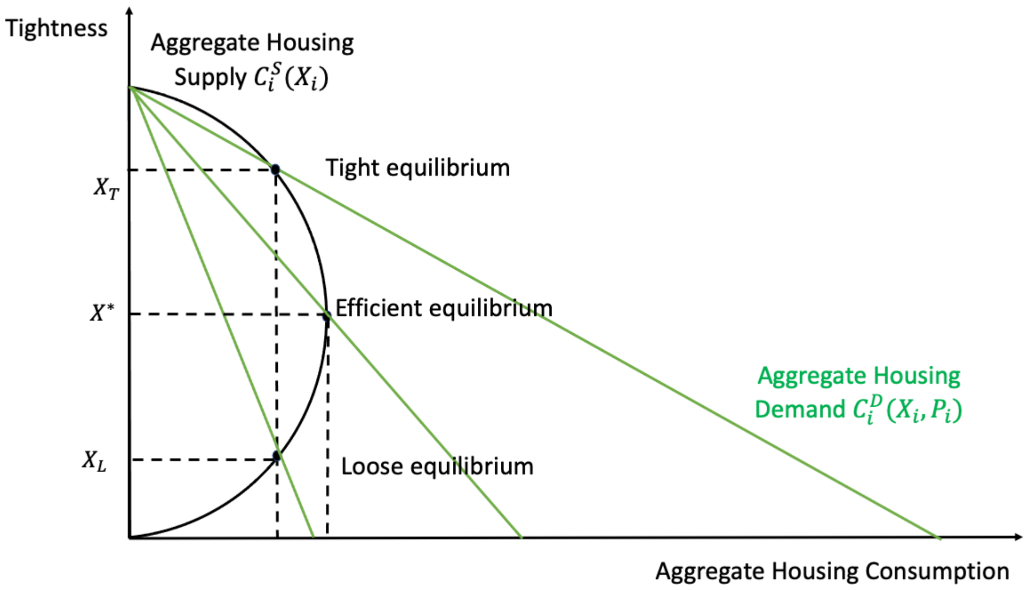
In a symmetric equilibrium, given the definition of aggregate housing demand and the fact that money market clears in each city, the aggregate numbers of visits can be expressed as $N_i V_i(X, P) = \frac{(1+\tau(X_i))\mathcal{C}_i^D(X_i,P_i)}{q(X_i)}$. Substituting this into the definition of housing market equilibrium and take the aggregate demand to the left hand side, $\mathcal{C}_i^D(X_i, P_i) = \frac{X_i q(X_i)\bar{K}_i}{1+\tau(X_i)}$. Lastly, since $f(X_i) = X_i q(X_i)$, this equation implies that

$$\mathcal{C}_i^D(X_i, P_i) = \frac{X_i q(X_i)\bar{K}_i}{1+\tau(X_i)} = \frac{f(X_i)\bar{K}_i}{1+\tau(X_i)} = \mathcal{C}_i^S(X_i) = (f(X_i) - \rho X_i)\bar{K}_i, \tag{11}$$

where the second inequality stems from (10). Subsequently, per household housing consumption in a symmetric equilibrium in city i satisfies

$$C_i = (f(X_i) - \rho X_i)\bar{K}_i \times \frac{1}{N_i}. \tag{12}$$

Figure 3: Tight, Efficient and Loose Equilibrium



Notes: Figure 3 illustrates three possible equilibrium concepts. When tightness $X = X^*$, aggregate housing consumption is maximised, and the equilibrium is efficient. A tight equilibrium X_T occurs when $X_i > X^*$. A loose equilibrium occurs X_L occurs when $X_i < X^*$.

2.5.1 Equilibrium Discussion I - Tight, Loose and Efficient Equilibrium

Due to the shape of the aggregate housing supply, there exits a level of tightness $X_i = X_i^*$ that maximises aggregate housing consumption. As per Michaillat and Saez (2015), I categorise all possible equilibria into the following regimes:

Definition 1. *An equilibrium is tight if $X_i > X_i^*$, loose if $X_i < X_i^*$, and efficient if $X_i = X_i^*$.*

Figure 3 depicts three regimes. Moreover, the comparative statics for different equilibria are as follows. In a tight equilibrium, ceteris paribus, an increase in tightness would lower aggregate housing consumption. This is due to the fact that the rise in search costs would surpass the growth in selling probability. Analogously, in a loose equilibrium, an increase in tightness would lead to higher aggregate consumption. Formally, taking the log of (11),

$$\frac{f'(X_i) - \rho}{f(X_i) - \rho X_i} > 0, \text{in a loose equilibrium}$$
$$\frac{f'(X_i) - \rho}{f(X_i) - \rho X_i} = 0, \text{in an efficient equilibrium}$$
$$\frac{f'(X_i) - \rho}{f(X_i) - \rho X_i} < 0, \text{in a tight equilibrium.} \tag{13}$$

The essence of the state-dependent impact of increased tightness on housing consumption captures the trade-off between thick market and congestion externality. With rising tightness, the selling probability increases at the rate of $f'(X_i)$, while the search cost escalates at the rate of ρ. The former aligns with the thick market effect, while the latter is associated with congestion externality. The relative magnitude of $f'(X_i)$ versus ρ, however, depends on the level of housing market tightness.

In a loose housing market, the efficiency of the matching process is impeded by low property visits. Consequently, an increase in X_i results in a substantial rise in selling probability due to increased visits, with only a marginal increase in search costs $\tau(X_i)$. In this scenario, the thick market effect dominates, leading to an enhancement in aggregate housing consumption. Conversely, when X_i increases in a tight housing market, congestion externality takes precedence over the thick market. This dominance leads to an overall reduction in the aggregate supply of housing services.

2.5.2 Equilibrium Discussion II - Fixed-price and Competitive Equilibrium

An implication of (11) is that there will be infinite array of combinations of (X_i, P_i) could satisfy equilibrium conditions. This arises due to the presence of just one equation in contrast to the two unknown variables. To address this issue, I embrace the fixed-price equilibrium concept proposed in Michaillat and Saez (2015), which treats P_i as a parameter and attains equilibrium through adjusting tightness X_i.

The rationale for adopting the fixed-price equilibrium concept stems from the observed persistent downward rigidity in both nominal and real rent. Notably, since 2010, a significant 85.3% of changes in nominal rent and 67.1% of changes in real rent have demonstrated non-negativity in 34 major European cities using data provided by PMA. This trend can be attributed, at least in part, to the widespread adoption of rent indexation, as illustrated by approximately 70% of residential stock in Munich in 2022 incorporating an indexation clause (REFIRE (2022)). This contractual provision empowers landlords to adjust rent in alignment with inflation.Michaillat and Saez (2015) have established that, within their framework, the comparative statics remain isomorphic whether prices are assumed to be partially or fully rigid. The analysis will proceed with the assumption that the rental price remains fixed from this point onward.

2.6 Migration

Migration takes places to equalise housing consumption across locations, which is an adaptation of Rosen (1979) and Roback (1982) framework. Taking logs on each side of (12) and rearranging,

$$\log N_i = \log\left(f(X_i) - \rho X_i\right) + \log \bar{K}_i - \log C_i$$

Taking total derivatives of the equation above and re-arrange,

$$\underbrace{-\frac{dN_i}{N_i}}_{\text{out-migration rate}} = \underbrace{\left[-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i} + \frac{\partial \log C_i}{\partial X_i}\right]}_{\text{Semi-elasticity of out-migration w.r.t. } \Delta \text{ tightness}} dX_i + \frac{\partial \log C_i}{\partial P_i} dP_i \tag{14}$$

where the left hand side signifies the out-migration rate of city i. Furthermore, the term $-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}+\frac{\partial \log C_i}{\partial X_i}$ encapsulates the semi-elasticity of out-migration concerning changes in tightness. As discussed earlier, the $-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}$ component can exhibit both negative and positive values. Consequently, an increase in X_i could result in either an increase or decrease in out-migration.

In a fixed-price equilibrium, that is, $dP_i = 0$, (14) can be re-expressed as

$$-\frac{dN_i}{N_i} = -\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}dX_i + \frac{1}{C_i}dC_i. \tag{15}$$

Equation (15) suggests that an increase in tightness X_i, which measures congestion faced by buyers, would lead to out-migration from city i, if such a city has a tight housing equilibrium. This outcome can be elucidated as follows.

First, households opt to migrate to improve their consumption in the model's framework, implying that $dC_i > 0$ when migration occurs. Additionally, in a tight equilibrium, $-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}$ is negative, as elaborated upon in Section 2.5.1. Hence, if dX_i is positive, $-\frac{dN_i}{N_i}$ is positive in a tight equilibrium. In other words, increased buyer congestion is associated with out-migration in a tight equilibrium.

Vice versa, if the housing market is in a loose equilibrium, $-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}$ is positive. Therefore, an increase in buyer congestion would be associated with in-migration. The state-dependent effect of congestion on migration again depends on the trade-off between thick market and congestion externality.

In summary, Section 2 introduces a spatial search and matching model, demonstrating that increased congestion experienced by buyers is linked to out-migration in tight housing markets. Moreover, the correlation between congestion and out-migration is state-dependent. Subsequent sections will validate the model's predictions using a proprietary dataset.

3 Data

Section 3 describes data used in this research. Acquiring granular housing market data at the city level is crucial for validating the predicted relationships between internal migration and housing market congestion in our model. Unfortunately, such detailed datasets are often unavailable to the public in Europe. In lieu of public data, I leverage information provided by Property Market Analysis (PMA), a leading independent real estate consultancy. To ensure the robustness of the study, a comprehensive set of validation tests is executed. These tests aim to evaluate the reliability and accuracy of the proprietary granular data, comparing it against well-documented facts and aggregate data sourced from National Statistical Agencies.

3.1 Primary Data Sources

In this research, I incorporate three primary categories of data: local housing market data, local internal migration flows data, and local economic condition data.

The granular local housing market data, covering the period from 1990 to 2021, is sourced from Property Market Analysis (PMA), a leading independent property consultancy. PMA provides comprehensive information on housing rents, stocks, and transactions across 34 prominent European cities. This dataset is used to construct a housing market congestion measure in alignment with the theoretical framework.

In terms of local internal migration flows, I leverage data from statistical authorities. Additionally, I utilise pairwise internal migration flows for cities in the United Kingdom. To address city size variations, I normalise internal migration flows within each city by dividing them by the city's mid-year population. This process yields migration outflow and inflow rates.

Lastly, for local economic condition data, pivotal as control variables, I gather information from Eurostat's *Regional Statistics By NUTS Classification* database and the Office for National Statistics (ONS)'s *Regional Datasets*. These variables, encompassing metrics like the unemployment rate, real GDP, and disposable income, align with established standards in the conventional literature (e.g., Nenov (2015), Stawarz et al. (2021)).

3.2 Data Validation

The validation process for PMA's data involves cross-sectional and temporal assessments. In the cross-sectional aspect, I establish correlations between local housing market data and economic indicators. Temporally, I aggregate housing market data over time, constructing time series for comparison with official statistical agencies. Additionally, I compare regression results using PMA's data with Nenov (2015)'s study based on Metropolitan Statistical Area (MSA) data in the United States.

Figure 4 scatterplots granular housing data provided by PMA against local economic data. Each circle represents a city. The solid red lines depict the line of best fit, where the dotted black lines are the 45-degree lines.

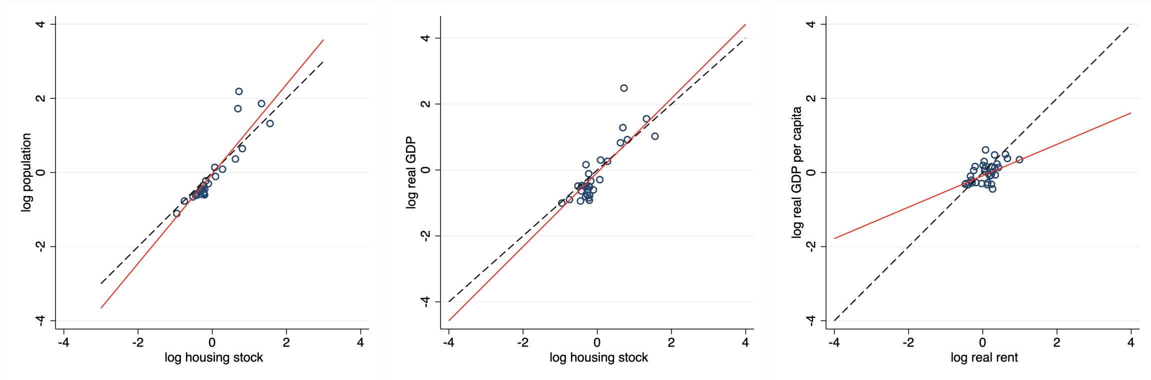
Panels 4a and 4b in Figure 4 depict the relationship between demeaned log housing stock and both demeaned log population, as well as demeaned log real GDP. These two panels underscore the intuitive notion that larger cities, in terms of both population and economic activity, tend to possess higher levels of housing stock, which are two known facts.

Panel 4c in Figure 4 illustrates the correlation between demeaned log real rent and demeaned log real GDP per capita, confirming the commonly observed trend that more prosperous areas tend to have higher rental prices (OECD and Eurostat (2012)).

Data validations are also conducted over the time dimension, involving comparisons between the aggregated granular housing data and time series published by statistical agencies. Countries

Figure 4: Cross-sectional Validation

(a) Housing stock and population (b) Housing stock and GDP (c) Housing rent and GDP



Notes: Figure 4 scatterplots granular housing data provided by PMA against local economic data. Each circle represents a city. The solid red lines depict the line of best fit, where the dotted black lines are the 45-degree lines. Panels 4a and 4b depict the relationship between demeaned log housing stock and both demeaned log population, as well as demeaned log real GDP. Panel 4c illustrates the correlation between demeaned log real rent and demeaned log real GDP per capita.

with the most detailed granular data are the United Kingdom and Germany, and consequently, I have aggregated data from these two countries and plotted them against time series published by the ONS and DESTATIS.

Figure 5 compares cyclical components of PMA's rent, stock, and transaction probability with their counterparts from the ONS and DESTATIS. These cyclical components are extracted using the the Hodrick-Prescott (HP) filter. The blue lines are detrended time series using aggregated granular data obtained from PMA, the dotted black lines are detrended ONS and DESTATIS time series. Recession years are in grey shades. The variation in the starting year for each detrended time series is a result of differences in data availability. Panels 5a and 5b correspond to the United Kingdom, while panels 5c and 5d are related to Germany. Hence, it is evident that the aggregated PMA data and the time series from the ONS and DESTATIS exhibit notably similar cyclical patterns. Table 1 provides quantitative evidence of the strong correlations observed in the cyclical components between the proprietary data and the official time series.

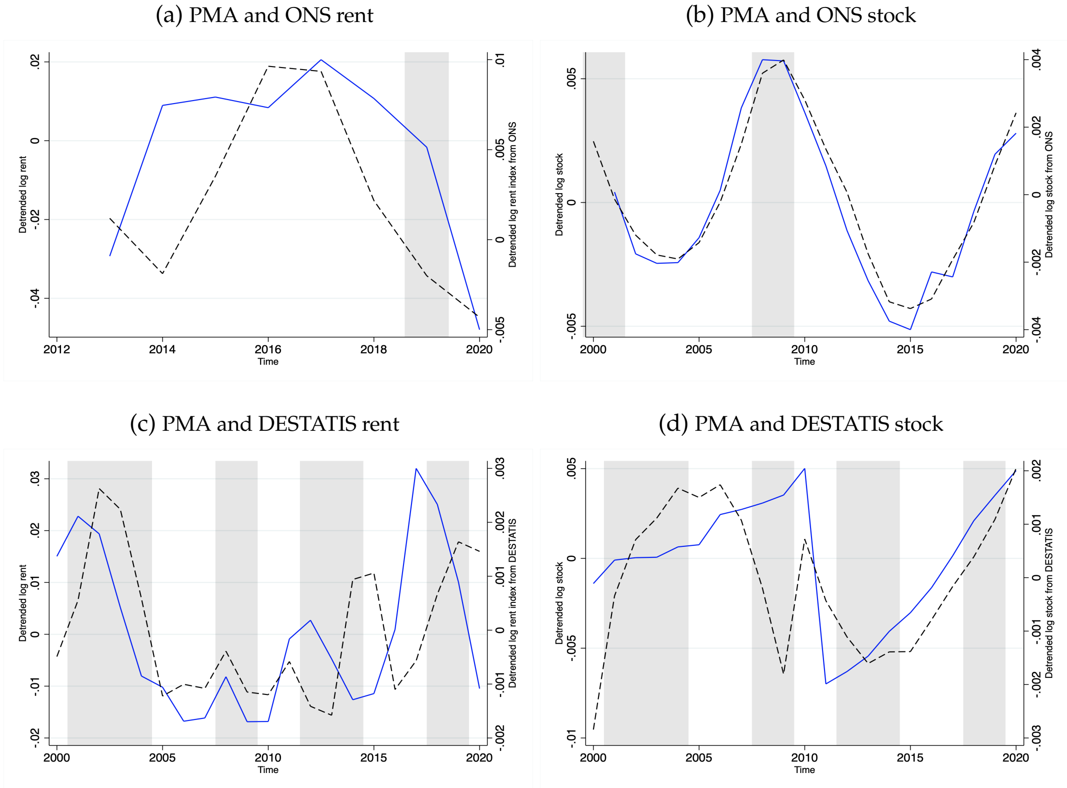
Table 1: Correlations of Cyclical Components Between PMA and ONS/DESTATIS Data

	United Kingdom + Germany	United Kingdom	Germany
	(1)	(2)	(3)
Rent	0.440	0.627	0.334
Stock	0.775	0.972	0.567

Notes: Table 1 shows correlations of cyclical components between aggregated PMA data and time series from the ONS (United Kingdom) and DESTATIS (Germany). These cyclical componets are obtained using the HP filter. Column (1) shows correlations using both British and German data. Column (2) shows correlations using British data only. Column (2) shows correlations using German data only.

In addition to the cross-sectional and time-series validation, I conducted a regression similar to the one used in Nenov (2015) on the data employed in this research. The regression specification is as follows:

Figure 5: Time Series Validation



Notes: Figure 5 compares cyclical components of PMA's rent, stock, and transaction probability with their counterparts from the ONS and DESTATIS. These cyclical components are extracted using the the Hodrick-Prescott (HP) filter. The blue lines are detrended time series using aggregated granular data obtained from PMA, the dotted black lines are detrended ONS and DESTATIS time series. In each panel, left axis are scales for detrended PMA time series, right axis are scales for detrended time series from the ONS and DESTATIS. Recession years are in grey shades. The variation in the starting year for each detrended time series is a result of differences in data availability. Panels 5a and 5b correspond to the United Kingdom, while panels 5c and 5d are related to Germany.

$$\text{log out-migration rate}_{it} = \alpha + \beta_1 \text{rent}_{it} + C_{it}'\Gamma + \eta_i + \gamma_t + \epsilon_{it}, \tag{16}$$

where i and t represent indices for city and time, respectively. The dependent variable represents the log of the aggregate number of inter-regional out-migrants divided mid-year population in city i at time t. rentit is the average real housing rent in city i at time t. Cit denotes a set of controls, including real disposable income per capita and local unemployment rates. The vector Γ comprises the coefficients associated with controls. η_i represents the city fixed effect, controlling for local amenities. γ_t is the time fixed effect, and the error term is denoted as ϵ_{it}.

Table 2 presents the estimation results from Equation (16). Column 1 showcases the correlation between log real rent and log out-migration rate in Nenov (2015) using official MSA data in the United States, while Column 2 represents the same correlation for Europe using PMA data. The correlations are approximately 0.3 in both the United States and Europe.

In summary, PMA's proprietary data consistently demonstrates a high degree of reliability and accuracy, as confirmed through cross-sectional, time-series, and regression validations. Leveraging this novel dataset, I proceed to establish several key stylised facts regarding the relationship between

Table 2: Comparison with Nenov (2015): Rent and Out-migration rate

Dep. Variable:	log out-migration rate	
	(1)	(2)
log real rent	0.306***	0.319**
	(0.0985)	(0.138)
N	1338	291
adj. R^2	0.94	0.05
City FE	✓	✓
Time FE	✓	✓
Cluster robust SE	✓	✓
Controls	✓	✓

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Table 2 presents the estimation results from Equation (16). Column 1 is the correlation between log real rent and log out-migration rate in Nenov (2015) using the United States data. Column 2 replicates the same regression using the novel European data obtained from PMA. Controls include real disposable income per capita and local unemployment rates

housing markets and internal migration.

4 Stylised Facts

In this section, I validate the model's predictions regarding the relationships between housing market congestion and inter-regional relocation. Initially, I construct a measure of housing market congestion in accordance with the theoretical framework. Subsequently, I conduct regressions to assess whether the correlations anticipated by the model are upheld empirically.

4.1 Measuring Housing Market Congestion

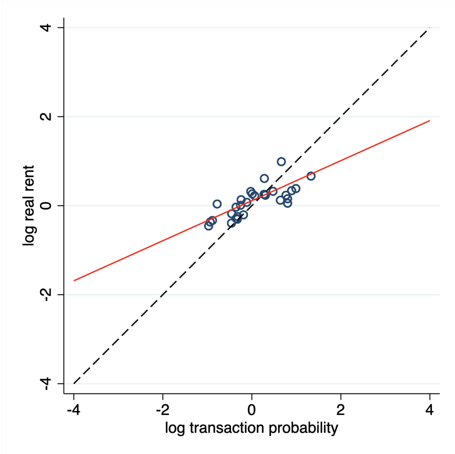
The theoretical framework, detailed in Section 2, posits that housing market tightness captures congestion experienced by home buyers and renters. However, the number of home visits remains unobserved. Alternatively, I construct transaction probability, which corresponds to the $f(X_i)$ variable in the model. This variable is formulated following Equation (2) as the ratio of housing transactions to housing stock within a city. According to the model, an increase in transaction probability signifies a decrease in the probability of a successful purchase, leading to congestion among both buyers and renters.

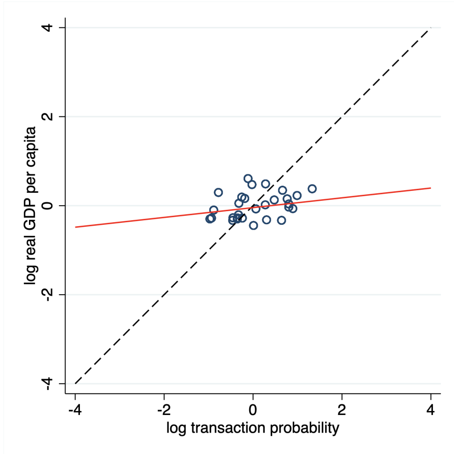
Acknowledging a key limitation, it's noteworthy that the housing transaction probability is derived from the home ownership market, whereas the primary focus of this research is on the home rental market. This limitation arises due to the unavailability of rental transaction data. Nevertheless, as illustrated in 6a, more congested home ownership markets are associated with higher rents in 34 major European cities. This implies that renters could have faced heightened competition, leading to increased congestion within these markets.

Figure 6: Transaction Probability With Rent and GDP per Capita

(a) Trans. probability and rent

(b) Trans. probability and GDP per capita

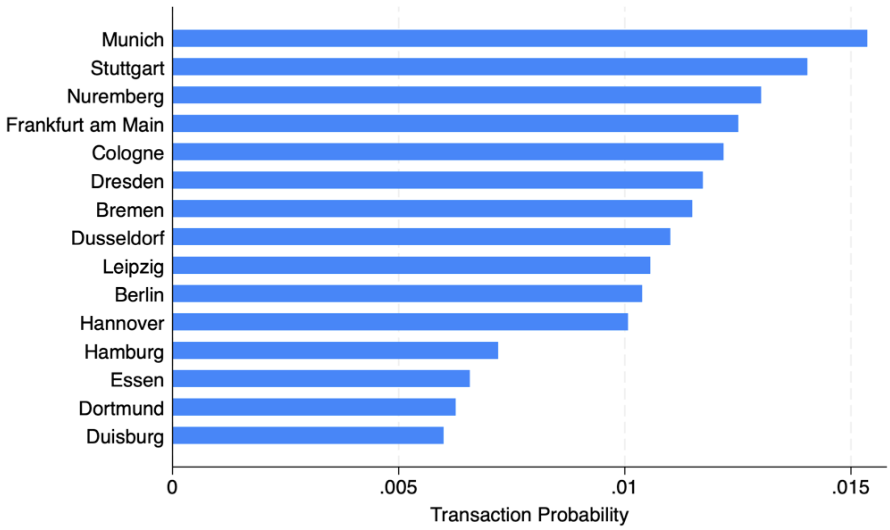




Notes: Panels 6a and 6b display the relationship between demeaned log transaction probability and demeaned log real rents, as well as demeaned log real GDP per capita. Transaction probability measures housing market congestion faced by buyers and renters, and is constructed as the ratio of housing transactions to housing stock within a city.

A plausible explanation for this correlation is that renters in areas with high housing transaction probability are more affluent, as indicated in 6b [4]. Using a country-specific example, richer German cities would have more congested home markets, as illustrated in Figure 7. Consequently, the demand for rental homes is higher, resulting in increased waiting times for buyers, as outlined in the theoretical framework.

Figure 7: Housing Market Congestion in German Cities



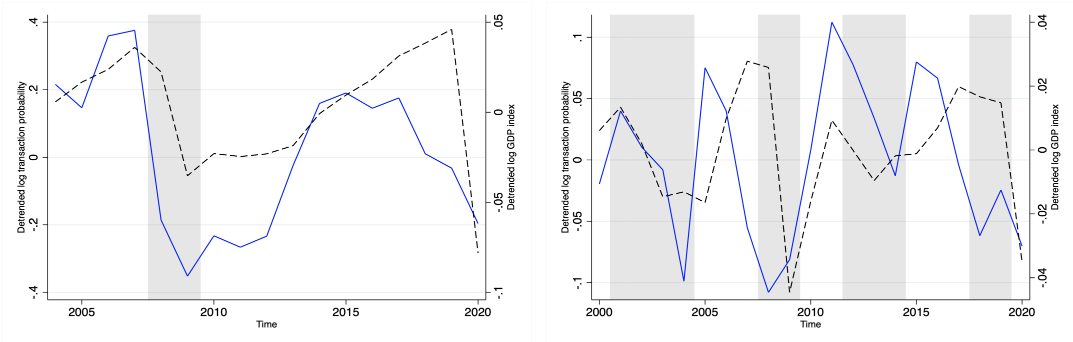
Notes: Figure 7 illustrates the measure of annual average housing market congestion for German cities. Housing market congestion is constructed as the ratio of housing transactions to housing stock within a city.

The observation that housing market congestion increases with income holds true over the business cycle. As depicted in Figure 8, the cyclical components of transaction probability are shown

[4]Correlations from 6a and 6b align with the existing literature such as Ioannides and Zabel (2018) and Ngai and Sheedy (2020a).

Figure 8: Cyclical Components of Transaction Probability and Real GDP

(a) Transaction probability and GDP UK (b) Transaction probability and GDP Germany



Notes: Figure 8 illustrates the cyclical components of transaction probability alongside the cyclical components of GDP for both the United Kingdom and Germany. The blue lines are detrended transaction probabilities, while the dotted black lines are detrended GDP.

alongside the cyclical components of GDP for both the United Kingdom and Germany. This illustration highlights that congestion faced by buyers and renters is pro-cyclical, aligning with the findings of Ioannides and Zabel (2018). Quantitatively, the detrended congestion demonstrates an overall correlation of 0.535 with detrended GDP.

Despite the model-implied measure of congestion being constructed using data from the home ownership market, there are indications that it could also reflect the waiting time faced by renters. Additionally, I restrict the analysis to periods with low mortgage rates (2009-2021) to enhance the comparability of ownership and rental markets as close substitutes. This approach would strengthen the robustness of the empirical findings.

4.2 Baseline Regressions

The baseline regression corresponds to Equation (14). However, I replace tightness with transaction probability, since the latter variable measures congestion in the empirical section. Nevertheless, since $f(X_i)$ strictly increases with X_i, results of the theoretical framework would still hold. Appendix A shows this formally.

$$\text{net out-migration rate}_{it} = \alpha + \beta_1 \text{trans-prob}_{it} + \beta_2 \text{rent}_{it} + C_{it}'\Gamma + \eta_i + \epsilon_{it}. \quad (17)$$

The dependent variable, denoted as net out-migration rate$_{it}$, is computed as the ratio of net emigrants in internal migration to the mid-year population in city i at time t. i corresponds to 34 major European cities in the model, while t corresponds to the time period of 2009-2021. trans-prob$_{it}$ denotes transaction probability, which is the ratio of housing transactions to housing stock, in city i at time t. This variable captures congestion faced by home buyers and renters. β_1 is the coefficient of interest. Given that the sample comprises 34 major European cities with some of the tightest housing markets in their respective countries, the theoretical framework predicts β_1 is positive and significant.

The rest of the variables in (17) are standard. rent$_{it}$ is the log real rent in city i at time t, which

Table 3: Correlations Between Net Out-migration Rate and Transaction Probability

Dep. Variable:	net out-migration rate			
	Panel A		Panel B	
	(1)	(2)	(3)	(4)
Transaction probability	0.174**	0.200***	-0.404***	-0.290
	(0.0630)	(0.0535)	(0.145)	(0.172)
log real rent	0.00929***	0.00227	0.00924***	0.0013
	(0.00373)	(0.00460)	(0.00326)	(0.00322)
Transaction probability × dummy			0.596***	0.501***
			(0.155)	(0.172)
N	266	266	266	266
adj. R^2	0.20	0.31	0.23	0.24
City & country FE	✓	✓	✓	✓
Time FE		✓		✓
Cluster robust SE	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panel A of Table 3 presents the estimation results of equation (17). Column (1) and (2) show the estimation results with and without time fixed effects respectively. The first row of panel A are estimates β_1 in equation (17), which is the correlation between housing transaction probability and net out-migration rate for all cities. The second row of panel A are estimates β_2 in equation (17), which is the correlation between housing rent and out-migration rate. Panel B of Table 3 shows the estimation results from equation (18). Column (3) and (4) are estimation results with and without the time fixed effects respectively. The coefficients in the first row represent the estimates of β_1 in equation (18), which denote the correlation between transaction probability and the net out-migration rate for cities characterised by loose housing markets. The coefficients in the third row represent the estimates of β_3 in equation (18), highlighting the difference in the correlation between transaction probability and the net out-migration rate between cities with tight and loose housing markets. Controls include real disposable income per capita and local unemployment rates.

serves as a control variable. Furthermore, it's worth noting that some of the effects of congestion on out-migration can potentially be mediated through rents. By including rent_{it} in Equation (17), it could help to disentangle the association between congestion and out-migration from the impact of rents. C_{it} denotes a set of controls, which includes real disposable income per capita and local unemployment rates. The vector Γ comprises the coefficients associated with controls. η_i is the city fixed effect, which controls for local amenities such as school quality. The error term is denoted as ϵ_{it}.

Panel A of Table 3 presents the estimation results for Equation (17). Columns (1) and (2) display the outcomes with and without time fixed effects, respectively. The results indicate a positive correlation between transaction probability and the out-migration rate, even after controlling for rent. This suggests a positive association between housing market congestion faced by buyers and net out-migration. Moreover, in line with existing literature, the point estimates for the correlation between the net out-migration rate and rent consistently show a positive relationship, though significance is observed only in the specification without the time fixed effect.

Given that the sample comprises 34 major European cities with some of the tightest housing markets in their respective countries, the findings in Panel A of Table 3 affirm the model-predicted positive correlation between housing market congestion and out-migration in cities characterised by tight housing markets. Furthermore, to the best of my knowledge, this study is the first to demonstrate this empirical pattern.

Furthermore, I validate the state-dependent nature of the impact of housing market congestion on inter-regional relocation, as envisaged by the model, using the following specification:

$$\text{net out-migration rate}_{it} = \alpha + \beta_1 \text{trans-prob}_{it} + \beta_2 \text{trans-prob}_{it} \times D_i + \beta_3 \text{rent}_{it} + \Gamma C_{it} + \eta_i + \epsilon_{it}. \quad (18)$$

The sole distinction between (17) and (18) lies in the inclusion of the dummy term D_i. This binary variable takes a value of 0 if the average annual transaction probability in city i is at the lowest quantile and 1 otherwise. In other words, cities with relatively less congested housing markets in the sample are indicated by $D_i = 0$. The remaining explanatory and control variables in (18) are identical to those in (17). Note that in Equation (18), β_1 represents the correlation between transaction probability and the net out-migration rate in cities characterised by relatively loose housing markets, which is predicted to be negative by the theoretical framework. On the other hand, $\beta_1 + \beta_2$ encapsulates this correlation for cities with relatively tight housing markets, which is predicted to be positive by the model.

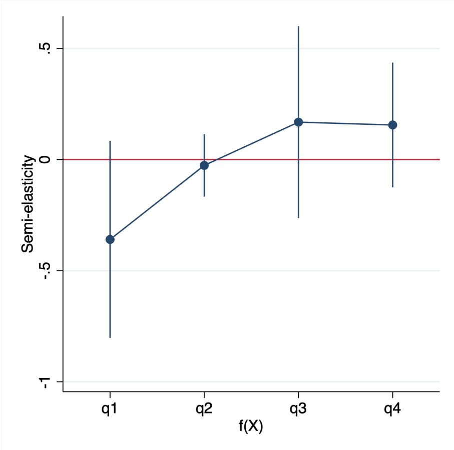
Panel B of Table 3 shows the estimation results from equation (18). Column (3) and (4) are estimation results with and without the time fixed effects respectively. The coefficients in the first row represent the estimates of β_1, which denote the correlation between transaction probability and the net out-migration rate for cities characterised by loose housing markets. The coefficients in the third row represent the estimates of β_3, highlighting the difference in the correlation between transaction probability and the net out-migration rate between cities with tight and loose housing markets.

Three interesting observations emerge from these results. First, for cities with relatively loose housing markets, there exists a negative association between transaction probability and out-migration, as implied by the estimates of β_1 in the first row. [5] Second, the difference in the correlation between transaction probability and out-migration between cities with tight and loose housing markets is positive and significant, as indicated by the estimates of β_2 in the third row. Third, the overall relationship between transaction probability and out-migration is positive for cities with relatively tight housing markets, as inferred from the fact that estimates $\beta_1 + \beta_2 > 0$. These findings emphasise the state-dependent nature of the association between housing market congestion and out-migration, validating the theoretical framework's prediction. Lastly, such a state-dependent relationship can also be generated by the theoretical framework, which is illustrated in Appendix D.

Figure 9 provides a visual representation of this state dependency by plotting the correlation between transaction probability and net out-migration rate, as represented by the coefficient β_1 from (17), across cities ranging from the loosest to the tightest housing markets. As depicted in Figure 9,

[5] Although the point estimate is only significant for the specification without the time fixed effect, the P value for the specification with the time fixed effect is 0.105, which is a borderline rejection at 10% significance level.

Figure 9: Correlation Between Transaction Probability and Net Out-migration Rate



Notes: Figure 9 illustrates the estimates of β_1 derived from Equation (17) for cities falling within different quarters of transaction probability, ranging from the lowest quarter (q1) to the highest quarter (q4). Vertical blue lines are the error bars.

the correlation between congestion faced by buyers and the out-migration rate is initially negative for cities in the bottom 25% in terms of housing demand relative to supply. This correlation increases with congestion, eventually turning positive for cities situated in the top half in terms of housing market tightness.

Two robustness tests are performed to validate the results in Table 3, which are reported in Appendix B. The first test, shown in Table B.1, utilises bootstrap standard errors to estimate (17) and (18) ,addressing concerns over the limited number of observations. The second test, illustrated in Table B.2, introduces a sign restriction and estimates (17) and (18) using a sub-sample in which real rent increases. This test aims to address concerns regarding whether transaction probability alone can adequately capture "hotness" in the housing market. After restricting the sign of change in real rent to positive, an increase in transaction probability would suggest a higher likelihood of buyer congestion within the market. The findings from these robustness tests align closely with the results of the baseline regression.

In conclusion, the empirical section substantiates the model's prediction of a positive correlation between housing market congestion for buyers and internal migration outflows in tight housing markets. Furthermore, it confirms the state-dependent nature of this correlation. In the next section, using pairwise migration data, I show that places with less housing market congestion could attract more emigrants after controlling for rent and local economic conditions.

4.3 Pairwise Migration

This section investigates correlations between destination characteristics and migration outflows. Utilising the pairwise migration data from 2014-2020 for major cities in the United Kingdom, I esti-

Table 4: Correlation Between Destination Transaction Probability and Out-migration

Dep. Variable:	log out-migration rate	
	(1)	(2)
Destination transaction probability	-6.828***	-6.828***
	(1.307)	(1.307)
N	2953	2953
adj. R^2	0.15	0.15
Origin - Destination FE	✓	✓
Origin - Time FE	✓	✓
Time FE	✓	✓
Cluster robust SE	✓	✓
Destination rent psf	✓	
Destination rent per unit		✓
Controls	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table estimates equation (19) to show that people migrate to places with less tight housing markets. Rent in column A is measured as real rent per square feet at the destination. Rent in column B is measured as real rent per unit at the destination. Additional controls include log destination real disposable income per capita and destination unemployment rate.

mate the following equation:

$$\text{log out-migration rate}_{ijt} = \alpha + \beta_1 \text{trans-prob}_{jt} + C'_{jt}\Gamma + \eta_{ij} + \delta_{it} + \gamma_t + \epsilon_{it}, \tag{19}$$

where i denotes migration origin and j represents migration destination. η_{ij} is the origin-destination fixed effect, δ_{it} is the origin-time fixed effect, and γ_t is the time fixed effect. Furthermore, given the wealth of data provided by PMA for the United Kingdom, destination housing rent, which is a part of the control C_{jt}, has measures both in terms of annual rent per square foot (psf) and annual rent per unit.

The estimation outcomes of Equation (19) are laid out in Table 4. Column (1) presents the point estimate using rent per square foot data, while Column (2) shows the same point estimate using rent per unit data. The findings suggest that out-migration to a destination is negatively correlated with that destination's housing transaction probability, implying that emigrants from major cities in the United Kingdom prefer to migrate to cities where they face less housing market search frictions.

Finally, the inclusion of pairwise migration data enables me to address concerns about migration being driven by job-related factors rather than housing market conditions. By narrowing down the sample to the below-median and the lowest quantile of distance between migration origin and destination, I enhance the likelihood of capturing instances where individuals can continue participating in the same labour market post-migration. Despite this restriction, as reported in Table C.3 in Appendix C, the observed negative and significant correlation between housing market congestion in the destination and migration flows remains robust. This finding aligns with Bergman et al. (Forthcoming), supporting the notion that workers' choices of neighborhoods within a city may be influenced by search and matching frictions in the housing market.

In conclusion, Section 4 has substantiated two relationships predicted by the model. First, housing market congestion is positively associated with out-migration for cities with tight housing markets. Second, this association is state-dependent, contingent on how tight the housing market is. Moreover, I demonstrate that emigrants from major cities in the United Kingdom prefer destinations with low housing market congestion. Given the empirical validation of the model's predictions, I employ the theoretical framework for policy analysis in Section 5.

5 Policy

Utilising the theoretical framework, this section evaluates popular housing market policies. Housing market policies encompass both demand-side and supply-side approaches. Demand-side policies, exemplified by programs such as *Housing Benefit* (HB) in the United Kingdom and *Mietzuschuss* in Germany, have been employed to provide rent subsidies historically. In recent years, there has been a growing emphasis on supply-side policies. The 2019 Conservative Government's manifesto in the United Kingdom pledged to "sustain efforts to continually increase the number of homes being constructed" (Wilson (2021)), mirroring similar commitments made in Ireland (Armstrong (2022)) and the Netherlands (Oostveen (2022)).

Both demand and supply-side policies carry significant weight; for example, HB is consistently ranked as one of the largest budget items within the Department for Work and Pensions in the United Kingdom. Meanwhile, the *Programma Woningbouw* in the Netherlands aims to add 900,000 new houses between 2022 and 2030. Given the substantial scale of these policies, it becomes imperative to assess their effectiveness, resonating with the long-standing "subsidy/house production" debate (Apgar Jr (1990), Galster (1997), Yates and Whitehead (1998)).

I show that a rent subsidy would be welfare-reducing if imposed to a city where buyers face high level of congestion, confirming the ineffectiveness of housing subsidy when the housing market is tight (Weicher (1990)). The rationale lies in the fact that subsidies would further escalate housing demand. Consequently, congestion externalities would outweigh thick market effects in a tight housing market, as illustrated by the comparative statics in 2.5.1. Supply-side measures, on the other hand, could be welfare-enhancing.

Moreover, I show that the presence of search and matching frictions is central in determining policy outcomes. The implications for policy significantly differ if the Housing market is Walrasian. Lastly, I highlight that migration would endogenously respond to policies, mitigating the positive effects of the good ones and lessening the negative impacts of the bad ones.

This section is organised as follows. First, for simplicity, I illustrates the effects of demand and supply-side policies without considering migration. Then, I revisit these evaluations in a context that accounts for migration.

5.1 Without Migration

To simplify, I examine the effectiveness of two policies in a migration-free environment. The demand-side policy consists of a rent subsidy financed through taxation, drawing loose parallels with real-world examples like HB. The supply-side policy involves expanding the housing stock funded by taxation, with the rental income from the additional houses being rebated to taxpayers. Consistent with earlier sections, I concentrate on implementing these policies in a city with a constrained housing market. This city aligns with the samples utilised in the empirical section and is prone to facing a housing crisis.

Recall that housing market equilibrium in city i is defined as aggregate housing demand meets supply. Therefore, $(1+\tau(X_i))^{\epsilon}(\mathcal{C}_i^S(X_i) - \mathcal{C}_i^D(X_i, P_i)) = 0$. Substituting in the definition of $C_i^S(X_i)$ and $\mathcal{C}_i^D(X_i, P_i)$, the equilibrium tightness in city i satisfies $f(X_i)(1+\tau(X_i))^{\epsilon-1} = \frac{\chi_i^{\epsilon}}{\bar{K}_i}\frac{\bar{\mu}_i}{P_i} \times N_i$.

5.1.1 Demand-side Policy

Consider a lump-sum rent subsidy S_T imposed in city T where the housing market equilibrium is tight, and is funded by lump-sum taxes in both city T and L, where the housing market equilibrium is loose in the latter city. The equilibrium tightness in each city satisfies the following equations respectively

$$f(X_T)(1+\tau(X_T))^{\epsilon-1} = \frac{\chi_T^{\epsilon}}{\bar{K}_T}\frac{\bar{\mu}_T + \frac{(\mathcal{S}_T - \mathcal{T}_T)}{N_T}}{P_T} \times N_T, \tag{20}$$

$$f(X_L)(1+\tau(X_L))^{\epsilon-1} = \frac{\chi_L^{\epsilon}}{\bar{K}_L}\frac{\bar{\mu}_L - \frac{\mathcal{T}_L}{N_L}}{P_L} \times N_L, \tag{21}$$

where $\mathcal{S}_T > 0$ and $\mathcal{T}_i > 0$ represent subsidy and lump-sum taxes in city T and L. Moreover, the government's budget is balanced, and hence, $S_T = \mathcal{T}_T + \mathcal{T}_L$, which implies $\mathcal{S}_T - \mathcal{T}_T > 0$. I then divide subsidy and taxes by population, and effectively, per household endowment increases in T, and decreases in L.

Because $f(X_i)$ and $(1+\tau(X_i))$ are increasing in X_i for $i = T, L$, the left hand side of (20) and (21) both increase with tightness. Therefore, the net rent subsidy (i.e. rent subsidy net of tax) would increase the tightness in the tight city, while the tax would decrease the tightness in the loose city. That is, $\frac{dX_T}{d(\mathcal{S}_T - \mathcal{T}_T)} > 0$ and $\frac{dX_L}{d\mathcal{T}_L} < 0$.

From Section 2.5.1, in a fixed-price equilibrium, an increase in tightness would decrease aggregate housing consumption if the equilibrium is tight, and vice versa if the equilibrium is loose. Therefore, $\frac{d\mathcal{C}_T}{d(\mathcal{S}_T - \mathcal{T}_T)} = \frac{d\mathcal{C}_T}{dX_T}\frac{dX_T}{d(\mathcal{S}_T - \mathcal{T}_T)} < 0$ since first term is negative and second term is positive. Moreover, $\frac{d\mathcal{C}_L}{d\mathcal{T}_L} = \frac{d\mathcal{C}_L}{dX_L}\frac{dX_L}{d\mathcal{T}_L} < 0$ since the first term is positive and second term is negative. Hence, rent subsidy funded by a lump sum tax would decrease aggregate housing consumption in both cities T and L. I define the aggregate welfare as the joint aggregate housing consumption across two cities, and therefore, a lump-sum subsidy would reduce welfare.

The adverse effects of a rent subsidy on housing consumption and aggregate welfare are fundamentally shaped by search and matching friction. In a Walrasian market, on the other hand, a rent subsidy would universally increase housing consumption in any city, and conversely, a lump-sum tax would have the opposite effect. Therefore, the welfare impact of a rent subsidy funded by a lump-sum tax is ambiguous.

Formally, when the search and matching cost $\rho = 0$, from (10), the aggregate housing supply in city i is $\mathcal{C}i^S = f(Xi)\bar{K}_i$, which strictly increases with tightness [6]. Moreover, $\tau(X_i) = 0$ since $\tau(X_i) \equiv \frac{\rho}{q(X_i)-\rho}$. Consequently, the aggregate housing demand in city i can be expressed as $\mathcal{C}i^D = \frac{\chi i^{\epsilon}\bar{\mu}}{P_i} \times N_i$, which is independent of tightness [7]. The equilibrium tightness in city i hence satisfies $f(X_i) = \frac{\chi_i^{\epsilon}\bar{\mu}i}{Pi\bar{K}_i} \times N_i$, indicating that housing market tightness still increases with endowment. Since endowment increases with net subsidy and decreases with tax, housing market tightness would also increase with net subsidy and decrease with tax.

Furthermore, $\frac{d\mathcal{C}i^S}{dXi} > 0$ for $i \in (T, L)$ in the absence of search and matching cost, and $\mathcal{C}_i = \mathcal{C}_i^S$ in a housing market equilibrium. As a result, $\frac{d\mathcal{C}T}{d(\mathcal{S}_T - \mathcal{T}_T)} = \frac{d\mathcal{C}T^S}{dX_T}\frac{dX_T}{d(\mathcal{S}_T - \mathcal{T}_T)} > 0$, as both terms are positive. Conversely, $\frac{d\mathcal{C}L}{d\mathcal{T}_L} = \frac{d\mathcal{C}L^S}{dX_L}\frac{dX_L}{d\mathcal{T}_L} < 0$, since the first term is positive but the second term is negative. Therefore, a tax-funded rent subsidy would increase housing consumption in city T while decreasing it in city L, resulting in an ambiguous implication on aggregate welfare.

Figure 10 depicts the effects of a rent subsidy in markets with and without search and matching frictions, illustrated in Panel A and B, respectively. The superscript 0 denotes values prior to the implementation of the policy, while the superscript 1 denotes values after the implementation of the policy. Figure 10a highlights that a rent subsidy effectively increases the endowment for all households in city T and shifts the demand curve outwards, resulting in higher tightness, which reduces aggregate consumptiohousing n in city T. Figure 10b shows that the tax lowers the endowment for all households in city L and shifts the demand curve inwards, resulting in lower tightness, which reduces aggregate housing consumption in city L.

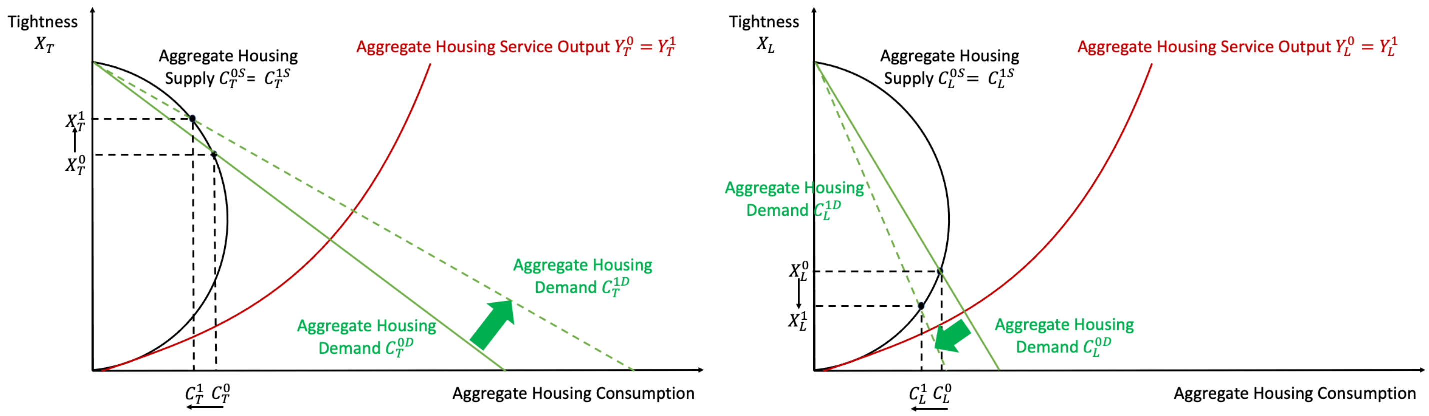
Without the search and matching frictions, a rent subsidy would still increase aggregate housing demand in city T; however, as depicted in Figure 10c, consumption also increases, contrasting the scenario where search and matching frictions are considered. Lastly, Figure 10d shows that the implications of the tax used to fund the rent subsidy in city L are qualitatively similar, regardless of whether search and matching frictions are considered or not - both tightness and consumption would decrease.

[6]Therefore, aggregate housing supply has a positive slope in the tightness - consumption space, which is illustrated in the Panel B of Figure 10

[7]Hence, aggregate housing supply is a straight line in the tightness - consumption space, which is illustrated in the Panel B of Figure 10

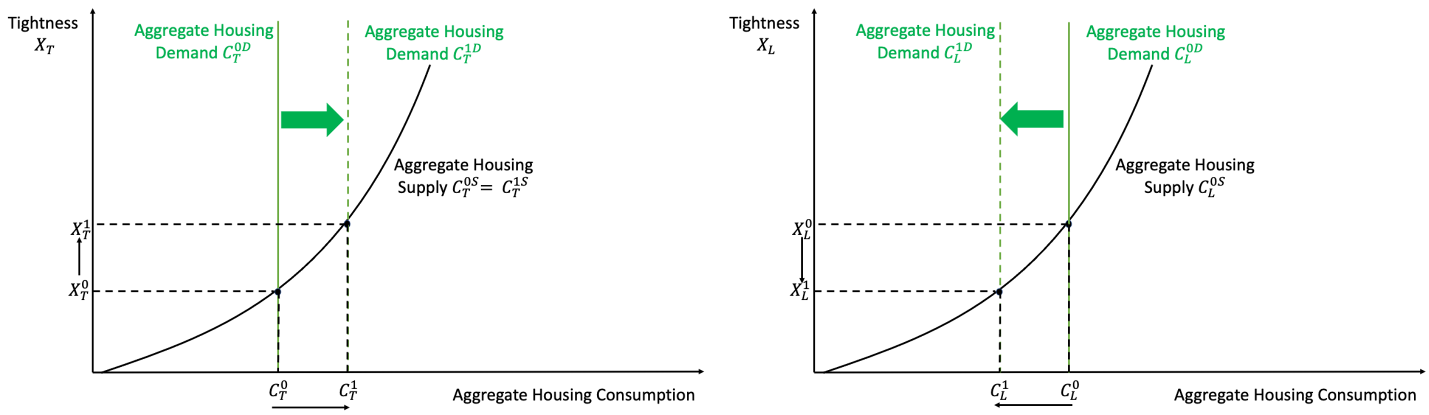
Figure 10: Implications of a Tax-funded Rental Subsidy

(a) City T (b) City L



Panel A: implications with search and matching frictions

(c) City T (d) City L



Panel B: implications without search and matching frictions

Notes: Figure 10 depicts the effects of a rent subsidy in markets with and without search and matching frictions, illustrated in Panel A and B, respectively. The superscript 0 denotes values prior to the implementation of the policy, while the superscript 1 denotes values after the implementation of the policy.

5.1.2 Supply-side Policy

Consider an expansion of housing stock in city T where the housing market equilibrium is tight, which is funded by lump-sum taxes imposed in both city T and L. The rental income from the additional housing stock is rebated to taxpayers such that no profits or losses are incurred. Therefore, after dividing rental incomes and taxes by population, as they effectively change per household endowment, tightness in each city satisfies the following equations respectively,

$$f(X_T)(1+\tau(X_T))^{\epsilon-1} = \frac{\chi_T^{\epsilon}}{\bar{K}_T + K'} \frac{\bar{\mu}_T + \frac{\mathcal{I}_T - \mathcal{T}_T}{N_T}}{P_T} \times N_T, \tag{22}$$

$$f(X_L)(1+\tau(X_L))^{\epsilon-1} = \frac{\chi_L^{\epsilon}}{\bar{K}_L} \frac{\bar{\mu}_L + \frac{\mathcal{I}_L - \mathcal{T}_L}{N_L}}{P_L} \times N_L, \tag{23}$$

where $K^{'}$ represents the additional housing stock. $\mathcal{T}_T$ and $\mathcal{T}_L$ stand for lump-sum taxes in city T and L. $\mathcal{I}_T$ and $\mathcal{I}_L$ represent the rental income generated from the additional housing stock in city T and L. Since no profits or losses are made from the additional housing stock, $\mathcal{I}_i - \mathcal{T}_i = 0$ for $i \in (T, L)$.

Therefore, employing an analysis analogous to the ones used in investigating the demand-side policy, an expansion of the housing stock funded by taxes would increase aggregate housing consumption in city T. To elaborate, after the implementation of the policy, the right-hand side of (22) would decrease since $K^{'} > 0$, and hence, tightness would decrease in city T, resulting in an increased aggregate housing consumption according to comparative statics reported in 2.5.1. On the other hand, aggregate consumption is unchanged in city L since supply and demand stay constant. The policy's effect on aggregate welfare, which is the total housing consumption across two cities, is positive.

The policy implications of expanding the housing stock funded by a lump-sum tax differ between Walrasian and frictional markets. In the absence of search and matching frictions, changes in housing supply alone do not impact aggregate housing consumption, as the demand is represented by a vertical line in the tightness-consumption space. Therefore, the expansion of housing supply does not lead to improved consumption in city T, unlike the case when market frictions are considered. Consequently, the expansion of the housing stock funded by taxes would not alter the aggregate welfare in a Walrasian market. This finding contrasts with the potential positive implications for welfare that arise when considering market frictions.

Figure 11 illustrates the implications of a tax-funded housing expansion with and without search and matching frictions, depicted in Panel A and B, respectively. Figure 11a shows that increasing the housing stock would shift the aggregate housing supply out in city T. Consequently, tightness decreases and housing consumption increases in city T. Housing consumption is unchanged in city L, as depicted in 11b.

As highlighted in Figure 11c, an expansion in housing stock still shifts the aggregate housing supply outward in the absence of search and matching frictions, resulting in decreased tightness.

However, this change alone would not affect consumption in a Walrasian market. Lastly, Figure 11d shows that the implications of the housing stock expansion in city T does have have any effect in city L, regardless of whether search and matching frictions are considered or not.

5.2 With Migration

After allowing for migration, the equilibrium tightness satisfies

$$f(X_i)(1+\tau(X_i))^{\epsilon-1} = \frac{\chi_i^{\epsilon}}{\bar{K}_i}\frac{\bar{\mu}_i}{P_i} \times (N_i + \Delta N_i(X_i, P_i)), \tag{24}$$

where $\Delta N_i(X_i, P_i)$ represents the change in population. From previous derivations, $\Delta N_i(X_i, P_i) < 0$ in a fixed-price equilibrium when $i = T$. In other words, when tightness increases in a city where the housing market is in a tight equilibrium, there will be out-migration. Conversely, when tightness decreases in such a city, there will be in-migration.

These characteristics indicate that migration would offset policy interventions in city T by responding inversely to changes in tightness. For example, if a policy increases the endowment $\bar{\mu}$, the right-hand side of (24) rises. Consequently, the left-hand side of (24) also increases, leading to a higher X_i. However, $\Delta N_i(X_i, P_i)$ would be negative due to the increase in tightness. Thus, the rise in the right-hand side of (24) is less pronounced compared to the scenario without migration. Consequently, the increase in housing market tightness X_i would be less significant than in the scenario without migration, as the rise on the right-hand side of (24) would be smaller.

Appendix E discusses the policy implications of rental subsidy and stock expansion after accounting for migration. In both cases, the changes in tightness and consumption are of a smaller magnitude compared to the scenario when migration is absent.

Overall, Section 5 highlights that while both rental subsidy and housing stock expansion alleviate housing crisis, they have contrasting effects when implemented in a city where housing demand is high relative to supply. Rental subsidy would be ineffective, while housing stock expansion could be welfare-enhancing. Moreover, search and matching frictions would be essential to generate these policy implications.

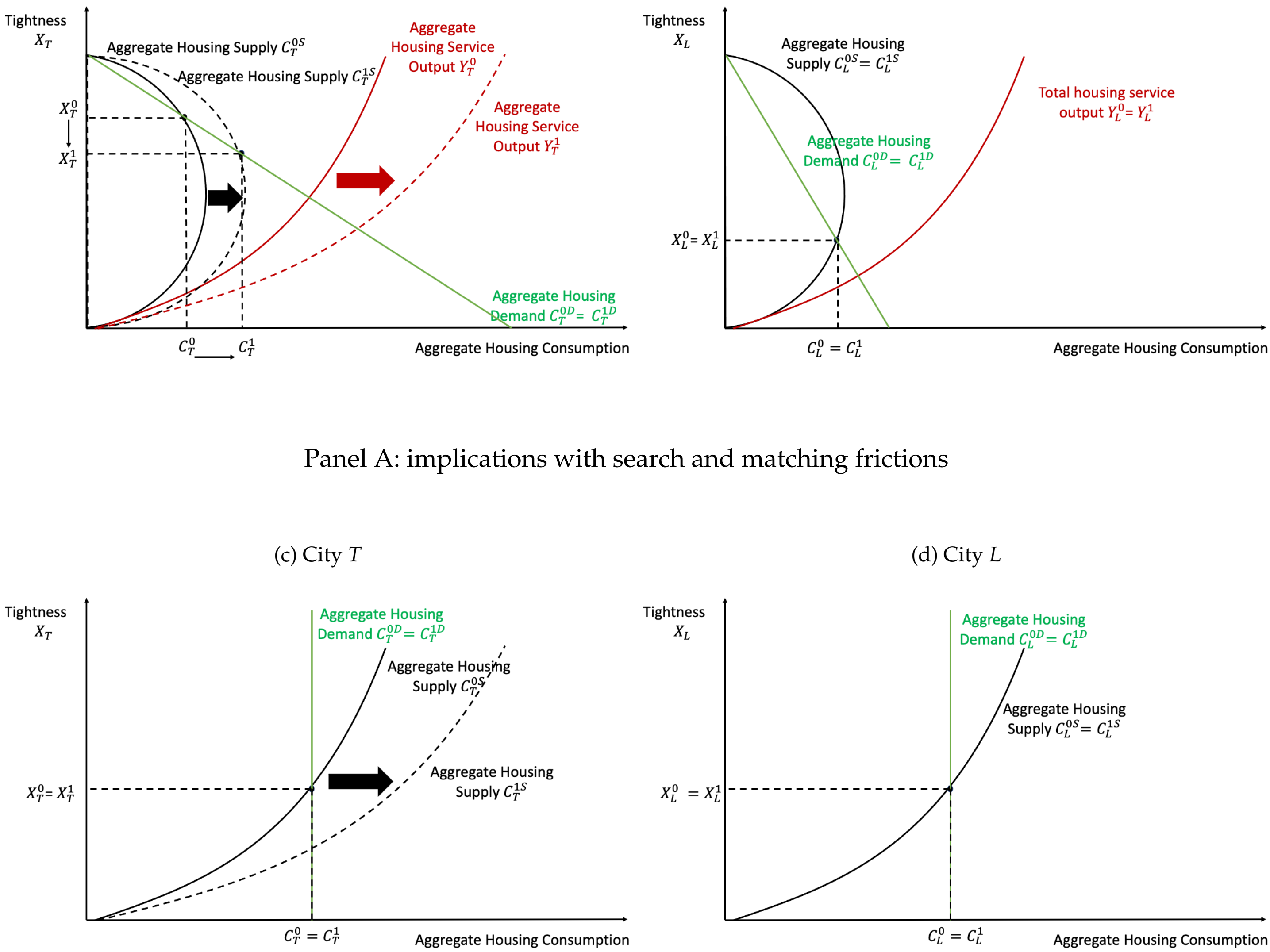
6 Conclusion

In summary, this research proposes that congestion faced by renters in the housing market could be associated with internal migration trends. This mechanism is distinct from the well-established concepts of "lock-in" and cost-related pathways.

First, I present a canonical framework demonstrating that heightened housing market congestion in cities with tight housing markets correlates with out-migration. Additionally, I establish that the

Figure 11: Implications of a Tax-funded Housing Stock Expansion

(a) City T (b) City L



Panel A: implications with search and matching frictions

(c) City T (d) City L

Panel B: implications without search and matching frictions

Notes: Figure 11 illustrates the implications of a tax-funded housing expansion with and without search and matching frictions, depicted in Panel A and B, respectively. The superscript 1 denotes values prior to the implementation of the policy, while the superscript 0 denotes values after the implementation of the policy.

relationship between congestion and inter-regional relocation depends on the state of the housing market; increased congestion could lead to in-migration if the housing market is loose.

Using a proprietary dataset covering 34 major European cities, I empirically validate the model's predictions. I observe a generally positive, yet state-dependent, correlation between out-migration and congestion experienced by buyers, revealing novel empirical patterns.

Policy evaluations offer crucial insights, highlighting the limitations of rent subsidies in cities with tight housing markets, contrasting with the potential welfare-enhancing effects of housing stock expansions. The presence of search and matching frictions is pivotal to these policy implications, with outcomes diverging significantly in a Walrasian housing market.

In conclusion, this research enhances our understanding of the relationship between housing markets and migration decisions. The derived implications could inform more effective place-based policies.

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Housing Market Congestion and Internal Migration

Charles Cheng Zhang

Online Appendix

Content

A Migration With Transaction Probability

Appendix A shows that the model's predictions would be the same when the variable of interest becomes transaction probability.

Times and divide $f(X_i)$ on the right hand side of (14),

$$\underbrace{-\frac{dN_i}{N_i}}_{\text{out-migration rate}} = \underbrace{[-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i} + \frac{\partial \log C_i}{\partial X_i}]\frac{dX_i}{f(X_i)}}_{\text{Semi-elasticity of out-migration w.r.t. trans. probability}} f(X_i) + \frac{\partial \log C_i}{\partial P_i} dP_i. \tag{25}$$

This equation corresponds to the baseline regression (17). In a fixed-price equilibrium, (25) can be re-expressed as

$$-\frac{dN_i}{N_i} = [-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}\frac{dX_i}{f(X_i)}]f(X_i) + \frac{1}{C_i}dC_i. \tag{26}$$

Households opt to migrate to improve their consumption in the model's framework, implying that $dC_i > 0$ when migration occurs. Additionally, in a tight equilibrium, $-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}$ is negative, as elaborated upon in Section 2.5.1. Lastly, $f(X_i)$ is always positive by construction. Hence, if dX_i is positive, $-\frac{dN_i}{N_i}$ is positive in a tight equilibrium. In other words, increased buyer congestion is associated with out-migration in a tight equilibrium.

Vice versa, if the housing market is in a loose equilibrium, $-\frac{f'(X_i)-\rho}{f(X_i)-\rho X_i}$ is positive. Therefore, an increase in buyer congestion would be associated with in-migration. The state-dependent effect of congestion on migration again depends on the trade-off between thick market and congestion externality.

Therefore, when the variable of interest is $f(X_i)$, representing transaction probability, the relationship between housing market congestion and internal migration remains consistent with the model introduced in Section 2, where tightness X_i is the primary focus.

B Baseline Regression Robustness Check

Appendix B performs two robustness tests. The first robustness test estimates equation (17) and (18) using bootstrap standard errors. The second robustness tests estimates the same two equations, but restricting sample size to positive changes in real rent. The results are reported in the following two tables.

Table B.1: Robustness Check: Bootstrap SE

Dep. Variable:	net out-migration rate	
	(1)	(2)
Transaction probability	0.200***	-0.290*
	(0.0462)	(0.165)
log real rent	0.00227	0.00238
	(0.00561)	(0.00466)
Transaction probability × dummy		0.50***
		(0.165)
N	266	266
adj. R^2	0.23	0.25
City & country FE	✓	✓
Time FE	✓	✓
Bootstrap SE	✓	✓
Controls	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Column (1) of table B.1 presents the estimation results of equation (17) using bootstrap standard errors. The first row of column (1) is the estimate of β_1 in equation (17), which is the correlation between housing transaction probability and net out-migration rate for all cities. The second row of column (1) are estimates β_2 in equation (17), which is the correlation between housing rent and out-migration rate. Column (2) of Table 3 shows the estimation results from equation (18). The coefficients in the first row represent the estimates of β_1 in equation (18), which denote the correlation between transaction probability and the net out-migration rate for cities characterised by loose housing markets. The coefficients in the third row represent the estimates of β_3 in equation (18), highlighting the difference in the correlation between transaction probability and the net out-migration rate between cities with tight and loose housing markets. Controls include real disposable income per capita and local unemployment rates.

Table B.2: Robustness Check: Sign Restriction On Rent

Dep. Variable:	net out-migration rate	
	(1)	(2)
Transaction probability	0.136**	-0.244
	(0.0582)	(0.196)
log real rent	0.000982	0.00138
	(0.00464)	(0.00474)
Transaction probability × dummy		0.391*
		(0.198)
N	203	203
adj. R^2	0.26	0.28
City & country FE	✓	✓
Time FE	✓	✓
Cluster Robust SE	✓	✓
Controls	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Column (1) of table B.2 presents the estimation results of equation (17) after restricting changes in log real rent to positive. The first row of column (1) is the estimate of β_1 in equation (17), which is the correlation between housing transaction probability and net out-migration rate for all cities. The second row of column (1) are estimates β_2 in equation (17), which is the correlation between housing rent and out-migration rate. Column (2) of Table 3 shows the estimation results from equation (18). The coefficients in the first row represent the estimates of β_1 in equation (18), which denote the correlation between transaction probability and the net out-migration rate for cities characterised by loose housing markets. The coefficients in the third row represent the estimates of β_3 in equation (18), highlighting the difference in the correlation between transaction probability and the net out-migration rate between cities with tight and loose housing markets. Controls include real disposable income per capita and local unemployment rates.

C Pairwise Regression Sample Restriction

Table C.3: Correlation Between Destination Transaction Probability and Out-migration

Dep. Variable:	log out-migration rate	
	(1)	(2)
Destination transaction probability	-5.494***	-3.774**
	(1.700)	(1.147)
N	1397	637
adj. R^2	0.13	0.09
Origin - Destination FE	✓	✓
Origin - Time FE	✓	✓
Time FE	✓	✓
Cluster robust SE	✓	✓
Destination rent psf	✓	
Destination rent per unit		✓
Controls	✓	✓

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

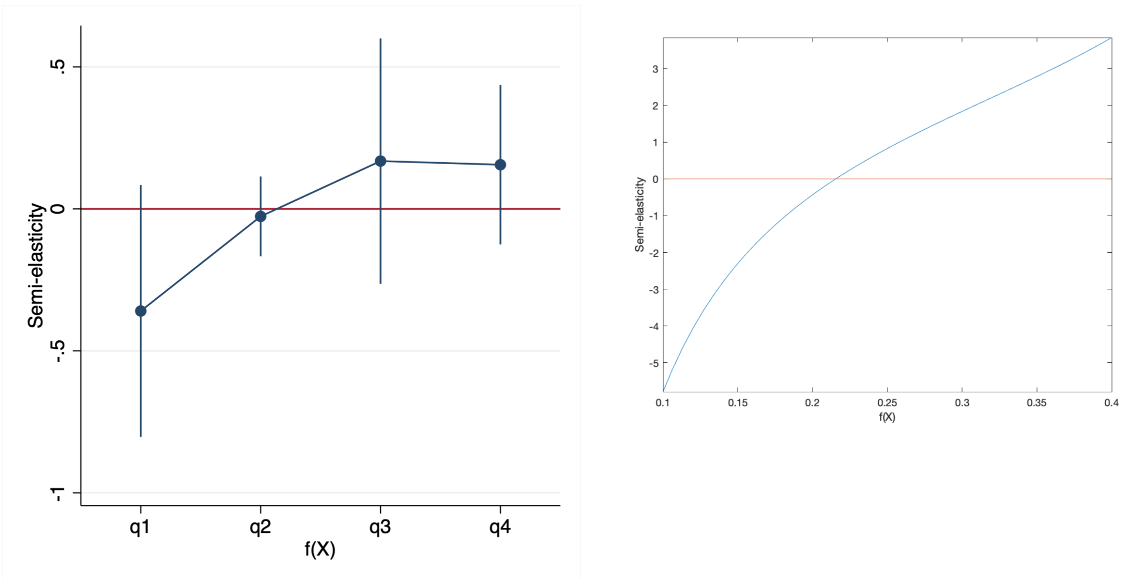
Notes: This table estimates equation (19) with restricted samples. Column A presents the estimation results after restricting sample to the below-median origin-destination migration pairs in terms of distance. Column B presents the estimation results after restricting sample to the closest 25 % origin-destination migration pairs in terms of distance. The distances between origin and destinations are calculated using Google Map. Additional controls include log destination real disposable income per capita and destination unemployment rate.

D Regression and Model-implied Semi-elasticity

Figure D.1: Regression and Model-implied Semi-elasticity

(a) Regression-implied semi-elasticity

(b) Model-implied semi-elasticity



Notes: Figure D.1 plots regression and model-implied semi-elasticity of out-migration to transaction probability $f(X)$ for different levels of $f(X)$. Figure D.1a illustrates this semi-elasticity for different quantiles of $f(X)$ from the baseline regression (17). Figure D.1b depicts this semi-elasticity implied by equation (15) for continuous values of $f(X)$.

E Demand and Supply-side policies

Appendix E discusses the implications of rental subsidy and housing stock expansion when allowing for migration. After allowing for migration, some of the policy implications would become ambiguous. However, in general, the changes in aggregate consumption would be of a smaller magnitude compared to the case when migration is absent.

E.1 Demand-side Policy

Consider the same rent subsidy $\mathcal{S}_T$ imposed in city T which is funded by lump-sum taxes $\mathcal{T}_T$ and $\mathcal{T}_L$, as in section 5.1.1. After taking migration into account, the equilibrium tightness in these cities satisfy the following respectively,

$$f(X_T)(1+\tau(X_T))^{\epsilon-1} = \frac{\chi_T^{\epsilon}}{\bar{K}_T}\frac{\bar{\mu}_T + \frac{(\mathcal{S}_T - \mathcal{T}_T)}{N_T - \Delta N}}{P_T} \times (N_T - \Delta N), \tag{27}$$

$$f(X_L)(1+\tau(X_L))^{\epsilon-1} = \frac{\chi_L^{\epsilon}}{\bar{K}_L}\frac{\bar{\mu}_L - \frac{\mathcal{T}_L}{N_L + \Delta N}}{P_L} \times (N_L + \Delta N). \tag{28}$$

In a two-city setting, the number of emigrants matches the number of immigrants. As such, I omit the subscripts on ΔN for concreteness. Moreover, since lump-sum subsidy and taxes effectively change per household endowment, they are divided by population and added after $\bar{\mu}$.

From (27), the implementation of a tax-funded rental subsidy would still increase tightness after allowing for migration, since the net subsidy $\mathcal{S}_T - \mathcal{T}_T > 0$. However, this increase in tightness is of a smaller magnitude when compared to the scenario without migration. This difference arises because when X_T increases, ΔN is positive, introducing a negative wedge on the right-hand side. This can be shown formally below.

Proposition 1. *A rent subsidy would increase tightness in city T to a lesser extent when compared to the scenario in the absence of migration.*

Proof. The right-hand side of (20) and (27) can be expanded in as the following,

$$\text{RHS of (20)} = \underbrace{\frac{\chi_T^{\epsilon}}{\bar{K}_T}\frac{\bar{\mu}_T}{P_T} \times N_T}_{\text{Term 1}} + \underbrace{\frac{\chi_T^{\epsilon}}{\bar{K}_T}\frac{\bar{\mu}_T}{P_T} \times (\mathcal{S}_T - \mathcal{T}_T)}_{\text{Term 2}}. \tag{29}$$

$$\text{RHS of (27)} = \underbrace{\frac{\chi_T^{\epsilon}}{\bar{K}_T}\frac{\bar{\mu}_T}{P_T} \times (N_T - \Delta N)}_{\text{Term 1}} + \underbrace{\frac{\chi_T^{\epsilon}}{\bar{K}_T}\frac{\bar{\mu}_T}{P_T} \times (\mathcal{S}_T - \mathcal{T}_T)}_{\text{Term 2}}. \tag{30}$$

Since $\chi_T, \epsilon, \bar{K}_T, \bar{\mu}_T$ and P_T are all fixed parameters in a fixed-price equilibrium, they do not change when accounting for migration. Moreover, the net subsidy $\mathcal{S}_T - \mathcal{T}_T$ are the same in (29) and (30). Therefore, term 2 are the same in (29) and (30). However, since ΔN is positive when X_T increases, term 1 is smaller in (30). Hence, the right-hand side increases by less in (27) after facing a rent subsidy compared to (20). Subsequently, the left-hand side also increases less in (27), implying that tightness increases by a smaller extent in (27) compared to (20). ■

Furthermore, given that $\Delta N \geq 0$, the population in city L would increase. Consequently, the right-hand side of (28) becomes larger when compared to the scenario without migration, where $\Delta N = 0$. Consequently, tightness in city T would be higher than in the case where migration is absent.

One simplification that I have made is that I only let households in city T to migrate. Without this assumption, since aggregate and per-household housing consumption both decrease in city T and L after a rent subsidy, the direction of migration would be unclear in my qualitative setting.

In summary, when considering migration, the implementation of a rent subsidy funded by a lump-sum tax could lead to an increase in tightness within city T, although this increase is less significant compared to when migration is absent. Additionally, tightness in city L would decrease less when migration is allowed. As previously explained, an increase in tightness reduces aggregate housing consumption in city T but increases it in city L. As a result, after taking migration into account, changes in aggregate housing consumption would become less negative in both cities compared to the case without migration when facing an expansionary demand-side policy in city T. Consequently, the aggregate welfare would decrease less compared to the scenario when migration is absent. In essence, migration would mitigate the negative effects associated with the lump-sum tax funded rent subsidy.

Much like the scenario without migration, the presence of search and matching frictions in the housing market continues to exert influence on the implications of the rent subsidy policy when migration is permitted. Figure E.2 depicts the effects of a rent subsidy in markets with and without search and matching frictions, illustrated in Panel A and B, respectively. The superscript 0 denotes values prior to the implementation of the policy, the superscript 1 denotes values after the implementation of the policy, and the superscript NM denotes values in the absence of migration, which are the cases discussed in Section 5. Moreover, the effect of migration is highlighted by purple arrows.

From Figure E.2a, the effect of migration on tightness and consumption is in the same direction but with smaller magnitudes compared to the scenarios without migration in city T, denoted by the superscript NM. This is because out-migration would endogenously occur in response to increases in tightness, mitigating the negative implications of the rent subsidy in city T. Moreover, as illustrated in E.2b, city L's consumption improves due to in-migration.

However, when search and matching frictions are not considered, city T would experience in-migration instead of out-migration, as depicted in E.2c. This is due to the fact that aggregate and per household housing consumption would rise in city T after the rent subsidy, which attracts households in city L to relocate. As a result, aggregate housing consumption would increase even more than the case without migration. Conversely, due to out-migration and the subsequent decrease in demand, aggregate consumption would decrease more in city L after allowing for migration, as depicted in figure E.2d.

E.2 Supply-side Policy

Consider the same expansion of housing stock in city T funded by taxes as in section 5.1.2. After taking migration into account, the equilibrium tightness in these cities satisfy the following respectively,

$$f(X_T)(1+\tau(X_T))^{\epsilon-1} = \frac{\chi^{\epsilon}}{\bar{K_T}+K'} \frac{\bar{\mu}_T + \frac{\mathcal{I}_T - \mathcal{T}_T}{N_T - \Delta N}}{P_T} \times (N_T - \Delta N), \tag{31}$$

$$f(X_L)(1+\tau(X_L))^{\epsilon-1} = \frac{\chi_L^{\epsilon}}{\bar{K_L}} \frac{\bar{\mu}_L + \frac{\mathcal{I}_L - \mathcal{T}_L}{N_L + \Delta N}}{P_L} \times (N_L + \Delta N), \tag{32}$$

where $\mathcal{I}_i - \mathcal{T}_i = 0$ since no profits or losses are incurred.

From (31), an expansion in housing stock would lower the housing market tightness in city T, similar to the scenario without migration. However, this decrease in tightness is of a smaller magnitude when compared to the scenario without migration. This difference arises because when X_T decreases, ΔN is negative, which could offset some of the reduction on the right-hand of (31) caused by the expansion in housing stock $K^{'}$. This can be shown formally as follows:

Proposition 2. *A housing stock expansion would decrease tightness in city T to a lesser extent when compared to the scenario in the absence of migration.*

Proof. The right-hand side of (22) and (31) can be expanded in as the following,

$$\text{RHS of (22)} = \frac{\chi_T^{\epsilon}}{\bar{K_T}+K'} \frac{\bar{\mu}_T}{P_T} \times N_T \tag{33}$$

$$\text{RHS of (31)} = \frac{\chi_T^{\epsilon}}{\bar{K_T}+K'} \frac{\bar{\mu}_T}{P_T} \times (N_T - \Delta N). \tag{34}$$

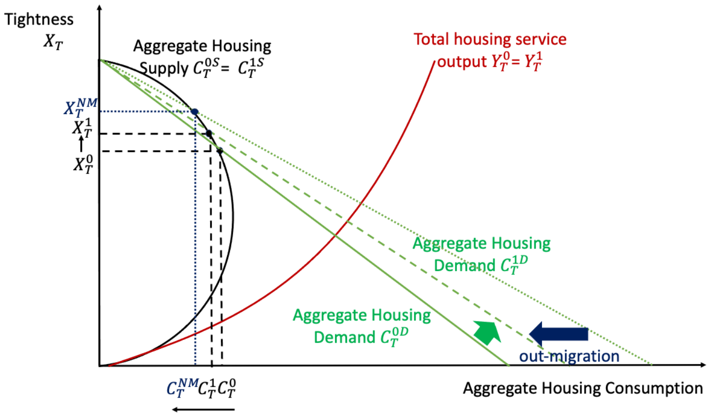
Since $\chi_T, \epsilon, \bar{K_T}, \bar{\mu}_T$ and P_T are all fixed parameters in a fixed-price equilibrium, they do not change when accounting for migration. Since ΔN is negative when X_T decreases, term 1 is bigger in (34). Hence, the right-hand side decreases by less in (31) after facing a tax-funded housing stock expansion compared to (22). Subsequently, the left-hand side also decreases less in (31), implying that tightness decreases by a smaller extent in (31) compared to (22). ■

Furthermore, since $\Delta N \leq 0$, city L could experience out-migration. Therefore, the right-hand side of (32) would be smaller compared to the scenario without migration when implementing the same housing stock expansion policy. Therefore, tightness would be lower in city L after allowing for migration facing the same supply-side policy.

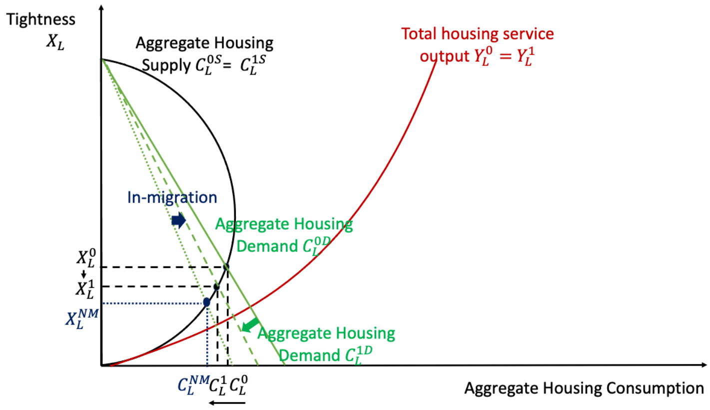
In summary, when considering migration, the implementation of a housing stock expansion funded by a lump-sum tax could lead to a decrease in tightness within city T, although this decrease

Figure E.2: Implications of a tax-funded rental subsidy

(a) City T

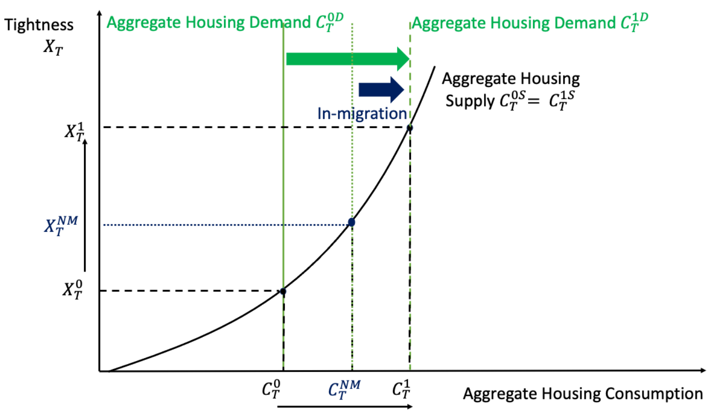


(b) City L

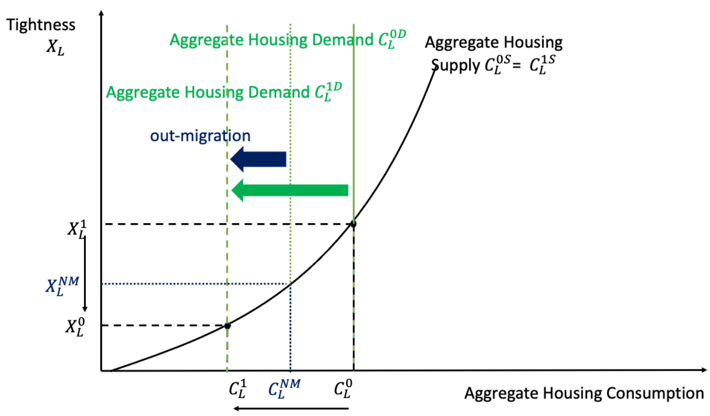


Panel A: implications with search and matching frictions

(c) City T



(d) City L



Panel B: implications without search and matching frictions

Notes: Figure E.2 depicts the effects of a rent subsidy in markets with and without search and matching frictions, illustrated in Panel A and B, respectively. The superscript 0 denotes values prior to the implementation of the policy, the superscript 1 denotes values after the implementation of the policy, and the superscript NM denotes values in the absence of migration, which are the cases discussed in Section 5. Moreover, the effect of migration is highlighted by purple arrows.

is less significant compared to when migration is absent. Additionally, due to out-migration in city L, its housing market tightness would decrease more when migration is allowed. As previously explained, a decrease in tightness improves aggregate housing consumption in city T but reduces it in city L. As a result, after accounting for migration, the changes in aggregate housing consumption would be less positive in city T and more negative in city L compared to the case without migration when implementing an expansionary supply-side policy in city T. Consequently, the aggregate welfare would be lower compared to the scenario when migration is absent.

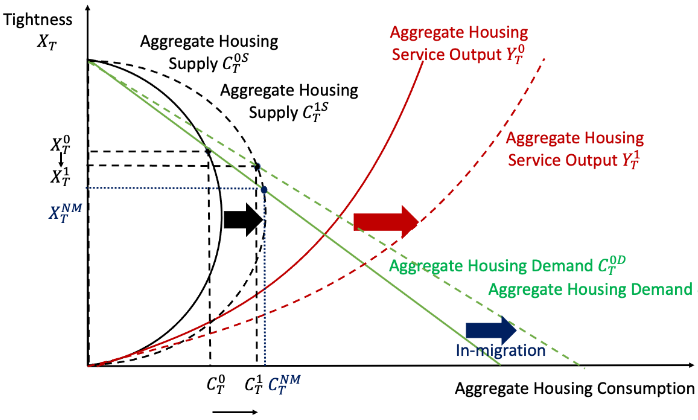
Much like the scenario without migration, the presence of search and matching frictions in the housing market continues to exert influence on the implications of the housing stock expansion when migration is permitted. Figure E.3 depicts the effects of a rent subsidy in markets with and without search and matching frictions, illustrated in Panel A and B, respectively. The superscript 0 denotes values prior to the implementation of the policy, the superscript 1 denotes values after the implementation of the policy, and the superscript NM denotes values in the absence of migration, which are the cases discussed in Section 5. Moreover, the effect of migration is highlighted by purple arrows.

From figure E.3a, the effect of migration on tightness and consumption is in the same direction but with smaller magnitudes compared to the scenarios without migration in city T, denoted by the superscript NM. This is because in-migration would endogenously occur in response to increases in tightness, counteracting the positive implications of the rent subsidy in city T. Moreover, as illustrated in E.3b, city L's consumption worsens due to out-migration.

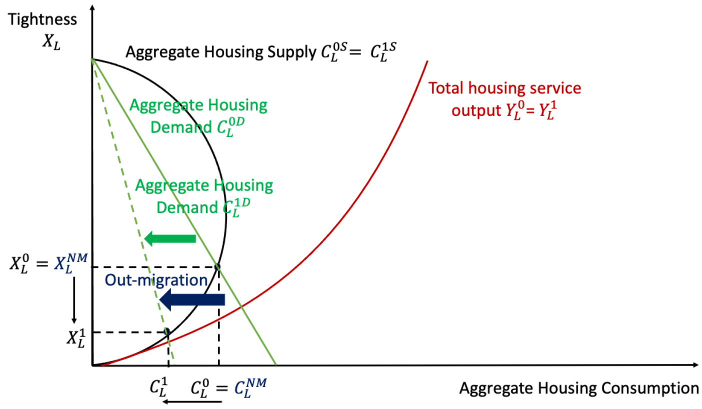
On the other hand, since aggregate and per household housing consumption would decline in both city T and L when search and matching frictions are not considered, as depicted in Panel B of figure E.3, the direction of migration is undetermined. Figure E.3c and E.3d present a possible scenario where there is emigration from city T and immigration from city L. In general, the city that receives migrants would witness a increase in aggregate housing consumption, and vice versa for the city that experience out-migration.

Figure E.3: Implications of a tax-funded housing stock expansion

(a) City T

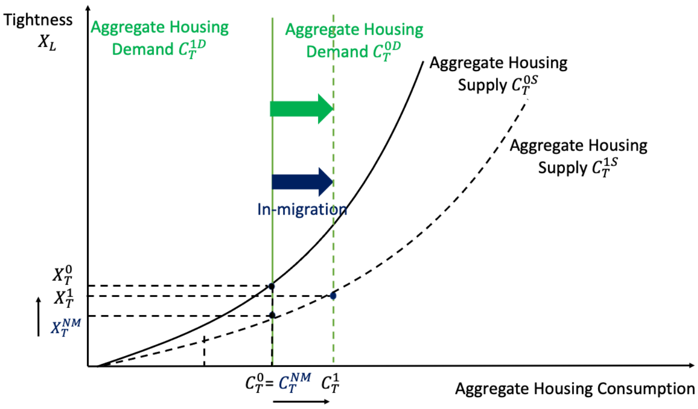


(b) City L

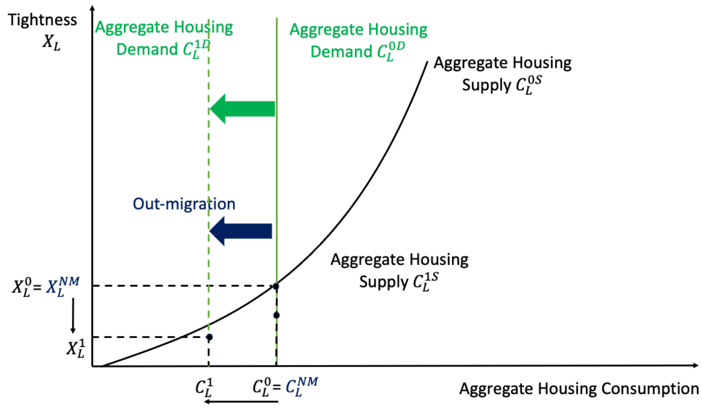


Panel A: implications with search and matching frictions

(c) City T



(d) City L



Panel B: implications without search and matching frictions

Notes: Figure E.2 depicts the effects of a tax-funded housing stock expansion in markets with and without search and matching frictions, illustrated in Panel A and B, respectively. The superscript 0 denotes values prior to the implementation of the policy, the superscript 1 denotes values after the implementation of the policy, and the superscript NM denotes values in the absence of migration, which are the cases discussed in Section 5. Moreover, the effect of migration is highlighted by purple arrows.