Equilibrium Evictions*

Dean Corbae
University of Wisconsin - Madison and NBER
Andrew Glover
Federal Reserve Bank of Kansas City
Michael Nattinger
University of Wisconsin - Madison

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Abstract

We develop a simple equilibrium model of rental markets for housing in which eviction occurs endogenously. Both landlords and renters lack commitment; a landlord evicts a delinquent tenant if they do not expect total future rent payments to cover costs, while tenants cannot commit to paying more rent than they would be able or willing to pay given their outside option of searching for a new rental. Renters who are persistently delinquent are more likely to be evicted and pay more per quality-adjusted unit of housing than renters who are less likely to be delinquent. Evictions due to a tenant's inability to pay are never socially efficient, and lead to lower quality investment in housing and too few vacancies relative to the socially optimal allocation. Government policies that restrict landlords' ability to evict can improve welfare relative to Laissez-Faire, though a full moratorium on evictions should be reserved for crises and temporary. Finally, rent support is generally a better policy than restricting evictions.

Keywords: Eviction, Rental Burden, Housing Externalities, Two-sided Lack of Commitment, Competitive Search, Hand-to-Mouth Households.
JEL Codes: R28, R30, R31

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1 Introduction

While there is currently a fair amount of empirical work on evictions in economics and sociology (such as the popular book Evicted: Poverty and Profit in the American City by sociologist Matthew Desmond [9]), scant structural work exists on the social costs of eviction. A structural framework can provide a laboratory for conducting policy counterfactuals, such as eviction moratoriums and rental support. To this end, we build a structural model of rental markets in below-median-income neighborhoods and calibrate it to U.S. labor market data for renters, aggregate eviction rates, and landlords' income from rental units.

We propose a model of directed search in which people with idiosyncratic income fluctuations transition between renting and being unhoused. They are matched with rental units of varying quality owned by landlords who bear the costs of creating vacancies and investing in the quality of their units. An individual's utility from living in a unit depends on their unit's quality, but also the overall housing quality in the neighborhood, as discussed in Desmond and Gershenson [10] and empirically supported by Autor, et al [4] and Diamond and McQuade [12]. We use the model to measure the positive and normative response of evictions and vacancy creation in the rental market both in the steady state and in response to aggregate shocks that increase unemployment, such as the Covid-19 crisis.

In our model, the search process is directed to a particular submarket (as in Moen [23] and Menzio and Shi [22]) rather than random (as in Mortensen and Pissarides [24]). On one side of the market, landlords choose the quality of the rental and offer a menu of rental contracts when creating vacancies. On the other side of the market, renters choose what type of housing vacancies to apply to and pay rent as long as they are employed, but face heterogeneous risks of unemployment spells, during which they cannot afford to pay rent. Renters and landlords searching for each other are brought into contact by a constant-returns-to-scale matching function, with search on both sides directed to submarkets. Each submarket is defined by the quality of the rental unit, the monthly rent that the renter agrees to pay, and renter characteristics or "type" (here proxied by their employment prospects). The competitive search equilibrium concept ensures that inefficiency is not due to search and matching externalities and guarantees that our equilibrium is conditionally block recursive: the renter and landlord's values of searching in a given submarket only depend on the equilibrium distribution of housing and employment through the externality. Conditional block recursivity allows us to easily study aggregate shocks to the labor market, such as the Covid-19 pandemic.

The critical friction for evictions to occur in equilibrium is two-sided lack of commitment. Barring legal constraints, a landlord who is not being paid rent can evict their tenant and search for a paying one, while a renter has no commitment to remain in a unit if they would be better off looking for a new rental. The landlord of an unemployed tenant incurs costs without receiving rent and therefore requires an increase in future rent in order to allow the tenant to remain. However, once the tenant is re-employed there is a limit on how much they are willing to pay since they can search for a new rental instead - in fact, this is when they are most attractive to other landlords since employment is persistent. Eviction occurs whenever the landlord requires more future rent to keep a currently unemployed tenant than what the tenant would be willing to pay upon re-employment. In this case, continuing with the match would deliver negative expected profits to the landlord, whereas their outside option of posting a new vacancy delivers zero, so they evict the tenant. In contrast, a benevolent social planner would never destroy a match with a positive social surplus regardless of whether a tenant can pay rent. This is because, from a social perspective, how the surplus is split between landlord and renter is irrelevant.

We calibrate the model to match salient features of rental and labor markets including the share of renters who are evicted each year, the income-gradient of rent burdens, the quality gradient of rent-to-quality ratios, and the spillover from an increase in the quality of some rentals in a neighborhood to the value of nearby units. Importantly, our model gives an equilibrium perspective on what Desmond and Wilmers [11] call "exploitation". They find that low-quality rentals have much higher rent relative to their market value than do high-quality rentals. However, in our model expected-discounted profits are identically equal to zero across all units ex-ante, but this leads to higher rent relative to quality in low-quality units because landlords know that lower profits will accrue ex-post from units where eviction is likely. They respond by investing less in such units while charging relatively high rent in order to generate revenue before eviction occurs.

In the calibrated equilibrium, inefficient evictions occur.[1] As a consequence, the competitive equilibrium features much lower housing supply for people who face high eviction risk — at the extreme, there is no supply of housing for these individuals when they are unhoused and unemployed, whereas the planner would only let them to be unhoused for 53 days on average. Furthermore, the quality of housing that landlords supply for high-eviction risk tenants is only 61 percent as good as the planner would like. Less supply and lower quality investment by landlords leads to lower aggregate housing quality, which spills over to renters who are not at risk of eviction as well. On net, aggregate welfare from the competitive equilibrium is 27.3 percent lower than from the planner's allocation (partially due to the planner's allocation internalizing housing spillovers, but mostly due to the competitive

[1] We allow for efficient evictions as well, due to unexpectedly high operating costs, but these amount to a small share of total evictions in our calibration.

equilibrium's inefficient evictions and resulting suboptimal housing supply).

Given that evictions lead the competitive equilibrium to be suboptimal, we use the model to evaluate policies that reduce evictions. The most direct policy is what we call "eviction restrictions", which reduce the probability that a landlord who would like to evict their tenant are allowed to do so. We find that some restrictions are optimal in order to reduce the number of positive surplus matches destroyed ex-post. However, severe restrictions reduce landlord profits, which leads them to supply less housing and reduce quality investment ex-ante (along the lines of the unintended consequences of firing costs that reduce labor demand in Hopenhayn and Rogerson [15]). We find that the optimal eviction policy forces landlords to wait about 1.5 months, on average, before being allowed to evict a delinquent tenant, which is just slightly less restrictive than our estimate of typical restrictions in the U.S. which amount to a two month average delay. In contrast to eviction restrictions, rent support paid to landlords with unemployed tenants can eliminate evictions and actually increase housing supply. Finally, we leverage the model's conditional block recursivity to show that a full eviction moratorium can raise welfare if temporarily imposed during a deep crisis in which separation rates rise and job-finding rates fall dramatically (such as the Covid-19 pandemic).

Literature

To our knowledge, there are few other structural models of evictions and rental housing markets. Abramson [1] and Imrohoroglu and Zhao [17] focus on the details of the demand side of rental housing, whereas our main contributions are on the supply side. First, they focus on the decision of renters to go delinquent, but treat the landlord's eviction choice as exogenous; we endogenize the landlord's decision to evict a delinquent tenant and the resulting inequality in housing outcomes. Second, they do not model search and matching frictions in rental markets, but assume that an unhoused person finds a new rental as soon as they can afford the rent; in our model, a person may be persistently unhoused even after finding a new job. Our competitive search framework also allows us to characterize rental market tightness. Third, they assume that housing sizes are exogenously given and indivisible, which leads to some people being homeless because they cannot afford the lowest-sized housing; we endogenize housing quality and match data on heterogeneity in rent-to-quality acrosss units. Finally, they do not characterize the socially efficient allocation of housing as a point of comparison for their competitive equilibria and policy counterfactuals; we use the socially optimal allocation to isolate the market failures that lead to inefficiency in competitive equilibria.

Specifically, Abramson builds an overlapping generations model of households who face idiosyncratic income and divorce risk. Households rent houses from real-estate investors by signing long-term noncontingent leases specifying a per-period rent which is fixed for the duration of the lease. Since contracts are non-contingent, households may endogenously default on rent (and do so in equilibrium). An eviction case is filed against a default. Each period the household is in default, it is evicted with an exogenous probability that captures the strength of tenant protections against evictions in the city. Once evicted, an unhoused person can move into another rental as soon they can afford the rent and prefer doing so to remaining unhoused. Similarly, Imrohoroglu and Zhao build a consumption-savings model in which households face income and health shocks and choose whether to be home owners or renters, as well as the type of house they live in and whether or not to pay their rent, with eviction taken as an exogenous outcome based on the renter's decisions.

Abramson and Van Niewerburgh [2] use Abramson's framework to study the gains from both public and private rental insurance. Such insurance pays the rent for a tenant for a fixed number of months when they cannot by collecting premia when the tenant is employed. They find that private insurance is difficult to support under their assumed contract terms, but public insurance with mandated coverage can raise welfare significantly by subsidizing at-risk tenants. Our rent support policies are similar to their public insurance with mandates, since it is financed with lump-sum taxes. However, our model differs from theirs' by endogenizing the landlords' eviction decision - they assume that landlords attempt to evict unless they receive the entire rent payment, so rent insurance always pays 100% of rent. In our model, landlords endogenously choose whether to evict and we find that evictions can be reduced substantially even if landlords are only partially compensated for missed rent.

Organization

The paper is organized as follows. Section 2 describes data facts. Section 3 lays out the model environment. Section 4 solves for the efficient level of rental quality and tightness. Section 5 illustrates how the fundamental friction in our model - two-sided lack of commitment - leads to inefficient evictions in a decentralization despite a very general set of rental contracts. Section 6 describes a decentralized competitive search equilibrium with simple fixed rental rate contracts, which we calibrate and quantitatively compare to the planner's allocation. Section 7 analyzes the welfare effects of both eviction restrictions and direct rental subsidies in a stationary equilibrium. Finally, Section 8 considers optimal policies during crisis events and Section 9 concludes.

2 Empirical Facts

We use a combination of empirical facts and our own data analysis to motivate and discipline our structural model. We first list these facts and then present analysis from the Survey of Consumer Finance (SCF), the Current Population Survey (CPS), the Rental Housing Finance Survey (RHFS), and a merge of the American Community Survey (ACS) with housing supply elasticities from Baum-Snow and Han [6].[2]

- About 35 percent of U.S. households rent rather than own their homes (CPS).
- In a typical year, $2-3$ percent of renting households are evicted (Eviction Lab).
- Eviction is more likely among low-income renters. Collinson, et al. [8] find that people who have an eviction filed against them earn only $300 per week, on average, during the two years preceeding eviction.
- Renters are twice as likely to be evicted after losing their jobs (Desmond and Gershenson [10]).
- Renters have low net worth: about $6300 for the median renter in 2019 (SCF). Of this, the median renter had only $1100 in cash-like assets (checking and savings accounts) and a quarter of renters had under $120. The median rent was $830. Lower-income renters have almost no liquid assets.
- Among renters, we estimate that 43 percent are hand-to-mouth (based on the definition from Kaplan, Violante, and Weidner [18]) and 57 percent would be unable to cover rent plus half of their typical bi-weekly income. For renters below median income, 72 percent are hand-to-mouth.
- Rent as a share of income (the rent burden) is declining in renter income, ranging from 30 to 50 percent for households below median income (SCF).[3]
- We calculate that rent is lower, relative to market value, for units with high valuations (RHFS). Similarly, Desmond and Wilmers ([11]) find that rent is more similar between poor and nonpoor neighborhoods than property values which are substantially higher in nonpoor neighborhoods.
- Autor, Palmer and Pathak ([4]) estimate that changes in rental unit market value spill over to similar units. After Cambridge, MA eliminated rent control, the market value of rent controlled units rose about twice as much as similar non-controlled units, but

[2]Appendix A provides details of variable definitions and further discussion of sample selection used in our statistics from the SCF, CPS, RHFS.

[3]Abramson [1] finds slightly higher numbers for specific cities.

non-controlled units (which were not directly affected by the end of rent control) still saw price appreciation.

- Based on Baum-Snow and Han [6], the average elasticity of housing supply was roughly 0.14 for census tracts with many renters and low median incomes.

2.1 Low-Income Renters are Hand-to-Mouth

We use the 2019 Survey of Consumer Finance to decompose the median renter's financial net worth into liquid assets (checking and savings accounts), illiquid assets, and debt. We define a renter as someone who reports a positive monthly rent for housing services and restrict our sample to households between the ages of 25 and 70. We also use the definition of hand-to-mouth from Kaplan, Violante, and Weidner [18] (i.e. liquid wealth less than half of biweekly income) to estimate that the share of renters who are hand-to-mouth is 43 percent overall and 72 percent if we include rent commitments and look at lower-income renters in the SCF (i.e. those below median income). Table 1 reports the median and bottom quartile value for rent, liquid assets, and income for all renters, but also for lower-income renters.

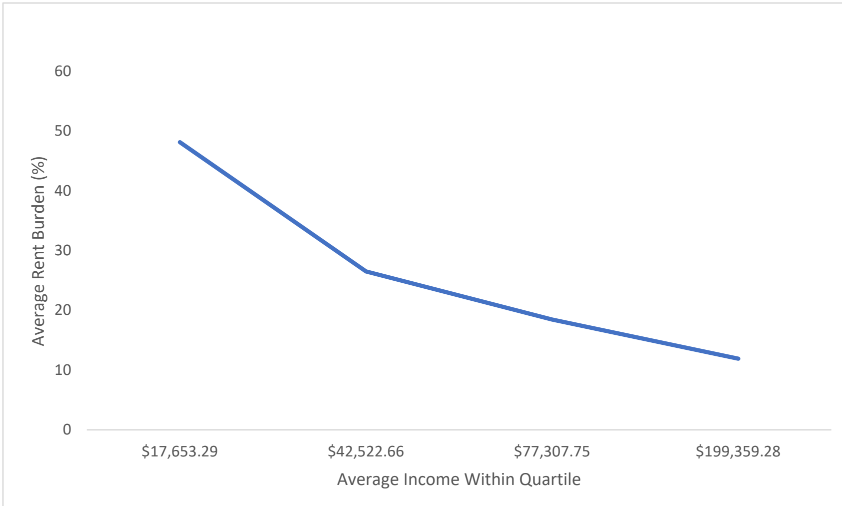
Table 1: Summary Statistics for Renters in SCF

	Overall		Low Income	
Variable	Median	25th Pctile	Median	25th Pctile
Rent	$860	$600	$690	$500
Liquid Assets	$1020	$100	$250	$0
Networth	$6700	$10	$2590	$0
Income	$38,688	$21,380	$21,380	$14,254

Overall the median rent in 2019 was $860, which was 43 percent higher than the bottom quartile $600. On the other hand, median liquid assets was over ten times the bottom quartile and median income was nearly twice the bottom quartile, which means that the rent burden is falling with income. In fact, the average rent burden falls from 48 percent to just 27 percent when income rises from the bottom to the second quartile of household income and continues to fall with income, as can be seen in Figure 1 where we plot the average rent burden against the average income within each income quartile.

This data suggests that, for the population of low-income renters for whom our model is most appropriate, it is unlikely that missed rent could feasibly be capitalized into future payments. Furthermore, an unemployed renter would be unable to pay rent out of liquid savings and has little wealth even including illiquid assets.

Figure 1: Rent Burden by Income, 2019 SCF



2.2 Renter Employment Dynamics

The decision to evict is forward-looking: a landlord must determine whether a tenant is likely enough to pay rent going forward to cover the costs of keeping the unit occupied. Therefore, to simulate our quantitative model we need to estimate ex-ante heterogeneity in employment transitions, which allow landlords to determine expected future profits by a tenant's current employment status and underlying type. To do so, we estimate latent Markov processes on employment status, allowing for permanent heterogeneity in transition rates. We do this using the Current Population Survey in 2018-19 to create panels of employment status and earnings. This survey provides up to eight interview months for each household: four in the first round, followed by eight months out of the sample, and then four more upon returning to the sample. We use this data to create a balanced panel of low-income renters: individuals who report being renters in one of the eight interview months and with an average earnings below the overall median.

We will treat a person's type as unobservable and estimate heterogeneous transition matrices between employment status to best match the unconditional distribution of households over the number of interviews. This distribution is shown in Table 2 and provides the first evidence that the data needs multiple worker types comes from the spikes in the share of people employed for four months out of eight and the share employed for zero months. In addition, it is well known that eight-month and one-month employment transitions like in the right-hand columns of Table 2 are difficult to match with a single Markov process (see Gregory, et al. [14] and Ahn, et al. [3] for recent examples).

Table 2: Fraction of Months Employed for Low-Income Renters in CPS, 2019

Months	Share	Transition	Share
8	55.4%	$P(e_{t+1} = 1 \mid e_t = 0)$	30.2%
7	8.4%	$P(e_{t+1} = 1 \mid e_t = 1)$	94.3%
6	4.5%	$P(e_{13} = 1 \mid e_4 = 0)$	40.6%
5	4.0%	$P(e_{13} = 1 \mid e_4 = 1)$	88.8%
4	8.0%		
3	3.2%		
2	3.5%		
1	5.8%		
0	7.2%	$\mathbb{E}[\text{wage} \mid n > 4]/\mathbb{E}[\text{wage} \mid 4 \geq n \geq 1]$	1.3394

This procedure does not identify whether a given person is $L-$ or $H-$type, so we cannot directly calculate average earnings by type. However, it implies that $H-$types spend a significantly higher share of months employed than do $L-$types. The data suggests that $H-$types are both more likely to be employed and earn more when they do have a job. For those who are employed more than four of their eight interview months, earnings average 34% higher than those who were employed between one and four months.

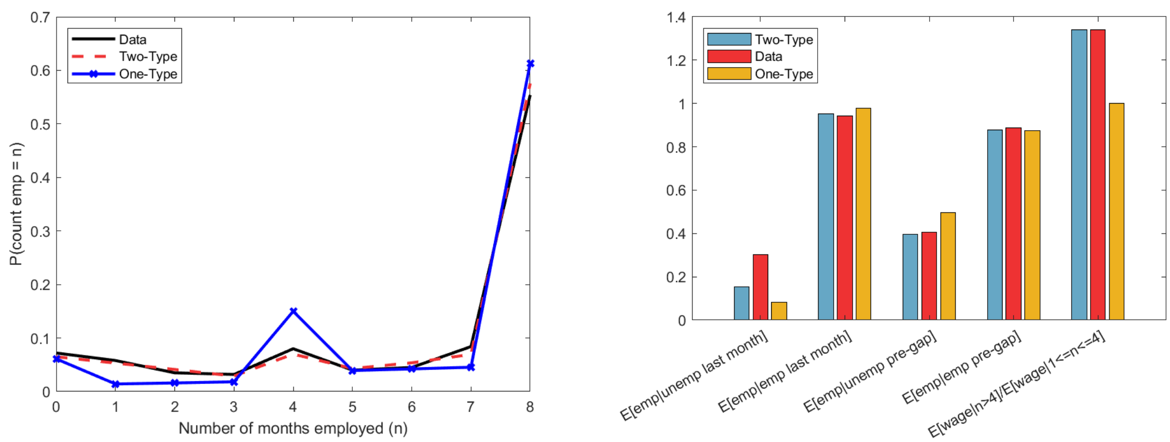
We use the above moments to estimate Markov processes for two permanent latent types, which involves estimating six parameters - the share of $L-$types, the e to e' transition probabilities for each type $p_{i,e,e'}$, and the relative earnings when employed for $H-$types. We choose these parameters to match a total of fourteen moments: the share of people employed $n = 0, 1, ..., 8$ months, the unconditional one-month transition rates from $e \in \{0, 1\}$ to $e' = 1$, the probability of being employed upon re-entering the sample conditional on employment status in the month before rotation, and the average earnings of those employed more than four months relative to those employed between one and four months. Table 3 shows the parameters that best match the above targets.

Table 3: Parameters for Earnings Dynamics

Parameter	Value
$p_{L,1,1}$	0.48
$p_{L,0,1}$	0.11
$p_{H,1,1}$	0.98
$p_{H,0,1}$	0.23
$\frac{y_H}{y_L}$	2.13
μ_L	0.19

Figures 2a and 2b demonstrate how this process fits the data and compares the two-type process to a single-type process. First, we can see that the two-type process nearly perfectly matches the unconditional share of workers employed for each of $n = 0, 1, ..., 8$ months. Second, the two-type process is better than the one-type process at matching the probability a person is employed upon re-entering the sample if they rotated out as unemployed and signficantly better at matching the one-month transition from unemployment to employment. Taken together, these results support a two-type process, with the parameters of best fit given in Table 7.

Figure 2: Employment Dynamics Fit



(a) Share Employed n Months (b) Conditional Employment Rates & Wage Gap

Our procedure consistently estimates heterogeneity in employment transitions, but we acknowledge that our balanced sample may miss some tenants at risk of eviction. The CPS interviews members from a given address from month to month, which means that somebody who is evicted will not be in the same housing unit for a follow up interview. Therefore, we will miss people who report being unemployed and move before being interviewed again. This attrition likely biases our job-finding rates upward, since we are oversampling those with relatively short unemployment durations who find a job quickly enough to avoid eviction before their next interview. While over-estimating the job-finding rate of individuals at risk for eviction could affect our precise quantitative results, a lower job-finding rate for type L individuals would only strengthen the incentive for landlords to evict them. We are less concerned about bias in the separation rate, since somebody who is interviewed the month before losing their job is likely to remain in the same unit the following month as well.

2.3 Rental Value, Rent Rates, and Landlord Profits

Our final data source is the 2018 Rental Housing Finance Survey, which is a cross-sectional survey of landlords that asks detailed information about their rental units, their income from the rentals, their costs, and the market value of their units. We use the distribution of the market values of each unit and calculate the average rent and market value for the bottom 15% and the next 16-50%, which correspond to the quality of units for our $L-$types and $H-$types, respectively. Table 4 provides these measures in 2018 dollars.

Table 4: Summary Statistics from RHFS

Market Value Pctile	Rent	Market Value
Bottom 15	\$456	\$19,227
16 — 50	\$640	\$62,319

In addition, we will use the average operating costs from the RHFS as the mean of the distribution of fixed costs in our model. Operating costs in the RHFS include things like utilities, insurance, landscaping, management expenses, but also our estimates of mortgage interest and taxes. The mean operating cost in 2018 for properties below the median in value was \$256 and the standard deviation was \$262.[4]

2.4 Inferring the Supply Elasticity of Rentals

To our knowledge, there is no readily available estimate of the supply elasticity of rental units with respect to rent. We therefore infer it using estimates of the supply elasticity of total housing with respect to price in census tracts that are comparable to our model's households. Specifically, we use estimates of the supply elasticity from Baum-Snow and Han [6] at the census tract level for 30,838 tracts during the years 2000-2010. We then merge median household income and counts of households by owner/renter status from the 2005-2009 American Community Survey. Table 5 presents summary statistics for the overall supply elasticity across all tracts and those that we consider comparable to our model because the median household income is below the national median and the share of renters is greater than 50%.

[4] We describe the calculation of operating costs in Appendix A.

Table 5: Housing Supply Elasticities

Variable	Mean	25^{th} Pctile	Median	75^{th} Pctile	Count
All Tracts	0.38	0.13	0.32	0.61	30,838
Model-Comparable Tracts	0.14	0.02	0.17	0.32	3,823

2.5 Spillovers

Many studies find evidence that housing markets exhibit positive neighborhood externalities. For example, Diamond and McQuade [12] find that housing built for low-income residents spills over to reduce home prices in high-income neighborhoods. Autor, Palmer and Pathak [4] provide estimates that are most easily mapped into our structural model's outcomes. They look at the market value of units in Cambridge, MA as rent control was lifted. Importantly, Cambridge had both controlled and uncontrolled rentals in close proximity to one another, in neighborhoods with many rent controlled units and in neighborhoods with few rent controlled units.

Table 6 shows their estimates and standard errors. POST is an indicator that takes the value 0 before the law change eliminating rent control and 1 after. RCI is a continuous index for the share of previously rent-controlled housing in the 0.2-mile radius around the unit. RC and NON-RC are indicators for whether a specific unit was originally subject to rent control (RC = 1) or not (NON-RC=0). The point estimates suggest that the market value of rent controlled units rose by 25 log points, but even units that were not previously subject to rent control saw an increase of 13 log points. We therefore discipline spillovers in our model so that a change in rent that increases affected rentals leads their value to increase by twice as much as unaffected rentals. However, since their estimate for the spillover is not significant at the 5 percent level, we will also consider an economy without spillovers.

Table 6: Spillover Estimates from Autor, Palmer, and Pathak

Variable	Estimate
POST $\times$ RCI $\times$ RC	0.25
	(0.18)
POST $\times$ RCI $\times$ NON-RC	0.13
	(0.09)

We will use these estimates to discipline the spillover of aggregate rental quality onto the flow utility of housing for an individual renter. Specifically, we will conduct an experiment where randomly assign some units to have rent control and choose the parameter governing housing externalities to match the relative change in quality for non-controlled units to that of controlled ones.

3 Environment

There is a unit measure of people of two types $i \in \{H, L\}$ who live for an infinite number of discrete periods. The fraction of type i is denoted μ_i which we will take from data in Table 2. People can be either housed ($j = h$) or unhoused ($j = u$) and either employed ($e = 1$) or unemployed ($e = 0$), meaning they can be in one of four states at any point in time.

The two types of people differ in the probability of being employed in the next period given by a type dependent Markov Process $p_{i,e,e'} = Pr(e'|i, e)$ where $(e', e) \in \{0, 1\} \times \{0, 1\}$. They also differ in their income from employment $y_{i,e=1} = y_i$. We assume that $H-$types are more likely to keep or find a job, i.e. $p_{H,e,1} > p_{L,e,1}$ for all e. Further, conditional on being employed, type H have higher income $y_H > y_L > \alpha$. Thus, type H have a higher job finding rate, a lower separation rate, and higher expected earnings than type L consistent with the data in Table 2. An unemployed household generates $y_{i,e=0} = \alpha$ units of the consumption good.

People have linear utility over housing $\mathcal{U}_j$ for $j \in \{u, h\}$ and their consumption of non-housing goods C above a subsistence threshold α. That is, flow utility is given by $C - \alpha + \mathcal{U}_j$ with $C \geq \alpha$. Housed utility depends on both the quality of one's own housing (q) as well as the total quality of all housing (Q) in the neighborhood, which we interpret as a positive spillover externality.[5] Specifically, the period utility for a given person of type i living in housing of quality q is $\mathcal{U}_h = q \cdot \mathcal{E}(Q)$, with $\mathcal{E}(0) = 1$ and $\mathcal{E}'(Q) \geq 0$. Our interpretation of the externality ($\mathcal{E}(Q)$) is that people like to be surrounded by high-quality housing in their neighborhood, so the externality operates through the quality of neighboring units, not the income or employment of the residents of those units. We use estimates from Table 6 to discipline the parameterization of this externality. We normalize the flow utility of an unhoused person $\mathcal{U}_u = 0$. People discount utility across periods with factor β.

Matching unhoused people to new housing takes time due to search frictions. Specifically, if there are V vacant housing units and U unhoused people in period t, then $M(U, V)$ new matches between housing and unhoused people will be created for $t + 1$. We assume that M has constant returns to scale and define tightness as $\theta = \frac{U}{V}$, the rental finding rate as $\phi(\theta) = \frac{M(U,V)}{U} = M(1, \theta^{-1})$ with $\phi'(\theta) < 0$, and the rental filling rate as $\psi(\theta) = \frac{M(U,V)}{V} = M(\theta, 1)$

[5] Since we have a unit measure of people and the quality of unhoused is zero, Q is also the average quality.

and $\psi'(\theta) > 0$.[6] Hence it is hard (easy) to find (fill) a rental unit in a tight market. A housed person separates from her housing unit with exogenous probability σ in each period. Once a separation occurs, the unit's quality depreciates fully (i.e. it requires posting a new vacancy and investment $c(q)$). For simplicity, we assume that enough physical rental units are available that free entry holds. The costs of investing in quality are thought of as refurbishment of the unit for new residents (e.g. repainting, fixing or replacing appliances, etc.). Note, however, that this does not mean that the elasticity of rental supply is infinite - it depends on the matching function's elasticity and the marginal cost of housing quality. In fact, we target an estimate of the elasticity of rental housing supply from Table 5 in our calibration.[7]

Creating a new housing unit costs κ (in units of utility) up front and having an occupant in the unit costs f units each period. This cost is stochastic and drawn iid over time from a logistic distribution (with pdf denoted $g(f)$) with mean $\overline{f}$ and variance σ_f^2. We use data from subsection 2.3 on operating costs in the RHFS to discipline these parameters. Furthermore, the unit's quality, q, requires a one-time investment that costs $c(q)$ units of utility after the match occurs with $c'(q) > 0$ and $c''(q) > 0$ for $q \geq \overline{f}$.

The timing in any given period is as follows:

1. A person's employment status is realized, which determines their income y_i if employed and income α if unemployed. The probability of being employed this period depends on the employment status last period.

2. Landlords with occupied housing draw fixed cost f from a logistic distribution.

3. Landlords decide whether to evict the tenant or not. Evicted tenants are unhoused this period and can search for new housing; if found, they will begin the next period housed.

The rest of the period unfolds for housed people according to:

H.1 Housed people receive utility $q \cdot \mathcal{E}(Q)$ from housing services while unhoused people receive zero utility from housing services.

H.2 Share σ exogenously separate and will be unhoused in the next period.

For the unhoused, the following events occur

[6] We note that the housing definition of "tightness" is opposite that of its definition in labor search.

[7] We assume that units depreciate fully upon separation to avoid keeping the stock units as a state variable. If anything, the motive for landlords to evict a tenant would be strengthened if they could accrue positive expected-discounted profits from renting a previously created unit to a new tenant.

U.1 New housing vacancies are created at cost κ.

U.2 Unhoused match with landlords according to $M(U,V)$ and will start the next period with a rental.

U.3 Newly matched housing units receive quality investment q at cost $c(q)$.

4 Efficient Housing Allocations

We now characterize socially efficient housing allocations using the methods developed by Lucas and Moll [21] and Nuno and Moll [26], taken to discrete time in Ottonello and Winberry [27], and discrete choice by Nattinger and von Hafften [25].

We assume that the planner is subject to the same technological constraints as the decentralized economy. The planner internalizes the housing externality and makes all decisions for renters and landlords to maximize the discounted stream of social welfare subject to the search frictions. Noting that the employment process is exogenous and enters welfare additively, the planner's problem can be fully characterized through their optimization over the discounted stream of housing social surplus.

We start by writing the problem recursively. Letting $s_h = (i, e, q)$ denote the beginning-of-period idiosyncratic state-space of the household of type i in employment state e that begins the period housed ($j = h$) in a unit of any quality q with corresponding beginning-of-period measure $\mu_h(s_h)$.[8] Similarly, let $s_u = (i, e)$ be the corresponding case for unhoused ($j = u$) with beginning-of-period measure $\mu_u(s_u)$. The planner chooses rental tightness and quality $\{q(s_u), \theta(s_u)\}_{\forall s_u}$ for those who are unhoused and whether to evict $\{\epsilon(s_h, f) \in \{0,1\}\}_{\forall (s_h, f)}$ those who are housed. The aggregate housing social surplus function $S(\mu_h, \mu_u)$ is written as:

$$S(\mu_h, \mu_u) = \max \int\int (1 - \epsilon(s_h, f))(q \cdot \mathcal{E}(Q) - f) g(df) \mu_h(ds_h) \\ - \int [\kappa + c(q(s_u))\psi(\theta(s_u))](\theta(s_u))^{-1} \mu^*(ds_u) + \beta \cdot S(\mu'_h(s'_h), \mu'_u(s'_u)) \quad (1)$$

subject to:

$$Q = \int\int (1 - \epsilon(s_h, f)) q g(df) \mu_h(ds_h) \quad (2)$$

[8] We write the housing state very generally to encompass any possible distribution over quality q.

where

$$\mu^*(s_u) = \mu_u(s_u) + \int\int \epsilon(s_h, f) 1_{i'=i} 1_{e'=e} g(df) \mu_h(ds_h), \tag{3}$$

$$\mu_h'(s_h') = (1-\sigma) \int\int p_{i,e,e'} 1_{i'=i} 1_{q'=q} (1-\epsilon(s_h, f)) g(df) \mu_h(ds_h) \tag{4}$$
$$+ \int \phi(\theta(s_u)) p_{i,e,e'} 1_{i'=i} 1_{q'=q(s_u)} \mu^*(ds_u),$$

$$\mu_u'(s_u') = \sigma \int\int p_{i,e,e'} 1_{i'=i} (1-\epsilon(s_h, f)) g(df) \mu_h(ds_h) \tag{5}$$
$$+ \int (1-\phi(\theta(s_u))) p_{i,e,e'} 1_{i'=i} \mu^*(ds_u).$$

The transitions for housed and unhoused measures of agents are given in equations (4)-(5) while $\mu^*(s_u)$ in (3) is the within-period measure of searching households, including both those that entered the period unhoused and those that entered the period housed but were subsequently evicted.

The important thing to note from this problem is that the social surplus from a given match is independent of the employment status or type of a tenant. That is, no fundamental cost or preference parameter depends on these states. Likewise, the costs of creating matches are independent of type or employment status. The only way that (i, e) enter are in the laws of motion via $p_{i,e,e'}$, but these are probability weights and the outcomes they multiply are independent of e'. Therefore, there is no *fundamental* reason for housing allocations to depend on employment status or type. This leads to our first theorem, which is proven in Appendix B.

Theorem 1. *The solution to the planner's problem is* egalitarian*: the optimal housing quality and market tightnesses are independent of i and e. Furthermore, the optimal eviction rule is independent of i or e.*

We will use this social planner's allocation as a basis for comparison to our decentralized equilibria. Our main analysis is a calibrated quantitative model and we will compare the allocations and welfare between the equilibrium and this general social planner's problem. However, we will first make some simplifying assumptions that will allow us to highlight how two-sided lack of commitment gives rise to inefficient evictions in a qualitative analysis.

Assumption 1. *There are no externalities ($\mathcal{E}(Q) = 1$) and a constant fixed cost $\overline{f}$ while a unit is occupied (i.e. $\sigma_f = 0$). Further,*

$$c'^{-1}\left(\frac{\beta}{1-\beta(1-\sigma)}\right) > \overline{f}. \tag{6}$$

Corollary 1. *Under Assumption 1, there exists a non-trivial efficient stationary allocation where evictions never occur with $\theta^{SP} > 0$, $q^{SP} > 0$. The allocations solve*

$$c'(q^{SP}) = \frac{\beta}{1-\beta(1-\sigma)}, \tag{7}$$

$$\frac{\kappa}{(\theta^{SP})^2} - \phi'(\theta^{SP})c(q^{SP}) = -\beta\phi'(\theta^{SP})\left[\frac{q^{SP} - \overline{f} + \big(\kappa + \psi(\theta^{SP})c(q^{SP})\big)(\theta^{SP})^{-1}}{1-\beta\big(1-\sigma-\phi(\theta^{SP})\big)}\right]. \tag{8}$$

The proof is in Appendix B, but intuitively these expressions say that the planner equates the marginal cost of quality to the expected discounted marginal benefit. In this simplified version there is no externality, so the marginal benefit one one more unit of q in each period is one and this accrues until an exogenous separation occurs, since with a constant fixed cost there are no endogenous separations. The second expression then equates the expected marginal cost of creating a new vacancy to the expected discounted marginal benefit. One extra vacancy increases the probability of getting another match, which accrues the present value of flow surpluses based on the quality investment q^{SP}, but costs κ up front and $c(q^{SP})$ if the match occurs.

5 Inefficient Evictions with History Dependent Rent Contracts

We now show that a competitive equilibrium features inefficient evictions due to two-sided lack of commitment. Throughout we maintain Assumption 1, so that there are no externalities and the operating cost is constant: Corollary 1 therefore applies so any evictions are inefficient. We define a competitive search equilibrium with arbitrarily flexible rent contracts. Tenants can only pay rent when they are employed, but there is no bound on what they could *feasibly* pay in that state (i.e. $y_{i,1}$ is sufficiently large that any rent transfer can be made when the tenant is employed). However, tenants can always leave a match and search for a new housing unit if doing so would deliver higher utility, so not all rent contracts will be individually rational. Likewise, a rent contract may not be individually rational for a landlord, who always has the option to evict a tenant. Finally, landlords post rent contracts and tenants direct their search to the rent contract that delivers highest expected discounted utility.

We first define a *history dependent rent contract* as $\mathbf{r} = (r_t)_{t=0}^{\infty}$ with $r_t : \{0,1\}^{t+1} \to \mathbb{R}$. This specifies the rent that a tenant will pay from any period t on, if the match continues, after a history of employment statuses $(e_j)_{j=0}^t$. Due to linearity of preferences and profits, this is equivalent to posting promised utilities, but we use rent contracts in order to maintain continuity with our quantitative model in Section 6. We define a *continuation rule*, $\mathbf{k} = (k_t)_{t=0}^{\infty}$ with each $k_t : \mathcal{R} \times \{0,1\}^{t+1} \to \{0,1\}$, where $\mathcal{R}$ is the set of all $\mathbf{r}$. This rule takes value one if, after employment history e^t and following rent contract $\mathbf{r}$, *both* the tenant and landlord would choose to continue a match, in which case we write $k_t(\mathbf{r}, e^t) = 1$. In summary, $(\mathbf{r}, \mathbf{k})$ is a complete contingent plan for rent and separations in all possible dates and states.

For a given rent contract and continuation rule, we define landlord values as

$$L_{i,e}(\mathbf{r}, \mathbf{k}, e^{t-1}) = k_t(\mathbf{r}, (e^{t-1}, e))\Big[e \cdot r_t\big((e^{t-1}, e)\big) - \overline{f} + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'} L_{i,e'}\big(\mathbf{r}, \mathbf{k}, (e^{t-1}, e, e')\big)\Big], \tag{9}$$

Equation (9) says that a landlord with a tenant who enters t with employment history e^{t-1} and is employed in t receives either zero if the match ends or the rent for that period specified by the rent contract following the employment history. The landlord incurs the occupancy cost $\overline{f}$ and then has an expected discounted future value that depends on the rent contract, continuation rule, and future employment of their tenant. A landlord with an unemployed tenant in a continuing match receives zero rent, incurs the occupancy cost, and then receives expected discounted value based on the tenants employment in the next period.

Tenant value functions are then given by

$$R_{i,e}(\mathbf{r}, \mathbf{k}, e^{t-1}, q) = k_t(\mathbf{r}, (e^{t-1}, e))\Big[q - e \cdot r_t\big((e^{t-1}, e)\big) + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'} R_{i,e'}\big(\mathbf{r}, \mathbf{k}, (e^{t-1}, e, e'), q\big)\Big] \tag{10}$$

Equation (10) says that a tenant receives the flow utility q whenever a match continues and then receives future discounted expected value based on their employment status. Importantly, if the match is destroyed then the tenant is able to search immediately and receives value $V_{i,e}^*$. This is the value of searching for new housing given the equilibrium contracts, continuations, tightness and housing quality posted for unhoused individuals of worker type

i and current employment status e. This value is given by

$$
\begin{aligned}
V^*_{i,e} &= \max_{\mathbf{r},\mathbf{k},\theta,\{q_{e'}|e'\in\{0,1\}\}} \beta\Big[\phi(\theta)\sum_{e'\in\{0,1\}} p_{i,e,e'}R_{i,e'}\big(\mathbf{r},\mathbf{k},(e,e'),q_{e'}\big) &(11)\\
&+ \Big(1-\phi(\theta)\Big)\sum_{e'\in\{0,1\}} p_{i,e,e'}V^*_{i,e'}\\
&\text{s.t.}\\
\kappa+\psi(\theta)c(q_{e'}) &\geq \psi(\theta)\beta\sum_{e'\in\{0,1\}} p_{i,e,e'}L_{i,e'}\big(\mathbf{r},\mathbf{k},(e,e')\big), \forall e'\in\{0,1\} &(12)\\
L_{i,e}\big(\mathbf{r},\mathbf{k},(e^{t-1},e_t)\big) &\geq 0 \text{ for any } (e^{t-1},e_t)\in\{0,1\}^t &(13)\\
R_{i,e}\big(\mathbf{r},\mathbf{k},(e^{t-1},e_t),q_{e'}\big) &\geq V^*_{i,e} \text{ for any } (e^{t-1},e_t)\in\{0,1\}^t &(14)
\end{aligned}
$$

That is, the equilibrium value of being unhoused is generated by the equilibrium contracts, housing qualities, and market tightness. Those equilibrium allocations maximize the unhoused value for a person of type i and employment status e subject to three constraints. First, free entry in (12) requires that landlords post contracts until the cost of doing so, net of expected quality investment, is equal to the expected discounted value of having a tenant. In equilibrium, this constraint binds with equality. offering such an allocation must make non-negative expected discounted profits net of posting costs and quality investment costs in . Second, landlords are always allowed to evict a tenant, so their discounted expected future profits must always be profitable or evict ($k_t(\mathbf{r},e^t)=0$) in (13). Third, tenants can always move out and search for new housing, so must either receive their value of being unhoused by staying in a unit or move out ($k_t(\mathbf{r},e^t)=0$) in (14). These latter two constraints formalize the two-sided lack of commitment friction.

We will now provide a condition that guarantees that inefficient evictions occur in equilibrium. We proceed in two steps. First, we establish that any equilibrium without evictions gives rise to the social planner's egalitarian allocation of qualities and tightness. We then provide a condition that guarantees that evictions must occur if the equilibrium allocation matches the planners. All proofs are in Appendix C.

Lemma 1. *If* $(\mathbf{r}_{i,e},\mathbf{k}_{i,e},q_{i,e},\theta_{i,e})_{i\in\{H,L\},e\in\{0,1\}}$ *is an equilibrium without evictions (i.e.* $k_{i,e,t}(\mathbf{r}_{i,e},e^t)=1$ *for all* e^t *because the participation constraints (13)-(14) are slack), then* $q_{i,e}=q^{SP}$ *and* $\theta_{i,e}=\theta^{SP}$ *for each* i *and* e*.*

Essentially, competitive search guarantees that the equilibrium allocation is efficient as long as the the match surplus coincides with the social surplus. If a contract can be written that avoids eviction, then the optimal contracts choose q to maximize the joint match surplus and rent is set so that landlords are incentivized to post the efficient number of vacancies. Importantly, this result means that matching externalities do not generate inefficiency by themselves. Instead, inefficiency will arise due to evictions driven by two-sided lack of commitment, as we show in the following theorem.

Theorem 2. *If*

$$\overline{f} > \frac{\beta(1-\sigma)p_{i,0,1}}{1-\beta\Big((1-\sigma)p_{i,0,0}-\phi(\theta^{SP})\Big)}\left[q^{SP}+\frac{1}{\theta^{SP}}\Big(\kappa+\beta\psi(\theta^{SP})c(q^{SP})\Big)\right] \tag{15}$$

then there cannot be a competitive equilibrium with $k^*_{i,t}(\mathbf{r}^*_i, e^t) = 1$ *for all* e^t*. Since there are never evictions in the efficient allocation, this means that the competitive equilibrium is inefficient.*

Note that Condition (15) is more likely to hold under intuitive conditions. First, if the flow operational cost $\overline{f}$ is high, then landlords must receive more rent in future employment states in order to keep an unemployed renter.[9] Since the renter can always leave upon re-employment, this higher rent is less likely to be individually rational. Second, if $p_{i,0,1}$ is low then unemployment is expected to persist, so landlords expect to receive rent less frequently and therefore require a larger increase upon re-employment. Third, if q^{SP} is large then tenants are more willing to pay in order to keep a match while if θ^{SP} is low then they are willing to pay less since they find another unit more quickly upon leaving a match. Importantly, Assumption 1 and the social planner's allocations are independent of $p_{i,0,1}$. This means that, for parameters that satisfy Assumption 1, there is always some $\tilde{p} > 0$ such that Condition 15 holds for $p_{i,0,1} \leq \tilde{p}$.

6 Quantitative Model

Having established evictions as a general feature of a decentralized model due to two-sided lack of commitment, we now turn to a quantitative model with constant rent contracts. We think that constant rent contracts better approximate reality in a monthly model and are quantitatively more tractable to work with. Theorem 2 shows that evictions are not necessarily due to ad-hoc restrictions on contracts.

6.1 Equilibrium

Our baseline decentralized equilibrium is designed to match the features of rental markets for lower-income people. Landlords post vacancies and invest in the quality of the rental

[9] Note that a high $\overline{f}$ can be consistent with Assumption 1 if $c'^{-1}(\frac{\beta}{1-\beta(1-\sigma)})$ is large.

units they create. We assume that renters must pay rent whenever employed. Landlords can choose to evict at the start of any period. Unhoused people direct their search to rentals of quality $q_{i,e}$ in submarkets of tightness $\theta_{i,e}$. The fixed terms of the rental contract $r_{i,e}$ (determined at the start of a match) must compensate the landlord for the vacancy creation, quality investment, and upkeep costs $(\kappa, c(q_{i,e}), f)$. Further, our quantitative model includes neighborhood externalities, which appear to be an important feature of housing markets as documented in Section 2.5.

Empirically, Section 2 showed that lower-income renters (with incomes below the median income of all renters) have few liquid assets, especially relative to rent. Specifically, median liquid assets for that group are \$250 while median rent is \$690, for the bottom quartile rent is \$500, and both liquid assets net worth are zero. Therefore an unemployed renter would be unlikely to have enough money to pay rent and renters would have a hard time paying missed rent once they found another job. For this reason, we focus our model of low income renters as hand-to-mouth, lacking savings or the ability to pay missed past rent.

A landlord who has a renter in state (i, e) with constant rent r, housing quality q, and draws fixed cost f from a logistic distribution solves the following problem determining the landlord's choice to evict

$$L_{i,e}(r,q,f) = \max_{\epsilon} \left(1-\epsilon\right)\left[r \cdot e - f + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'} \mathbb{E}_{f'}\left[L_{i,e'}(r,q,f')\right]\right]. \quad (16)$$

Note that unemployed renters pay $r \cdot 0 = 0$. The solution to (16) induces $\epsilon_{i,e}(r,q,f)$. A landlord chooses to evict (i.e. sets $\epsilon_{i,e}(r,q,f) = 1$) if and only if

$$f > r \cdot e + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'} \mathbb{E}_{f'}\left[L_{i,e'}(r,q,f')\right] \quad (17)$$

Note that this condition means that both employed and unemployed tenants may be evicted if the draw of f is sufficiently large. However, a currently employed tenant will require a higher fixed cost to be evicted.

The logistic distribution allows us to write eviction probabilities in closed form as

$$\mathbb{E}_f\left[\epsilon_{i,e}(r,q,f)\right] = \left(1 + e^{\frac{r \cdot e - \overline{f} + \beta(1-\sigma)\sum_{e' \in \{0,1\}} p_{i,e,e'} \mathbb{E}_{f'}\left[L_{i,e'}(r,q,f')\right]}{\sigma_f}}\right)^{-1} \quad (18)$$

This expression shows that the probability of eviction is lower if $e = 1$, but also if $p_{i,e,1}$ is higher. Therefore, for a given type, tenants are more likely to be evicted when they lose their jobs while types with lower job-finding or job-keeping rates will be evicted more frequently (which corresponds to $L-$types in our calibration).

A renter in a unit of quality q with constant rent r given the landlord's optimal eviction choice $\epsilon_{i,e}(r,q,f)$ has the following values:

$$R_{i,e}(r,q,f) = \Big(1-\epsilon_{i,e}(r,q,f)\Big)\Big[y_i - r\cdot e - \alpha + q\mathcal{E}(Q) + \beta(1-\sigma)\sum_{e'\in\{0,1\}} p_{i,e,e'}\mathbb{E}_{f'}\big[R_{i,e'}(r,q,f')\big]\Big] + \epsilon_{i,e}(r,q,f)V^*_{i,e} \tag{19}$$

where the value $V^*_{i,e}$ is the equilibrium value of searching for a type$-i$ person with employment status e and is defined below.

Landlords post contracts over fixed rent r and quality q to which unhoused people direct their search to a submarket with tightness θ. The decentralized equilibrium allocations maximize unhoused utility in (20) subject to the free entry condition in (21):

$$V^*_{i,e} = y_{i,e} - \alpha + \max_{r\le y_i-\alpha,q,\theta}\beta\Big[\phi(\theta)\sum_{e'\in\{0,1\}} p_{i,e,e'}\mathbb{E}_{f'}\big[R_{i,e'}(r,q,f')\big] + \big(1-\phi(\theta)\big)\sum_{e'\in\{0,1\}} p_{i,e,e'}V^*_{i,e'}\Big] \tag{20}$$

s.t.

$$\kappa \ge \beta\psi(\theta)\Big[\sum_{e'\in\{0,1\}} p_{i,e,e'}\mathbb{E}_{f'}\big[L_{i,e'}(r,q,f')\big] - c(q)\Big], \tag{21}$$

Free entry requires (21) holds with equality. Given the presence of subsistence consumption α, a renter of type i can afford to pay at most rent $r_i = y_i - \alpha$. The solution to (20) and (21) yields $(r_{i,e}, q_{i,e}, \theta_{i,e})$.

We can now define a steady-state equilibrium.

Definition 3. *A steady-state competitive search equilibrium with constant rent contracts is given by*

(i). rents $r_{i,e}$ on units of quality $q_{i,e}$ and vacancy posting for those contracts with tightness $\theta_{i,e}$ satisfy (20) and (21) with equality given (16) through (19),

(ii). eviction choices $\epsilon_{i,e}(r,q,f)$ satisfy (17),

(iii). a fixed point of the laws of motion over employment and housing $\mu^h_{i,e'}(r_{i,k}, q_{i,k})$ in (22) and $\mu^u_{i,e'}$ in (23) for $i \in \{H, L\}$, $e' \in \{0, 1\}$, and $k \in \{0, 1\}$ given by:

$$\begin{aligned} \mu^h_{i,e'}(r_{i,k}, q_{i,k}) &= \mathbb{E}_f \Bigg[\sum_{e \in \{0,1\}} \Big(1 - \epsilon_{i,e}(r_{i,k}, q_{i,k}, f)\Big) p_{i,e,e'}(1-\sigma)\mu^h_{i,e}(r_{i,k}, q_{i,k}) \Bigg] \\ &\quad + p_{i,k,e'}\phi(\theta_{i,k}) \Big(\mu^u_{i,k} + \widetilde{\mu}^u_{i,k} \Big) \end{aligned} \tag{22}$$

$$\begin{aligned} \mu^u_{i,e'} &= \sigma \mathbb{E}_f \Bigg[\sum_{e \in \{0,1\}} p_{i,e,e'} \sum_{k \in \{0,1\}} \Big(1 - \epsilon_{i,e}(r_{i,k}, q_{i,k}, f)\Big) \mu^h_{i,e}(r_{i,k}, q_{i,k}) \Bigg] \\ &\quad + \sum_{e \in \{0,1\}} \Big(1 - \phi(\theta_{i,e})\Big) p_{i,e,e'} \big(\mu^u_{i,e} + \widetilde{\mu}^u_{i,e} \big) \end{aligned} \tag{23}$$

where

$$\widetilde{\mu}^u_{i,e} = \sum_{k \in \{0,1\}} \mathbb{E}_f \Bigg[\epsilon_{i,e}(r_{i,k}, q_{i,k}, f) \mu^h_{i,e}(r_{i,k}, q_{i,k}) \Bigg]. \tag{24}$$

(iv). aggregate housing quality is given by:

$$Q = \mathbb{E}_f \Bigg[\sum_{i \in \{H,L\}} \sum_{e \in \{0,1\}} \sum_{k \in \{0,1\}} \Big(1 - \epsilon_{i,e}(r_{i,k}, q_{i,k}, f)\Big) \mu^h_{i,e}(r_{i,k}, q_{i,k}) q_{i,k} \Bigg]. \tag{25}$$

The fixed point of the law of motion in (22) maps those who are housed and not evicted as well as those unhoused who find a rental (the right hand side) into those who are housed (the left-hand side) while maintaining the fixed contract terms $(r_{i,k}, q_{i,k})$ corresponding to employment status, $k \in \{0, 1\}$, when they first found their housing. Equation (23) is an analogue law of motion for the unhoused measure and (24) defines the within-period measure of searching households, including both those that entered the period unhoused and those that entered the period housed but were subsequently evicted.

In the case without externalities (i.e. $\mathcal{E}(Q) = 1$), the expressions in equations (16)-(21) are independent of the distributions $\mu^h_{i,e}$ of people over housing and employment states. This means that the equilibrium is *block recursive* and we can calculate the equilibrium objects in (i) and (ii) separately from those in (iii) through (iv). With an externality, we need to know the distributions since they affect Q, so our equilibrium is *conditionally block recursive*.[10] That is, given Q, we do not need the distributions in order to calculate (i) and (ii). This simply requires adding another nest in the fixed point problem.

[10] This concept of conditional block recursivity has been used in other settings, such as Chaumont and Shi [7].

6.2 Calibration

We now make assumptions about the functional forms and assign parameter values in our quantitative model. First, we make the following functional form assumptions. The cost function is $c(q) = c_0(q - \bar{f})^2$. We use $M(U, V) = \frac{U \cdot V}{\left(U^\nu + V^\nu\right)^{\frac{1}{\nu}}}$ which gives finding and filling rates of $\phi(\theta) = \frac{1}{(1+\theta^\nu)^{\frac{1}{\nu}}}$ and $\psi(\theta) = \frac{\theta}{(1+\theta^\nu)^{\frac{1}{\nu}}}$. This matching function gives non-constant elasticities of the finding and filling rates with respect to θ, but remains bounded in $(0, 1)$. We assume the functional form of the externality is given by $\mathcal{E}(Q) = e^{\eta Q}$. This implies an externality semi-elasticity $\eta = \frac{d\log(\mathcal{E}(Q))}{dQ}$.

Table 7 lists parameters that we set externally, while the remaining we estimate via simulated method of moments. Employment transitions and the relative income of $H-$types are estimated from the CPS as described in Section 2.2. We set the exogenous separation rate, σ, so that tenants live in the same house for 3 years on average. We normalize $r_L = 1$ and then set $y_L = 2$ and $\alpha = 1$ to match a 50% rent burden for $L-$types. The discount factor is set to be consistent with an annual risk-free rate of 4%. Finally, we set $\lambda = 0.5$ so that it takes landlords two months to evict a tenant, on average, which is consistent with survey evidence. We are left with six free parameters (the externality spillover, the elasticity of the matching technology, the parameter governing costliness of quality investment, the cost of posting a vacancy, and the operational cost parameters), which we choose to best fit eight additional moments, as listed in Table 8.

Table 7: Calibration Outside of Model

Earnings Process	
$p_{L,1,1}$	0.48
$p_{L,0,1}$	0.11
$p_{H,1,1}$	0.98
$p_{H,0,1}$	0.23
y_H	4.26
y_L	2
μ_L	0.19
μ_H	0.81
Other	
β	$0.96^{1/12}$
σ	1/36
α	1
λ	0.5

Table 8: Parameters Calibrated in Model

Parameter	Value	Moment	Data	Model
η	0.088	spillover (Autor, et al.)	0.5	0.53
ν	1.519	vacancy rate (Census Bureau)	6.60	6.32
κ	0.341	eviction rate (Eviction Lab)	0.50	0.40
c_0	10.636	r_H/y_H (SCF)	0.33	0.37
$\bar{f}$	0.392	mean f (SCF)	0.55	0.39
σ_f	0.33	var f (SCF)	0.32	0.36
		r/q slope (RHFS)	0.45	0.32
		supply elasticity	0.14	0.13

The estimates of the remaining six parameters $b = (\eta, \nu, \kappa, c_0, \bar{f}, \sigma_f)$ of our overidentified model are listed in Table 8. All parameters are jointly dependent on the listed moments, we present which moments we believe help most in identifying the parameter. The operating cost distribution parameters are chosen so that the logistic distribution's mean and standard deviation from the model match the empirical counterparts in Section 2.3, with each measured realative to $L-$type rent. Importantly, in the data we only see the distribution of fixed costs for those renters who aren't evicted while the parameters $\overline{f}$ and σ_f govern the distribution of all operating cost draws. We therefore simulate the distribution of operating costs for those who aren't evicted in the model and match the mean and variance to the data.

While most of the moments are matched in the stationary equilibrium, two moments require calculating both the stationary equilibrium and a local change: the supply elasticity and the spillover parameter. For the supply elasticity, we impose rent ceilings marginally below equilibrium values for each type and then calculate the percentage change in total non-evicted matches relative to the percentage change in total housing quality (which is our proxy for rental property value).[11] For the externality, we recreate the policy experiment from Autor et al. [4] in our model by comparing the baseline equilibrium to an equilibrium where 40 percent of renters of each type are randomly assigned to become rent-constrained, imposing that $r \leq 0.95\bar{r}_i$ where $\bar{r}_i$ is the average r of the housed of type i in the baseline stationary equilibrium. The rent ceiling reduces the quality chosen by these renters, which lowers total quality Q and spills over to the unconstrained renters within the experiment. We interpret $qe^{\eta Q}$ as being proportional to the value from the housing. The spillover moment is then computed as the difference in mean value from housing for the unconstrained renters as a fraction of the difference in mean value from housing for the constrained renters, i.e. $\frac{2.43-2.41}{2.43-2.392}$ from the table below, computed at the calibrated equilibrium.

[11] See Appendix D.3 for more details.

Spillover Experiment Results

Qualities	Baseline	Unconstrained	Constrained
Q	1.668	1.639	1.639
mean $qe^{\xi Q}$	2.43	2.41	2.392

In Table 9 we compute a local measure Λ^* of the elasticity of our estimated parameters to a change in each of the model moments in Table 8 based on Andrews, et. al. [5] (hereafter AGS).[12] Element (i, j) of Λ^* can be interpreted as the elasticity of our estimate of parameter i with respect to moment j. For example, we can interpret the upper-left element of Table 9 as implying that a 1 percent increase of r_H/y_H would lead to a decrease of our estimate of ξ of 0.33 percent. Table 9 suggests that our parameters are most sensitive to the r/q slope and mean of f conditional on not evicting.[13]

Table 9: Sensitivity Matrix Λ^*

	r_H/y_H	eviction rate	r/q slope	experiment	vacancy rate	mean f	var f	elasticity
ξ	-0.33	-0.0	-1.2	0.03	-0.38	-0.95	0.14	0.0
ν	0.12	-0.15	0.54	-0.0	0.25	0.45	0.06	-0.01
c_0	-0.14	0.11	-0.49	0.0	-0.05	-0.4	-0.04	0.01
κ	0.53	-0.05	1.77	-0.0	0.25	1.39	-0.19	-0.0
σ_f	0.02	-0.0	-0.0	-0.0	0.0	-0.0	-0.44	-0.0
$\underline{f}$	-0.19	0.08	-0.64	0.0	-0.07	-0.51	-0.02	-0.0

6.3 Model Properties

We illustrate the equilibrium workings of the baseline model in the calibrated economy in Tables 10 through 12. Key for understanding the eviction decision and contract terms is the earnings prospects of our two types of renters that came from the CPS in Table 1. Specifically, the data suggests $p_{H,e,1} > p_{L,e,1}$ and $y_H > y_L$ so that type H have higher expected income than type L and shorter duration of unemployment. These income prospect differences induce differences in equilibrium rental terms (rental rates and qualities) where a high income renter pays 55 percent higher rates and receives substantially (384 percent) higher quality housing than a low earner evident in equation 10. This is consistent with the lower rent-to-quality ratios among low and higher earners. Importantly a high earner who is currently

[12] In Appendix E we present the calculation of Λ^*. Intuitively, Λ^* can be interpreted as a matrix of elasticities, and is hence invariant to the scale of the parameters and moments.

[13] Again, as discussed above, selection accounts for why there is not a perfect relation between $\overline{f}$ and mean f as well as σ_f and var f.

unemployed is offered a contract (albeit with slightly lower finding rate than her employed counterpart) while a low earner who is unemployed does not even receive a housing contract (i.e. is unhoused). Therefore, in equilibrium there are only three rental contracts $\mathcal{C} \equiv \{(r_{H,1}, q_{H,1}), (r_{H,0}, q_{H,0}), (r_{L,1}, q_{L,1})\}$ offered. Consistent with the contract offerings, Table 10 documents that the rental finding rate is higher for type H than type L, where the expected duration of homelessness for a type H person is under two months while it is just under five months for an employed type L person.

Table 10: Calibrated Equilibrium

Policies	Baseline
$(r_{H,1}, q_{H,1})$	(1.546,2.128)
$(r_{H,0}, q_{H,0})$	(1.713,2.14)
$(r_{L,1}, q_{L,1})$	(1.0,0.438)
$(r_{L,0}, q_{L,0})$	$\emptyset$
$(\epsilon_{H,1}(r_{H,1}, q_{H,1}), \epsilon_{H,0}(r_{H,1}, q_{H,1}))$	(7.46e-44,1.22e-36)
$(\epsilon_{H,1}(r_{H,0}, q_{H,0}), \epsilon_{H,0}(r_{H,0}, q_{H,0}))$	(2.59e-50,2.57e-42)
$(\epsilon_{L,1}(r_{L,1}, q_{L,1}), \epsilon_{L,0}(r_{L,1}, q_{L,1}))$	(0.049,0.788)
$(\epsilon_{L,1}(r_{L,0}, q_{L,0}), \epsilon_{L,0}(r_{L,0}, q_{L,0}))$	$\emptyset$
$(\theta_{H,1}, \phi(\theta_{H,1}))$	(0.571,0.791)
$(\theta_{H,0}, \phi(\theta_{H,0}))$	(0.69,0.743)
$(\theta_{L,1}, \phi(\theta_{L,1}))$	(4.499,0.209)
$(\theta_{L,0}, \phi(\theta_{L,0}))$	$\emptyset$

Notes: This table contains equilibrium quantities computed from the baseline model.

The differences in earnings prospects between type H and L have important implications for equilibrium eviction $\epsilon_{i,e}(r, q)$ across the different contracts. Table 10 documents that landlords effectively never evict a type H renter who becomes unemployed (i.e. $\epsilon_{H,0}(r, q) \approx 0$). Since they will soon be back to paying a high rent, $H-$types would only be evicted for an incredibly high fixed cost draw. On the other hand, type$-L$ tenants are evicted for many draws of the operational cost: even when they are employed they face a 5% probability of eviction and when unemployed they are evicted 79% of the time.[14]

[14]These are the desired eviction probabilities, the landlord is only allowed to evict half of the time due to our baseline eviction regulations.

Table 11: Stationary measure $\mu_{i,e}^j$ for baseline

Housing state j	Employed $e=1$	Unemployed $e=0$
$\mu_{L,e}^h(r_{L,1}, q_{L,1})$	0.007	0.013
$\mu_{L,e}^h(r_{L,0}, q_{L,0})$	0.0	0.0
$\mu_{L,e}^u$	0.028	0.144
$\mu_{H,e}^h(r_{H,1}, q_{H,1})$	0.646	0.062
$\mu_{H,e}^h(r_{H,0}, q_{H,0})$	0.061	0.012
$\mu_{H,e}^u$	0.025	0.003

Table 11 presents the equilibrium stationary cross-sectional distribution $\mu_{i,e}^j$ of the population of housed and unhoused $j \in \{h, u\}$ renters of type $i \in \{H, L\}$ of employed and unemployed $e \in \{0, 1\}$ households. While the fractions of each type $\mu_H = 0.81 = \sum_{e,j} \mu_{H,e}^j$ and $\mu_L = 0.19 = \sum_{e,j} \mu_{L,e}^j$ from the data in Table 7 are exogenously pinned down, the distribution within type is endogenous. The table makes clear that while there are only 19 percent of low earning renters in the population we focus on, they account for a large fraction of the homeless $\sum_{i,e} \mu_{i,e}^u$. Specifically, they account for $\frac{\sum_e \mu_{L,e}^u}{\sum_{i,e} \mu_{i,e}^u} = 86.0$ percent of below median income unhoused renters. Note further that some measure of employed households can be unhoused; these are those who either did not find housing because of finding rates between roughly one fifth and three quearters in Table 10 or because of separations.

6.4 Efficiency

We have shown that inefficient evictions can occur, but how large of an effect do they have on the rental market as a whole and what are the welfare consequences? In Table 12 we compare the equilibrium allocation of quality and rental finding rates between our decentralized equilibrium and that chosen by the social planner not subject to the commitment friction and who internalizes the externality. Recall that there is a fundamental difference in eviction rates between the planner's problem (i.e. eviction only occurs if the social surplus becomes negative due to a large operational cost draw). In fact, nearly no $L-$type is evicted in the planner's allocation while in the decentralized equilibrium $L-$type unemployed renters are evicted with probability 0.79. Since employment status does not matter for the social planner, individual quality does not depend on employment status (i.e. q^{SP}) while individual quality in the decentralized equilibrium does depend on employment status (i.e. $q_{i,e}$). Since the planner internalizes the positive externality, they choose uniformly higher quality than the decentralized outcome, especially so for type L households. This quality dominance chosen by the planner implies a 59 percent higher total quality level Q^{sp} than its decentralized counterpart Q. Importantly, there are vastly different fractions of type L housed in the two allocations: 97% of $L-$types are housed in the planner's allocation, but only 8% in the decentralized equilibrium.

Table 12: Allocations in Planner's and Competitive Equilibrium

Variable	Competitive Equilibrium	Planner
Q	1.668	2.654
$\big(q_{H,1}, \phi(\theta_{H,1})\big)$	(2.128,0.791)	(2.743,0.821)
$\big(q_{H,0}, \phi(\theta_{H,0})\big)$	(2.14,0.743)	(2.743,0.821)
$\big(q_{L,1}, \phi(\theta_{L,1})\big)$	(0.438,0.209)	(2.743,0.821)
$\big(q_{L,0}, \phi(\theta_{L,0})\big)$	$\emptyset$	(2.743,0.821)
L-type frac housed	0.076	0.967
H-type frac housed	0.966	0.967

Notes: Columns list the allocations of each variable from the planner's solution and the competitive equilibrium. The rows labeled "i-type frac housed" are defined to be $\frac{\sum_e \mu^h_{i,e}}{\mu_i}$.

These differences in allocations translate to large differences in aggregate discounted social surpluses. In Table 13 we calculate the losses from using the competitive equilibrium allocations of housing quality, tightness, and eviction decisions rather than the planner's optimal choices. We also decompose how far the competitive allocation is from the efficient one both due to lack of commitment and to the externality. The row labeled "Baseline Q" reports the loss in steady-state aggregate social surplus, relative to the planner's optimum, using the tightnesses and qualities from the competitive equilibrium and assuming that matches are destroyed for type L tenants whenever they lose their jobs. The row labeled "Planner Q" is similar, except that we fix the externality term at its value from the planner's allocation ($\mathcal{E}(Q) = \mathcal{E}(Q^{sp})$). This calculation isolates the loss in welfare from the competitive equilibrium's lack of commitment from the difference in the externality term. We find that the majority of the loss (totalling -23.4 percent) from the competitive equilibrium is due to lack of commitment, while another 3.9 percentage points is due to the externality (-27.3 percent in total). Hence the lack of commitment generates 86% of the total welfare loss, while landlords failing to internalize the externality generates 14% of the loss.

Table 13: Welfare Loss From Competitive Equilibrium Relative to Planner Allocation

Allocation	Aggregate Welfare Loss
Planner Q	-23.4
Baseline Q	-27.3

Notes: The mathematical definitions can be found in equations (45) and (44) of Appendix D.3.

In summary, we find that the quantitative effect of inefficient vacancies is large. This is especially true for tenants who are at risk of eviction, but due to the externality it has a negative effect on the housing allocation of even those tenants who are almost never evicted. As a result, households would gain significantly in terms of welfare if they could be born into an economy with the efficient housing allocation. Since this allocation is not incentive feasible, we now ask whether commonly discussed policies can push the competitive equilibrium in the right direction.

7 Quantitative Policy Evaluation

The inefficiency of the competitive equilibrium motivates us to consider possible policy responses, which may bring allocations closer to the planner's solution and raise welfare. We first consider restrictions on evictions, which is a direct attempt to overcome the problem that landlords cannot commit to keep an unemployed renter if eviction delivers higher profits. This reduces evictions but also expected profits for landlords and therefore reduces supply ex-ante. We then consider a subsidy to landlords that incentivizes them to keep unemployed renters who would otherwise be evicted by ensuring that the expected discounted profits are positive, even when the renter cannot pay today. In the next section we consider the effect of eviction policies in dealing with a crisis (i.e. outside of the steady state).

7.1 Eviction Policies

Since evictions are the fundamental cause of inefficiency in the competitive equilibrium, we first ask how much regulation should be imposed on landlords who wish to evict. In our baseline calibration, a landlord who wants to evict a delinquent renter is allowed to do so with probability $\lambda = 0.5$,[15] but in principal regulation could range from laissez-faire ($\lambda = 1$) to a complete moratorium ($\lambda = 0$). A policy maker who sets λ trades off two forces: (i) increased social surplus from maintaining a match arising from a low λ; (ii) lower landlord profits (hence lower quality and/or vacancies) if landlords can't evict an unemployed person arising from a low λ.

Figure 3 illustrates the properties of the competitive search equilibrium across λ. The top-left panel shows that quality-to-rent for $L-$types rises as eviction restrictions become less severe. Likewise, the top-right panel shows that the finding rate for $L-$types rises with λ. In each case, a more restrictive eviction policy reduces landlords' expected discounted profits from matching with an $L-$type, which leads to less investment in quality and fewer vacancies.

[15] As in Abramson [1] this probability captures the strength of tenant protections against evictions.

These outcomes provide an example of the unintended consequences of eviction restrictions similar to the unintended consequences of firing costs in Hopenhayn and Rogerson [15]; eviction restrictions which lower landlord profitability hurt rental supply just as firing costs lower firm profitability resulting in higher unemployment. However, as eviction restrictions become more lenient, more $L-$types get evicted, so the share housed is hump-shaped as shown in the bottom-right panel. Together, these results imply a flattened hump-shape of aggregate quality in λ as shown in the bottom-left panel.

Figure 3: Unhoused Employed Low-type Renter Policies

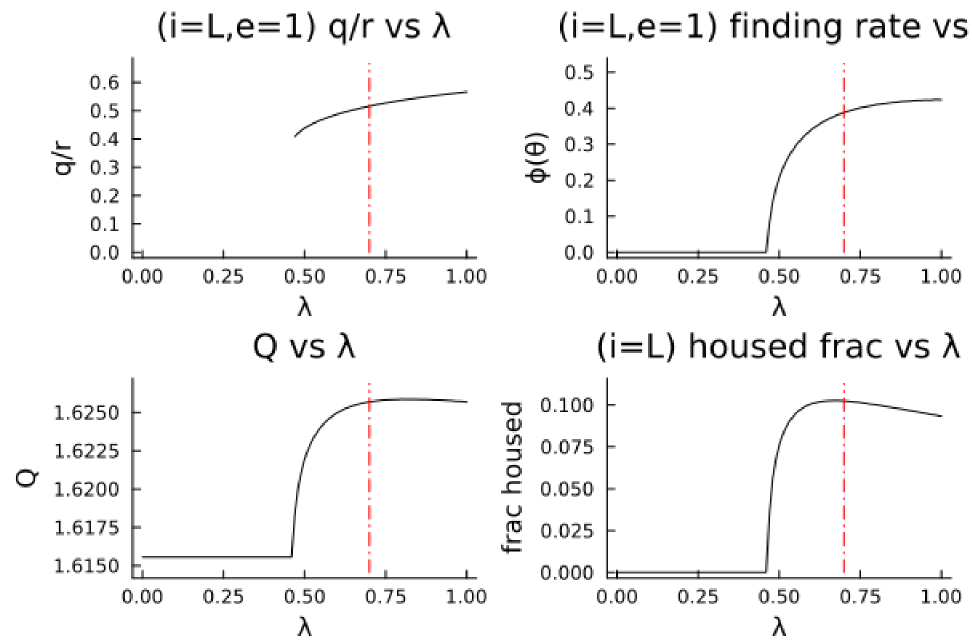
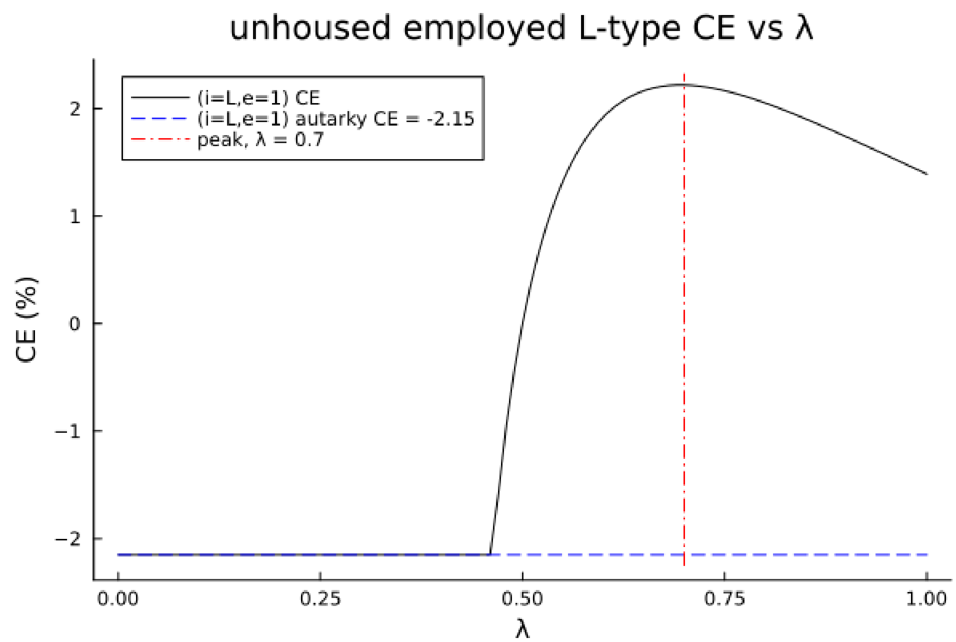


Figure 4 illustrates the welfare effects (in consumption equivalents) for an unhoused employed type L renter from different eviction restrictions. Specifically, if there are no restrictions (i.e. $\lambda = 1$), utility is lower than if there is some degree of restrictions. In fact, as the example shows, utility is maximized at $\lambda = 0.70$. On the other hand, starting at $\lambda = 0.46$ down to $\lambda = 0$, an unhoused employed L type person is so "costly" to a landlord that they do not find a rental unit. For $\lambda > 0.46$ the employed type L subsistence constraint $c_{L,1} = y_L - \alpha - r_L$ is binding implying $r_L = 1$. The binding constraint implies the landlord cannot recoup a future higher rental rate than r_L=1.[16] Thus, Figure 4 illustrates that some restrictions on eviction are optimal since eviction destroys matches with positive social surplus but a full out eviction moratorium means all type L, both employed and unemployed, cannot find rental units.

[16] In contrast type H do not face a binding constraint throughout $\lambda \in [0, 1]$ and pay approximately 55 percent more than the type L rent.

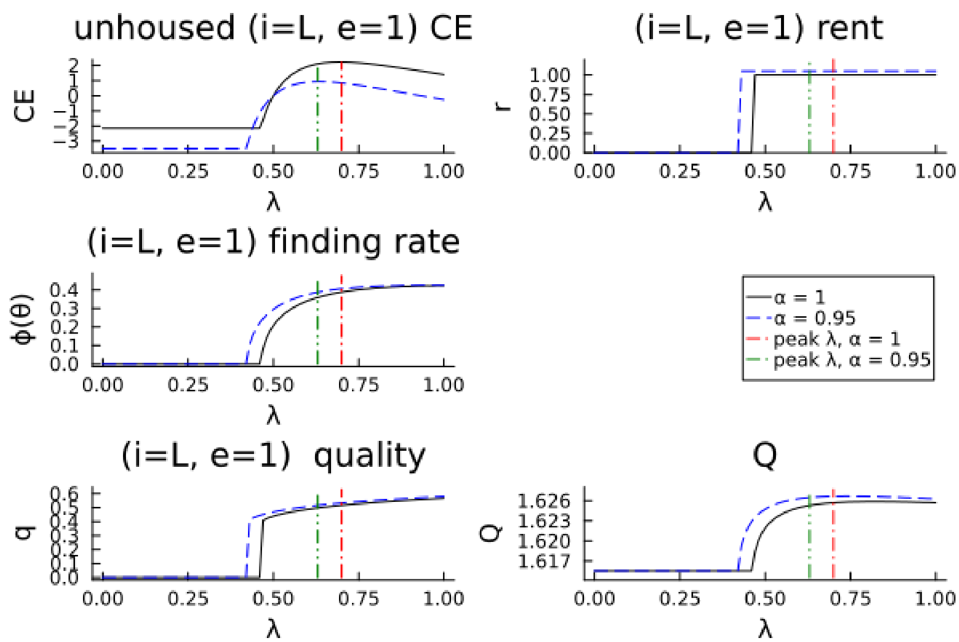
Figure 4: Unhoused Employed Low-type Renter Value



Notes: Black line: Consumption equivalent welfare relative to baseline ($\lambda = 0.5$) as defined in equation (46) in Appendix D.3. Peak at $\lambda = 0.7$ (red line). Blue line: permanently unhoused consumption equivalence when $\theta_{L,1} = 0$.

Figure 5 illustrates the effect of a binding constraint on rental payments implied by the subsistence consumption requirement faced by all households. In particular, we consider the consequences of relaxing the constraint (in particular we set $\alpha = 0.95$ rather than $\alpha = 1$ as in the baseline calibration). The top right panel makes clear that reducing subsistence consumption means that the L type person can afford to pay the landlord a higher rent when employed. In that case, the landlord is able to recoup more profits during type L employment spells. Therefore, holding λ constant, there would be a large increase in vacancy creation and quality investment by landlords. Optimal policy responds by reducing λ, which reduces evictions relative to the baseline $\alpha = 1$ case. In both cases, the L-type renter has a large welfare gain for some interior λ values, as evidenced by the top-left panel. The more constrained ($\alpha = 1$) L-type renter has a maximum welfare gain of 2.2 percent at $\lambda = 0.70$ while the less constrained ($\alpha = 0.95$) L-type gains 0.9 percent at $\lambda = 0.63$. The bottom-right panel shows that the equilibrium Q value increases for these λ levels, which passes through to the H-type renter through the externality, implying a Pareto improvement to welfare. Q rises to a maximum of 1.625 for $\alpha = 1$ and 1.626 for $\alpha = 0.95$, which increases the H-type unhoused employed welfare by 0.02 and 0.009 percent.

Figure 5: Interaction Between Ability to Pay Rent and Policy



Notes: Black line: Outcomes for $\alpha = 1$ with peak at $\lambda = 0.7$ (red line) as in previous Figures. Dotted Blue line: Outcomes for $\alpha = 0.95$ with peak at $\lambda = 0.6$.

7.2 Rent Support

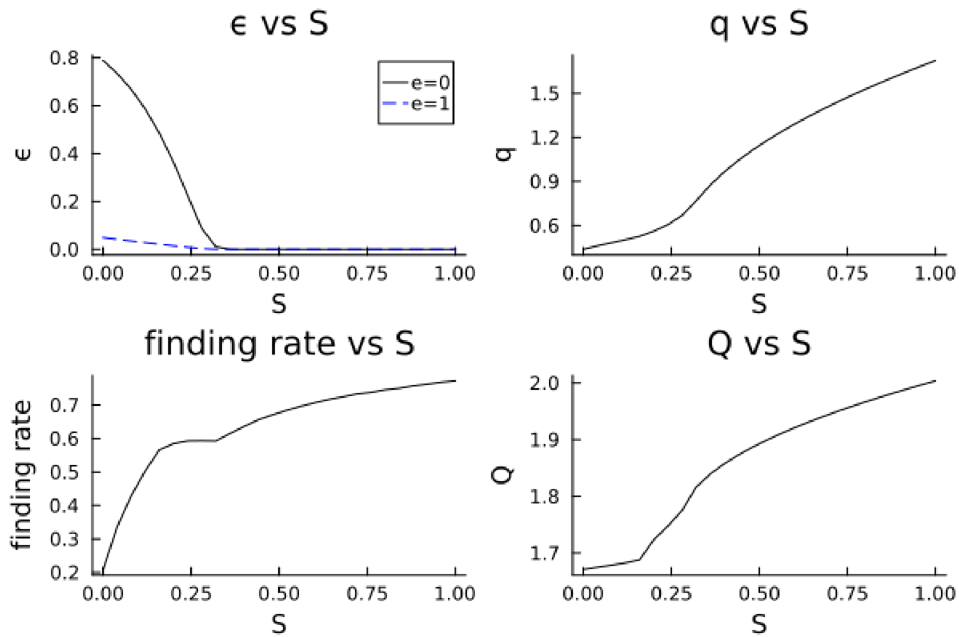
Instead of a policy restricting evictions as in the previous section, here we consider (partial) rent support paid to landlords when their tenant is unemployed. Specifically, we consider a policy that pays landlords a subsidy, S, whenever their $L-$type tenant is unemployed. This is financed on a flow basis by taxing the $H-$type individuals who are employed an amount T given by:

$$T = \frac{\mu^h_{L,0}}{\mu^h_{H,1} + \mu^u_{H,1}} S. \tag{26}$$

We are only subsidizing the $L-$types since the eviction rate on $H-$types is near zero. We only tax the $H-$type because the $L-$type cannot afford to pay any taxes and still consume above the subsistence threshold.

To understand the changes in the equilibrium caused by the rental subsidy, Figure 6 shows rental market outcomes for the $L-$type individual as S rises. Since the type L renter continues to face a binding budget constraint, the subsidy has no effect on their payment r but does reduce their chance of being evicted as shown in the top left panel since it increases the net amount received by landlords. As the expected profits of renting to an $L-$type rise due to the subsidy, landlords respond by increasing the quality of housing they provide and the number of vacancies they post. As a result, total Q increases with the subsidy.

Figure 6: Effect of Subsidy on Rental Market



Notes: Rental market outcomes for $L-$types as subsidy to landlord rises. Upper-right, bottom-left, and bottom-right panels plot outcomes for employed $L-$types.

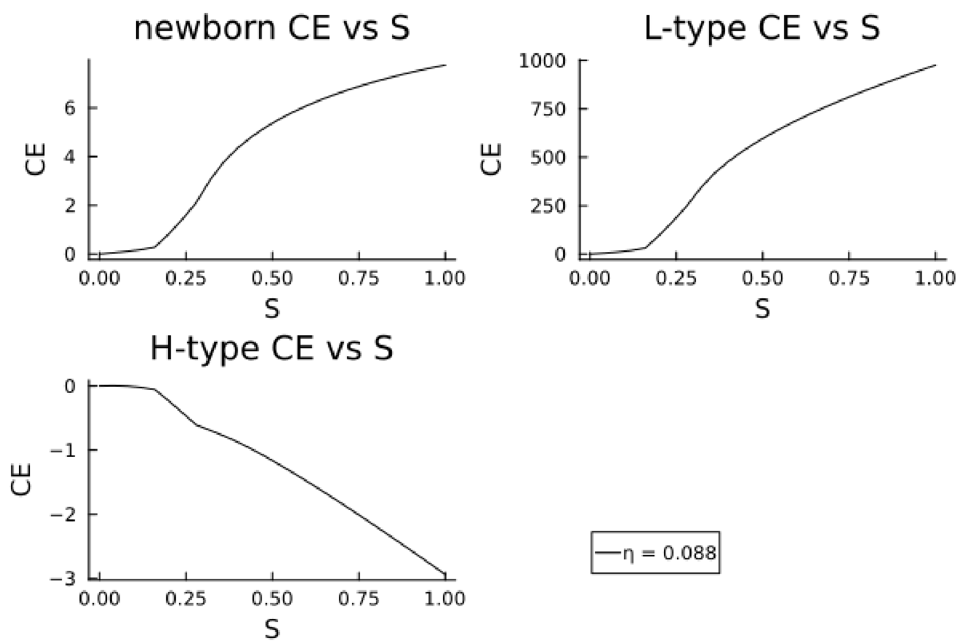
In Figure 7, we plot the effect of these changes on the welfare of each type at birth as well as the expected welfare of a newborn before their type is drawn.[17] We see that welfare is increasing for the $L-$type as we increase the subsidy, especially after $S = 0.16$, which is the point at which unemployed and unhoused $L-$types have a positive probability of finding a rental unit. $H-$types' welfare is declining in the subsidy, since they are subject to the tax and the higher the subsidy the more $L-$types are housed. However, the welfare gains for the $L-$ type are orders of magnitude larger than the losses for the $H-$types, so ex-ante welfare rises in S over the range of values we consider.

8 Economic Crises

We now add aggregate uncertainty to our environment. In particular there are two aggregate states, $s \in \{G, B\}$ where $s = G$ corresponds to a baseline state like that parameterized above and $s = B$ corresponds to a crisis state where there is a sudden spike in unemployment. The timing of our model with aggregate uncertainty matches exactly the timing without aggregate uncertainty, but the Markov process on employment states depends on the current

[17] We assume everyone is born unhoused and with an employment status drawn from the stationary distribution implied by their type-specific Markov chain.

Figure 7: Welfare Effects of Subsidy



Notes: Discounted expected utility for newborn as subsidy to landlords rises. See equations (47) and (48) in Appendix D.3 for the appropriate calculation of consumption equivalent.

aggregate state. Specifically, the job-finding rates $p_{i,0,1}(s)$ and job retention rates $p_{i,1,1}(s)$ are aggregate state dependent. The aggregate state itself evolves according to a Markov process with realization prior to point 1 in our timing.[18]

Given the landlord and renter values conditional on matching which are described in Appendix F, the unhoused renter solves the following:

$$V^*_{i,e}(s,\mu) = y_{i,e} - \alpha + \max_{r \le y_i - \alpha, q, \theta} \beta \mathbb{E}_{s'|s} \Bigg[\phi(\theta) \Bigg(\sum_{e' \in \{0,1\}} p_{i,e,e'}(s) \mathbb{E}_{f'} R_{i,e'}(r,q,f';s',\mu') \Bigg) + \big(1-\phi(\theta)\big) \Bigg(\sum_{e' \in \{0,1\}} p_{i,e,e'}(s) V^*_{i,e'}(s',\mu') \Bigg) \Bigg]$$

s.t.

$$\kappa \ge \beta \psi(\theta) \mathbb{E}_{s'|s} \Bigg[\sum_{e' \in \{0,1\}} p_{i,e,e'}(s) \mathbb{E}_{f'} L_{i,e'}(r,q,f';s') - c(q) \Bigg],$$

As discussed above, state $s = G$ is parameterized as in the benchmark above which

[18] We solve the model using techniques as in Krusell and Smith [19]. See Appendix D for more details.

appears again in Table 14. We model the bad state $s = B$ after the observed job finding rates observed during the Covid-19 pandemic. We assume that state $s = G$ is very persistent (expected duration is 100 years) while the crisis state $s = B$ is transitory (expected duration is 4 months). In this environment, we consider three choices for eviction policies. Specifically, we allow for the eviction success rate to be aggregate-state dependent, $\lambda(s)$, and consider a no-moratorium policy $(\lambda(G), \lambda(B)) = (1/2, 1/2)$, crisis moratorium in a B state but not in a G state $(\lambda(G), \lambda(B)) = (1/2, 0)$, and full moratorium $(\lambda(G), \lambda(B)) = (0, 0)$. We assume that crisis policy changes occur with a delay of one month in transitioning from a good to bad state, due to slow-acting bureaucracy.

Table 14: Aggregate Uncertainty Parameterization

Parameters	Values
Covid 19 Calibration	
$(p_{L,0,1}(G), p_{H,0,1}(G))$	(0.17,0.89)
$(p_{L,1,1}(G), p_{H,1,1}(G))$	(0.57,0.96)
$(p_{L,0,1}(B), p_{H,0,1}(B))$	(0.09,0.80)
$(p_{L,1,1}(B), p_{H,1,1}(B))$	(0.45,0.91)
$Pr(s' = G \| s = G)$	0.9992
$Pr(s' = G \| s = B)$	0.25

Table 15 lists the equilibrium outcomes with aggregate uncertainty. We will start with the two columns under "No Moratoria", the effect of a crises on equilibrium variables is can be seen by comparing the $s = G$ and $s = B$ columns. While type H individuals are barely affected by the crisis (their finding rate falls marginally), the type-L renters are excluded from the search market. In addition, the type-L tenants who become unemployed are more likely to be evicted in the crisis. As seen from the black solid line in Figure 8, this leads to a deep decline in the share of type L people who are housed that persists for over eight months after the crisis ends.

The next two columns in Table 15 shows the effect of an eviction moratorium during the crisis that is removed once the economy recovers. The finding rates and rental quality of the L-type renter falls slightly even in good times, due to negative effects on rental supply coming from future expectations. For an $L-$type who finds themselves unhoused during the crisis, even with the moratorium it is impossible to find new housing. However, the blue dashed line in Figure 8 shows that the crisis moratorium eliminates the sharp fall in housing during the crisis, despite the one-period delay in the eviction moratorium. This is because many landlords will still find it optimal to retain their renters through the crisis instead of separating outright.

In terms of welfare, at the onset of a crisis the gain from maintaining matches just outweighs the loss from lower finding rates. As a result, $L-$types gain marginally (average $L-$type welfare at the onset of the crisis is approximately 0.001% higher with a temporary moratorium). While type H people are mostly unaffected by the eviction policy, spillovers from less overall quality lead them to lose slightly from the crisis moratorium. While a temporary eviction moratorium during the crisis can be welfare improving, a permanent moratorium is a bad policy for the same reason as in the steady-state model. The last two columns of Table 15 show that a permanent moratorium completely shuts down rental markets for type L rentals, leading to an ever declining share who are housed in Figure 8. This reduces welfare for type L people dramatically (by 1.4 percent) and also reduces welfare for the type H people since aggregate quality falls considerably.

Table 15: Aggregate Uncertainty Equilibrium Outcomes

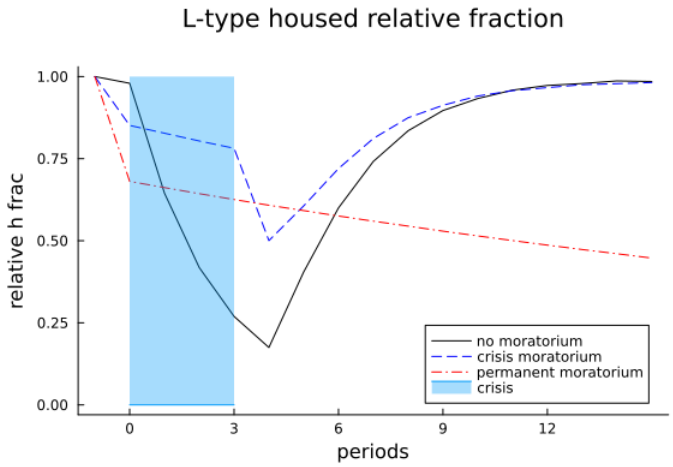
	No Moratoria		Crisis Moratoria		Full Moratoria	
	$s = g$	$s = b$	$s = g$	$s = b$	$s = g$	$s = b$
$(r_{H,1}, q_{H,1})$	(1.572,2.148)	(1.709,2.158)	(1.572,2.148)	(1.709,2.158)	(1.572,2.148)	(1.709,2.158)
$(r_{H,0}, q_{H,0})$	(1.694,2.122)	(1.786,2.143)	(1.694,2.122)	(1.786,2.143)	(1.694,2.122)	(1.786,2.143)
$(r_{L,1}, q_{L,1})$	(1.0,0.438)	$\emptyset$	(1.0,0.437)	$\emptyset$	$\emptyset$	$\emptyset$
$(r_{L,0}, q_{L,0})$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
$\phi(\theta_{H,1})$	0.758	0.751	0.758	0.751	0.758	0.751
$\phi(\theta_{H,0})$	0.781	0.768	0.781	0.768	0.781	0.768
$\phi(\theta_{L,1})$	0.208	0.0	0.206	0.0	0.0	0.0
$\phi(\theta_{L,0})$	0.0	0.0	0.0	0.0	0.0	0.0
Q	1.679	1.676	1.679	1.678	1.673	1.673

Table 16: Renter Value and Moratorium Policy

	Crisis Moratoria	Full Moratoria
CE_L	0.001	-1.32
CE_H	-0.08	-0.09

To demonstrate the effect of the aggregate state-dependent moratorium policy, we plot the response of the fraction of L-type renters housed during a 4-period crisis. In Figure 8 we plot the responses under a no-moratorium policy (i.e. $(\lambda(G), \lambda(B)) = (1/2, 1/2)$) and under a crisis-moratorium policy (i.e. $(\lambda(G), \lambda(B)) = (1/2, 0)$). As before, we assume a 1-period policy delay at the onset of the crisis. The difference in outcomes for the L-type renters is stark. Without the moratorium policy 73 percent of housed L-type renters are evicted the end of the crisis, and as many as 79 percent are unhoused immediately following the crisis.

Figure 8: Aggregate Uncertainty Experiment



Notes: Dashed Black line: L-type response to 3-period crisis with $(\lambda(G), \lambda(B)) = (1, 1)$. Blue line: L-type response to 3-period crisis with $(\lambda(G), \lambda(B)) = (1, 0)$. Dash-dotted red line: L-type response to 3-period crisis with $(\lambda(G), \lambda(B)) = (0, 0)$.

Under the state-dependent moratorium policy, however, the L-type renters are more likely to remain housed throughout the crisis, with 18 percent separating at the onset, during the policy delay, and the rest of the separations during this time occuring exogenously at rate $1 - \sigma$. Evictions are allowed again after the crisis has concluded, starting in period 4, and a large mass of renters is evicted at this time. By the end of period 3, the last crisis period, 78 percent of the L-type renters remain housed relative to 27 percent without the moratorium policy. While the lifting of the moratorium after the crisis leads to a later rise in evictions, causing the relative fraction housed to fall to 51 percent in period 4, there are large gains to L-type renters during the crisis itself. Overall, many more L-type renters are able to remain housed throughout the crisis under the crisis moratorium policy. For sake of comparison, under a permanent moratorium policy (i.e. $(\lambda(G), \lambda(B)) = (0, 0)$) the L-type rental market shuts down and while the moratorium prevents a sudden wave of evictions, except for in the policy-delay period, it results in disastrous long-run consequences. By period 12 under the permanent moratorium, the fraction of L-types housed is 50 percent of the baseline steady-state fraction and the fraction housed under this policy eventually converges to a new steady state without any housed L-type renters.

9 Conclusion

We present an equilibrium theory of rental markets in which the quality and tightness of the rental market is endogenous. Our model is realistic enough to capture salient features of rental markets in lower-income neighborhoods, such as eviction rates, higher rent burdens and rent-to-quality for the lowest income tenants, and large neighborhood externalities that exacerbate housing inequality. However, it is stylized enough that we can fully characterize the socially optimal allocation of housing, which is starkly egalitarian - evictions almost never occur and are never due to tenants being unable to pay rent. Furthermore, the quality and supply of housing are independent of a person's employment status or income.

Importantly, the model is a useful laboratory for considering the social desirability of eviction restrictions and rent support for unemployed people, during both normal economic conditions and crises. The model illustrates that there can be important unintended consequences of eviction moratoriums emanating from the supply side of the rental market; eviction restrictions to keep people in rentals, even if ex-post socially optimal, result in lower supply of both vacancies and quality of rentals. Policymakers who wish to reduce evictions for at-risk renters without distorting the supply of housing (either quality or quantity) should instead subsidize the rent of unemployed tenants by paying the landlord directly.

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A Appendix: Data

We describe the variables and sample selection for the Survey of Consumer Finance, Current Population Survey, and Rental Housing Finance Survey.

A.1 Survey of Consumer Finance

The Board of Governors provides a cleaned version of the Survey of Consumer Finance that provides useful variables defined at the household level. We use the following:

Table 17: SCF Variables

Name	Description
Rent	Monthly rent spending on all housing
Liquid Assets	Value of checking and savings balances
Networth	Value of all real and financial assets less all debts
Income	Income from all sources

A.2 Current Population Survey

We have matched individuals from 2018 to 2019 from monthly interviews in the CPS using their household identifier, individual identifier, state of residence, sex, race, and age. We then used the following variables to classify individuals by renter status, select working-age renters with below-median earnings, calculate average earnings, and estimate transition rates between employment statuses:

Table 18: CPS Variables

Name	Description
Housing type (hetenure)	Whether person owns housing, rents, or neither
Age (prtage)	Age of individual in years
Earnings (maximum value of prernwa)	Reference week's earnings
Employment (lfs)	Labor force status

A.3 Rental Housing Finance Survey

In order to calculate operating costs, which we map to f in our model, we use the operating cost variable from the RHFS as well as our own imputation of interest expenses for any debt on the rental unit as well as property taxes on the rental unit.

The RHFS measure of operating costs includes utilities, insurance, landscaping, management company expenses, payroll expenses, maintenance, and security. We add to this an estimate of interest payments, which we compute using the RHFS information on mortgages. We first take the initial amount borrowed, which is given in the RHFS. We then take the date when the first mortgage was taken, which is given in 3-10 year ranges, and use the average interest rate during the period of origination to calculate the average interest payment in 2018 on the mortgage assuming a standard 30-year term. Finally, we add $\frac{1}{12}$ percent of the rental unit's market value to approximate the monthly property tax cost.

B The Socially Optimal Allocation

As in the text, the social planning problem is given by the following:

$$\begin{aligned} S(\mu_h, \mu_u) = \max \int \int & (1 - \epsilon(s_h, f))(q \cdot \mathcal{E}(Q) - f) g(df) \mu_h(ds_h) \\ & - \int [\kappa + c(q(s_u))\psi(\theta(s_u))](\theta(s_u))^{-1} T^{**}(\mu^h, \mu^u, \epsilon(\cdot))(ds_u) \\ & + \beta \cdot S(T^*_h(\mu^h, \mu^u, q(\cdot), \theta(\cdot), \epsilon(\cdot)), T^*_u(\mu^h, \mu^u, q(\cdot), \theta(\cdot), \epsilon(\cdot)) \end{aligned}$$

subject to:

$$Q = \int\int (1 - \epsilon(s_h, f)) q g(df) \mu_h(ds_h),$$

where the operators are given by:

$$T^{**}(\mu^h, \mu^u, \epsilon(\cdot))(s^u) = \mu^u(s^u) + \int\int \epsilon(s^h, f) 1_{i'=i} 1_{e'=e} g(f) df d\mu^h(s^h)$$

$$T^{*,h}(\mu^h, \mu^u, q(\cdot), \theta(\cdot), \epsilon(\cdot))(s^{h\prime}) = (1-\sigma) \int\int p_{i,e,e'} 1_{i'=i} 1_{q'=q} (1 - \epsilon(s^h, f)) g(f) df d\mu^h(s^h)$$
$$+ \int \phi(\theta(s^u)) p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} dT^{**}(\mu^h, \mu^u, \epsilon(\cdot))(s^u)$$

$$T^{*,u}(\mu^h, \mu^u, q(\cdot), \theta(\cdot), \epsilon(\cdot))(s^{u\prime}) = \sigma \int\int p_{i,e,e'} 1_{i'=i} (1 - \epsilon(s^h, f)) g(f) df d\mu^h(s^h)$$
$$+ \int (1 - \phi(\theta(s^u))) p_{i,e,e'} 1_{i'=i} dT^{**}(\mu^h, \mu^u, \epsilon(\cdot))(s^u)$$

As we show in Appendix G, the stationary planner's allocation is identical to those derived from solving the following household-level problems for each i, e

$$\omega^u_{i,e} = \max_{q,\theta} -[\kappa + c(q)\psi(\theta)](\theta)^{-1} + \beta\big(1 - \phi(\theta)\big) \sum_{e' \in \{0,1\}} p_{i,e,e'} \omega^u_{i,e'} \tag{27}$$
$$+ \beta\phi(\theta) \sum_{e' \in \{0,1\}} p_{i,e,e'} \omega^h_{i,e'}(q)$$

$$\omega^h_{i,e}(q) = \mathbb{E}_f \Bigg[\max_{\epsilon \in \{0,1\}} \epsilon \omega^u_{i,e} + \tag{28}$$
$$(1-\epsilon)\bigg(q\mathcal{E}(Q) + \mathcal{E}'(Q)Qq - f + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'} \omega^h_{i,e'}(q) + \beta\sigma \sum_{e' \in \{0,1\}} p_{i,e,e'} \omega^u_{i,e'} \bigg) \Bigg]$$

at the value of Q such that

$$Q = \sum_{i \in \{H,L\}} \sum_{e \in \{0,1\}} \mathbb{E}_f \left[1 - \epsilon^{SP}_{i,e}(q^{SP}_{i,e}, f) \right] q^{SP}_{i,e} \mu^{SP}_{i,e}, \tag{29}$$

where each $x^{SP}_{i,e}$ is the value arising from the maximization problems in (27) and (28) and the laws of motion for employment and housing status. The first-order conditions for q and θ are

$$c'(q) = \beta \sum_{e' \in \{0,1\}} p_{i,e,e'} \frac{\partial \omega^h_{i,e'}(q)}{\partial q} \tag{30}$$

$$\kappa - \theta^2 \phi'(\theta_{i,e}) c(q) = \theta^2 \phi'(\theta) \beta \sum_{e' \in \{0,1\}} p_{i,e,e'} \left[w^h_{i,e'}(q) - \omega^u_{i,e'} \right], \tag{31}$$

where

$$\frac{\partial \omega^h_{i,e'}(q)}{\partial q} = \mathbf{E}_f \left[\left(1 - \epsilon_{i,e}(q,f) \right) \left(\mathcal{E}(Q) + \mathcal{E}'(Q)Q + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'} \frac{\partial w^h_{i,e'}(q)}{\partial q} \right) \right. \tag{32}$$

and the eviction rule $\epsilon_{i,e}(q,f) = 0$ unless

$$q\mathcal{E}(Q) + \mathcal{E}'(Q)Qq - f + \sum_{e' \in \{0,1\}} p_{i,e,e'} \left(\beta(1-\sigma)\omega^h_{i,e'}(q) + \beta\sigma\omega^u_{i,e'} \right) - \omega^u_{i,e} < 0, \tag{33}$$

in which case $\epsilon_{i,e}(q,f) = 1$. Condition 33 is intuitive: the planner only chooses to destroy a match if the expected discounted surplus is negative. The surplus is made of benefits: the direct flow utility $q\mathcal{E}(Q)$ plus the externality benefit $\mathcal{E}'(Q)Qq$ plus the expected discounted future surplus. From this, we subtract costs: the flow cost f and the value of having the tenant re-enter the pool of house seekers $\omega^u_{i,e}$.

Note that the flow benefit and cost parameters are independent of i or e. The only way that type or employment status enter any expression are through the weights on future values ($p_{i,e,e'}$). Through repeated substitution, this implies that the allocations are independent of i or e. We therefore prove Theorem 1 by conjecturing that the per-match values are independent of i or e and then solving for the first-order conditions, which do not have i or e on any parameter once we sum over the probabilities.

Proof of Theorem 1

Proof. Assume that $\omega^j_{i,e} = \omega^j$. Then the above value functions, first-order conditions, and envelope conditions are independent of i or e, as is the condition for eviction. □

Corollary 1 follows immediately by setting $\mathcal{E}(Q) = 1$ and verifying that Assumption 1 guarantees that condition 33 is slack.

C Proofs From Section 5

Proof of Lemma 1:

Proof. First, if the participation constraints are slack and $k_{i,e,t}(\mathbf{r}_{i,e}, e^t) = 1$ for all e^t then the first-order conditions on rent gives

$$\phi(\theta_{i,e}) = \lambda_{i,e,e'}\psi(\theta_{i,e}), \tag{34}$$

where $\lambda_{i,e,e'}$ is the multiplier on the zero-profit conditions in (12) (we have one of these for each e'). The definitions of ϕ and ψ as matches per unhoused tenant and matches per vacant unit imply that $\phi(\theta_{i,e})\theta_{i,e}^{-1} = \psi(\theta_{i,e})$, therefore $\lambda_{i,e,e'} = \theta_{i,e}^{-1}$.

The first-order condition on $q_{e'}$ then gives

$$\beta\phi(\theta_{i,e})\frac{\partial R_{i,e'}(\mathbf{r}, \mathbf{k}, (e, e'), q_{e'})}{\partial q} = \lambda_{i,e,e'}\psi(\theta_{i,e})c'(q_{i,e'}). \tag{35}$$

Using 34 and calculating the marginal value of q in R from 10 gives

$$c'(q_{i,e}) = \beta\frac{1}{1-\beta(1-\sigma)} \tag{36}$$

which means that $q_{i,e} = q^{SP}$ for any employment history or i.

The first-order condition on $\theta_{i,e}$ gives

$$\begin{aligned} -\phi'(\theta_{i,e}) \textstyle\sum_{e'\in\{0,1\}} p_{i,e,e'} \left(R_{i,e'}\big(\mathbf{r}, \mathbf{k}, (e, e'), q^{SP}\big) - V^*_{i,e'} \right) = \\ \beta\tfrac{\psi'(\theta_{i,e})}{\theta_{i,e}} \textstyle\sum_{e'\in\{0,1\}} p_{i,e,e'} \left[L_{i,e'}\big(\mathbf{r}, \mathbf{k}, (e, e')\big) - c(q^{SP}) \right] \end{aligned} \tag{37}$$

We now define the match surplus for any e^t as

$$S_{i,e}(\mathbf{r}, \mathbf{k}, e^t) \equiv R_{i,e}\big(\mathbf{r}, \mathbf{k}, e^t\big) + L_{i,e}\big(\mathbf{r}, \mathbf{k}, e^t\big) - V^*_{i,e}, \tag{38}$$

which can be written recursively as

$$\begin{aligned} S_{i,e}(\mathbf{r}, \mathbf{k}, e^t) \;&=\; q - \overline{f} + \beta(1-\sigma)\sum_{e'\in\{0,1\}} p_{i,e,e'} S_{i,e'}\big(\mathbf{r}, \mathbf{k}, (e^t, e')\big) \\ &-\; \beta\phi(\theta_{i,e})\sum_{e'\in\{0,1\}} p_{i,e,e'} S_{i,e'}(\mathbf{r}, \mathbf{k}, (e, e')) + \beta\psi(\theta_{i,e})\theta_{i,e}^{-1}\sum_{e'\in\{0,1\}} p_{i,e,e'} L_{i,e'}(\mathbf{r}, \mathbf{k}, (e, e')). \end{aligned} \tag{39}$$

Note that the flow surplus $q - \overline{f}$ in (39) is independent of $\mathbf{r}$ since the payment cancels when adding tenant and landlord payoffs. Therefore the surplus is independent of employment history before the current period, which itself only matters for the conditional expectations over e', and we can simply write $S_{i,e}$. Since the zero-profit condition binds, we can simplify the surplus to just

$$S_{i,e} = q - \overline{f} + \beta\Big(1 - \sigma - \phi(\theta_{i,e})\Big) \sum_{e' \in \{0,1\}} p_{i,e,e'} S_{i,e'} + \theta_{i,e}^{-1}\big(\kappa + \beta\psi(\theta_{i,e})c(q^{SP})\big) \tag{40}$$

Given that $\phi(\theta) = \psi(\theta)\theta^{-1}$, we know that $\phi'(\theta) = \psi'(\theta)\theta^{-1} - \theta^{-2}\psi(\theta)$. Using this fact and adding like terms to both sides of Equation 37 and using the zero-profit condition again gives

$$\beta\phi'(\theta_{i,e}) \sum_{e' \in \{0,1\}} p_{i,e,e'} \left[S_{i,e'} - \frac{c(q^{SP})}{\beta}\right] = -\theta_{i,e}^{-2}\kappa \tag{41}$$

Now note that we have two equations in two sets of unknowns ($S_{i,e}$ and $\theta_{i,e}$), but there is no dependence on i or e for any parameter other than $p_{i,e,e'}$. Therefore, we conjecture that $S_{i,e} = S$ and $\theta_{i,e} = \theta$ and have

$$-\beta\theta^2\phi'(\theta)\frac{q - \overline{f} + \theta^{-1}\big(\kappa + \beta\psi(\theta)c(q^{SP})\big)}{1 - \beta(1 - \sigma - \phi(\theta))} = \kappa - \theta^2\phi'(\theta)c(q^{SP}), \tag{42}$$

which is exactly the same condition as the planner's, so we can conclude that $\theta = \theta^{SP}$. □

Proof of Theorem 2:

Proof. By the previous lemma, an equilibrium without eviction always delivers the egalitarian social planner's allocation of θ and q. In order for this allocation to be incentive compatible for landlords in a period when their tenant is unemployed, we need $L_{i,1}(\mathbf{r}_i^*, \mathbf{k}_i^*, (e^{t-1}, 0)) \geq \underline{L}$, where $\underline{L}$ satisfies

$$-\overline{f} + \beta(1 - \sigma)p_{i,0,1}\underline{L} = 0 \rightarrow \underline{L} = \frac{\overline{f}}{\beta(1 - \sigma)p_{i,0,1}}. \tag{43}$$

That is, $\underline{L}$ is the lowest expected future profits upon the tenant becoming re-employed that would keep a landlord from evicting them. If the landlord receives $\underline{L}$, the surplus for the tenant upon re-employment is

$$R_{i,1}(\mathbf{r}_i^*, \mathbf{k}_i^*, e^{t-1}) - V_{i,1}^* = \frac{q - \overline{f} + \frac{1}{\theta^{SP}}\Big(\kappa + \beta\psi(\theta^{SP})c(q^{SP})\Big)}{1 - \beta(1 - \sigma - \phi(\theta^{SP}))} - \frac{\overline{f}}{\beta(1 - \sigma)p_{i,0,1}}.$$

This must be positive for the tenant to remain in the unit rather than walk away, but is negative if Condition 15 holds. Since the tenant would leave if asked to pay future rent that delivered $\underline{L}$ in period $t+1$ following history $(e^{t-1}, 0)$, the landlord would have evicted in period t. $\square$

D Appendix: Computation

Here we summarize the algorithm used to compute the different equilibria in this paper.

D.1 Computation of Stationary Equilibrium

We solve for the equilibrium numerically by discretizing the value function across grids, $(r, q) \in \mathcal{R} \times \mathcal{Q}$. We first numerically solve for the landlord's value across $\mathcal{R} \times \mathcal{Q}$, which is independent of Q. We can then invert the free entry conditions to yield equilibrium submarket tightnesses $\theta_{i,e}(r, q)$ which are also independent of Q. We then guess Q^n, solve the conditional renter values and policies using value function iteration on $\mathcal{R} \times \mathcal{Q}$, compute the stationary measure by iterating on equations (22) and (23), and calculate Q^{n+1} implied by the stationary measure. We repeat the process until convergence.

1. Discretize $(r, q) \in \mathcal{R} \times \mathcal{Q}$ for appropriate grids $\mathcal{R}, \mathcal{Q}$.

2. Compute $L_{i,e}(r, q)$ numerically, and invert the free entry condition to yield $\theta_{i,e}(r, q)$.

3. Initialize guesses: $Q^0, V_{i,e}^{*,0}, R_{i,e}^0$.

4. Given guesses $Q^n, V_{i,e}^{*,n}, R_{i,e}^n$ compute updates to $V_{i,e}^{*,n+1}, R_{i,e}^{n+1}$ and search policies by solving (19), (20).

5. Given the search policies, iterate on (22) and (23) to solve for the stationary distribution $\mu_{i,e}^{h,n}(r, q)$. Compute Q^{n+1} as implied by $\mu_{i,e}^{h,n}(r, q)$.

6. Check for convergence of all equilibrium objects. If not converged, return to 4.

D.2 Computation of Equilibrium with Aggregate Uncertainty

Due to the externality term $\mathcal{E}(Q)$, the version of the model with aggregate uncertainty as described in section 8 cannot be solved exactly and hence we approximate the solution in the spirit of Krusell and Smith (1998) [19]. In particular, while the true renter problem includes in the state space the entire distribution of renters, $\mu_{i,e}^h(r, q), \mu_{i,e}^u$, we approximate the solution by replacing the distribution of renters in the state space with a summary statistic - in our case, Q itself. We guess a forecasting rule $Q' = a(s) + b(s)Q$, discretize $Q \in \tilde{\mathcal{Q}}$, solve for the renter values and policies, simulate a pseudopanel of households using the policy rules, and update the forecasting rule $a(s), b(s)$ using forecasting regressions implied by our pseudopanel. We repeat until convergence of the forecasting rule. To summarize, we compute the equilibrium using the following steps:

1. Discretize $(r, q) \in \mathcal{R} \times \mathcal{Q}$ for appropriate grids $\mathcal{R}, \mathcal{Q}$.

2. Compute $L_{i,e}(r, q; s)$ numerically, and invert the free entry condition to yield $\theta_{i,e}(r, q; s)$.

3. Discretize $Q \in \tilde{\mathcal{Q}}$, and initialize guesses of $a^0(s), b^0(s)$.

4. Given guesses $a^n(s), b^n(s)$ compute renter values and policies.

5. Given the search policies, simulate a pseudopanel of $N = 20000$ households for a sample of $T = 9500$ periods, in addition to a $T_0 = 500$ period burn-in.

6. Compute $a^{n+1,u}(s), b^{n+1,u}(s)$ from forecasting regressions.

7. Check for convergence of all equilibrium objects. If not converged, update $a^{n+1}(s) = \rho a^{n+1,u}(s) + (1 - \rho)a^n(s)$ and $b^{n+1}(s) = \rho b^{n+1,u}(s) + (1 - \rho)b^n(s)$ for tuning parameter $\rho \in (0, 1]$ and return to 4.

D.3 Appendix: Definition of Model Statistics

Here we define summary statistics reported in our tables and figures throughout the paper.

In Table 13 we calculate aggregate welfare differences associated with competitive equilibrium under different assumptions relative to the planner's allocation. To do so, first we compute $W^{sp}_{\mathcal{E}(Q^{sp})}$ as the value of the social planner's objective function (defined in equation (1)) evaluated at the stationary planner's allocation $((q^{sp}_{i,e}, \theta^{sp}_{i,e}), \forall (i, e) \in \{H, L\} \times \{0, 1\})$ and the $\mu^j_{i,e}(\theta^{sp}_{i,e})$ implied by the planner's allocation. Then we compute $W^{base}_{\mathcal{E}(Q)}$ as aggregate social surplus associated with our baseline decentralized equilibrium (i.e. the maximand from equation (1) evaluated at the decentralized values of $((q_{i,e}, \theta_{i,e}), \forall (i, e) \in \{H, L\} \times \{0, 1\}$ and $\mu^j_{i,e}$ implied by the competitive equilibrium allocation and eviction policies). Finally, we compute $W^{base}_{\mathcal{E}(Q^{sp})}$ as the objective function obtained by the decentralized equilibrium, if the externality term was evaluated at the externality value associated with the planner's allocation. The quantities reported in the table are then:

$$\text{Baseline } Q = \frac{W^{base}_{\mathcal{E}(Q)} - W^{sp}_{\mathcal{E}(Q^{sp})}}{W^{sp}_{\mathcal{E}(Q^{sp})}}, \tag{44}$$

$$\text{Planner } Q = \frac{W^{base}_{\mathcal{E}(Q^{sp})} - W^{sp}_{\mathcal{E}(Q^{sp})}}{W^{sp}_{\mathcal{E}(Q^{sp})}}. \tag{45}$$

In Figure 4 we report the CE value for L-type renters in equilibria characterized by alternative moratorium policies. Specifically, we calculate $\text{CE}_L = \frac{V^*_{L,1}(\lambda) - V^*_{L,1}(\lambda=1/2)}{V^*_{L,1}(\lambda=1/2)}$ for $\lambda \in [0,1]$. We report the same quantities in Figure 5 where we additionally vary $\alpha \in \{1, 0.95\}$. Comparisons are within-α, i.e. for this figure we report:

$$\text{CE}_L = \frac{V^*_{L,1}(\lambda,\alpha) - V^*_{L,1}(\lambda = 1/2, \alpha)}{V^*_{L,1}(\lambda = 1/2, \alpha)}, \tag{46}$$

for each α.

Figure 7 reports type-specific newborn welfare calculations expressed in terms of CE along with a non-type specific newborn welfare relative to the no-subsidy decentralized equilibrium. Specifically, the type i-specific CE_i numbers refer to:

$$\text{CE}_i = \frac{V^{nb}_i(S) - V^{nb}_i(S=0)}{V^{nb}_i(S=0)}. \tag{47}$$

The non-type-specific CE numbers further integrate out the type of household, i.e. $V^{nb} = \sum_i \mu_i V^{nb}_i$ and CE refers to:

$$\text{CE} = \frac{V^{nb}(S) - V^{nb}(S=0)}{V^{nb}(S=0)}. \tag{48}$$

Finally, we report CE numbers for the aggregate uncertainty case in Table **??** relative to our baseline aggregate economy without eviction restrictions. We average the values of each type under each $\lambda(s)$ policy and then compute the welfare metric. That is, let $\overline{V}_i(\lambda(G), \lambda(B))$ be the average value of a renter of type i under a given set of policies, then CE_i is:

$$\text{CE}_i = \frac{\overline{V}_i(\lambda(G), \lambda(B)) - \overline{V}_i(1/2, 1/2)}{\overline{V}_i(1/2, 1/2)}. \tag{49}$$

D.4 Supply Elasticity

We impose rent ceilings on each type 1% below their baseline equilibrium values and re-compute the stationary equilibrium. Then, we compute the finite-difference approximation to:

$$\text{elasticity} = \frac{\partial \text{ housing quantity}}{\partial \text{ housing value}} \times \frac{\text{housing value}}{\text{housing quantity}}$$

where:

$$\begin{aligned}
\text{housing value} &= Q\mathcal{E}(Q)/\text{housed mass} \\
\text{housed mass} &= \mathbb{E}_f\Bigg[\sum_{i\in\{H,L\}}\sum_{e\in\{0,1\}}\sum_{k\in\{0,1\}}\Big(1-\epsilon_{i,e}(r_{i,k},q_{i,k},f),\Big)\mu^h_{i,e}(r_{i,k},q_{i,k})\Bigg] \\
\text{housing quantity} &= \text{housed mass} + \text{vacancy mass}, \\
\text{vacancy mass} &= \sum_{i,e}\theta^{-1}(i,e)\mu^*(i,e),
\end{aligned}$$

where the contribution to vacancy mass for the $i = L, e = 0$ renter is zero.

E Appendix: Calculation of Λ^* Matrix

We first compute the Λ matrix from Andrews, Gentzkow, and Shapiro (2017) [5]. The matrix is defined as:

$$\Lambda = -\left(G'WG\right)^{-1} G'W \tag{50}$$

where $G = \mathbb{E}\left[\nabla_b \widehat{g}(b)\right]$ is the 8×6 probability limit of the Jacobian and W is the probability limit of the weighting matrix, which we have simply taken to be the identity matrix. Λ measures how sensitive the parameter estimates are to local perturbations of the data moments. Further, there is a tight connection between Λ and standard errors in GMM/SMM. Specifically, given (50), the limiting distribution of the estimates can be written

$$\sqrt{T}\left(\widehat{b} - b_0\right) \xrightarrow{d} \mathcal{N}\left[0, \Lambda\Omega\Lambda'\right] \tag{51}$$

where $\Omega = \mathbb{E}\left[g(b)g(b)'\right]$ is the limiting variance-covariance matrix of the data moments, b_0 is the true parameter value, and T is sample size. For a given Ω, (51) makes clear that small values of Λ are associated with more precise parameter estimates.

Table 19: AGS Sensitivity Matrix Λ

	r_H/y_H	eviction rate	r/q slope	experiment	vacancy rate	mean f	var f	elasticity
ξ	-0.09	-0.0	-0.4	0.01	-0.01	-0.15	0.04	0.0
ν	0.57	-0.45	3.08	-0.01	0.06	1.22	0.3	-0.11
c_0	-4.57	2.31	-19.64	0.1	-0.09	-7.59	-1.19	1.02
κ	0.55	-0.03	2.26	-0.0	0.01	0.85	-0.2	-0.01
σ_f	0.02	-0.0	-0.0	-0.0	0.0	-0.0	-0.45	-0.0
$\underline{f}$	-0.22	0.06	-0.94	0.0	-0.0	-0.36	-0.02	-0.0

Once we have computed Λ, we then rescale each element of Λ to calculate Λ^* as is reported in Table 9. Specifically, while the (i,j)'th element of Λ corresponds to $\frac{\partial b_i}{\partial m_j}$ where m_j is the j'th moment, we define Λ^* such thet the (i,j)'th element refers to $\frac{\partial b_i}{\partial m_j} \times \frac{m_j}{b_i}$. Λ^* hence is a matrix of elasticities of the parameter estimates with respect to the data moments, as opposed to the derivative of the parameter estimates with respect to the data moments. We note that the derivative depends on the scaling of the parameters and moments whereas the elasticity is invariant to the scale of these objects. Hence, we report Λ^* in Table 9.

In practice, we approximate G with a finite-difference approximation. That is, when computing the derivative of moment j with respect to parameter i, we approximate $\frac{\partial \hat{g}_j(b)}{\partial b_i} \approx \frac{\hat{g}_j(b+\vec{s}_j)-\hat{g}_j(b)}{s_j}$, where s_j is the step size chosen for parameter j and $\vec{s}_j$ is a 6×1 vector containing s_j as the j-th element and 0 for all other elements. We use a 1 percent finite-difference so $s_j = 0.01 \times \theta_j$.

To extend our discussion of identification within our model beyond the 8 that we target to match moments, we compute an extended Jacobian where the set of moments considered includes additional equilibrium policies and quantities and our set of parameters includes the parameters that we calibrate outside of the model. We report this extended Jacobian in Appendix G.3.

F Appendix: Aggregate Uncertainty

A landlord who has a renter with constant rent r and housing quality q with flow cost f has the following values:

$$L_{i,e}(r,q,f;s) \quad = \quad \max_{\epsilon} \left(1-\epsilon\right)\left[r \cdot e - f + \beta(1-\sigma) \sum_{e' \in \{0,1\}} p_{i,e,e'}(s)\mathbb{E}_{f',s'}\left[L_{i,e'}(r,q,f';s')\right]\right].$$

A renter in a unit of quality q with constant rent r has the following values:

$$\begin{aligned}
R_{i,e}(r,q,f;s,\mu) \quad &= \quad \Big(1-\epsilon_{i,e}(r,q,f;s,\mu)\Big)\Big[y_i - r\cdot e - \alpha + q\mathcal{E}(Q) \\
&+ \quad \beta(1-\sigma)\sum_{e'\in\{0,1\}} p_{i,e,e'}(s)\mathbb{E}_{f',s'}\left[R_{i,e'}(r,q,f';s',\mu')\right]\Big] \\
&\quad +\epsilon_{i,e}(r,q,f;s,\mu)V^*_{i,e}(s,\mu)
\end{aligned}$$

G Full Derivation of the Socially Optimal Allocation

We proceed by first characterizing the optimal policies of the Planner, and then by showing that the same policies are induced by individual-level optimization problems.

G.1 Characterizing the Socially Optimal Policies

Let us begin with the optimization problem given by (1). We can write the Lagrangian of the Planner with Lagrange multiplier λ^Q on the adding-up constraint for Q:

$$\begin{aligned}
\mathcal{L} = &\int\int (1-\epsilon(s^h,f))(q\mathcal{E}(Q)-f)g(f)df\,d\mu^h(s^h) \\
&-\int [\kappa + c(q(s^u))\psi(\theta(s^u))](\theta(s^u))^{-1}dT^{**}(\mu^h,\mu^u,\epsilon(\cdot))(s^u) \\
&+\beta\cdot S(T^{*,h}(\mu^h,\mu^u,q(\cdot),\theta(\cdot),\epsilon(\cdot))(s^h),T^{*,u}(\mu^h,\mu^u,q(\cdot),\theta(\cdot),\epsilon(\cdot))(s^u)) \\
&+\lambda^Q\left(\int\int(1-\epsilon(s^h,f))qg(f)df\,d\mu^h(s^h)-Q\right)
\end{aligned}$$

Now we begin characterizing the optimal policies. The Planner's first order condition with respect to total quality Q gives us the shadow value of housing quality:

$$\begin{aligned}
\lambda^Q &= \mathcal{E}'(Q)\int\int(1-\epsilon(s^h))qg(f)df\,d\mu^h(s^h) \\
&= \mathcal{E}'(Q)Q.
\end{aligned}$$

Following Moll and Nuno (2018), we will now assume that the Gateaux derivative of the Planner's housing surplus function with respect to the measure of households in a given housing state $\frac{\partial S(\mu^h,\mu^u)}{\partial \mu^j(s^j)}$ exists. By the envelope theorem, we can then write the following:

$$
\begin{aligned}
\frac{\partial S(\mu^h,\mu^u)}{\partial \mu^u(s^u)} &= -[\kappa + c(q(s^u))\psi(\theta(s^u))](\theta(s^u))^{-1} \\
&+ \beta\Bigg(\phi(\theta(s^u))\int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})}\underbrace{\frac{\partial \mu^{h\prime}(s^{h\prime})}{\partial T^{*,h}(\cdot)(s^{h\prime})}}_{=1} p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} ds^{h\prime} \\
&+ (1-\phi(\theta(s^u)))\int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})}\underbrace{\frac{\partial \mu^{u\prime}(s^{u\prime})}{\partial T^{*,u}(\cdot)(s^{u\prime})}}_{=1} p_{i,e,e'} 1_{i'=i} ds^{u\prime}\Bigg), \\
&= -[\kappa + c(q(s^u))\psi(\theta(s^u))](\theta(s^u))^{-1} \qquad (52)\\
&+ \beta\Bigg(\phi(\theta(s^u))\int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} ds^{h\prime} \\
&+ (1-\phi(\theta(s^u)))\int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} p_{i,e,e'} 1_{i'=i} ds^{u\prime}\Bigg),
\end{aligned}
$$

$$
\begin{aligned}
\frac{\partial S(\mu^h,\mu^u)}{\partial \mu^h(s^h)} &= \int (1-\epsilon(s^h,f))\Bigg(q\mathcal{E}(Q) - f + \lambda^Q q \\
&+ \beta(1-\sigma)\int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} \underbrace{\frac{\partial \mu^{h\prime}(s^{h\prime})}{\partial T^{*,h}(\cdot)(s^{h\prime})}}_{=1} p_{i,e,e'} 1_{i'=i} 1_{q'=q} ds^{h\prime} \\
&+ \beta\sigma \int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} \underbrace{\frac{\partial \mu^{u\prime}(s^{h\prime})}{\partial T^{*,u}(\cdot)(s^{h\prime})}}_{=1} p_{i,e,e'} 1_{i'=i} ds^{u\prime}\Bigg) g(f) df \\
&+ \int \epsilon(s^h,f) g(f) df \Bigg(- [\kappa + c(q(s^u))\psi(\theta(s^u))](\theta(s^u))^{-1} \\
&+ \beta\Bigg(\phi(\theta(s^u)) \int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} \underbrace{\frac{\partial \mu^{h\prime}(s^{h\prime})}{\partial T^{*,h}(\cdot)(s^{h\prime})}}_{=1} p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} ds^{h\prime} \\
&+ (1-\phi(\theta(s^u))) \int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} \underbrace{\frac{\partial \mu^{u\prime}(s^{h\prime})}{\partial T^{*,u}(\cdot)(s^{h\prime})}}_{=1} p_{i,e,e'} 1_{i'=i} ds^{u\prime}\Bigg)\Bigg), \\
&= \int (1-\epsilon(s^h,f))\Bigg(q\mathcal{E}(Q) - f + \lambda^Q q \qquad (53) \\
&+ \beta(1-\sigma)\int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} p_{i,e,e'} 1_{i'=i} 1_{q'=q} ds^{h\prime} \\
&+ \beta\sigma \int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} p_{i,e,e'} 1_{i'=i} ds^{u\prime}\Bigg) g(f) df \\
&+ \int \epsilon(s^h,f) g(f) df \Bigg(- [\kappa + c(q(s^u))\psi(\theta(s^u))](\theta(s^u))^{-1} \\
&+ \beta\Bigg(\phi(\theta(s^u)) \int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} ds^{h\prime} \\
&+ (1-\phi(\theta(s^u))) \int \frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} p_{i,e,e'} 1_{i'=i} ds^{u\prime}\Bigg)\Bigg),
\end{aligned}
$$

where we have used throughout that $\frac{\partial \mu^{j\prime}(s^{j\prime})}{\partial T^{*,j}(\mu^h(s^h),\mu^u(s^u),q(\cdot),\theta(\cdot),\epsilon(\cdot))(s^{j\prime})} = 1$, implied by the constraints of the original optimization problem given by (1).

Next we can consider the optimal household - level policies. Consider first the Planner's first order condition with respect to $q(s^u)$:

$$
\begin{aligned}
&c'(q(s^u))\psi(\theta(s^u))(\theta(s^u))^{-1}\left(\mu^u(s^u) + \int\int \epsilon(\hat{s}^h,f) 1_{i=\hat{i}} 1_{e=\hat{e}} g(f) df d\mu^h(\hat{s}^h)\right) \\
=&\beta \frac{\partial}{\partial q(s^u)} S(T^{*,h}(\mu^h,\mu^u,q(\cdot),\theta(\cdot),\epsilon(\cdot)), T^{*,u}(\mu^h,\mu^u,q(\cdot),\theta(\cdot),\epsilon(\cdot)))
\end{aligned}
$$

Broadly following Ottonello and Winberry (2023), we make the assumption that the order of differentiation can be swapped in the following expression, and then the order of integration and differentiation can be swapped:

$$
\begin{aligned}
&\frac{\partial}{\partial q(s^u)} S(T^{*,h}(\mu^h, \mu^u, q(\cdot), \theta(\cdot), \epsilon(\cdot)), T^{*,u}(\mu^h, \mu^u, q(\cdot), \theta(\cdot), \epsilon(\cdot))) \\
=& \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} \underbrace{\frac{\partial \mu^{h\prime}(s^{h\prime})}{\partial T^{*,h}(\cdot)(s^{h\prime})}}_{=1} \frac{\partial T^{*,h}(\cdot)(s^{h\prime})}{\partial q(s^u)} ds^{h\prime} + \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} \underbrace{\frac{\partial \mu^{u\prime}(s^{u\prime})}{\partial T^{*,u}(\cdot)(s^{u\prime})}}_{=1} \frac{\partial T^{*,u}(\cdot)(s^{u\prime})}{\partial q(s^u)} ds^{u\prime} \\
=& \int \frac{\partial}{\partial q(s^u)} \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} T^{*,h}(\cdot)(s^{h\prime}) ds^{h\prime} + \int \frac{\partial}{\partial q(s^u)} \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} T^{*,u}(\cdot)(s^{u\prime}) ds^{u\prime} \\
=& \frac{\partial}{\partial q(s^u)} \left(\int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} T^{*,h}(\cdot)(s^{h\prime}) ds^{h\prime} + \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} T^{*,u}(\cdot)(s^{u\prime}) ds^{u\prime} \right)
\end{aligned}
$$

Noting that only some $T^{*,j}(\cdot)$ terms are relevant for the derivative (i.e. only terms involving the renters searching in the current period), and the terms are linearly separable:

$$
\begin{aligned}
=& \frac{\partial}{\partial q(s^u)} \Bigg(\int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} \left[\int \phi(\theta(\hat{s}^u)) p_{\hat{i},\hat{e},e'} 1_{i'=\hat{i}} 1_{q'=q(\hat{s}^u)} dT^{**}(\mu^h, \mu^u, \epsilon(\cdot))(\hat{s}^u) \right] ds^{h\prime} \\
&+ \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} \left[\int (1 - \phi(\theta(\hat{s}^u))) p_{\hat{i},\hat{e},e'} 1_{i'=\hat{i}} dT^{**}(\mu^h, \mu^u, \epsilon(\cdot))(\hat{s}^u) \right] ds^{u\prime} \Bigg)
\end{aligned}
$$

Noting that the derivative only is nonzero only where $\hat{s}^u = s^u$ (since only there does the choice variable $q(s^u)$ show up):

$$
\begin{aligned}
=& \frac{\partial}{\partial q(s^u)} \Bigg(\int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} \phi(\theta(s^u)) \left(\mu^u(s^u) + \int \int \epsilon(\hat{s}^h, f) 1_{i=\hat{i}} 1_{e=\hat{e}} g(f) df d\mu^h(\hat{s}^h) \right) ds^{h\prime} \\
&+ \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} (1 - \phi(\theta(s^u))) p_{i,e,e'} 1_{i'=i} \left(\mu^u(s^u) + \int \int \epsilon(\hat{s}^h, f) 1_{i=\hat{i}} 1_{e=\hat{e}} g(f) df d\mu^h(\hat{s}^h) \right) ds^{u\prime} \Bigg) \\
=& \left(\mu^u(s^u) + \int \int \epsilon(\hat{s}^h, f) 1_{i=\hat{i}} 1_{e=\hat{e}} g(f) df d\mu^h(\hat{s}^h) \right) \\
\times& \frac{\partial}{\partial q(s^u)} \left(\phi(\theta(s^u)) \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(s^{h\prime})} p_{i,e,e'} 1_{i'=i} 1_{q'=q(s^u)} ds^{h\prime} + (1 - \phi(\theta(s^u))) \int \frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})} p_{i,e,e'} 1_{i'=i} ds^{u\prime} \right).
\end{aligned}
$$

By substituting this expression back into the FOC, and canceling the measure of searching households in this state from either side we obtain:

$$
\begin{aligned}
&c'(q(s^u))\psi(\theta(s^u))(\theta(s^u))^{-1} \\
=&\beta\frac{\partial}{\partial q(s^u)}\left(\phi(\theta(s^u))\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{h\prime}(s^{h\prime})}p_{i,e,e'}1_{i'=i}1_{q'=q(s^u)}ds^{h\prime}+(1-\phi(\theta(s^u)))\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{u\prime}(s^{u\prime})}p_{i,e,e'}1_{i'=i}ds^{u\prime}\right)
\end{aligned} \tag{54}
$$

Next, consider the Planner's first order condition with respect to $\theta(s^u)$:

$$
\begin{aligned}
&c(q(s^u))\psi'(\theta(s^u))(\theta(s^u))^{-1}-[\kappa+c(q(s^u))\psi(\theta(s^u)](\theta(s^u))^{-2} \\
=&\beta\frac{\partial}{\partial\theta(s^u)}S(T^{*,h}(\mu^h,\mu^u,q(\cdot),\theta(\cdot),\epsilon(\cdot)),T^{*,u}(\mu^h,\mu^u,q(\cdot),\theta(\cdot),\epsilon(\cdot)))
\end{aligned}
$$

By performing the same steps as in the $q(s^u)$ case, one can simplify the RHS and show that:

$$
\begin{aligned}
&c(q(s^u))\psi'(\theta(s^u))(\theta(s^u))^{-1}-[\kappa+c(q(s^u))\psi(\theta(s^u)](\theta(s^u))^{-2} \\
=&\beta\frac{\partial}{\partial\theta(s^u)}\left(\phi(\theta(s^u))\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{h\prime}(s^{h\prime})}p_{i,e,e'}1_{i'=i}1_{q'=q(s^u)}ds^{h\prime}+(1-\phi(\theta(s^u)))\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{u\prime}(s^{u\prime})}p_{i,e,e'}1_{i'=i}ds^{u\prime}\right) \\
=&\beta\phi'(\theta(s^u))\left(\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{h\prime}(s^{h\prime})}p_{i,e,e'}1_{i'=i}1_{q'=q(s^u)}ds^{h\prime}-\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{u\prime}(s^{u\prime})}p_{i,e,e'}1_{i'=i}ds^{u\prime}\right).
\end{aligned} \tag{55}
$$

Now we consider the exit decision, broadly following Nattinger and von Hafften (2023). As in Nattinger and von Hafften (2023), we leverage the absolute continuity of the distribution over a dimension, in our case f, ensuring this discrete choice has a differential change in welfare.[19] Hence the eviction rule implies, for $\epsilon(s^h,f)=1$:

$$
\begin{aligned}
&\left(q\mathcal{E}(Q)-f+\lambda^Q q+\beta(1-\sigma)\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{h\prime}(s^{h\prime})}p_{i,e,e'}1_{i'=i}1_{q'=q}ds^{h\prime}+\beta\sigma\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{u\prime}(s^{u\prime})}p_{i,e,e'}1_{i'=i}ds^{u\prime}\right)g(f) \\
<&\Bigg(-[\kappa+c(q(i,e))\psi(\theta(i,e))](\theta(i,e))^{-1} \\
&+\beta(1-\phi(\theta(i,e)))\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{u\prime}(s^{u\prime})}p_{i,e,e'}1_{i'=i}ds^{u\prime}+\beta\phi(\theta(i,e))\int\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial\mu^{h\prime}(s^{h\prime})}p_{i,e,e'}1_{i'=i}1_{q'=q(i,e)}ds^{h\prime}\Bigg)g(f),
\end{aligned}
$$

[19] The optimality condition for the optimization problem written at the household level, (28), is over a differential change in societal welfare. Ensuring that the Planner's equivalent decision in the original problem (1) ensures that the optimality conditions align for our representation of the Planner's problem. Further, as in Nattinger and von Hafften (2023), this fact ensures that the Planner is only indifferent between eviction and non-eviction for a measure 0 of households, which allows us to solve for the optimal allocation without having to solve for the fraction of the mass within a location of the state-space.

and $\epsilon(s^h, f) = 0$ otherwise.

G.2 Related Household Optimization Problems

Now we define the following functions and optimization problems, written at the household level:

$$\hat{V}^h(i,e,q,f;\mu^h,\mu^u) := q\mathcal{E}(Q) - f + \mathcal{E}'(Q)Qq + \beta(1-\sigma)\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q)}\right] + \beta\sigma\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right]$$

$$V^u(i,e;\mu^h,\mu^u) := \max_{q(i,e),\theta(i,e)} -[\kappa + c(q(i,e))\psi(\theta(i,e))](\theta(i,e))^{-1} + \beta(1-\phi(\theta(i,e)))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right] + \beta\phi(\theta(i,e))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q(i,e))}\right] \quad (56)$$

$$V^h(i,e,q;\mu^h,\mu^u) := \mathbb{E}_f\left[\max_{\epsilon(i,e,q,f)\in\{0,1\}}(1-\epsilon(i,e,q,f))\hat{V}^h(i,e,q,f;\mu^h,\mu^u) + \epsilon(i,e,q,f)V^u(i,e;\mu^h,\mu^u)\right] \quad (57)$$

First we will show that the FOC's of the household-level search problem in (56) match those of the Planner given by (54) and (55). The FOC of (56) w.r.t. $q(i,e), \theta(i,e)$ are, respectively:

$$\begin{aligned}
&c'(q(i,e))\psi(\theta(i,e))(\theta(i,e))^{-1}\\
=&\beta\frac{\partial}{\partial q(i,e)}\left(\phi(\theta(i,e))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q(i,e))}\right] + (1-\phi(\theta(i,e)))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(s^{u\prime})}\right]\right),\\
&c(q(i,e))\psi'(\theta(i,e))(\theta(i,e))^{-1} - [\kappa + c(q(i,e))\psi(\theta(i,e)](\theta(i,e))^{-2}\\
=&\beta\phi'(\theta(i,e))\left(\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q(i,e))}\right] - \mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime},\mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right]\right).
\end{aligned}$$

By inspection, these match the FOCs of the Planner problem, and hence the optimal policies are identical. Additionally, the $\epsilon(i,e,q,f)$ policy from the maximization problem given f is given by $\epsilon(i,e,q,f) = 1$ if $V^u(i,e;\mu^h,\mu^u) > \hat{V}^h(i,e,q,f;\mu^h,\mu^u)$, and $\epsilon(i,e,q,f) = 0$ otherwise. Plugging the values in, and evaluating $V^u(i,e;\mu^h,\mu^u)$ at its optimal policies (which, again, match the Planner), we recover that $\epsilon(i,e,q,f) = 1$ if:

$$
\begin{aligned}
&\left(q\mathcal{E}(Q) - f + \mathcal{E}'(Q)Qq + \beta(1-\sigma)\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q)}\right] + \beta\sigma\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right]\right) \\
<&\Bigg(- [\kappa + c(q(i,e))\psi(\theta(i,e))](\theta(i,e))^{-1} \\
&+ \beta(1-\phi(\theta(i,e)))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right] + \beta\phi(\theta(i,e))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q(i,e))}\right]\Bigg),
\end{aligned}
$$

which again matches the Planner's policy. Finally, as the optimal policies all match the Planner, by comparing terms it is immediate that the value achieved by (56) exactly equals the marginal social value given by (52), and similarly that the value achieved by (57) exactly equals the marginal social value given by (53). Hence, $V^u(i,e;\mu^h,\mu^u) = \frac{\partial S(\mu^h,\mu^u)}{\partial \mu^u(i,e)}, V^h(i,e,q;\mu^h,\mu^u) = \frac{\partial S(\mu^h,\mu^u)}{\partial \mu^h(i,e,q)}$ and the Housing Surplus Bellman equations are given by:

$$
\begin{aligned}
\frac{\partial S(\mu^h, \mu^u)}{\partial \mu^u(i,e)} &= \max_{q(i,e),\theta(i,e)} -[\kappa + c(q(i,e))\psi(\theta(i,e))](\theta(i,e))^{-1} + \beta(1-\phi(\theta(i,e)))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right] \\
&\quad + \beta\phi(\theta(i,e))\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q(i,e))}\right] \\
\frac{\partial S(\mu^h, \mu^u)}{\partial \mu^h(i,e,q)} &= \mathbb{E}_f\Bigg[\max_{\epsilon(i,e,q,f)\in\{0,1\}} (1-\epsilon(i,e,q,f))\Bigg[q\mathcal{E}(Q) - f + \mathcal{E}'(Q)Qq + \beta(1-\sigma)\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{h\prime}(i,e',q)}\right] \\
&\quad + \beta\sigma\mathbb{E}_{e'|i,e}\left[\frac{\partial S(\mu^{h\prime}, \mu^{u\prime})}{\partial \mu^{u\prime}(i,e')}\right]\Bigg] + \epsilon(i,e,q,f)\frac{\partial S(\mu^h, \mu^u)}{\partial \mu^u(i,e)}\Bigg]
\end{aligned}
$$

In a stationary economy, $\mu^h = \mu^{h\prime}, \mu^u = \mu^{u\prime}$ and we can simply define $\omega^h(i,e,q) = \frac{\partial S(\mu^h,\mu^u)}{\partial \mu^h(i,e,q)}, \omega^u(i,e) = \frac{\partial S(\mu^h,\mu^u)}{\partial \mu^u(i,e)}$ and our Housing Surplus Bellman equations can be written:

$$
\begin{aligned}
\omega^u(i,e) = &\max_{q(i,e),\theta(i,e)} -[\kappa + c(q(i,e))\psi(\theta(i,e))](\theta(i,e))^{-1} + \beta(1-\phi(\theta(i,e)))\mathbb{E}_{e'|i,e}\left[\omega^u(i,e')\right] \\
&+ \beta\phi(\theta(i,e))\mathbb{E}_{e'}\left[\omega^h(i,e',q(i,e))\right]
\end{aligned} \tag{58}
$$

$$
\begin{aligned}
\omega^h(i,e,q) = &\mathbb{E}_f\Bigg[\max_{\epsilon(i,e,q,f)\in\{0,1\}} (1-\epsilon(i,e,q,f))\Big[q\mathcal{E}(Q) - f + \mathcal{E}'(Q)Qq + \beta(1-\sigma)\mathbb{E}_{e'|i,e}\left[\omega^h(i,e',q)\right] \\
&+ \beta\sigma\mathbb{E}_{e'|i,e}\left[\omega^u(i,e')\right]\Big] + \epsilon(i,e,q,f)\omega^u(i,e)\Bigg]
\end{aligned} \tag{59}
$$

These equations are equivalent to equations (27) and (28) in Appendix B.

The adding-up constraint then implies:

$$Q = \sum_{i\in\{H,L\}} \sum_{e\in\{0,1\}} \mathbb{E}_f \left[1 - \epsilon_{i,e}^{SP}(q_{i,e}^{SP}, f)\right] q_{i,e}^{SP} \mu_{i,e}^{SP}, \tag{60}$$

where each $x_{i,e}^{SP}$ is the value arising from the maximization problems in (27) and (28) and the laws of motion for employment and housing status. The first-order conditions for q and θ can now be written more simply as:

$$c'(q) = \beta \sum_{e'\in\{0,1\}} p_{i,e,e'} \frac{\partial \omega_{i,e'}^h(q)}{\partial q}$$

$$\kappa - \theta^2 \phi'(\theta_{i,e}) c(q) = \theta^2 \phi'(\theta) \beta \sum_{e'\in\{0,1\}} p_{i,e,e'} \left[w_{i,e'}^h(q) - \omega_{i,e'}^u \right],$$

where

$$\frac{\partial \omega_{i,e'}^h(q)}{\partial q} = \mathbf{E}_f \left[\left(1 - \epsilon_{i,e}(q,f)\right) \left(\mathcal{E}(Q) + \mathcal{E}'(Q)Q + \beta(1-\sigma) \sum_{e'\in\{0,1\}} p_{i,e,e'} \frac{\partial w_{i,e'}^h(q)}{\partial q} \right) \right.$$

and the eviction rule $\epsilon_{i,e}(q,f) = 0$ unless

$$q\mathcal{E}(Q) + \mathcal{E}'(Q)Qq - f + \sum_{e'\in\{0,1\}} p_{i,e,e'} \left(\beta(1-\sigma)\omega_{i,e'}^h(q) + \beta\sigma\omega_{i,e'}^u \right) - \omega_{i,e}^u < 0,$$

in which case $\epsilon_{i,e}(q,f) = 1$. These expressions match those given in Appendix B

G.3 Appendix: Jacobian

Table 20: Expanded Jacobian

	ξ	ν	C_0	κ	σ_f	$\bar{f}$	$p_{L,1}$	$p_{H,1}$	$p_{L,0}$	$p_{H,0}$	y_L	y_H	μ_L
r_H/y_H	0.0	0.19	-0.0	-0.04	0.0	0.11	0.0	-1.28	0.0	0.16	0.0	-0.08	0.0
eviction rate	2.28	0.48	-0.01	-6.54	4.19	-2.1	9.29	0.0	10.49	0.0	3.27	0.0	2.81
r/q slope	-0.15	0.07	0.01	-0.43	0.24	-0.05	1.03	-1.21	0.69	-0.06	0.12	0.0	0.0
experiment	-181.92	-10.95	-1.58	-49.45	5.66	5.33	-9.17	-15.41	-9.65	-141.54	-3.38	0.0	3.07
vacancy rate	2.84	-20.94	-2.59	-21.04	5.25	-9.27	11.82	-14.11	12.29	-72.28	4.32	0.0	3.74
mean f, no evict	-0.01	-0.0	0.0	0.02	-0.03	0.01	-0.03	-0.0	-0.04	-0.0	-0.01	0.0	-0.01
var f, no evict	0.0	0.0	-0.0	-0.0	2.21	-0.0	0.01	0.0	0.01	0.0	0.0	0.0	0.0
elasticity	9.98	0.34	-0.85	9.44	-2.66	5.26	-5.98	-12.26	-1.27	107.17	26.27	0.0	6.5
$q_{L,1}$	-0.2	0.01	-0.0	-0.57	0.32	-0.11	1.4	0.0	0.94	0.0	0.6	0.0	0.0
$q_{H,1}$	0.0	0.79	-0.06	0.0	0.0	0.43	0.0	0.67	0.0	1.36	0.0	0.0	0.0
$q_{H,0}$	0.0	0.0	-0.18	-1.5	0.0	0.18	0.0	-0.22	0.0	1.05	0.0	0.0	0.0
Q	0.02	0.45	-0.07	-0.25	0.06	0.25	0.15	0.41	0.16	0.64	0.06	0.0	-2.02
$r_{L,1}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
$r_{H,1}$	0.0	0.88	0.01	0.0	0.0	0.48	0.0	-4.81	0.0	0.85	0.0	0.0	0.0
$r_{H,0}$	0.0	0.0	-0.13	-1.97	0.0	0.24	0.0	-6.18	0.0	-0.17	0.0	0.0	0.0
$\theta_{L,1}(r_{L,1}, q_{L,1})$	-25.95	-4.7	0.06	83.3	-46.03	33.1	-85.7	0.0	-76.81	0.0	-29.59	0.0	0.0
$\theta_{H,1}(r_{H,1}, q_{H,1})$	0.0	4.56	0.58	2.42	-0.0	1.39	0.0	2.87	0.0	13.31	0.0	0.0	0.0
$\theta_{H,0}(r_{H,0}, q_{H,0})$	0.0	-0.29	-0.13	-1.77	-0.0	-0.46	0.0	-0.63	0.0	10.56	0.0	0.0	0.0
$\phi(\theta_{L,1}(r_{L,1}, q_{L,1}))$	1.1	0.23	-0.0	-3.07	2.09	-0.96	4.52	0.0	3.38	0.0	1.75	0.0	0.0
$\phi(\theta_{H,1}(r_{H,1}, q_{H,1}))$	0.0	-1.61	-0.23	-1.0	0.0	-0.56	0.0	-1.17	0.0	-5.42	0.0	0.0	0.0
$\phi(\theta_{H,0}(r_{H,0}, q_{H,0}))$	0.0	0.32	0.05	0.7	0.0	0.18	0.0	0.25	0.0	-4.05	0.0	0.0	0.0

Note: Boxed upper-left corner is Jacobian matrix from the computation of Λ from Andrews, Gentzkow, and Shapiro (2017) [5].