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Sticky Rents: A Simple Implicit-Contracts Theory*

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Shelter inflation, driven by continuing-tenant rents, accounts for one-third of the consumer price index (CPI). Yet continuing-tenant rent inflation, notoriously sticky, has attracted almost no theoretical attention. Standard sticky price theories cannot explain the basic facts. We provide a simple theory yielding implicit contracts as an equilibrium. The landlord will wish to renege when costs rise; reputation is unavailable to enforce the contract. A well-established mechanism serves: landlord off-equilibrium-path play might result in renter frustration and endogenous breakup. Our implicit-contracts theory gracefully explains nominal (rather than real) rigidity, and provides a microfounded explanation of key rental market facts.

Keywords: continuing-tenant rent, inflation, frustration, customer anger, costly punishment

JEL Classification: R31, R21, E31

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1 INTRODUCTION

The CPI is one of the most important economic indicators, used (for example) in Social Security cost-of-living adjustments, in financial contracts, and in wage escalation. Moreover, it is the basic foundation of the personal consumption expenditures price index (PCE) that forms the inflation objective of the Federal Open Market Committee (FOMC). Since shelter is, by far, the biggest component in the CPI (as well as a major component in the PCE), and moreover is quite cyclical, its dynamics are central to understanding inflation.[1] Importantly, following the widespread practice of measuring the housing consumption of homeowners via the rental-equivalence method in the System of National Accounts, official price indexes in the US (and in many other countries) measure shelter inflation using movements in housing rents.

Movements in officially measured housing rents are, however, puzzling from several perspectives. CPI rent inflation lags rent inflation measured by other (unofficial) indexes, such as the Zillow ZORI index. Adams et al. (2024) demonstrated that the main reason for this lag is that the CPI measures the rent inflation in all rental units, while other indexes only measure the rent inflation in vacant units. The lag, then, is driven by the rent inflation experienced by continuing tenants. In fact, Gallin et al. (2025) demonstrate that continuing-tenant rents comprise over 90 percent of the CPI. To understand CPI rent dynamics, one must understand continuing-tenant rent movements.

And continuing-tenant rent inflation is extremely sticky, particularly in detached rental units (typically managed by small landlords). It is not uncommon for continuing-tenant rents to remain unchanged for years (e.g., Verbrugge et al. (2017)),[2] and when leases are renewed, on average, landlords impose smaller rent increases than would be possible for a new tenant. Putting this fact differently, the rent resets that occur upon unit vacancy (i.e., the new-tenant rent resets) are systematically larger than the rent resets experienced by continuing tenants.[3]

This rigidity is puzzling for several reasons. First, the typical rental contract in the US is for 12 months, after which a new contract must be signed—meaning any menu cost is already incurred annually, whether or not rent changes. Second, tenants face large moving costs, seemingly leaving substantial scope for landlords to raise rents. Simple models with

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[1] For instance, time-series modeling of said dynamics has proven useful for forecasting PCE inflation (Verbrugge and Zaman (2024)). Furthermore, movements in the prices of nontraded services more generally are central to understanding real exchange rate dynamics.

[2] Profound rigidity in rents is not only the case in the US context (Genesove (2003), Gallin and Verbrugge (2017), Gallin et al. (2025), and Decker (2025)), but also in the German and Japanese contexts (Hoffmann and Kurz-Kim (2006); Shimizu et al. (2010); Diewert et al. (2020); and Suzuki et al. (2021)).

[3] This fact is well-known and is the basis for the vacancy-adjustment procedure in the CPI shelter indexes; see, e.g., Crone et al. (2010).

moving costs predict large rent increases at the first renewal opportunity. Third, if search preceded the initial lease signing and the tenant selected this unit from alternatives, the tenant's valuation almost certainly exceeds the initial rent, providing additional impetus for rent increases. Yet continuing-tenant rents often remain nominally unchanged for extended periods. Some powerful mechanism must keep these rents rigid.

Standard sticky-price theories used in macroeconomic modeling cannot explain these patterns. The "Calvo fairy" ostensibly allows annual price changes, yet rents remain unchanged. Menu costs are paid annually but rents don't adjust. Quadratic adjustment costs don't explain nominal rigidity. (Additional inconsistencies, such as the dispersion of rent changes, are documented in Gallin et al. (2025).) Implicit contract theories offer a natural alternative—landlords might provide rent-risk insurance to continuing tenants—but have faced a fundamental criticism in the labor market context: if contracts insure against real income fluctuations, why don't agents demand inflation indexation, undermining nominal rigidity?

This paper's contribution. We provide a microfounded theory based on implicit contracts that naturally generates nominal rent rigidity while addressing the standard criticism from labor economics. Our model features three key elements. First, enforcement relies on frustration-based renter departure following an unexpected rent increase—a mechanism well-documented in experimental and empirical studies, reviewed below—rather than reputation, which cannot operate over the short horizons typical of rental relationships. Second, the model generates a separating equilibrium: longer-tenure renters receive rent insurance (in exchange for higher initial rents) in a "sticky-rent" market, while shorter-tenure renters participate in a "flexible-rent" market, explaining differential rigidity across rental unit types.

Third, the frustration-based enforcement mechanism naturally generates nominal rather than real rigidity. The rental context differs fundamentally from labor markets: nominal rent rigidity *benefits* renters, whose real rent burden falls with inflation, delivering a windfall beyond the contracted insurance against cost shocks. Renters therefore have no incentive to seek inflation indexation. Meanwhile, the same frustration mechanism that prevents landlords from raising rents in response to cost shocks also prevents inflation-based increases—any rent increase would violate renter expectations and trigger departure. Thus, the implicit contract logic that struggles to explain nominal wage rigidity may naturally explain nominal rent rigidity.

This paper contributes to several literatures.

Price stickiness is a central issue in macroeconomics, and has spawned a vast literature (see, e.g., Carlton (1986); Nakamura and Steinsson (2013); Carvalho et al. (2021)). However, its deep sources remain contested (e.g., Blanco et al. (2024)). Most New Keynesian models—which are the workhorse models for central banks around the world—use tractable simplifications like Calvo pricing or state-dependent pricing, which posit arbitrary "costs" or constraints to changing prices. But the modeling details matter: for instance, the appropriate monetary policy response to shocks depends upon the precise source of price stickiness (see, e.g., Caballero and Engel (1993) or Alvarez et al. (2017)). Unsurprisingly then, the study of price stickiness remains an area of active theoretical and empirical research (e.g., Golosov and Lucas Jr (2007); Nakamura and Steinsson (2008, 2011); Head et al. (2012); Kehoe and Midrigan (2015); L'Huillier and Zame (2022); Schmitt-Grohé and Uribe (2022); Blanco et al. (2024); Morales-Jiménez and Stevens (2024)). In the context of this literature, the precise source of rent rigidity will have different implications for the macroeconomy, such as the pass-through of aggregate shocks, and the extent to which rents respond to monetary policy. For instance, if continuing-tenant rents are sticky because landlords must pay a decision cost to update them, or because a price change of zero has a nonzero but merely modest advantage, then rents may become much more flexible if inflation rises.

There is a small theoretical literature explaining stickiness in rents. Some informal theories have been around for decades. The "depreciation equals inflation theory" argues that landlords can raise real rent without changing nominal rent by allowing the quality of the housing unit to deteriorate. The "good tenant" theory posits that landlords keep rents below market for good tenants——those who pay on time and cause little damage and headaches——in order to retain them. Residency discounts have been noted and discussed for decades (e.g., Downs (1981)); for formal treatments of the discounts-for-good-tenants notion, see Guasch and Marshall (1987), Kim (2020) and Gallin et al. (2025), and see also Barker (2003)). This explanation can readily explain why the rent paid by continuing tenants is lower than the rent paid by new tenants (a "sit" discount), but it does not explain why the gap between the current rent and the hypothetical new-tenant rent would grow over time—which is a feature of the data (Gallin et al. (2025))—and it also fails to explain the small-versus-large landlord rigidity distinction observed in the data. Wang and Zhou (2000) and Lai et al. (2007) focus on overbuilding and (sometimes high) equilibrium vacancy rates. In both models, the strategic equilibrium implies that the equilibrium rent features a positive vacancy rate. The models feature an infinite number of continuation periods, but from period two onward, the environment is essentially static, so everything is unchanged going forward. Thus the rent is downward-rigid (i.e., does not clear the market) and remains unchanged in perpetuity (so it is sticky in that sense); but the models do not explain why rents remain unchanged from the first period to the second. In Gallin and Verbrugge (2019), the decision to offer an existing tenant a nominally unchanged rental contract allows the landlord to preempt tenant search and avoid renegotiation. Risk-averse small landlords may prefer this option since it diminishes vacancy risk, while landlords with a large number of units do not face such risk: any new contract rent maps into a given fraction of vacant units.

Given the fact that our theory generates implicit contracts in equilibrium, this paper is also related to a large labor economics literature, where implicit contracts have long been used to explain rigidity of wages in continuing firm-worker relationships (see, e.g., Rosen (1985), Beaudry and DiNardo (1995), or Kudlyak (2014)). However, in this paper we posit a novel enforcement mechanism that applies to customer-firm relationships. (We discuss the standard labor market criticism of implicit contracts in Section 3.4.)

Finally, the paper is connected to a large and growing literature—containing both theoretical and empirical studies—that links, in various ways, known human imperfections to market interactions or interactions in games. Of particular relevance for the present work is the literature linking customer markets and customer anger,[4] with some notable contributions, including Okun (1981), Apel et al. (2005), Renner and Tyran (2004), Cavallo et al. (2014), and Rotemberg (2005); more studies are noted below. The existence of pricing norms is taken for granted in the customer markets literature, and supported by a plethora of evidence (see, e.g., Blinder et al. (1998), Cavallo et al. (2014), Rigobón (2015)), including evidence in a vast marketing literature.[5] This literature finds that firms regard customer antagonism as a key constraint on their pricing behavior; many of these papers provide compelling real-world examples. A growing literature in game theory, discussed below, posits and locates evidence for behavioral motivations such as altruism, fairness norms, frustration and anger, and responses that are readily interpreted as punishment. It is difficult to describe the outcome of over one hundred dictator game experiments—whose results are similar across socioeconomic groups, degree of money at stake, and cultures–without reference to notions of anger and punishment (for a meta-analysis, see Engel (2011)). Some researchers see a link between these types of motivations and evolutionary success; for instance, Sell et al. (2009) argue that anger is a process of the natural selection for behaviors that provide superior bargaining outcomes, and Akerlof (2016) notes that enforcement of norms is critical for the success of organizations and societies. Conversely, the detrimental influence of visceral factors such as anger on decision making is often underappreciated both ex ante and ex post; see Loewenstein (2000), who notes that "the feeling of injustice that people experience when they believe that they have been treated unfairly" often causes them to act in a way that harms their economic interests.[6] Given the abundant evidence (including neurobiological

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[4] The psychology literature on anger is enormous, and in addition to making inroads into economics, it has begun to make inroads into many other fields such as business administration, health sciences, linguistics, political science, psychophysiology, and sociology, supported by neuroscience evidence; see, e.g., Potegal et al. (2010).

[5] Indeed, the notion that fairness norms may be a constraint in pricing goes back decades; see, e.g., Okun (1981), Kahneman et al. (1986), or Franciosi et al. (1995).

[6] He further notes, "In the classic pattern of all visceral factors, angry negotiators become obsessed with causing pain to the other side, impatient to impose that pain (and relatively indifferent to the long-term consequences of doing so), and selfish (i.e., unconcerned about collateral damage to other parties)" (p. 430). Most self-control problems stem from the influence of visceral factors. Loewenstein concludes, "Economic models that ignore visceral factors [only yield accurate predictions] when applied to behavior characterized

evidence) for the important role that emotions such as frustration and anger play in some circumstances, exploring the theoretical implications of these human characteristics seems well-warranted.

2 MODEL

We here present a model aimed at explaining two key stylized facts and one prominent piece of anecdotal/survey evidence, in the US rental market (see Genesove (2003), Gallin and Verbrugge (2017) and Gallin et al. (2025)):

1. Rents of continuing tenants in detached units are far stickier than rents of tenants in large apartment buildings. They are more likely to remain unchanged, and are less aligned with new-tenant rents.
2. Mobility rates are lower for tenants in detached units.
3. Small landlords—i.e., landlords who own few rental units—routinely answer questions like "Since overall rents have risen, why don't you raise the rent on your unit?" with responses like "If I raise the rent, there is a good chance that my tenant will leave, and then I will have to pay turnover costs."[7]

There are two periods. For simplicity, both renters and landlords are assumed to face no wealth constraints. There are several types of renters, all of whom are risk-averse. At the beginning of the game, upon paying entry costs, potential landlords enter, choosing to be the landlord of a rental unit of type A or D. Prior to period 1, each renter costlessly chooses to be matched to a type A or type D unit. At the end of period 1, some renters receive relocation shocks, which will trigger a move. Next, if a given match does not receive such a shock, the landlord plays "Renegotiate" (hereafter denoted *Renege*—which will result in a renegotiated period-2 rent) or "Do Not Renegotiate" (hereafter denoted DNR—which will result in a renewal of the rental contract at the period-1 rent). Then the renter decides whether to play *Stay* or to play $Move$; the latter choice means searching for and relocating to an alternative unit, thereby incurring moving costs m and paying the "new-tenant" rent

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by low levels of visceral factors. To predict or make sense of viscerally driven behavior, it is necessary to incorporate visceral factors into models of economic behavior."

[7] For instance, a small landlord gave Verbrugge this response, during the 2024 Inflation Conference at the Cleveland Fed. And when the Gallin et al. (2025) paper was being presented at the UEA meetings in the summer of 2024, one participant indicated that they were a landlord, and noted that their management company had suggested raising the rent on their tenant by \$10. The participant responded, "No! What if they leave? Then I'll lose more money." In our experience, such sentiments are quite common among small landlords, who dominate the D market. Downs (1981) asserts that small landlord behavior is best described as turnover minimization. See also Decker (2025) for additional supportive survey evidence.

that prevails in that unit's market. If the renter does move (prompted either by an exogenous shock, or by choice), the rental unit will become available to enter the search process, but the landlord may choose to exit.

There are two broad categories of **renters**, differentiated by their reliability. A measure ι of renters are unreliable, and a measure 2 of renters are reliable. Unreliable renters always renege on their rental contracts, do not pay their rent, and must be evicted. Eviction imposes a cost of E on the landlord. Reliability is concealed information, but it can be revealed if a landlord pays screening costs, described below.[8] We select parameters such that paying screening costs is always the dominant strategy.

Renters are further differentiated by two idiosyncratic random variables that are distributed independently of one another and that are private information. First, for each renter i, there is a binary variable $\rho_i \in \{\rho_1, \rho_2\}$, with $1 > \rho_1 > \rho_2 = 0$, governing the likelihood that renters receive a moving shock. We refer to renters with $\rho = \rho_1$ as type 1 (or "short-tenure") renters, and the others as type 2 (or "long-tenure") renters. For simplicity, we assume that a fraction $\rho_{type1} = \frac{1}{2}$ of renters are of type 1. Near the end of period 1, moving shocks occur.

Second, renters experience *frustration* in response to a breach of an implicit contract, but differ in the degree to which this bothers them. Ultimately, the possibility of losing frustrated renters (i.e., breakage of the customer relationship, as in Anderson and Simester (2010)) will keep landlords on the equilibrium path. Why does our model rely upon this fundamental-yet-rarely-incorporated aspect of human neurobiology?[9] As mentioned above, in this two-period game, reputation can play no role in enforcing second-period equilibrium behavior, since the game ends. One might argue that restricting the game to two periods is unrealistic. It isn't. American Community Survey data from 2022 indicate that only a third of renters stay in a rental unit for more than four years, leaving limited room for otherwise-standard

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[8] In this model, screening costs stand in for any cost associated with tenant loss and turnover of the unit. Unreliable renters ensure that screening is always worthwhile, but play no other role in equilibrium. We retain them for two reasons. First, screening costs and screening effort are a large part of turnover costs for small landlords. Second, we want to allow for potential extensions where imperfect screening matters.

[9] For more on the neuroscience, see, e.g., Blair (2012) or Dugré and Potvin (2023). Frustration at perceived ill-treatment, and a proclivity to "punish" the infraction, align with insights and evidence from a very long literature in psychology (for instance, see the article by Miller et al. (1958), which abridges an earlier 1941 article in the *Psychological Review*; Berkowitz (1989); and Dollard et al. (2013)).

There are some formal economic modeling antecedents, such as Rotemberg (2005), Hart and Moore (2008), and Battigalli et al. (2019), that rely upon variants of this mechanism. Extending a good deal of experimental evidence (e.g., Leibbrandt (2020)) to the real world, Anderson and Simester (2010) provide empirical evidence demonstrating the existence of antagonism by customers in response to price changes that they perceive as unfair, and subsequent breakage of the customer relationship. (Cochrane (2025) provides a compelling recent example related to tariff pass-through.) In short, frustration-motivated costly action is now an established fact about human behavior, and exploring its theoretical implications seems warranted. In the present context, frustration and anger provide a realistic mechanism whose (only) role is to rule out off-equilibrium-path beliefs and actions, and thereby to enforce the implicit contract.

mechanisms such as reputation-building. Moreover, adding periods would not resolve—and might deepen—the puzzle. With longer horizons and upward-drifting rents, the present value of deviating increases, making the enforcement problem more severe. What matters is not the number of periods per se, but whether reputation can enforce contracts. Given typical tenancy durations and the one-shot nature of the landlord-tenant relationship (landlords don't develop market-wide reputations observable to new tenants), reputation is unavailable regardless of whether we model two, three, or four periods. The two-period structure captures this essential feature parsimoniously.

We apply the model of belief-dependent frustration from Battigalli et al. (2019) and Dufwenberg et al. (2025).[10] In this framework, "frustration" measures the material harm inflicted upon player i as a result of unexpected play by player j. In the present model, frustration arises if the landlord deviates from the equilibrium by breaching the implicit contract and raising the rent. Players may differ in their sensitivity to such frustration. Those renters who are particularly sensitive to frustration, as we explain next, have an incentive to respond by taking actions that reduce the landlord's payoffs, even though this may reduce their material payoffs. For such renters, this "costly punishment" is well-justified.

Frustration is measured as the gap between one's initial expected payoff π, and the best possible (inferior) payoff at the time of decision-making. In particular, given a history h and a set of (first-order) beliefs α_i about play by each player (including oneself) at each decision node, player i's frustration (at the end of period 1) is given by

$$F_i\left(h;\alpha_i\right) = \max\left\{E\left[\pi_i\left|h_0;\alpha_i\right.\right] - \max_{a_i\in A_i(h)} E\left[\pi_i\left|h;\alpha_i\right.\right], 0\right\} \tag{1}$$

where h_0 is the initial history, π_i is the payoff to i, and $a_i \in A_i\left(h\right)$ denotes player i's action choice at history h, so that $\max_{a_i\in A_i(h)} E\left[\pi_i\left|h;\alpha_i\right.\right]$ gives the maximum possible expected payoff available to player i given the history of play h.[11] We fully specify renter payoffs and utility momentarily.

In the present model, based upon their beliefs α_i and the set of equilibrium rents, renters initially decide which type of rental unit to search for; in equilibrium, each reliable renter will be matched with certainty. In this game, frustration could only arise after observing the landlord's action at the end of period 1, if the landlord behaves contrary to the renter's expectations and in a manner that harms the renter. A renter who expects her landlord to play *DNR* will become frustrated if the landlord instead chooses to raise the rent by playing *Renege* (though she won't become frustrated if unexpected landlord play involves a

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[10] This approach is very similar in spirit to those of Rotemberg (2005, 2011) and Akerlof (2016). In these papers, agents can become angry in response to the actions of other agents who are perceived to violate fairness norms, and this can result in costly punishment of the other player.

[11] Frustration is equal to 0 at the initial history $\emptyset$.

reduction in the rent). But raising the rent, by itself, need not cause frustration: a renter who fully expects *Renege* (or *DNR*) will not be frustrated upon seeing the landlord behave as expected. As 1 indicates, if her beliefs specify mixing play on the part of the landlord, the less the renter expects this particular play by the landlord, the more frustrated she will be. Finally, the better is her payoff when the landlord plays as expected, the more frustrated she will be if the landlord plays differently.

Thus, a renter i's utility has two components. The first component, common to all renters, is a function of material payoffs. The utility from the material payoff to renter i is given by $\pi_i = \pi_{i,1} + \pi_{i,2}$, defined as

$$\pi_{i,1} = \ln\left(y - R_{i,1}\right)$$

$$\pi_{i,2} = \ln\left(y - R_{i,2} - I^m m\right)$$

where $R_{i,k}$ is the nominal rent that renter i is paying in period k, I^m is an indicator variable that takes the value 1 if the renter moves at the end of the first period, and m is moving costs. A renter who is homeless in period k has a payoff of 0 in that period.

The second component, the component involving frustration, is a function of the idiosyncratic term γ_i that is private information. In particular, applying the Battigalli et al. (2019) model, renter i's "belief-dependent decision utility" from taking action a_i at history h is given by:

$$u_i\left(h, a_i; \alpha_i\right) = E\left[\pi_i \left|\left(h, a_i\right); \alpha_i\right.\right] - \gamma_i F_i\left(h; \alpha_i\right) E\left[\pi_j^{LL} \left|\left(h, a_i\right); \alpha_i\right.\right].$$

Thus, utility is the sum of the material payoff term and the utility loss (if any) due to frustration. In this expression, $\gamma_i \geq 0$ is renter i's sensitivity to frustration, and $E\left[\pi_j^{LL} \left|\left(h, a_i\right); \alpha_i\right.\right]$ is the expected payoff to i's (current, period-1) landlord j when renter i takes action a_i. Note that renter utility falls as landlord payoffs rise: it galls the renter to see the landlord materially benefit from this violation of her expectations. Hence, the renter is motivated to take actions that reduce the landlord's payoff (namely, to move), and will do so if this is not too costly.[12] Higher frustration increases the negative weight placed on the landlord's payoff, thereby increasing the motivation to punish the landlord by moving. We assume that the frustration parameter is distributed independently and uniformly over $[0, \gamma^{max}]$. Thus, landlords play against a continuum of renter types.

Potential **landlords** are risk-neutral.[13] Prior to period 1, there is costly but otherwise

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[12] In a richer model wherein screening is not perfect, the renter would also "hope" that the landlord ends up with a "bad," high-cost renter, though for simplicity this possibility is assumed away in the present context. For a model where good and bad renters play a key role in determining equilibrium rents, see Gallin et al. (2025).

[13] We do not deny that small landlords might be risk-averse and prefer sticky rents (as in Gallin and

unrestricted entry in the housing market; producing a rental unit makes one a landlord. To enter prior to period 1, prospective landlords must pay $F_A > 0$ per unit to produce an "A" type of rental unit, and $F_D \geq F_A$ per unit to produce a "D" type of rental unit. For simplicity, we assume that it is costless to exit, or to enter, at the end of period 1. Existing units in period 1 incur a period-1 operating cost, and existing units in period 2 incur a period-2 operating cost. In particular, each landlord must pay a cost c per unit in period 1 (whether or not the unit is occupied), and a cost $\Theta \in \{\theta_L, \theta_H\}$ per unit in period 2 (whether or not the unit is occupied), with $\theta_H > c > \theta_L > 0$. (These costs are common across landlords. In the model, movements in costs are a convenient way to model rent risk that often arises from opportunity cost pressures, following changes in local economic conditions.) The value of Θ is revealed at the end of period 1, prior to the realization of moving shocks. Its distribution is such that with probability p_θ, $\theta = \theta_L$. For simplicity, we set $p_\theta = \frac{1}{2}$.

There is a matching process that matches renters to landlords, described below. In the matching market, owners of type A units pay a (per unit) screening cost of C_A to screen renters, while owners of type D units pay a screening cost of C_D to screen renters, with $E > C_D > C_A > 0$. Given this inequality, it follows that landlords always pay screening costs if they enter the search process for a given period. (As we informally associate type A units with apartment units, and type D units with detached units, the cost differential might be justified by economies of scale in the screening technology, perhaps partly driven by a high opportunity cost of time of nonprofessional landlords.) Payment of screening costs is public information. (As noted above, in this model, screening costs are shorthand for any costs that a landlord must bear when a unit is vacant, such as costs associated with getting the unit ready for a new tenant.)

A rental contract $R \in \mathbf{R}^+$ specifies the (one-period) rent owed by the renter to the landlord if matched. The only explicit contracts are one-period contracts; no legal mechanism exists that would allow a landlord to commit to playing DNR, and no legal mechanism exists that would allow a renter to commit to playing $Stay$. However, as will be seen below, for some parameters an "implicit contract" will emerge as equilibrium play, with the equilibrium specifying that landlords play DNR (and hance, an unchanged rent), and the renter playing $Stay$.

The matching process is competitive. In particular, at the beginning of a period, landlords with an available unit pay screening costs, and enter the market with a contract posting. Households entering the search process direct their search to the most attractive contracts. Matching is bilateral; thus, each household can apply to only one contract. If the number of units in the search process equals or exceeds the number of searching renters, each renter

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Verbrugge (2019)), though we think the present explanation better explains why small landlords *fear tenant departure* specifically in response to rent increases (as documented in surveys). Our frustration-based mechanism specifically explains this fear. Of course, both mechanisms could operate in tandem.

will be matched with probability one.

At the end of period 1, if a tenant does not receive a moving shock, the landlord decides whether to play *Renege* or *DNR*. If the landlord plays *Renege*, for simplicity we assume that there is a Nash bargaining rule, defined over observable characteristics, that specifies that second-period rent R_2 will be selected according to

$$\max_{R_2} \left\{ \ln\left(y - R_2\right) - \ln\left(y - R_{2,\Theta}^{NewTenant} - m\right) \right\}^{w} \left\{ (R_2 - \Theta) - 0 \right\}^{1-w}$$

where $R_{2,\Theta}^{NewTenant}$ is the second-period (new-tenant) rent that the tenant must face if she moves (which is a function of Θ, the realization of the cost shock), renters have a Nash bargaining weight w,[14] and we have imposed the condition that, given free exit and entry, the outside option of the landlord is a return of 0. We adopt two tie-breaking rules: 1) if a continuing renter is indifferent between moving and staying, he will stay; and 2) outside of that situation, if a renter is indifferent between participating in the D market and the A market, he will select the A market.

The timeline of the game is given in Figure 1. This game is a leader-follower game that has some similarity to an ultimatum game, in the sense that player 1 (the landlord) may either play "cooperatively" (by playing *DNR*) or "greedily" (by playing *Renege* when costs rise), after which the renter has the opportunity to "punish" the landlord by moving. Moving will impose a cost on both parties: the renter must pay a moving cost (and then pay the prevailing "new-tenant" rent on a searched unit, which might exceed the renegotiated rent), and the landlord must either pay a screening cost (and then charge the prevailing new-tenant rent on a searched unit), or exit the market.

$t = 0$	→	End of Period 1	→	Period 2
1. Entry		1.Θ revealed		1. R_2 paid
2. Matching		2. Landlord: *Renege*/*DNR*		2. Game ends
3. R_1 set		3. Moving shocks		
		4. Renter: *Stay*/*Move*		

Figure 1. Timeline of the Game

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[14] One might argue that, in reality, the bargaining weight w is likely to vary across markets, with weaker landlord bargaining power for smaller landlords. While differential bargaining power could explain some rent rigidity patterns, it cannot explain why rents remain *unchanged* (rather than merely adjusting slowly), nor why small landlords specifically fear tenant departure in response to rent increases. In this paper, we tie our hands and seek to explain rent rigidity differentials without appealing to differential bargaining weights, demonstrating that frustration-based enforcement alone can generate the observed patterns. In reality, both mechanisms likely operate.

One might propose that detached units simply face higher decision or adjustment costs, explaining greater rigidity through conventional mechanisms. However, this cannot explain three key facts: (i) contracts are renegotiated annually regardless of whether rent changes, so the "menu cost" is already paid; (ii) small landlords specifically cite fear of tenant departure—not rent adjustment costs—as their reason for not raising rents; and (iii) rents frequently remain precisely unchanged (zero change) rather than exhibiting small adjustments, as gradual adjustment-cost models would predict. These facts point toward a strategic, relationship-based explanation rather than a mechanical friction.

3 EQUILIBRIUM

3.1 Polymorphic Sequential Equilibrium

We adopt the polymorphic sequential equilibrium concept from Battigalli et al. (2015), which extends the sequential equilibrium concept in Battigalli et al. (2019) to include the situation where a game is played by agents of different types, drawn at random and independently from a large population. Players of different types have different plans or strategies in equilibrium; for instance, facing a situation in which the landlord unexpectedly plays *Renege*, a very frustration-sensitive renter might plan to play *Move* but a less frustration-sensitive renter might plan to play *Stay*. Players are assumed to correctly anticipate how another player of type l will play, given the population distribution of types. (In this concept, if an agent has the opportunity to observe a move of another player, she updates her beliefs about their type. However, in the present game, such updating is irrelevant, in that it cannot impact subsequent play.) All players hold the same belief system, and this belief system is correct, in that it is consistent with behavior: the first-order belief of any player i about another player j (of type l) will match player-j-of-type-l's behavior strategy. A **polymorphic sequential equilibrium** is a profile of prices (rents) specified in every possible outcome of play, a set of strategies specified at each node of play by each type of player, and a belief system corresponding to the strategies played at each node of the game by each type of player, such that each player is maximizing his or her expected payoff. Each sequential equilibrium thus represents a commonly understood and incentive-compatible way to play the game by rational (utility-maximizing) agents. We focus here on polymorphic sequential equilibria involving pure strategies.

3.2 *Characterization of Separating Equilibrium*

Given suitable parameter restrictions (specified below), there exists a separating equilibrium featuring distinct sequential equilibria in the A and D markets. We first provide an informal description of the equilibrium, then formally characterize it through a series of results that establish: (i) equilibrium rents and vacancy rates; (ii) incentive-compatibility constraints ensuring no player wishes to deviate; and (iii) parameter restrictions guaranteeing existence. **Proposition 1** in the Appendix provides a formal existence theorem, and the numerical example in Section 3.4 demonstrates that the parameter restrictions can be satisfied. The Appendix also provides details on a solution algorithm, since some parts require a numerical solution.

3.2.1 *Informal Description*

The A market equilibrium. Only type-1 (short-tenure) renters enter this market.[15] At the end of period 1, if a moving shock does not occur, the landlord plays *Renege* with probability one when costs rise. Renters anticipate this play and do not become frustrated; in equilibrium, they respond by playing *Stay*. Competition between landlords drives down the initial rent below cost: type A landlords offer new tenants a rental contract such that $R_{A,1} = c + C_A + F_A - (1-\rho)\Delta$, where Δ denotes expected period-2 profits, compensating for first-period losses.[16] In period 2, given competition between landlords engaged in the search process, type A landlords whose units become vacant offer new tenants a zero-markup rental contract $R_2^{NewTenant,\Theta} = \Theta + C_A$. The vacancy rate is zero in both periods.

The D market equilibrium. Only type-2 (long-tenure) renters enter this market. Equilibrium play specifies that landlords play DNR with probability 1, implementing an implicit contract with sticky rent $R_1 = R_2 = R$. Renters play *Stay* with probability 1, even when costs fall and new-tenant rents become tempting. Only type D units occupied in period 1 remain in period 2; vacant units exit since they cannot compete on price with type A units. Long-tenure renters effectively receive rent-risk insurance from their landlords and pay for this via a higher initial rent $R > R_{A,1}$. While all renters are risk-averse and value such insurance, it is only attractive to type-2 renters, who face a lower probability of a moving shock, and thus are more likely to benefit from it. Landlords benefit from providing this insurance by economizing on screening costs, since their renters don't move. The implicit contract is enforced by the threat of frustrated renter departure: a sufficiently large fraction

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[15] The model in Halket and di Custoza (2015), which explains the observed differential in market tightness across the D and A markets, also generates a separating equilibrium of this nature, in which only longer-tenure renters participate in the D market.

[16] This provides a potential microfoundation for the common practice among large landlords of offering discounts to first-time renters.

of renters would play *Move* in response to a deviation to *Renege* when costs rise, forcing the landlord to exit. Occupied D units typically earn positive expected profits, implying positive equilibrium vacancy during period 1.

Table 1 compares the equilibrium in the A and D markets.

Table 1. Equilibrium Comparison Across Markets

Feature	**A Market**	**D Market**
Renter type	Short-tenure	Long-tenure
Landlord play	*Renege* when $\theta = \theta_H$	DNR always
Rent dynamics	Flexible, tracks costs	Sticky, unchanged
First-period rent	Below cost ($R_{A,1} < c$)	Above cost ($R > c$)
Vacancy rate	Zero	Positive
Interpretation	Spot market	Implicit contract

3.2.2 Formal Characterization

We now establish these claims formally through a sequence of results.

Result 1: Period-2 New-Tenant Rents, Unit Exit, and Vacancy.

There is no spot market for type D units; all vacant units of this type exit. The market clears at $R_2^{NewTenant,\Theta} = \Theta + C_A$. The vacancy rate in period 2 is zero.

Proof: At the beginning of period 2, suppose there are $1 + \upsilon_A$ type A units and $1 + \upsilon_D$ type D units available. In period 2, since the game ends, only spot-market considerations matter. Type A units can exit costlessly and face period-2 costs of Θ, so they will not offer rents below $R_2^{NewTenant,A,\Theta} = \Theta + C_A$. As $C_D > C_A$, type D units face higher screening costs and cannot compete, so all vacant type D units exit. Competition among type A landlords drives rents down to $R_2^{NewTenant,\Theta} = \Theta + C_A$, which clears the market. Free exit implies that the vacancy rate is zero. □

Result 2: Type ***A*** **Market Rents, Vacancy, and** ***Renege*** **Equilibria**

A sequential equilibrium specifying that landlords play *Renege* with probability 1 when costs rise always exists in the A market. We call these *Renege* equilibria. In any such equilibrium:

(a) Renegotiated rents satisfy the Nash bargaining solution:

$$\max_{R'}[\ln(y - R') - \ln(y - R_2^{NewTenant,\Theta} - m)]^w[(R' - \Theta)]^{1-w}$$

yielding rents R'_{A,θ_H} and R'_{A,θ_L} for the two cost realizations. (This is a transcendental equation requiring a numerical solution; see the Appendix. We denote renegotiated rents with primes: R' indicates the rent resulting from Nash bargaining, after the landlord plays *Renege*.)

(b) First-period rent is determined by the zero-expected-profit condition:

$$R_{A,1} = c + C_A + F_A - (1-\rho)\Delta$$

where expected period-2 profit is

$$\Delta = \frac{1}{2}[R'_{A,\theta_H} - \theta_H] + \frac{1}{2}[\tilde{R}_{A,\theta_L} - \theta_L]$$

and $\tilde{R}_{A,\theta_L} \in \{R_{A,1}, R'_{A,\theta_L}\}$ depending on whether the equilibrium specifies *DNR* or *Renege* when costs fall.

(c) Incentive compatibility requires that renters weakly prefer *Stay* over *Move*:

$$R'_{A,\theta_H} \leq R_2^{NewTenant,\theta_H} + m$$

and (if *DNR* when costs fall) $R_{A,1} \leq R_2^{NewTenant,\theta_L} + m$.

(d) The vacancy rate is zero in both periods.

Proof: Renters anticipate *Renege* play and experience no frustration. Free entry and competition drive first-period rents to the zero-expected-profit level. Since period-2 rents yield positive profit regardless of the cost realization, the expected period-2 profit conditional on retaining one's renter is $(1-\rho)\Delta > 0$. Any landlord offering $R_{A,1} + \epsilon$ for $\epsilon > 0$ would fail to attract renters, while any landlord offering $R_{A,1} - \epsilon$ would be strictly better off raising the rent to $R_{A,1}$. The Nash bargaining outcome ensures both parties prefer agreement to disagreement (moving), establishing incentive compatibility. □

Remark: When costs fall, the Nash bargaining solution may yield $R'_{A,\theta_L} < R_{A,1}$, in which case the landlord is better off playing *DNR* (keeping rent unchanged)–as long as the renter would stay. Hence, the equilibrium specifies *DNR* when costs fall if and only if $R_{A,1} \leq R_2^{NewTenant,\theta_L} + m$.

Result 3: Necessary Conditions for Separating Equilibrium

For a separating equilibrium to exist with type D units offering an implicit contract $R_1 = R_2 = R$, the following conditions are necessary:

(IC1: Type-1 Sorting) Type-1 renters must weakly prefer the A market:

$$\text{return}_{1,A} \geq \text{return}_{1,D}(R)$$

where

$$\text{return}_{1,A} = \ln(y - R_{A,1}) + (1-\rho)\left[\frac{1}{2}\ln(y - \tilde{R}_{A,\theta_L}) + \frac{1}{2}\ln(y - R'_{A,\theta_H})\right]$$

$$+\rho\left[\frac{1}{2}\ln(y-R_2^{NewTenant,\theta_L}-m)+\frac{1}{2}\ln(y-R_2^{NewTenant,\theta_H}-m)\right]$$

and

$$\text{return}_{1,D}(R)=(2-\rho)\ln(y-R)+\rho\left[\frac{1}{2}\ln(y-R_2^{NewTenant,\theta_L}-m)+\frac{1}{2}\ln(y-R_2^{NewTenant,\theta_H}-m)\right]$$

(IC2: Type-2 Sorting) Type-2 renters must strictly prefer the D market:

$$\text{return}_{2,D}(R)>\text{return}_{2,A}$$

where

$$\text{return}_{2,D}(R)=2\ln(y-R)$$

$$\text{return}_{2,A}=\ln(y-R_{A,1})+\frac{1}{2}\ln(y-\tilde{R}_{A,\theta_L})+\frac{1}{2}\ln(y-R'_{A,\theta_H})$$

(IC3: Renter No-Move When Costs Fall) Type-2 renters must prefer staying over moving when costs fall:

$$R\leq R_2^{NewTenant,\theta_L}+m$$

(IC4: Landlord Plays DNR) The landlord must prefer honoring the implicit contract when costs rise. This requires that a sufficient mass of frustrated renters would depart, making deviation unprofitable:

$$R-\theta_H>(1-p_{\text{Move}})[R'_{D,\theta_H}-\theta_H]$$

where R'_{D,θ_H} solves the Nash bargaining problem in the D market (analogous to Result 2), and p_{Move} is determined by the frustration threshold γ^* as described below.

(DE: Detached Entry) Expected profits in the D market must be non-negative:

$$\frac{1}{1+\upsilon_D}\left[(R-c-C_D-F_D)+\frac{1}{2}(R-\theta_L)+\frac{1}{2}(R-\theta_H)\right]+\frac{\upsilon_D}{1+\upsilon_D}(-C_D-F_D-c)\geq 0$$

Proof: Each condition represents a standard incentive-compatibility or participation constraint. Conditions IC1-IC3 ensure no renter wishes to deviate. Condition IC4 ensures the landlord doesn't wish to deviate; we elaborate on this below. Condition DE ensures landlords are willing to enter. □

Remark: Type D units can only coexist in equilibrium with type A units if there is a separating equilibrium.

Result 4: Frustration Threshold and Landlord Incentive Compatibility

The landlord's incentive to honor the implicit contract is enforced by frustrated renter departure. Following a deviation to *Renege* when $\Theta = \theta_H$, a renter with frustration sensitivity γ_i compares:

$$u_i(\text{Move}) = \ln(y - R_2^{NewTenant,\theta_H} - m)$$

$$u_i(\text{Stay}) = \ln(y - R'_{D,\theta_H}) - \gamma_i[\ln(y - R) - \ln(y - R'_{D,\theta_H})][R'_{D,\theta_H} - \theta_H]$$

The critical frustration sensitivity γ^* satisfies $u_i(\text{Move}) = u_i(\text{Stay})$:

$$\gamma^* = \frac{\ln(y - R'_{D,\theta_H}) - \ln(y - R_2^{NewTenant,\theta_H} - m)}{[\ln(y - R) - \ln(y - R'_{D,\theta_H})][R'_{D,\theta_H} - \theta_H]}$$

Given the uniform distribution of γ_i on $[0, \gamma^{\max}]$, the probability a renter moves is:

$$p_{\text{Move}} = \frac{\gamma^{\max} - \gamma^*}{\gamma^{\max}}$$

Constraint IC4 follows immediately from comparing expected profits from DNR versus *Renege*.

Proof: The indifference condition follows from setting the utility expressions equal and solving for γ^*. The probability calculation follows from the uniform distribution assumption. □

A set of beliefs, rents and plans such that these conditions are satisfied would yield a pair of sequential equilibria that are a pure strategy separating equilibrium.

3.3 Numerical Example

We now demonstrate the existence of the separating equilibrium through a numerical solution using the parameter values in Table 2.

Type A Market Solution: Following Steps 1-4 of the Appendix:

New-tenant rents: $R_2^{NewTenant,\theta_H} = 1285$; $R_2^{NewTenant,\theta_L} = 1135$.

Nash bargaining (solved numerically) yields: $R'_{A,\theta_H} = 1299.1, R'_{A,\theta_L} = 1141.5$.

Assume that the *Renege* equilibrium features DNR when costs fall. Then the zero-profit condition yields $R_{A,1} = 1188.18$. This exceeds $R'_{A,\theta_L} = 1141.5$, so the landlord prefers DNR. Now verify that the tenant prefers to play *Stay*, i.e., 1188=$R_{A,1} \leq R_2^{NewTenant,\theta_L} + m = 1135 + 100$.

Type D Market Solution: Following Steps 5-9:

Type-1 indifference condition yields: $R = 1210.21$.

Type-2 preference verification: $return_{2,D} = 11.338 > return_{2,A} = 11.335$

Frustration Threshold and Landlord IC:

Nash bargaining solution for D market deviation: $R'_{D,H} = 1299.1$

Table 2. Parameter Values

Parameter	Description	Value
y	Income	1500.0
c	Period 1 operating cost	1000.0
F_A	Entry cost for type A units	100.0
F_D	Entry cost for type D units	130.0
C_A	Screening cost for type A	210.0
C_D	Screening cost for type D	280.0
ρ	Moving shock probability (type 1 renters)	1/2
θ_L	Low cost realization	925.0
θ_H	High cost realization	1075.0
w	Nash bargaining weight for renters	1/3
m	Moving costs	100.0
$\gamma^{\max}$	Maximum frustration sensitivity	0.1

Critical frustration sensitivity: $\gamma^* = 0.0068$

Probability of moving if the landlord reneges: $p_{Move} = (0.1 - 0.0068)/0.1 = 0.932$

Landlord IC constraint: $135.21 > 15.24$

Discussion: The high p_{Move} indicates that the implicit contract is strongly enforced—93 percent of renters would depart if the landlord reneged. This makes deviation highly unprofitable. (Putting this differently, γ^{max} could be much lower–i.e., the average level of frustration could be much lower–and this equilibrium would still hold.) Also note that when new-tenant rents rise, renegotiated rents of type A units track those new-tenant rents fairly closely. When new-tenant rents fall, the gap between new-tenant rents and current rents becomes negative. In the data, this is the pattern that is observed for units in large apartment complexes.

We report the results of a robustness analysis in the Appendix. This verifies that the above equilibrium is not knife-edge.

3.4 Nominal versus Real Rigidity

A long-standing criticism of implicit contract models in labor economics is that while the theoretical mechanisms generate *real* rigidity, the empirical phenomenon requiring explanation is *nominal* rigidity. We argue that this criticism does not apply to the rental market context, due to a fundamental asymmetry in who benefits from rigidity.

3.4.1 The Labor Market Problem

In the labor context, implicit contracts often explain why firms do not reduce wages during downturns, providing workers with income insurance (see Azariadis (1975) or Barro and Grossman (1971)). However, when aggregate inflation occurs, a nominally rigid wage represents a *real* wage cut. Under the implicit contract interpretation, workers should perceive this real wage erosion as a violation of the insurance arrangement—just as they would perceive an explicit nominal wage cut as a violation. If workers become frustrated by real wage cuts (as the implicit contract logic suggests), they should demand inflation adjustments to maintain real wages, undermining nominal rigidity. This tension between the theory's natural prediction (real rigidity) and the phenomenon requiring explanation (nominal rigidity) has long been recognized (see, e.g., Blanchard and Fischer (1989)).

Formally, let W_t denote the nominal wage and P_t the price level in period t. If the implicit contract specifies insurance against real income fluctuations, the worker's expected real wage should satisfy:

$$E_t\left[\frac{W_{t+1}}{P_{t+1}}\right] = \frac{W_t}{P_t}$$

This implies:

$$W_{t+1} = W_t \cdot \frac{E_t[P_{t+1}]}{P_t}$$

The contract naturally generates inflation indexation, not nominal rigidity. Nominal rigidity ($W_{t+1} = W_t$) would only emerge if workers systematically fail to anticipate inflation or suffer from money illusion—assumptions at odds with the rational expectations framework underlying the implicit contract model.

3.4.2 The Rental Market Difference

The rental market exhibits a crucial reversal: nominal rent rigidity *benefits* the renter at the *landlord's* expense. When the rent remains nominally fixed while prices rise, the renter's real rent burden falls, providing the renter with a windfall gain and imposing a real loss on the landlord.

In our model, the implicit contract provides renters with insurance against rent increases arising from cost shocks Θ. But we could interpret cost shocks as inflation shocks; the renter prefers insurance against rent changes arising from either source. Unlike in the labor market context, the renter has no incentive to renegotiate toward real rigidity (inflation indexation) since nominal rigidity is strictly better from the renter's perspective.

The landlord might prefer inflation indexation. However, the enforcement mechanism preventing the landlord from raising the rent in response to *cost* shocks applies with just as much force to preventing rent increases in response to *inflation*. If the landlord, citing "general inflation," reneged on the implicit contract, this would violate the renter's expectations just as much as raising the rent when $\Theta = \theta_H$. Frustrated renters would depart, making such increases unprofitable.[17] In short, the same frustration-based departure mechanism that enforces the implicit contract against Θ-based rent increases will enforce it against inflation-based rent increases. Unlike in the labor context, the party benefiting from nominal over real rigidity (the renter) is precisely the party whose frustration enforces the contract.

3.4.3 Implications for Nominal Rigidity

This asymmetry has two important implications. First, implicit contract models may provide a more natural explanation for nominal rigidity in rental markets than in labor markets. The standard criticism—that rational agents should index contracts to inflation—loses force when one party strictly prefers nominal rigidity and possesses the enforcement mechanism to sustain it.

Second, broadly speaking, implicit contract models enforced using renter frustration offer predictions about the relationship between rent inflation and rent rigidity that differ from those of traditional sticky-price models. In particular, as inflation accelerates, the divergence between nominally rigid rents and new-tenant rents widens, increasing the temptation for landlords to deviate. However, note that this same divergence also serves to increase renter frustration following any attempted deviation from the implicit contract, strengthening the enforcement mechanism and preventing renegotiation. This contrasts with menu-cost or

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[17] This assumes renters do not perceive aggregate inflation as justification for rent increases, consistent with survey evidence that consumers view cost-based justifications for price increases as more legitimate than demand-based or inflation-based justifications (see, e.g., Kahneman et al. (1986) or Rotemberg (2005)). Thus, the logic of the enforcement mechanism applies with even more force when facing inflation shocks.

Calvo models, which typically predict that rigidity decreases during high-inflation episodes (e.g., Nakamura and Steinsson (2008)), but is consistent with the evidence in rental markets, as we explain next.[18]

Empirically, Genesove (2003) documents substantial nominal rigidity in rents even during the high-inflation 1970s. And Gallin et al. (2025) demonstrate that rent rigidity did not fall even as rent inflation rose sharply during the pandemic period. These facts are consistent with our frustration-based enforcement mechanism, but difficult to reconcile with standard sticky-price theories. This evidence suggests the implicit contract interpretation may be particularly well-suited to the rental market context.

3.5 Implications for DSGE Modeling

The model succeeds in accounting for the two stylized facts, and one piece of anecdotal evidence, listed at the beginning of Section 2. But could it be embedded in richer models, such as DSGE models, that have a more aggregate perspective?

The inclusion of housing has become more common in DSGE models, although it remains challenging to model the evolution of rents vis-a-vis house prices in any way other than (an empirically-questionable) frictionless arbitrage condition of one form or another (for an exception, see Sommer et al. (2013)). Does the present model yield any useful suggestions for DSGE modeling?

We think this model may well offer some insights that could help guide the simplified reduced-form modeling that is often necessary in larger models. One of its central takeaways is an important dimension of heterogeneity: the strategic relationship between landlords and renters differs notably across structure types, resulting in different rent dynamics. Apartment rent movements behave much more like those deriving from standard pricing models, models that feature one firm selling to many anonymous buyers. Apartment rents feature much less rigidity than other rents, being much more likely to move every four quarters. In reduced form, the model could be used to justify modeling apartment rents along the following lines: new tenants receive a transitory new-tenant discount (akin to a "sale" price), followed by conventionally specified temporally sticky price dynamics (with modest downward rigidity) and a constant separation risk.

Conversely, the strategic relationship between the landlord and the tenant in a detached unit is much more akin to a bargaining relationship between peers. The present model might be used to justify a "rigid" rent renegotiation process along the following lines. As long as the match continues to feature joint surplus, the current rent is a focal equilibrium,

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[18] Of course, in a richer model featuring more rent uncertainty, a large enough gap would trigger renegotiation. But the "inaction" region (i.e., the DNR region) is surely widened notably by the frustration mechanism.

and will not be renegotiated (see Hall (2005)). But if cost or opportunity cost movements are sufficiently large, these rents will be renegotiated, with something much closer to equal bargaining weights than would be expected with a large landlord. More generally, detached-unit rent movements behave much more like those deriving from models featuring relationship contracts or long-term contracts between firms.

4 CONCLUSION

Continuing-tenant rents are notoriously sticky and often nominally rigid, especially for detached units. Small landlords often state that they fear raising the rent, since it may provoke tenants to leave. In this paper, we provide a simple theory that provides a potential explanation for these facts. In doing so, we continue a tradition of exploring the theoretical implications of well-established characteristics of human neurobiology and behavior.

In this theory, sticky rents arise in an equilibrium characterized by an implicit contract, such that longer-duration tenants receive insurance against rent risk, "purchased" via a higher initial rent. The resultant implicit-contracts theory explains nominal (rather than real) rigidity in the rental market, and is consistent with key facts in that market.

But how is this contract enforced? The presence of moving costs provides landlords with a strong temptation to renege on this implicit contract, knowing that (in general) large moving costs mean that a tenant's material payoffs are higher if the tenant stays and pays the higher rent. Our model is a two-period model, not unrealistic given the fact that tenants rarely stay in a unit more than a handful of years. In this context, there is no role for reputation to enforce an implicit contract. Thus, it is difficult to explain why landlords do not raise the rent. Something powerful must be at play to keep this rent unchanged.

In our model, renter frustration—i.e., the presence of frustration-sensitive renters who will choose to leave in response to contract violations—is used as an enforcement mechanism to rule out off-equilibrium-path play by landlords. This explanation accords well with survey evidence from landlords. Somewhat surprisingly, this type of mechanism has only a few theoretical antecedents, despite its existence being thoroughly attested in the empirical literature.

Of course, such a simple model cannot be expected to explain all the facts about rental market dynamics elucidated in Gallin et al. (2025). Our theory is necessarily stark and leaves out other aspects of rental markets—such as the prevalence of rounding, and the likely existence of risk aversion on the part of some landlords—that might play a role in generating rent stickiness. Nonetheless, we hope that it can provide a starting point for richer models that grapple with explaining the important and profound rigidity of continuing-tenant rents.

5 DECLARATIONS

5.1 CRediT authorship contribution statement

Hugh Montag: Writing – review and editing, Conceptualization. Randal Verbrugge: Writing – review and editing, Writing – original draft, Formal analysis, Conceptualization.

5.2 Declaration of competing interest

The authors declare that we have no relevant or material financial interests that relate to the research described in this paper.

5.3 Declaration of generative AI and AI-assisted technologies in the manuscript preparation process.

During the preparation of this work the authors used Claude 4.5 Sonnet (offline) for identifying weaknesses in an earlier draft, checking our math, improving the writing, improving the formalization of the numerical solution description and the characterization of the equilibrium, and writing the first draft of the numerical solution code. This tool also drafted the first version of Section 3.4, based on a terse prompt and its knowledge of the literature. After its use, the authors reviewed and edited the content as needed, and take full responsibility for the content of the published article.

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6 APPENDIX

6.1 Proposition 1

Proposition 1

A separating equilibrium exists if there exist (R, υ_D) with $R > R_{A,1}$ and $\upsilon_D \geq 0$ such that conditions IC1-IC4 and DE in Result 3 are simultaneously satisfied.

Proof: Results 1-4 establish that if such (R, υ_D) exist, the described strategy profile and beliefs constitute a polymorphic sequential equilibrium. Competition among type D landlords will drive R down until either IC1 binds (making type-1 renters indifferent) or DE binds (making expected profits zero). The equilibrium specifies R at the lower of these two bounds, with υ_D adjusting to satisfy DE. Existence requires that at this R, all IC constraints are satisfied. $\square$

Remark on **parameter restrictions**: Proposition 1 does not provide closed-form parameter restrictions guaranteeing existence because: (i) the Nash bargaining solutions R'_{A,θ_H}, R'_{A,θ_L}, and R'_{D,θ_H} involve transcendental equations; (ii) the equilibrium rent R must simultaneously satisfy IC1 (which determines it as the solution to a transcendental equation) and IC2-IC4 (which provide bounds).

We conjecture that a separating equilibrium requires $C_D - C_A$ to be of intermediate size (large enough to create value from avoiding turnover, but not so large as to eliminate a DNR equilibrium and make type D entry unprofitable), $\rho_1 - \rho_2$ to be sufficiently large so that sorting occurs, and γ^{max} to be sufficiently large, so there is a sufficient mass of frustrated renters to enforce the implicit contract. Our baseline calibration satisfies these conditions with considerable slack. We provide a robustness analysis in Section 6.3.

6.2 Numerical Solution Steps

There are nine steps.[19]

Step 1: Set Parameters

$y, c, F_A, F_D, C_A, C_D, \rho, \theta_L, \theta_H, w, m, \gamma^{max}$

Step 2: Solve for New-Tenant Rents (Result 1)

$$R_2^{NewTenant,\theta_L} = \theta_L + C_A$$

$$R_2^{NewTenant,\theta_H} = \theta_H + C_A$$

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[19] Complete simulation code (in RATS) is available from the authors upon request. The algorithm checks whether all IC constraints are satisfied for the computed equilibrium (R, υ_D). A simulation is deemed successful if: (i) the sorting constraints IC1 and IC2 hold; (ii) the landlord IC constraint IC4 holds; (iii) the no-move-when-costs-fall constraint holds; and (iv) expected profits for type D landlords are non-negative.

Step 3: Solve Nash Bargaining for Type A (for $\theta = \theta_H$)

The Nash Bargaining Problem:

$$\max_{R'}[\ln(y - R') - \ln(y - R_2^{NewTenant} - m)]^w[(R' - \Theta)]^{1-w}$$

FOC:

$$\frac{w}{y - R'} \cdot [(R' - \Theta)] = (1 - w)[\ln(y - R') - \ln(y - R_2^{NewTenant} - m)]$$

One may solve this iteratively. We seek a zero of the function:

$$f(R') = \frac{w(R' - \Theta)}{y - R'} - (1 - w)[\ln(y - R') - \ln(y - R_2^{NewTenant} - m)]$$

Use Newton-Raphson iteration:

$$R'_{n+1} = R'_n - \frac{f(R'_n)}{f'(R'_n)}$$

where:

$$f'(R') = \frac{w(y - \Theta)}{(y - R')^2} + \frac{1 - w}{y - R'}$$

Initialize: $R'_{A,\theta_H;0} = R'_0 = \theta_H + 200$ and update until a convergence criterion is reached, using the iteration above.

Remark on **convergence properties**:

The Nash bargaining solution has the following properties ensuring convergence:

1. **Existence**: The objective function

$$G(R') = [\ln(y - R') - \ln(y - R_2^{NewTenant} - m)]^w[(R' - \Theta)]^{1-w}$$

is continuous on the compact set $[\Theta, y - m - \epsilon]$ for small $\epsilon > 0$, guaranteeing existence of a maximum.

2. **Strict quasi-concavity**: Taking the log:

$$\ln G(R') = w[\ln(y - R') - \ln(y - R_2^{NewTenant} - m)] + (1 - w)\ln(R' - \Theta)$$

The second derivative is:

$$\frac{d^2 \ln G}{dR'^2} = -\frac{w}{(y - R')^2} - \frac{1 - w}{(R' - \Theta)^2} < 0$$

This confirms strict concavity, ensuring uniqueness of the maximum.

3. **Numerical convergence**: Newton-Raphson converges quadratically for strictly concave problems. We verify convergence when $|R'_{n+1} - R'_n| < 10^{-6}$, typically achieved in 4-6 iterations.

Step 4: Check if DNR Is Played When Costs Fall

a) Solve Nash bargaining for $\theta = \theta_L$ to get R'_{A,θ_L}.

b) Solve for $R_{A,1}$ (Result 2). If we set $R_{A,1}$ assuming DNR when low, this means:

$$R_{A,1} = c + C_A + F_A - (1-\rho)\left[\frac{1}{2}(R'_{A,\theta_H} - \theta_H) + \frac{1}{2}(R_{A,1} - \theta_L)\right]$$

$$\implies R_{A,1}[1 + \frac{(1-\rho)}{2}] = c + C_A + F_A + \frac{(1-\rho)}{2}[\theta_L - R'_{A,\theta_H} + \theta_H]$$

$$R_{A,1} = \left(\frac{2}{3-\rho}\right)\left[c + C_A + F_A - \frac{(1-\rho)}{2}\left({R'}_{A,\theta_H} - (\theta_L + \theta_H)\right)\right].$$

c) Check if: $R_{A,1} \leq R_2^{NewTenant,\theta_L} + m$. If yes, DNR equilibrium exists when costs fall.

Step 5: Solve for Type D Market Rent R

This requires solving the indifference condition for type-1 renters:

$$return_{1,A} = return_{1,D}$$

While this is a nonlinear equation in R, it is well-behaved and straightforward to solve using numerical root-finding.

Step 6: Verify Type-2 Renters Prefer D Market

$$return_{2,D} > return_{2,A}$$

Step 7: Solve for Frustration Threshold, γ^*, and p_{Move}.

a) Solve Nash bargaining for D market deviation (under $\theta = \theta_H$), i.e., R'_{D,θ_H}.

b) Set up the indifference condition. The utility expressions are:

$$u_i(Move) = \ln(y - R_2^{NewTenant,\theta_H} - m)$$

$$u_i(Stay) = \ln(y - R'_{D,\theta_H}) - \gamma_i[\ln(y - R) - \ln(y - R'_{D,\theta_H})][R'_{D,\theta_H} - \theta_H]$$

Setting these equal:

$$\ln(y - R_2^{NewTenant,\theta_H} - m) = \ln(y - R'D, \theta_H) - \gamma^*[\ln(y - R) - \ln(y - R'D, \theta_H)][R'_{D,\theta_H} - \theta_H]$$

Solving for γ^*: Rearranging, we get

$$\gamma^*[\ln(y - R) - \ln(y - R'D, \theta_H)][R'D, \theta_H - \theta_H] = \ln(y - R'_{D,\theta_H}) - \ln(y - R_2^{NewTenant,\theta_H} - m)$$

Therefore:

$$\gamma^* = \frac{\ln(y - R'_{D,\theta_H}) - \ln(y - R_2^{NewTenant,\theta_H} - m)}{[\ln(y - R) - \ln(y - R'_{D,\theta_H})][R'_{D,\theta_H} - \theta_H]}$$

c) Calculate: $p_{Move} = \frac{\gamma^{max} - \gamma^*}{\gamma^{max}}$.

Step 8: Verify Landlord IC Constraint

$$R - \theta_H > (1 - p_{Move})[R'_{D,\theta_H} - \theta_H]$$

Step 9: Check Remaining Constraints

a) $R \leq R_2^{NewTenant,\theta_L} + m$ (renter won't move when costs fall)

b) Expected profits ≥ 0 in D market

6.3 Robustness Analysis

To verify that the separating equilibrium is not knife-edge, we conduct Monte Carlo simulations randomly perturbing all parameters. Specifically, we draw 1,000 parameter vectors where each parameter is multiplied by $\eta_i \sim U[0.99, 1.01]$ and re-solve the model.[20]

Result: A separating equilibrium exists in all 1,000 simulations. Table 3 reports summary statistics for some key equilibrium objects.

Equilibrium objects vary smoothly with parameters. Type-1 sorting slack binds to approximately machine precision across simulations.

When perturbations are doubled to ±2 percent (i.e., $\eta_i \sim U[0.98, 1.02]$), 4.7 percent of the simulations fail to generate a separating equilibrium.[21] This confirms that while the equilibrium is locally robust, it does not exist for all parameter values.

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[20] The baseline moving-shock probability is set to $\rho = 0.51$ rather than 0.50 to ensure perturbations explore the interior of the existence region.

[21] When perturbations rise to ±1.5 percent (i.e., $\eta_i \sim U[0.985, 1.015]$), 0.1 percent of the simulations fail.

Table 3. Robustness: Summary Statistics Across 1,000 Simulations

Variable	Mean	Std Dev	Min	Max	Baseline
D market rent (R)	1211.4	4.16	1202.6	1222.7	1210.2
Frustration threshold (γ^*)	0.0069	0.0004	0.0061	0.0082	0.0068
Prob. move if deviation (p_{Move})	0.931	0.004	0.918	0.940	0.932
Landlord IC slack	121.1	5.20	107.0	134.2	119.8

Notes: Each parameter perturbed by ±1%. Landlord IC slack measures the return to DNR, minus the return to *Renege*.