LICENSING AND THE INFORMAL SECTOR IN RENTAL HOUSING MARKETS: THEORY AND EVIDENCE*

Andrew Samuel† Loyola University Maryland

Jeremy Schwartz ‡ Loyola University Maryland

Kerry Tan § Loyola University Maryland

Abstract

Although the goal of licensing is to ensure the quality of services, it can also induce firms to operate informally or exit altogether. This paper examines licensing in the rental housing market by developing a model that indicates licensing's impact on the size of the underground rental market, the number of vacancies, and homelessness are ambiguous. As a result, we calibrate the model using a unique dataset from Baltimore, which allows us to directly observe underground rentals and vacancies. Our calibrations show that licensing may have a modest impact on rents, while increasing quality more substantially.

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†Associate Professor, Department of Economics, Loyola University Maryland, 4501 N. Charles Street, Baltimore, MD 21210. Email: asamuel@loyola.edu

‡Corresponding Author: Associate Professor, Department of Economics, Loyola University Maryland, 4501 N. Charles Street, Baltimore, MD 21210. Email: jsschwartz1@loyola.edu

§Associate Professor, Department of Economics, Loyola University Maryland, 4501 N. Charles Street, Baltimore, MD 21210. Email: kmtan@loyola.edu

1 Introduction

Licensing is used to regulate many industries and occupations from day-care centers to rental properties. Currently, around 25% of occupations require some form of licensing in the U.S (Nunn, 2016). One industry that is regulated through licenses is the rental housing market. Among the 30 largest cities in the U.S., more than half require some form of rental licensing and recently, some cities have expanded their licensing requirements.[1] For example, at the time of writing this article, Austin, TX has a proposal to introduce rental licensing; Memphis, TN and Nashville, TN recently implemented rental licensing; and Minneapolis, MN and Baltimore, MD expanded their licensing requirements in 2016 and 2019. Thus, the use of licensing as a regulatory tool is not only widespread, but is also expanding.

Despite the prevalence of licensing, there is much debate concerning its value. Its presumptive goal is to maintain quality and safety for both consumers and workers. Particularly when consumers cannot easily observe quality, licensing can ensure consumers that the product they are purchasing meets certain standards (see Leland, 1979; Farmer et al., 2018; Farmer et al., 2020). As a result, licensing could limit the adverse outcomes that arise from asymmetric information.

Although scholars and policymakers acknowledge this benefit, they question its effectiveness because of two potential perverse side-effects (Schneider and Buehn, 2013). First, licensing increases barriers to entry, causing some firms to leave an industry even while it may improve quality among those firms who remain. The reduction in supply often affects low-income individuals acutely since they may only be able to afford low-quality products. Second, licensing creates scope for an "underground economy" of firms that operate without a license, thereby allowing them to bypass quality standards entirely.[2] Thus, whether licensing is beneficial can depend on the magnitude of these two side-effects.

Identifying the specific benefits and costs of licensing within the context of the rental housing market is especially important in comparison to other licensed occupations. In many rust belt and de-industriaized U.S. cities, the housing stock is not only of low-quality, but also low-income renters often must rent from "slum lords" who minimally invest in property maintenance. Thus, licensing may be important to ensure that rental housing meets some minimum quality standards (such as removal of lead paint) and improve the safety and health of occupants.[3]

Despite the benefits, the adverse side-effects from licensing can be especially consequential in an impoverished urban community. Specifically, licensing may reduce the availability of

[1] To the best of our knowledge, there is almost no systematic data on licensing landlords at the national level despite its widespread use.

[2] Following Dell'Anno and Schneider (2003), we define the underground economy as "those economic activities that circumvent government regulation, taxation, or observation." Note that we use the term "shadow" and "underground" interchangeably throughout this paper.

[3] In 2017, *The Baltimore Sun* reported that one family "paid $1,200 a month for a house that immediately began to fall apart around her. Hole in the roof, ceilings and walls. Water damage. Mold. Lead paint. And, worst of all, rats." (Donovan and Marbella, 2017).

affordable low-quality housing to economically vulnerable individuals, which can potentially increase homelessness and create a demand for underground units that rent without a license. These underground units, which typically do not meet quality standards, can be especially dangerous to tenants (Bruni, 1996). Thus, determining the impact of licensing on rental markets is a relevant issue beyond increasing our understanding more generally of the effect of occupational licensing requirements.

The goal of this paper is to determine the impact of licensing on the supply and demand of rental housing theoretically and empirically. We develop a theoretical model that mirrors the licensing policies of many cities, including Baltimore. The theoretical findings show that the impact of licensing on key housing variables such as rents, underground housing, and homelessness are ambiguous and depend on the specific parameters chosen. Thus, we calibrate the parameters of the model using a unique data set provided to us by Baltimore's Department of Housing. The calibration allows us to determine the likely impact of rental licensing on the rental market.

The regulatory structure of rental licensing in Baltimore shares many of the same critical features with rental regulations of other large U.S. cities, as well as with the regulations in other industries. This makes studying rental regulations in Baltimore a particularly useful exercise. In Baltimore landlords who rent properties that consist of one or two units are not required to be licensed. We refer to this portion of the rental market as the unregulated sector. On the other hand, the regulated sector consists of properties with three or more dwelling units, which are known as "multi-family dwellings," henceforth MFD. These MFDs are required to meet certain quality and safety standards before they are granted a license to rent.[4] Thus, theoretically, our model consists of two sectors: an unregulated sector of small scale firms and a regulated sector consisting of larger ones. Licensing requires that properties meet some standard of housing quality that is valued by consumers, but is costly for landlords to provide. Landlords can respond to this regulation in one of three ways: 1) comply with regulations and obtain a license, 2) not comply and rent in the shadow economy, or 3) keep their property vacant. The supply of housing in our model incorporates all these elements and is therefore is influenced significantly by these licensing policies.

Consumers in our model have heterogeneous preferences with regard to quality, so that some may be willing to give up higher quality housing in exchange for lower rent. We derive the demand and supply of high-quality and low-quality properties which determine equilibrium rents for both types of units. This in turn determines the number of properties who choose to operate underground or obtain a license, as well as the number of households who are homeless.[5]

Theoretically, we obtain several novel comparative statics with respect to fines and the scope of rentals subject to the licensing requirement. We find that increasing the fines

[4]The rational for such a two-tiered system ensures that bigger buildings, where safety hazards are more harmful, comply with all the safety provisions.

[5]We refrain from labeling our model as a general equilibrium model because agents are either landlords or tenants and do not have a choice. But it possesses many characteristics of a general equilibrium model.

(strengthening enforcement) for not complying and operating "underground" among properties in the regulated sector encourages more landlords to raise their quality and, thereby, meet the quality standards for licensed properties. This increases the equilibrium quantity of high-quality housing (of which licensed units are a subset), but it need not lower the rent of high-quality housing. This surprising result arises because when the fines for operating underground are raised, the supply of informal, low-quality housing falls, which raises rents for low-quality housing. As a result, some consumers now prefer to rent higher quality housing, which in the regulated sector are licensed, shifting the demand of high-quality rentals to the right. Since both supply and demand in the high-quality sector shift right, high-quality rents do not necessarily rise. Similar results also arise from evaluating the impact of raising fines on other market outcomes.

Next, we study the impact of altering the maximum number of units a property can have without being required to obtain a license, which we term the "regulatory threshold." Varying this threshold has some surprising implications for the rental market equilibrium. Specifically, expanding the range over which rentals must be licensed (lowering the regulatory threshold) increases the incentives for high-quality housing, since these landlords now face higher fines for providing low-quality housing. This increases the supply of high-quality housing, but decreases the supply of low-quality housing, which in turn increases low-quality rents. However, since high and low-quality housing are substitutes, the demand for high-quality housing rises. Consequently, because both supply and demand increase, it is not clear whether high-quality rents rise or fall in equilibrium. Further, since low-quality rents rise, homelessness also increases. Accordingly, once these interactions are accounted for, increasing the scope of licensing can have negative effects on the housing market that policymakers should be considering.

These theoretical results depend on several of the model's parameters. Thus, identifying the relevant parameter space is critically important in determining the impact of regulation. Accordingly, we conduct a calibration exercise using data from the universe of rental properties in Baltimore that overcomes these problems. A critical component of any such calibration is identifying the informal sector and firms that have exited the market due to regulations. We identify these data by merging data from two distinct administrative sources from Baltimore that are normally kept separate. By doing so, we are able to directly identify MFDs operating without a license. Additionally, because homes that are not rented do not vanish, and vacant properties are also tracked by the City, we can identify properties that exit the rental market.

This exercise makes several important contributions to two distinct strands of literature, which hitherto have not been integrated: (a) the literature on regulation and the informal sector and (b) the literature on housing regulations and affordability. Specifically, there is a vast literature on informality, but none of this research has been applied to rental markets. Similarly, although housing regulations have been studied previously, none of these papers has considered the possibility of an informal or underground rental market. At a very general level, therefore, our paper makes an important contribution by integrating insights from these two distinct research areas.

Our paper makes three key interrelated theoretical contributions and one main empirical contribution regarding informality and regulation. First, we not only carefully model the supply-side implications of regulation in an economy that allows for an informal market, but we also consider the important demand-side implications by allowing for heterogeneous tenants that may accept a quality and price trade off between formal and informal housing. Second, since tenants have heterogeneous preferences, our model also allows for quality differences between the informal and formal sector, unlike many other studies concerning the informal sector. Third, we consider two sectors: one that is regulated and another unregulated - a regulatory feature present in rental and many other licensing regimes. We elaborate on each of these contributions in the next section.

2 Literature Review

Theoretically, many earlier papers focus on the informal sector as the suppliers' response to evading regulations, but few consider the effects of the informal sector on demand and consumer surplus.[6] Cuff et al. (2011) and de Paula and Scheinkman (2007), however, study both supply and demand effects within the context of the formal and the informal factor markets. In Cuff et al. (2011), informal sector workers can only work for informal sector firms, whereas formal sector workers can work in either industry. Since the marginal product of labor is the same across formal and informal workers *inter-alia*, wages equalize between formal and informal workers.

In contrast to Cuff et al. (2011) who assume that informal labor can only work in the informal sector, de Paula and Scheinkman (2007) allow firms in both the formal sector to determine whether to use formal or informal inputs. Specifically, firms may produce intermediate goods used by other firms or final goods. Producers of final goods can choose intermediate goods that are produced formally or informally in addition to choosing whether to be formal or informal themselves. Their key prediction is that informal producers of final goods are more likely to produce with inputs that are also informal. They test these implications with data from a survey of firms in Brazil and find that their predictions are broadly supported by the data.[7]

Similar to these papers, we also contribute to the literature by modeling the role of supply and *demand* of informal and formal housing market. Consumers in our model have heterogeneous preferences with regard to quality so that some may be willing to give up higher quality housing in exchange for lower rent. We derive the demand and supply of high

[6]Another literature that we do not discuss directly is that connecting the informal sector to corruption such as Choi and Thum (2005) and Ahlin and Pinaki (2006). We ignore this literature because bribery is not widespread in the U.S., which is the source of our data. Similarly, we focus primarily on the literature on informality that incorporates both supply-side and demand-side effects.

[7]Winkelried (2005) studies a model of the informal economy where there is an entry fee to become licensed. He then uses this framework to study the impact of licensing and the informal sector or inequality.

and low-quality properties which determine equilibrium rents for both types of units. This in turn determines the number of properties who choose to operate underground or obtain a license, as well as the number of households who are homeless.[8]

Our works extends the work of Cuff et al. (2011) and de Paula and Scheinkman (2007) in several important ways. First, quality of housing in our framework is not the same across the formal and informal sector.[9] Thus, in contrast to Cuff et al. (2011), we find that rents do not equalize across these two sectors.

The second unique aspect of our paper is, as a consequence of modeling demand with heterogeneous preferences for housing quality, regulations can prevent the market from being fully covered. That is, expanding licensing can reduce market coverage so that there are some consumers who wish to purchase a low-quality informal sector product at a lower price, but may be unable to do so. Thus, in contrast to almost all the literature on informality, licensing in our framework can cause consumers to be priced out the market, which implies that licensing could increase homelessness. Thus, ignoring demand ignores the substitution effect between the high-quality/high price formal sector and low-quality/low price informal sector, which in turn overlooks potentially important effects of regulation *inter-alia*.[10] This last issue is particularly critical for the housing market since many low income tenants may prefer to occupy lower quality dwellings in exchange for lower rents if the alternative is no dwelling at all.

A final contribution of our theoretical work is that we model two sectors of the housing market: one that is regulated and one that is not. This realistically mirrors the polices of many U.S. cities that exclude certain housing from having to obtain a license, as well as other regulated industries that we discuss below. Introducing two such sectors generate ambiguous predictions regarding the implications of tightening regulations on rental markets. Indeed, we show that the impact of increased regulations on rents or the size of the informal sector depends on the magnitude of the model's parameters. This type of segmentation is not unique to rental licensing. For example, many cities require permits or licenses for large scale construction or building renovations, but smaller construction can often be done without a permit. Similarly, a small lemonade stand run by a neighborhood is not regulated, while larger food sellers surely are. Finally, daycare providers in many states are only required to be licensed if they have more than a certain number of children. To the best of our knowledge, this policy of segmenting markets has not been studied in any of the prior literature on licensing and the informal economy.[11]

[8]We refrain from labeling our model as a general equilibrium model because agents are either landlords or tenants and do not have a choice, yet it possesses many characteristics of a general equilibrium model.

[9]This is also the case in Amir and Burr (2015).

[10]See Farmer et al. (2020) for an analysis of some of these demand-side effects in the context of corruption and the informal sector.

[11]The uniqueness of this policy needs to be stressed in that it is not equivalent to a model in which there is optimal under-deterrence. Namely, in many enforcement frameworks it is optimal to allow small firms to remain unregulated because their social harm is lower than the cost of regulating those firms. Here the effects are more complex because allowing an unregulated sector affects the *payoff* of regulated firms as

Besides these theoretical contributions, an additional important aspect of this paper is our ability to realistically calibrate the model, which allows us to connect theory and data more closely. Reviewing the prior empirical literature on licensing and informal economic activity discloses two limitations. First, in most studies it is difficult to identify the counterfactual supply in the absence of regulation since firms that exit (or never entered) due to the regulatory burden imposed by licensing cannot be observed. Second, the association between licensing and the underground economy is often hard to determine because the shadow economy is also hard to observe. Measures of this informal economy usually rely on self-reported data from surveys which are not always reliable in this context (Schneider and Buehn, 2013). Thus, although there is a vast literature on licensing and the informal sector, Schneider and Buehn (2013) notes that

> *[t]he link between theory and empirical estimation of the shadow economy is still unsatisfactory.*

Our data possesses unique characteristics not found in most other data on the informal sector, which allows us to overcome these two limitations. As we noted earlier, we leverage a unique data set from Baltimore that allows us to observe landlords who are renting without a license, as well as identify those who choose to keep their property vacant and exit the rental market. Thus, we can calibrate our model to realistically reflect the number of vacant and underground properties.

Our findings also contribute to the separate and critically important literature on housing affordability. Indeed the debate concerning regulations and housing affordability is a debate that has been long lasting in the literature. Early in this debate, Hirsch et al. (1975) addresses theoretical claims in Ackerman (1971) that the costs of additional regulations will not be passed along to consumers. Hirsch et al. (1975) exploits variation in laws that allow tenants to withhold rent in order to compel landlords to maintain their properties. The paper shows that at least in the extreme case of properties entering receivership, regulatory costs do lead to higher rents. The weight of more recent studies support the notion that regulation can impact housing affordability. Malpezzi (1996) finds that rents, as well as home values, increase with greater regulation.[12] Glaeser et al. (2005) also finds that the regulatory environment in Manhattan leads to greater housing costs, leading the authors to conclude that about 50% of the price of a Manhattan condominium is related to regulatory costs.

From a theoretical standpoint, our model extends the work of these important papers by allowing landlords to respond to increased regulations by escaping underground. To our knowledge, none of these papers on housing affordability allow for this possibility. We show that the presence of an underground rental sector can alter the affects of regulation

consumers are willing to substitute products in one sector for another. This in turn affects the compliance decisions of firms in the regulated sector. These general equilibrium effects are typically not recognized in any of the models of optimal under-deterrence.

[12] This paper primarily focuses land use regulations rather than building code enforcement.

in important ways. As such, the existing literature may be misidentifying the effect of regulations by not accounting for the underground sector.

Our result, that raising regulations on landlords (through raising fines) does not necessarily raise rents, is especially important in light of the fact that most of the literature assumes that regulations typically raise rents. Recently, Ambrose and Diop (2018) develop a model where landlords have asymmetric information about the quality of tenants. Assuming that rents are increasing in the amount of regulations, their numerical model shows that increased regulation will result in more tenant screening because landlords need to mitigate the higher rates of tenant default due to the higher rents. Although this mechanism is insightful, their result relies on the assumption that rents are an increasing function of regulations. As we find, this need not be the case when there is both a formal and informal market for rentals.

The numerical exercises that we perform with our calibrated model also produce several insights relevant to this literature on regulation and affordability. First, our baseline model suggests that decreasing the threshold at which a property must be licensed increases quality and leads to only a limited number of new vacancies as some landlords avoid the new regulation by exiting the market, which is consistent with the goals of policymakers. Further, only a small portion of the increased regulatory costs are passed along to tenants, with rents increasing by only about 0.1% for high-quality units when the regulatory threshold falls from two to zero. Since the total supply of housing falls, rents also increase for low-quality units, but to a lesser degree. Second, an increase in fines generally has a small impact on rents and the overall supply of housing. Larger properties however experience a significant increase in vacancies and housing quality. Both of these findings support the empirical results in Malpezzi (1996), Glaeser et al. (2005), and Ambrose and Diop (2018), although the magnitude to which we find that regulatory costs influences rents is quite small.

We also explore several alternative scenarios to our baseline calibration with our Baltimore data. An exogenous expansion of the rental market among single family homes, as occurred after the Great Recession, can substantially lower rents and increase quality, while a greater differential between high and low-quality rents reduces the equilibrium quantity of high-quality units. Finally we also find that when the costs of maintaining high and low-quality units is more equal than our Baltimore data suggests, housing affordability decreases, but the quality of the housing stock increases.

3 A Model of Rental Housing Markets

We develop a model of rental housing that allows for both a formal and an informal rental housing market. There are a total of T landlords in a city who each possess one rental property. Each of these rental properties contains d distinct dwelling units of housing (apartments, lofts, etc.) where $d = \{1, 2, ...M\}$. Let $l(d)$ be the number of landlords who own properties with d units of housing so that $\sum_{d=1}^{M} l(d) = T$. We take this distribution as given, in the sense that each landlord is endowed with a property containing d distinct dwelling units.

Thus, given this framework, there are a total of $l(d)d$ units at any given d.

The above properties may either be high or low-quality with $\overline{\lambda}$ and $\underline{\lambda}$ representing high and low-quality respectively. This quality measure λ is a hedonic index where higher values of λ represent higher quality. Thus, $\overline{\lambda} > \underline{\lambda}$. The $l(d)d$ units for any d consist of two types: first, those that always remain high-quality and, second, those that endogneously choose quality based on market conditions. The fraction of properties of the first type that always remain high-quality is given by $\mu \in [0, 1]$. This fraction is included to acknowledge that some types of properties always remain high-quality at least in the short run. Specifically, properties that are owned or managed by nationwide property management firms (including luxury rentals) always remain high-quality because their owners have a national reputation for upscale housing. When market rents fall, such landlords usually simply exit the market (in the long-run) rather than lower quality. Similarly, public housing units are required to maintain certain standards and do not make endogenous quality decisions based on market conditions. Thus, for a given d, $\mu l(d)d$ always remain high-quality. The remaining $(1 - \mu)$ fraction of properties operate on the "quality margin," such that their quality depends on their landlord's decisions. For these $(1 - \mu)l(d)d$ properties, their landlords can choose to maintain them as high-quality units with quality level $\overline{\lambda}$, or as low-quality units at quality level $\underline{\lambda}$, with $\overline{\lambda} > \underline{\lambda}$. Alternatively, they may choose to keep their property vacant.

The quality choices of the $1-\mu$ landlords at the "quality margin" are determined by both market and regulatory forces. As is standard in this literature, the market's incentives for supplying high-quality housing depend on the costs and benefits to the landlords. As such, it costs landlords $k \sim U[0, K]$ (where U is the uniform distribution) to supply d units of housing at quality $\overline{\lambda}$ and αk to supply d units of housing at quality $\underline{\lambda}$, and $\alpha \in (0, 1)$.[13] That is, a landlord can supply all d units of high- (low-) quality at cost k (αk). However, high-quality housing is beneficial to a landlord because it commands a higher rent. Thus, $\overline{r} > \underline{r}$ is the market rent per unit of high- and low-quality housing, respectively, which price taking landlords receive for their housing (and that will be determined in equilibrium). Finally, it costs $\phi \geq 0$ to keep a property vacant. This cost reflects the opportunity cost of not selling or renting the property or simply the direct cost of preventing the property from falling into complete disrepair.[14]

The regulatory forces for providing high-quality housing depends on whether a property belongs to the regulated or unregulated sector. Specifically, there are two sectors in this rental market: the regulated sector, denoted by a superscript R, and the unregulated sector, denoted by N. Whether a landlord is regulated depends on the size of her property, d. Landlords with $d \leq d^P$ are unaffected by quality regulation. Instead, they choose whether to be high-quality $\overline{\lambda}$, low-quality $\underline{\lambda}$, or vacant based almost entirely on the market forces described above. However, landlords in the regulated sector can choose to be formally

[13] To clarify, the cost k is uniformly distributed over the domain $[0, K]$.

[14] Alternatively, we could assume that vacancy costs are variable so that costs are ϕd. However, such costs would be empirically reflected in the rents because the rents should also include the full economic benefit of providing low-quality housing relative to being vacant.

licensed, rent underground in the informal market, or be vacant. Choosing to be formally licensed requires that a landlord maintain her property up to the quality standard $\overline{\lambda}$, and joining the informal market is equivalent to choosing $\underline{\lambda}$ (and operating in the underground economy). That is, the quality choice $\overline{\lambda}$ is such that it satisfies the quality level required under regulation. Landlords who choose $\overline{\lambda}$ (i.e. licensed) incur a cost of $c \geq 0$ in addition to the costs of providing high-quality housing described earlier. These costs reflect any added regulatory burden imposed on landlords who belong to the regulated sector.[15] Finally, landlords that fail to meet the standards (i.e. choose low-quality) are caught and fined an expected fine of fd^2.[16] That is, the expected marginal fine is higher for landlords with bigger apartment buildings since it would be harder for them to hide any infractions.

To summarize, in both the regulated and the unregulated sector, landlords choose between being high-quality, low-quality, or vacant. But, in the regulated sector being high-quality is equivalent to being licensed and being low-quality is equivalent to being unlicensed. The key distinction between these two sectors lies in the different incentives for landlord choices. In the unregulated sector choices are determined entirely by market forces reflected in the rents $(\overline{r}, \underline{r})$ and costs k and ϕ, whereas in the regulated sector, landlords' decisions also depend on the regulatory costs c and fines fd^2.

We now consider the payoffs in each of the two sectors. To simplify our notation, let $\mathcal{T} = \{\overline{\lambda}, \underline{\lambda}, v\}$ be the set of available choices (types) for a landlord, where $\tau \in \mathcal{T}$. In the unregulated sector, landlords' payoff are

$$\pi^N(\tau) = \begin{cases} \overline{r}d - k \text{ if } \tau = \overline{\lambda} \\ \underline{r}d - f_N d^2 - \alpha k \text{ if } \tau = \underline{\lambda} \\ -\phi \text{ if } \tau = v. \end{cases} \tag{1}$$

It should be noted that although the above expressions reflect the payoffs in the unregulated sector, landlords are subject to some fines, f_N. These reflect the fact that in almost every city all property owners (even owner-occupied units) are subject to some housing quality regulations. As such, even an owner-occupied property may be fined, such as for leaving trash unattended. Since violations are usually associated with low-quality housing in our data, the fine f_N reflects this characteristic.

In the regulated sector, a landlord's payoff is

$$\pi^R(\tau) = \begin{cases} \overline{r}d - c - k \text{ if } \tau = \overline{\lambda} \\ \underline{r}d - \alpha k - fd^2 \text{ if } \tau = \underline{\lambda} \\ -\phi \text{ if } \tau = v. \end{cases} \tag{2}$$

[15] For example, landlords in the regulated sector need to be annually inspected, which requires scheduling and setting aside a time (including the time taken to coordinate with the inspection tenants). These and other regulatory costs are reflected in c, which may not be large.

[16] Specifically, if $\hat{f}$ is the fine, and a the probability of being sanctioned, then $f = a\hat{f}$.

We turn to consider landlord decisions in each of the two sectors. First, consider the unregulated sector. Here a landlord chooses

$$\lambda = \begin{cases} \overline{\lambda} \text{ if } k \leq \frac{d(\overline{r}-\underline{r})+f_N d^2}{(1-\alpha)} \equiv k \in [0, k_1^N] \\ \underline{\lambda} \text{ if } k \in [\frac{d(\overline{r}-\underline{r})+f_N d^2}{(1-\alpha)}, \frac{\underline{r}d-f_N d^2+\phi}{\alpha}] \equiv k \in [k_1^N, k_2^N] \\ v \text{ if } k > \frac{\underline{r}d-f_N d^2+\phi}{\alpha} \equiv k \in [k_2^N, K]. \end{cases} \quad (3)$$

In the regulated sector, a landlord chooses

$$\lambda = \begin{cases} \overline{\lambda} \text{ if } k \leq \frac{d(\overline{r}-\underline{r})+fd^2-c}{(1-\alpha)} \equiv k \in [0, k_1^R] \\ \underline{\lambda} \text{ if } k \in [\frac{d(\overline{r}-\underline{r})+fd^2-c}{(1-\alpha)}, \frac{\underline{r}d-fd^2+\phi}{\alpha}] \equiv k \in [k_1^R, k_2^R] \\ v \text{ if } k > \frac{\underline{r}d-fd^2+\phi}{\alpha} \equiv k \in [k_2^R, K]. \end{cases} \quad (4)$$

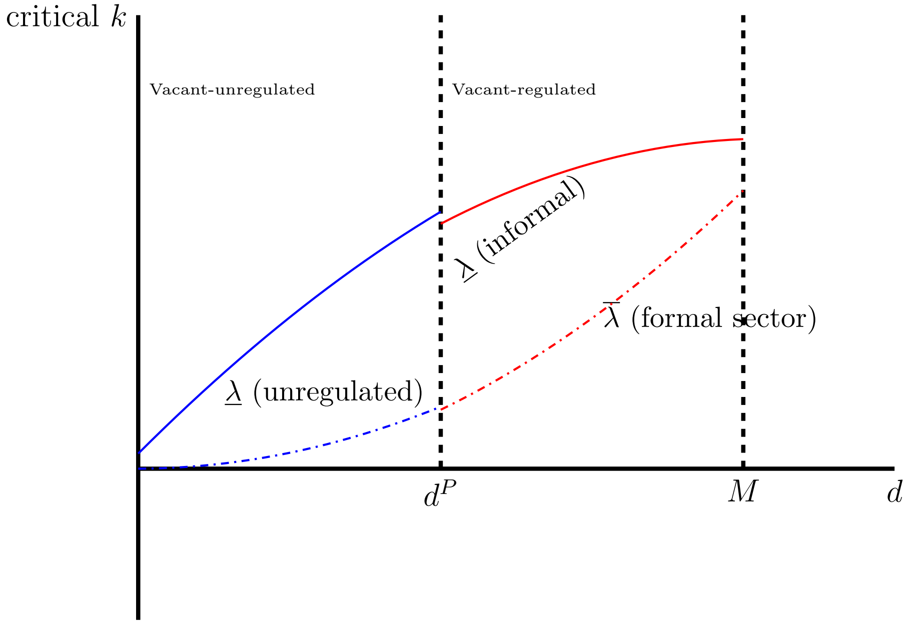


Figure 1: Landlord's Sector Choices as a Function of d

Figure 1 presents the k values that determine the cutoffs between landlords choosing to leave their properties vacant, rent as low-quality, or rent as high-quality. The figure presents the critical k values as a function of the number of units in a property d, and are drawn in blue for the unregulated sector. The area above the top blue line represents the proportion of properties that are vacant. The area in between the two critical values represent low-quality dwellings, whereas high-quality units are represented below the bottom line. In the unregulated sector, vacancies fall as d increases and rental income from a property increases. Instead of leaving properties vacant, a larger portion of those properties will be low-quality. Also, an increasing portion will be high-quality as the fines associated with low-quality properties grow with the number of dwellings.

The regulatory threshold introduces a discontinuity in these critical values as the cost of a license and the fines differ for properties with greater than d^p dwellings. As the number of dwellings increase in the regulated sector, the total size of the fine increases leading to a larger number of landlords choosing to be high-quality, and a shrinking number of properties operating underground. We assume that all three choice types ($\tau = \{\overline{\lambda}, \underline{\lambda}, \upsilon\}$) exist in equilibrium for the range of data available.

3.1 Supply of Housing

Using the landlords' decisions characterized above, we now derive the supply of housing. First, consider the supply of high-quality housing. The supply is

$$S(\overline{\lambda}) = \mu \underbrace{\sum_{d=1}^{M} l(d)d}_{\mathcal{U}} + \frac{1-\mu}{K(1-\alpha)} \left((\overline{r} - \underline{r}) \underbrace{\sum_{d=1}^{M} l(d)d^2}_{\mathcal{X}} + \underbrace{f_N \sum_{d=1}^{d^P} l(d)d^3 + f \sum_{d=d^P+1}^{M} l(d)d^3}_{\mathcal{F}} - c \underbrace{\sum_{d=d^P+1}^{M} l(d)d}_{\mathcal{C}} \right).$$

Therefore,

$$S(\overline{\lambda}) = \mu\mathcal{U} + \frac{1-\mu}{K(1-\alpha)} \left((\overline{r} - \underline{r})\mathcal{X} + \mathcal{F} - \mathcal{C} \right). \tag{5}$$

Similarly, the supply of low-quality housing is

$$\begin{aligned} S(\underline{\lambda}) = {} & \frac{1-\mu}{K\alpha(1-\alpha)} \times \\ & \{ (\underline{r} - \alpha\overline{r}) \underbrace{\sum_{d=1}^{M} l(d)d^2}_{\mathcal{X}} - \underbrace{(f_N \sum_{d=1}^{d^P} l(d)d^3 + f \sum_{d=d^P+1}^{M} l(d)d^3)}_{\mathcal{F}} + \alpha\, c \underbrace{\sum_{d=d^P+1}^{M} l(d)d}_{\mathcal{C}} \\ & + (1-\alpha)\, \phi \underbrace{\sum_{d=1}^{M} l(d)d}_{\Phi} \}. \end{aligned} \tag{6}$$

Therefore,

$$S(\underline{\lambda}) = \frac{1-\mu}{K\alpha(1-\alpha)} \left((\underline{r} - \alpha\overline{r})\mathcal{X} - \mathcal{F} + \alpha\mathcal{C} + (1-\alpha)\Phi \right). \tag{7}$$

3.2 Demand for Housing

We now consider the consumers in this market. There is a mass of atomistic consumers indexed by $\theta \sim U[0, \Theta]$ (where U represents the uniform distribution) who each choose to rent either 1 or 0 units of housing.[17] If they rent, their utility for housing is given by

$$W(\lambda) = \theta\lambda - r,$$

whereas their utility is 0 if they choose not to rent (in which case they are homeless). Note, that consumers with a higher θ obtain a higher utility from quality. Consumers choose either high-quality, low-quality, or no housing depending on their θ and the rent. Thus, a consumer demands a high-quality house if $\theta\overline{\lambda} - \overline{r} > \theta\underline{\lambda} - \underline{r}$ and no housing if $\theta\underline{\lambda} - \underline{r} < 0$. Thus, the demand for high-quality housing is

$$\mathcal{D}(\overline{\lambda}) = \Theta - \frac{\overline{r} - \underline{r}}{\Delta\lambda}, \tag{8}$$

where $\Delta\lambda = \overline{\lambda} - \underline{\lambda}$. The demand for low-quality housing is then

$$\mathcal{D}(\underline{\lambda}) = \frac{\overline{r} - \underline{r}}{\Delta\lambda} - \frac{\underline{r}}{\underline{\lambda}}. \tag{9}$$

All households with $\theta < \frac{\underline{r}}{\underline{\lambda}}$ choose no housing, which follows the standard notion of equilibrium (rational) homelessness in the model (O'Flaherty, 1995). It should be noted that these demand curves take rents as given, however, in equilibrium it will need to be verified that

$$\Theta - \frac{\overline{r} - \underline{r}}{\Delta\lambda} > 0.$$

3.3 Equilibrium

The equilibrium rents in this model are determined by setting the supply and demand of high and low-quality housing equal to each other. We identify an equilibrium in which there are positive levels of vacancies (essentially assuming that the really big buildings do not matter for this equilibrium). To identify such an equilibrium, we make the following set of assumptions:

Assumption 1

a. $(1-\mu)(\mathcal{C} - \mathcal{F}) + K\Theta(1-\alpha) - k\mathcal{U}\mu(1-\alpha) > 0$

b. $K(1-\alpha)(\mathcal{F} + \mathcal{X}\Delta\lambda(\Theta - \mathcal{U}\mu) - \mathcal{C}) > 0$

c. $K\mathcal{X}(\underline{\lambda} - \alpha\overline{\lambda})(\Theta - \mathcal{U}\mu) + \mathcal{C}(K\alpha + \mathcal{X}\underline{\lambda}(1-\mu)) + \Phi(K(1-\alpha) + \mathcal{X}\Delta\lambda)(1-\mu)) - \mathcal{F}(K + \mathcal{X}\overline{\lambda}(1-\mu)) \geq 0$

d. $(1-\mu)(\mathcal{F} + \mathcal{X}\Theta\Delta\lambda - \mathcal{C}) + K\mathcal{U}\mu(1-\alpha) \geq 0$

[17] This utility function is utilized in many "canonical" models of product differentiation with demand for quality (e.g. Tirole, 1988; Gal-Or, 1983). However, our basic results do not change under alternative specifications, including those found in hedonic models of housing quality (e.g. Follain and Jiminez, 1986).

Assumption 1 ($a.$) ensures that $\overline{r} > \underline{r}$ so that there is some incentive for high-quality housing. Assumption 1 ($b.$), ($c.$), and ($d.$) together ensure that the equilibrium demand and supply for high and low-quality housing is positive. While a full characterization of these assumptions in relegated to the appendix, both ($b.$) and ($d.$) can be satisfied as long as the cost of compliance is sufficiently small.

Proposition 1 *Under Assumption 1, Equations 5, 7, 8, and 9 form the system of equations that yield the equilibrium $\overline{r}^*$ and $\underline{r}^*$. In this equilibrium, rents in the high and low-quality markets are given by*

$$\underline{r}^* = \frac{\underline{\lambda}(\mathcal{F}(1-\mu) + K\alpha(\Theta - U\mu) - \Phi(1-\mu))}{\alpha K + \underline{\lambda}\mathcal{X}(1-\mu)} \tag{10}$$

$$\overline{r}^* = \underline{r}^* + \frac{\Delta\lambda(k\Theta(1-\alpha) + (1-\mu)(\mathcal{C} - \mathcal{F}) - K\mathcal{U}\mu(1-\alpha))}{K(1-\alpha) + \mathcal{X}\Delta\lambda(1-\mu)}. \tag{11}$$

Proof. See Online Appendix.

4 Policy Analysis

4.1 Comparative Statics

Our first set of results examine how fines impact the rental market equilibrium.

Proposition 2 *An increase in the expected regulated sector fine f*

1. *decreases the rent differential between formal and informal/low-quality housing*
2. *increases the rent of low-quality housing*
3. *has an ambiguous impact on rent of high-quality housing*
4. *decreases the quantity of informal housing*
5. *increases the quantity of high-quality housing*
6. *increases the vacancy rate*
7. *increases the level of homelessness.*

Proof. See Online Appendix.

This proposition reveals three key insights. First, an increase in the expected fines for being an informal rental increases the cost of supplying low-quality housing. This shifts the supply of low-quality/informal housing to the left as firms on the margin between being informal and formal, or informal and vacant, choose to become formal/licensed rentals or become vacant. Accordingly, the rents for low-quality housing (of which informal housing is a part) fall, *ceteris paribus*. In the market for high-quality housing, an increase in the fine shifts supply to the right, which pushes rents down for high-quality housing. However, this is offset by the fact that because formal and informal housing are substitutes, the increase in low-quality (informal) rent shifts the demand for high-quality housing to the right. Since both demand and supply in the high-quality (formal) market shift right, whether high-quality rents rise or fall depends on which effect is stronger.

Second, the impact of a change in the fine on the equilibrium quantity of high-quality (formal) housing can be understood by recognizing that since $S(\overline{\lambda})$ and $D(\overline{\lambda})$ shift right, $\overline{r}^*$ may rise or fall, but quantity always rises. Similarly, since $S(\underline{\lambda})$ shifts left, equilibrium quantity of low-quality housing falls.

Third, because the rent for low-quality housing rises, homelessness rises. However, although informal sector rents rise, the number of vacancies rise. An increase in the rent of low-quality housing makes renting more attractive. But this increase in the rent is not sufficient to offset the increase in the cost of renting informally (due to the higher fine) because consumers lower their demand for low-quality housing (and some exit the market; i.e. homelessness rises). Consequently, the net effect is that vacancies rise.

It is worth contrasting this result with the existing literature on the informal sector. The focus in this literature is on the supply-side effects of licensing (Choi and Thum, 2005; Ahlin and Pinaki, 2006; Amir and Burr, 2015). Hence, an increase in the fines for operating in the informal sector reduces the number of firms in the informal sector.[18] In other words, if formal and informal sector firms produce substitutable goods, then there are consequential demand-side effects that should not be overlooked.

Next, we study the impact of changing the threshold d^P on the equilibrium in this market. Note that changing the threshold involves a discrete change. Thus, we employ the theory of monotone comparative statics to determine how a change in the threshold affects the housing market equilibrium following methods discussed in Van Zandt (2002).

Proposition 3 *An increase in the regulatory threshold*

1. *has an ambiguous effect on the rent differential between formal and informal/low-quality housing if* $f > f_N$*. Otherwise, decreases the rent differential*

2. *decreases the rent of low-quality housing if and only if* $f > f_N$

3. *has an ambiguous impact on rent of high-quality housing*

4. *has an ambiguous effect on the quantity of informal/low-quality housing if* $f > f_N$*. If* $f < f_N$*, then it decreases the quantity of informal/low-quality housing*

5. *has an ambiguous effect on the quantity of high-quality housing*

6. *reduces vacancies if and only if* $f > f_N$

[18] Most of this literature does not consider the impact of this on prices.

7. reduces the level of homelessness if and only if $f > f_N$

Proof. See Online Appendix.

This proposition reveals several important consequences regarding changing the regulatory threshold d^P. Recall that raising the regulatory threshold implies that fewer landlords are required to meet quality standards. This increases the supply of low-quality housing shifting supply of low-quality housing to the right, lowering low-quality rents. Again, this results in both a supply and demand effect in the market for formal/high-quality firms. On the demand side, consumers substitute from high to low-quality housing because rents of low-quality housing falls. However, supply of high-quality housing may shift to the left or to the right because of two effects. Raising d^P implies that fewer landlords must bear cost c, which causes supply $S(\overline{\lambda})$ to increase. However, it also implies that fewer firms face the higher fine $f > f_N$ from being low-quality, which would cause supply $S(\overline{\lambda})$ to decrease. Thus, rents in the formal sector may rise or fall depending on whether supply increases or decreases. Similarly, quantity of formal/high-quality housing may increase or decrease. Thus, as noted earlier, accounting for both sides of this market yields important insights into how the presence of an informal sector affects regulation.

5 Calibration

We calibrate our model to mimic the housing market and policy of Baltimore, Maryland, a mid-sized post-industrial U.S. city about 40 miles northeast of Washington, DC. According to the U.S. Census Bureau's American FactFinder, Baltimore had a population of 619,796 in 2017, ranking it 30th among U.S. cities. The median household income in Baltimore was \$46,641 in 2017 compared to \$57,652 nationally, and the poverty rate was 22.4% compared to 14.6% for the U.S. This puts Baltimore somewhat less well off than the national average. The housing stock in Baltimore comprises 294,858 units, of which 126,233 (or 42.8%) were rental units. The median monthly rent was \$1,009, which is approximately the same as the national average. The following subsections present the data we use and the calibration methodology.

5.1 Data

To calibrate the model we use data from the Baltimore City Department of Housing & Community Development. The data covers the period between 2000 - 2015 and comes from several sources, including the city's tax assessment records, rental registration database, multi-family dwelling licenses, and building code enforcement records. After merging these datasets together, we are able to construct a database that includes detailed information on property size, regulatory status of the property (licensed, underground, or unregulated), as well as a set of property characteristics that can proxy for housing quality.

Table 1: Summary Statistics

Variable	Definition	Mean	Std. Dev.
dwelunit	Number of dwellings	2.007	10.575
citations	Number of citations	0.391	1.045
citations_perunit	Number of citations per unit	0.332	0.904
notices	Number of notices	0.149	0.487
notices_perunit	Number of notices per unit	0.113	0.380
vacant	Dummy variable for vacant property	0.076	0.265
licensed	Dummy variable for Licensed property that is not vacant	0.051	0.220
underground	Dummy variable for underground property that is not vacant	0.028	0.166
notvacant	Occupied property	0.080	0.271
yearbuilt	Year built	1922.675	21.339
$totalmarketvalue_perunit$	Total market value per unit	77,938.82	87,606.46
rowhouse	Dummy variable for rowhouse	0.729	0.444
semidetached	Dummy variable for semidetached	0.041	0.197
mfd	Dummy variable for multi-family dwelling	0.073	0.260
N_mfd	Number of unique multi-family dwellings in sample	4,800	
N_properties	Number of unique properties in the sample*	75,802	
N	Number of observations	446,790	

Note: *N_properties represents the number of unique rental properties. This may differ from the number of individual rental units, of which several may be within a single property, reported by the Census Bureau.

Table 1 provides some key descriptive statistics from our database for 2010 - 2015 sample period. In our theoretical model the size of the property determines whether landlords operate in the regulated sector, as well as the potential fines low-quality properties are subject to. The average property in Baltimore has about two dwellings, which reflects the high proportion of single family homes in the market. As depicted by Figure 2, 54% percent of units are single family homes, while 12% percent are two unit properties. Larger properties, such as those greater than six dwellings, are a much smaller proportion of the total number of properties (24%).

Our data also allows us to observe whether properties are in the regulated sector, and if so, whether they are operating with or without a license. As in the model presented in Section 3, Baltimore has a two-tiered regulatory structure. The first tier is the unregulated sector and is composed of single family homes and two unit properties. Landlords of these smaller properties are required to register with the city annually for a small fee, but are not required to undergo a formal inspection for building code violations.[19] Figure 2 also presents the proportion of rental units available in the unregulated market which are highlighted in blue, with almost two-thirds of all units are in the unregulated sector.

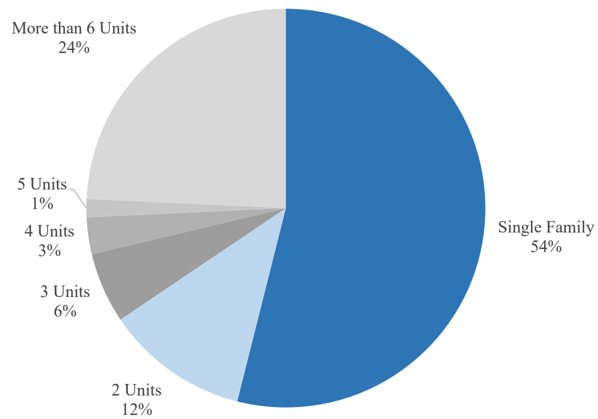
The second tier of regulation applies to MFDs that have greater than two units. MFDs are subject to greater regulation and must both register with city and obtain a rental license. Licenses are only approved after an annual inspection by a public inspector is completed and any code violations are abated.[20] MFDs comprise just 7.3% of the total properties (Table 1)

[19]Although city inspectors do not regularly visit these properties, complaints from tenants, neighbors, or random patrols may result in an inspection and a resulting enforcement action.

[20]After January 1, 2020, Baltimore allowed private firms to perform licensing inspections.

and make up 34% of all dwellings (Figure 2).

Figure 2: Rental Units by Property Size and Regulatory Sector



An aspect of our data that is particularly unique is our ability to identify properties that are operating underground. This is in contrast to much of the literature which must rely on more indirect measures of the informal sector. To identify properties illegally renting without a license, we merge the city's registration and licensing databases, which are typically maintained separately. By combining these two files we are able to identify non-owner occupied MFDs that should have a license, but for which we cannot find a corresponding printed license date.[21] These homes are almost certainly rented properties because there is no gain from (falsely) reporting such properties as vacant.[22] Thus, such homes are therefore very likely a MFD that is being rented without a license. In the sample period, 2.8% of all properties are operating underground.

In addition to the regulatory status of a property, we also observe whether a property has been left vacant. Vacant properties in Baltimore are required to register with the city, which allows us to determine exactly which properties are left unoccupied. In our sample period almost 8% of properties are vacant.

Finally, our data also includes several variables that will allow us to disentangle which properties are potentially high-quality. The first variable is simply the year the property was built with older properties more likely to be of poorer quality. In Baltimore the housing stock

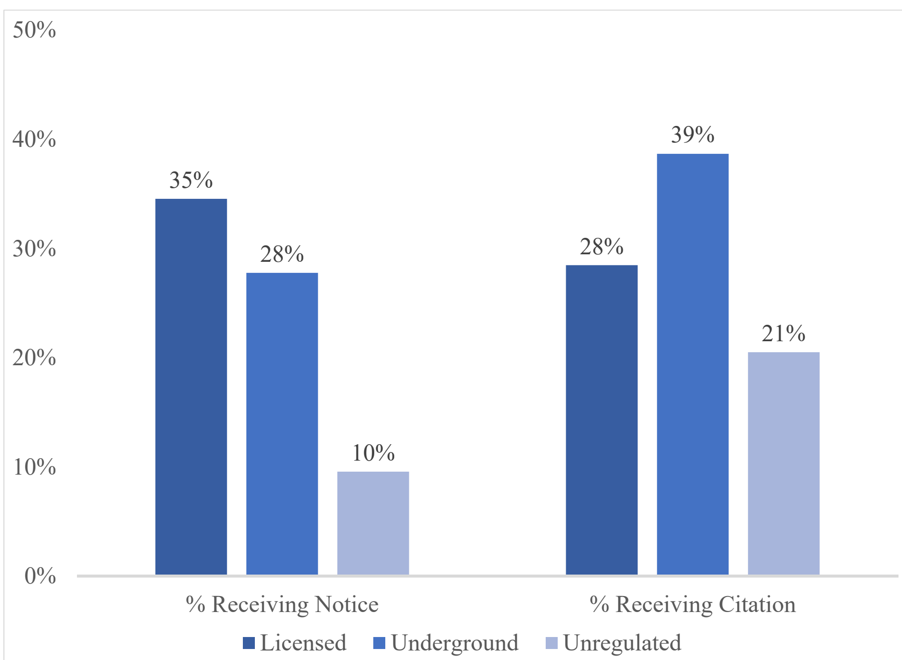
[21]It is certainly natural to ask why Baltimore has not undertaken a similar analysis and address properties operating underground by giving them an incentive to obtain a license. Unfortunately, the lack of enforcement resources in the city is the primary reason these properties are not fined.

[22]If anything, there is a cost of reporting a home as vacant because the city strongly dislikes vacant properties.

is slightly under a hundred years old. We also observe two different types of housing units, which could differ in quality from the standard detached single family homes available in Baltimore's wealthier neighborhoods. The first type is attached rowhouses which comprise about 70% of properties, and the second is semiattached properties which are 4% of all properties. A higher market value is also a likely indicator of quality. Since market value increases with the size of a property, we focus on market value of a property per dwelling unit, which in Baltimore averages about $80,0000. There is however a high variance in market value (standard deviation of $87,606) reflecting the large differences in income among Baltimore neighborhoods.

Table 1 and Figure 3 present data on two building code enforcement actions. The first are citations, which carry a fine and can be issued for relatively small infractions (e.g. minor health or sanitation violations, leaving trash out, rodent issues, letting the grass grow too long, or failing to register a property). The second enforcement action is a notice for a building code violation, which requires landlords to abate the deficiency within a certain period and can lead to fines if the violation persists. Both citations and notices may be issued as a result of a complaint from a tenant or neighbor, a random patrol from an inspector, or in the case of the regulated sector, during an annual inspection.

Figure 3: Enforcement Actions for Licensed, Underground, and Unregulated Markets



In our sample, properties average 0.149 notices per year, and the average number of notices per dwelling unit is 0.113. Figure 3 divides the prevalence of notices and citations by licensed properties, underground properties, and properties in the unregulated sector. The proportion of properties that receive a notice are highest among licensed properties, followed by those operating underground, and then those in the unregulated market. Given that underground and unregulated properties do not receive a regular inspection, the difference among these two groups in the number of notices may be indicative of poorer quality among the units that are in the regulated sector but deliberately avoid obtaining a license. However, drawing comparisons to licensed properties is a bit more difficult since regular inspections create an additional opportunity for these properties to receive a notice. As a result, we are hesitant to uses notices when trying to determine which properties are high-quality in our calibration.

Citations potentially provide a more consistent means to compare quality across different sectors of the housing market since they are less contingent on annual inspections. Among the whole sample, properties average 0.391 citations and the average number of citations per dwelling is 0.332. Figure 3 shows that the unregulated sector has the lowest likelihood of receiving a citation, followed by licensed units, and then underground units. While establishing cause and effect is difficult from simple descriptive statistics, the level of average citations suggests that simply being unregulated does not necessarily translate into poorer quality. In fact, underground units may be of poorer quality than those in the unregulated sector, and thus, deliberately avoiding regulations because they are not in compliance with the building code. A potential alternative explanation for the differing number of citations by sector is that Baltimore focuses enforcement on larger properties due to their limited resources. This leads to more citations of larger properties, not because quality is lower, but because they are simply targeted by the Housing Department more often or more rigorously. Similarly, a larger complex may generate more citations simply because size creates a greater likelihood of more violations. These explanations perhaps weaken the connection between citations and housing quality.

There is some evidence however that sheds doubt on these alternative explanations. If it was the case that size attracts citations, then we should see citations increase with the size of the property within the regulated sector. Regressing citations on the number of units in the regulated sector actually reveals a negative correlation.

Additionally, if it were possible to control for the size of a property and be able to observe differences in the number citations among unregulated, licensed, and underground properties, then we may be able to conclude that the pattern we observe in the descriptive statistics is not being generated by property size, but rather quality differences. While this is not possible, given that Baltimore explicitly regulates properties based on the number of dwellings, we can imperfectly control for size around the policy threshold. We do this by examining two and three dwelling properties and find a similar pattern emerges to the descriptive statistics based on the whole sample. The lowest number of citations is in the unregulated sector (two property dwellings), followed by those licensed in the regulated sector (three dwelling properties), and finally in the underground sector (three dwelling properties). Despite the evidence that citations may be a potential proxy for quality, we use a more robust method to determine which properties are high-quality for our calibration exercise, rather than relying solely on enforcement actions.

5.2 Parameters Choices

In this section we discuss how we leverage our data set in order to identify the parameters of the model, which are presented in Table 2. To provide a road map for how we determine the parameters, we employ four different methods: 1) we use characteristics of the Baltimore housing market to determine d^P, l_d, D, and Θ, 2) we set fines in each sector, f and f_N, to ensure vacancies fall with property size and to capture the likelihood of unregulated properties being fined, 3) K, c, ϕ, α, and μ help us fit the relationship between vacancy, quality, and property size that is predicted by the model to the actual data, and finally 4) we adjust $\bar{\lambda}$ and $\underline{\lambda}$ so that equilibrium rents in the model match the observed rents in Baltimore.

Table 2: Calibrated Parameters

Parameter	Baseline Value	Source and Description
d^P (Threshold of regulated sector)	2	Corresponds to Baltimore Policy
D (Maximum dwelling units)	10	Encompasses 98.7% of Baltimore properties
Θ (Demand when $\bar{r} = \underline{r}$)	77,988	Average dwellings in Baltimore properties with less than 10 units
f (fines regulated sector)	712.82	Calibrated to ensure monotonic increase in vacancy rate
f_N (Unregulated Fines)	148.11	Based on probability of fine in unregulated sector
K (Maximum cost parameter)	1,215,462	Match actual licensing and vacancy rates
c (Fixed cost of license)	0.000	Match actual licensing and vacancy rates
ϕ (Cost of vacancy)	364,276	Match actual licensing and vacancy rates
α (Cost parameter for λ_h)	0.722	Match actual licensing and vacancy rates
μ (Non-marginal high-quality units)	0.494	Match actual licensing and vacancy rates
$\bar{\lambda}$ (high-quality units)	0.743	Calibrated to match Baltimore rental data
$\underline{\lambda}$ (low-quality units)	0.647	Calibrated to match Baltimore rental Data

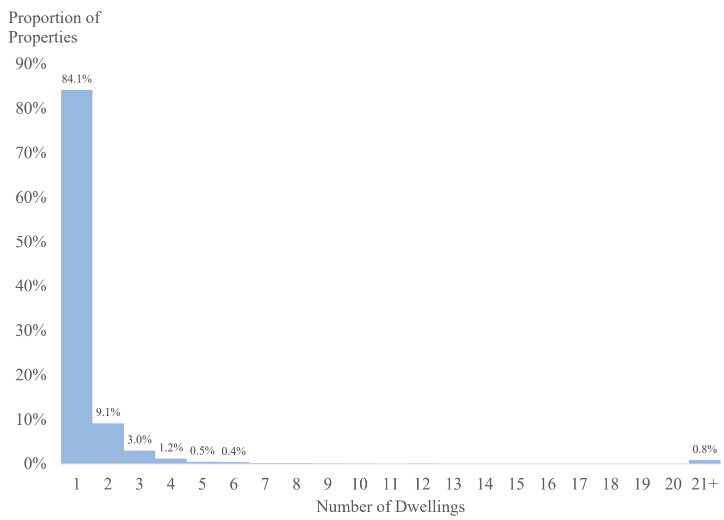
5.2.1 Aggregate Characteristics of Baltimore's Housing Market

We set parameters d^P, D, l_d and Θ to match some of the aggregate characteristics of Baltimore's housing market. First, in order to mirror the regulatory structure in Baltimore we set d^P to 2, the maximum number of units a property can have and not be required to obtain a license.

The next features of the Baltimore rental market that we capture is the maximum dwellings in a property, D. Properties in Baltimore range from single family homes to large complexes with as many as 652 units. However, an overwhelming number of properties have less than 10 units (98.8%) as depicted in Figure 4. Rather than include the whole sample in our analysis and have these very few large properties unduly influence the calibration, we truncate our sample at 10 units by setting $D = 10$.

Next, we set $l(d)$ to the average distribution across d dwelling units for the years within our sample and interpret Θ in Equation 8 as the total demand when rents are homogeneous across all quality types. If this was the case, we assume there would be demand for the total number of housing units in Baltimore, which is $\Theta = \sum_{d=1}^{M} l(d) = T = 77,988$ units within our truncated sample.[23]

Figure 4: Histogram of Rental Units



5.2.2 Fines in Unregulated and Regulated Sectors

We next turn to defining the value for f_N and f. To determine these two parameters, we first establish two thresholds levels of k (k_v^* and k_r^*) using Equations (3) and (4) such that properties are left vacant when $k > k_v^*$ and properties will be high-quality when $k_r^* > k$:

$$k_v^*(d) = \frac{\underline{r}d - \hat{f}d^2}{\alpha} I(d \geq d^p) + \frac{\underline{r}d - \hat{f}_N d^2 + \phi}{\alpha} I(d < d^p) \tag{12}$$

$$k_r^*(d) = \frac{d(\overline{r} - \underline{r}) + fd^2 - c}{(1-\alpha)} I(d \geq d^p) + \frac{d(\overline{r} - \underline{r}) + \hat{f}_N d^2}{(1-\alpha)} I(d < d^p), \tag{13}$$

where $I(d \geq d^p)$ is an indicator variable that is one for the regulated sector, and 0 otherwise.

Our model model predicts that the vacancy rate monotonically increases with d under the following sufficient condition:

$$\text{argmax}_d k_v^*(d) = D. \tag{14}$$

[23]The 77,988 rental units differs from the Census Bureau's reported number of units because we choose to truncate our sample at properties with ten rental units or less.

Absent this condition, Equation (3) suggests that vacancies may reach a minimum at a given d and potentially rise thereafter. This is not something we observe in the data. To avoid this, we set f such that condition (14) holds. This yields a fine of \$712.82. To determine fines in the unregulated sector f_N, we examine the proportion of properties in the unregulated sector that have received at least one fine during the sample period, which is just under 21%. Interpreting $f_N = pf$, where p is the probability of receiving a fine in the unregulated sector, we set $f_N = 0.21 \times f = \$148.11$.

5.2.3 Matching the Vacancies and High-Quality Function

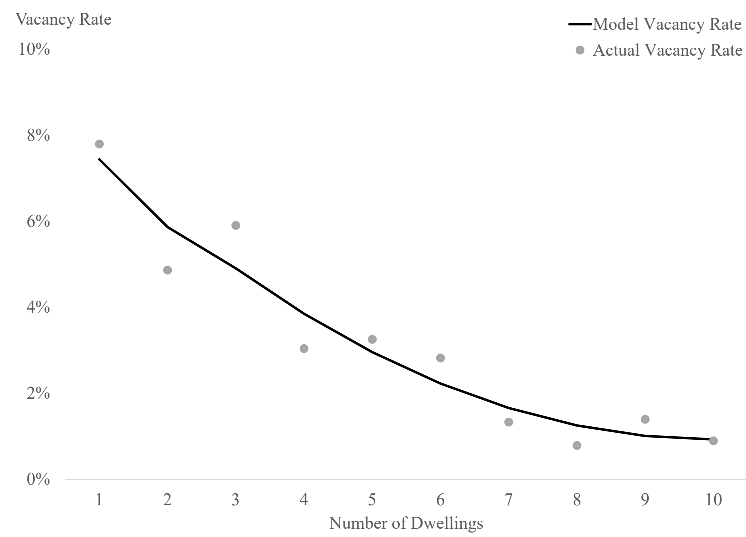
Next, we want the model to accurately reflect the number of vacant and high-quality units in Baltimore and we use the parameters K, c, ϕ, α, and μ to accomplish this. First, we determine the proportion of housing units that are vacant by property size as measured by number of dwelling units within a property. Figure 5 presents a scatter plot of the relationship between dwelling units and the proportion of vacancies.

Next, we turn to measuring the proportion of units that are high-quality. As in the model, we assume that obtaining a license in the regulated sector is equivalent to meeting the high-quality standard, but we do not have an analogous measure of quality for the unregulated sector. Since we do not observe housing quality directly for the unregulated sector, we use the set of proxies for quality that Section 5.1 describes to extrapolate the likelihood these properties would meet the quality threshold for a license had they been regulated. We start by limiting our sample to just the three dwelling properties which arguably are the most similar to the one and two dwelling unit properties that comprise the unregulated sector. We use this sample to estimate a probit model, regressing licensing status against the number of citations per dwelling, log of market value per dwelling unit, year the property was built, as well as dummy variables for row homes and semidetached properties. We also include city ward fixed effects. To ensure causality runs from market value per unit and citations per unit to licensing status, we lag these variables by one year. We then apply the resulting estimates from the probit model to one and two dwelling units to impute the probability that properties in the unregulated sector might be licensed. We project that 59% of two dwelling units would be high-quality compared to 35% of single family homes. More information on this estimation can be found in the Appendix along with the descriptive statistics for the three dwelling property sample and the probit regression results. Figure 5 shows the scatter plot of the proportion of properties that we estimate are high-quality for the unregulated sector and those licensed in the regulated sector.

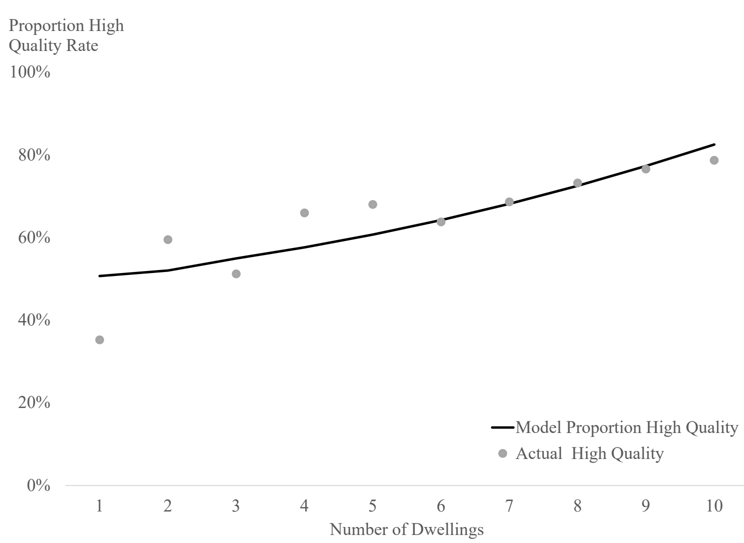
We then calibrate ϕ, α, K, μ and c to minimize the squared errors between the actual data for the proportion of properties that are vacant and high-quality by number of dwellings within a property and the predictions of the model.[24]

[24] By minimizing the squared errors between the actual vacancy rate and high quality rate by property size (from 1 to 10 dwellings) we have a total 20 distinct data points to calibrate our model. This allows us more than enough degrees of freedom to calibrate the model.

Figure 5: Actual versus Predicted Vacant and High-Quality Rates



(Panel A) Vacancy Rates



(Panel B) High-Quality / Licensing Rates

Note: The figure presents imputed quality for "Actual High Quality" using the methodology discussed in Section 5.2.3 for the unregulated sector and licensed units for the regulated sector.

Figure 5 also illustrates the model's predictions of the vacancy rate and the proportion of properties that are high-quality, along with the actual vacancy and high-quality rates from Baltimore can be found in Figure 5. The model does a very good job fitting to the actual vacancy rates across properties with different units as well as for high-quality dwellings. The one exception is the model's slightly higher prediction of high-quality single family homes.[25] The model appears to capture the general decline in vacancies and the increase in high-quality dwellings (licensing) that occurs among larger properties.

5.2.4 High- and Low-Quality Rents

Two parameters in the model still remain undetermined: $\underline{\lambda}$ and $\overline{\lambda}$, which we calibrate to ensure the equilibrium rents of the model mimic that of Baltimore. Unfortunately, we do not directly observe rents from any of our Baltimore data sources so we supplement our data set with two publicly available measures from Zillow: 1) the price-to-rent ratio and 2) the average rent by ZIP code j, which we refer to as Zr_j. To determine the rents for high and low-quality dwellings we take the following approach:

1. First, we start by dividing the market value of each property i in ZIP code j by the corresponding price-to-rent ratio for the ZIP code to develop an initial rent estimate for each property, which we refer to as r^1_{ij}.

2. Next, to ensure our estimate of the average rent for each ZIP code corresponds to the report average from Zillow, we create a second revised rent estimate $r^2_{ij} = r^1_{ij} \times \frac{Zr_j}{\frac{1}{I_j}\sum_i^{I_j} r^1_{ij}}$, where I_j is the total number of properties in ZIP code, j.

3. Then, using the probit estimates that we develop when imputing quality for all properties, we calculate $Pr_{ij}(high-quality)$ as the probability of a unit being high-quality.

4. We then calculate the mean rent for high-quality dwellings $\bar{r}$ as the weighted mean of r^2_{ij} using $Pr_{ij}(high - quality)$ as the probability weight, and the mean rent for low-quality $\underline{r}$ as the weighted mean of r^2_{ij} using $1 - Pr_{ij}(high - quality)$ as the probability weights.

The result of this procedure is an annual rent of $18,313 in the high-quality sector and $14,256 in the low-quality sector.[26] Finally, we can set $\underline{\lambda}$ and $\overline{\lambda}$ such that the equilibrium is consistent with $\overline{r}$ and $\underline{r}$ from the data using Equations (10) and (11), resulting in $\underline{\lambda} = 0.743$ and $\bar{\lambda} = 0.647$.

[25]The restriction that $c < 0$ is binding and becomes an obstacle in better fitting the data to the high-quality rates of smaller properties.

[26]The slightly higher average rents than those reported by the American Community Survey reflect the exclusion represent the more recent data available from the Zillow and the exclusion of larger (greater than ten units) luxury complexes in Downtown Baltimore.

6 Policy Experiments

In this section, we use the calibrated model to perform several numerical experiments to determine the sensitivity of rents, vacancies, housing quality, and the underground economy to a variety of regulatory changes. Specifically, we first study the impact of changing the regulatory threshold. Next, we study the impact of raising fines. Finally, we conduct additional sensitivity on these results.

6.1 Change in the Regulatory Threshold

We first examine the impact of a change in the minimum number of dwellings a property may own and operate without a license (d^p) on the housing market. Figure 6 displays the results of the simulation, including the number of high-quality units for each possible policy threshold (Panel A), the number of low-quality units (Panel B), the number of vacancies (Panel C), the amount of rent for high-quality units (Panel D), and the amount of rent for low-quality units (Panel E).

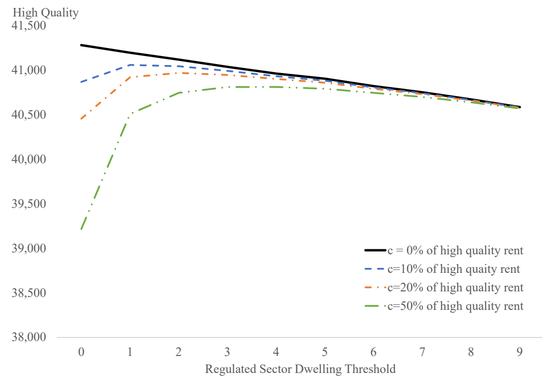
We present the results for the calibrated parameters described above (the solid black line, which we also refer to as the baseline calibration), as well as three additional sensitivities. Since our calibration yields a cost of licensing c close to its lower bound of zero, we are interested in the degree this influences our results. Consequently, we provide simulations for c equal to 10%, 20%, and 50% of the rent of high-quality units. Since c is the cost of being licensed, and is not incurred by the unregulated sector, this parameter is primarily determined by the quality differences between the two sectors. Our calibration captures greater proportions of high-quality units in the regulated sector relative to the unregulated sector by inferring a lower c. This is because a small c reduces the obstacles to being high-quality in the regulated sector, leading to a bigger increase in high-quality properties in the regulated versus unregulated sectors. The lower c could relate to lower explicit monetary costs of licensing or lower maintenance costs related to complying with the building codes. Consequently, our alternative simulations for c allow for the possibility that our imputation of high-quality in the unregulated sector might be too low relative to the proportion of units that are high-quality in the regulated sector.

We explore alternative licensing costs that are 10%, 20%, and 50% of annual high-quality rents. At these levels of c, the proportion of high-quality dwellings in the regulated sectors is just 9.4, 8.9 and 7.3 percentage points higher than in the unregulated sector compared to 22.0% higher in the baseline model.[27] This sensitivity analysis also enables us to generalize our results to different metro areas, which may impose different costs when requiring units to be licensed.

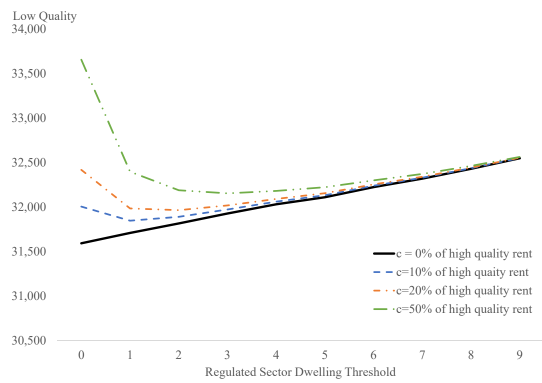
Under the baseline calibration (the solid black line), decreasing the threshold and increasing the scope of regulation to smaller properties has several effects. First, it increases

[27] If we have overestimated the housing quality in the unregulated sector, simulations with fewer high-quality units would yield the same parameters values as in our baseline calibration.

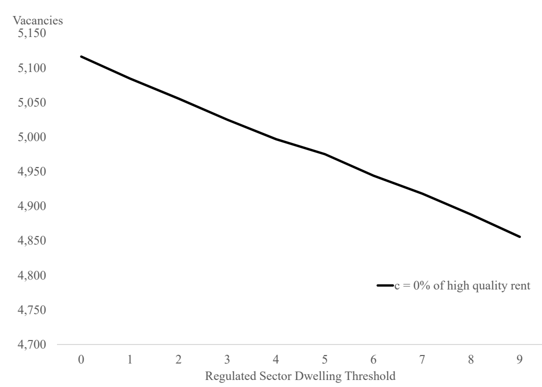
Figure 6: Housing Market Under Various Regulatory Thresholds



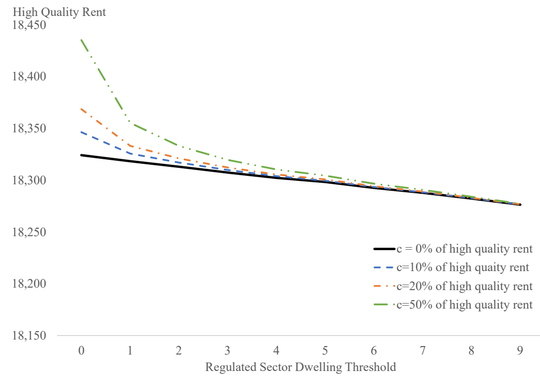
(Panel A) High-Quality Units



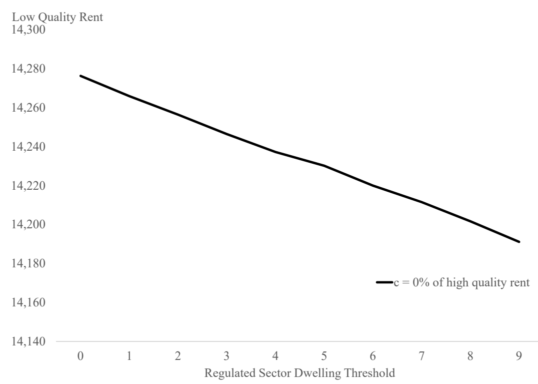
(Panel B) Low-Quality Units



(Panel C) Vacancies



(Panel D) High-Quality Rents



(Panel E) Low-Quality Rents

Note: Vacancy rates and low quality rents are invariant to c.

the number of low-quality dwellings that are subject to the larger fine ($f > f_N$) in the regulated sector. This fine effect increases the landlord's cost of providing low-quality dwellings, which in turn decreases supply and increases rents of low-quality units. This may be offset by a licensing cost effect that increases the supply of low-quality units if it is very costly to maintain a dwelling as a high-quality unit and obtain a license. However, c is near zero in our baseline calibration, negating the latter shift in supply.

We find that moving from a policy threshold of 2 to 0 decreases supply of low-quality units by 223 units, or 0.7%. This results in a modest increase in rent of 0.1% among low-quality units. Moving from a completely unregulated market ($d^p = 10$) to completely regulated one ($d^p = 0$) results in a drop in supply of 956 low-quality units, or a decrease of 3.0%, while rents would increase by 0.6%.

Landlords of low-quality units have two choices to avoid the cost of greater regulation: 1) they could simply leave their units vacant or 2) pay the licensing costs and offer a high-quality unit instead. We find that relatively few landlords make the choice to leave their unit vacant and the increase in vacancies is fairly small. A reduction in d^p from 2 to 0 increases the number of vacancies by just 60 units, or 1.2%, while a reduction in the threshold from ten to zero increases vacancies by 260 units, or 5.1%.

Fewer low-quality units reduces the total supply of housing in the city, which results in higher rents in the high-quality sector as well. high-quality rents increase by a modest 0.1% when reducing d^p from 2 to 0 and 0.3% for a reduction from 10 to 0 units. The higher equilibrium rent attracts some formerly low-quality landlords to become licensed and offer high-quality units. A reduction in the d^p from 2 to 0 increases the number of high-quality units by 162, or an increase of 0.4%, and reducing the regulatory threshold from 10 to 0 increases the number of high-quality units by 696, or 1.7%.

In our baseline calibration, an increase in regulation appears to have modest effects on affordability and quality and a potentially larger impact on quality. Our model suggest that Baltimore's recent decision to regulate all housing units ($d^p = 0$) will have fairly modest costs in terms of affordability with potentially more significant benefits in housing quality.

An increase in the costs of licensing, c, has a few interesting implications for our results. As the policy threshold falls, low-quality suppliers that find themselves in the regulated sector may want to avoid the higher fines by licensing their property, reducing the supply of low-quality units. The fine effect, however, can be offset by more landlords wanting to operate underground (low-quality) and avoid the high cost of licensing. Since the fines are a non-linear increasing function of the number of dwellings, a dominant fine effect will decrease the supply of low-quality units when reducing the policy threshold from 8 to 7 dwellings, for instance. On the other hand, when reducing the threshold from 2 to 1 dwellings, the licensing cost effect is more likely to be dominant, leading to an increase in the supply of low-quality units.

This is what we see in Panel B in Figure 6. When c is 10% of high-quality rent as in the baseline case, the number of low-quality units fall as the dwelling threshold is lowered from 9 to 2 units. However, when lowering the threshold from 1 to 0 units, the number of low-quality units actually increases. This suggests that when licensing costs are more significant, regulating all dwellings might be sub-optimal. In other words, single family homes should be left unregulated if the goal is high-quality. This pattern is accentuated with a higher licensing cost. When c is equal to 20% of high-quality rents, quality is maximized at a threshold of 2 units, whereas it is maximized at 3 units at 50%.

As in the baseline calibration, when the threshold falls, vacancies increase in newly regulated units to avoid the additional regulatory costs. This decline in supply in housing increases rents across the housing market. However, when the cost of licensing are significant, we may see a decline in high-quality units as the threshold moves closer to 0, further exacerbating the increase in rents we see in the baseline calibration. When lowering the threshold from 2 dwelling units to 0, rents for high-quality dwellings increase by \$30 annually for c equal to 10% of high-quality rents, \$47 for the 20% scenario, and \$102 for the 50% case. This sensitivity analysis suggests that the impact of adjusting the scope of regulation, as summarized by the regulatory threshold, can vary depending on the costs associated with licensing.

6.2 Increase in Fines

In our next policy experiment, we consider the effect of a 20% increase in fines in both the unregulated and regulated sectors.[28] This translates into an additional $29 in fines in the unregulated sector and about $143 in the regulated sector. Just a small portion of the increased fines are passed on to tenants with rents increasing by $20 for low-quality units and $11 for high-quality ones. These results suggest that rents are fairly insensitive to increases in fines.

Panels A and B in Figure 7 present the vacancy rate and the proportion of high-quality properties by property size (i.e. number of dwellings) for the scenario with 20% higher fines along with the baseline calibration. Smaller properties experience almost no discernible change in the proportion that are vacant or high-quality. This again is because total fines in our model are proportional to the number of dwellings in a property and thus, have a bigger impact on larger properties.

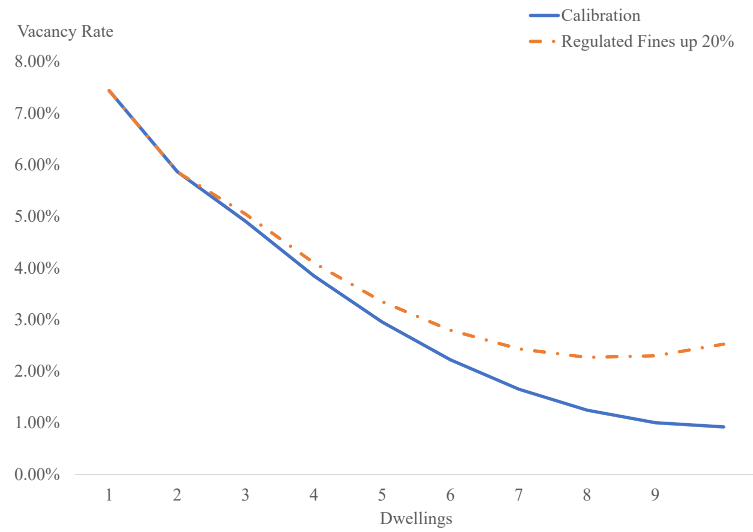
Indeed, the effect of this policy change is mostly felt among larger properties. For instance, the vacancy rate increases by 1.6 percentage points for properties with 10 units. An increase in fines among large properties in the informal sector results in landlords simply deciding to leave their properties vacant. This is consistent with the tenant screening model and empirical evidence in Ambrose and Diop (2018), which show that the while landlords may pass along the higher cost of regulation to tenants in the form of higher rents, landlords may also engage in greater tenant screening, resulting in higher vacancies.[29] This effect is higher for larger landlords who can more easily absorb the loss associated with leaving a unit vacant compared to smaller landlords, where a vacancy may reduce profits more substantially.

A final additional effect of higher fines is that the proportion of landlords among the largest properties that decide to become licensed, and operate a high-quality dwelling, increases by 4.2 percentage points. An additional way in which firms can avoid the fines that come when operating an underground and low-quality dwelling is to simply offer high-quality units and operate in the formal sector.

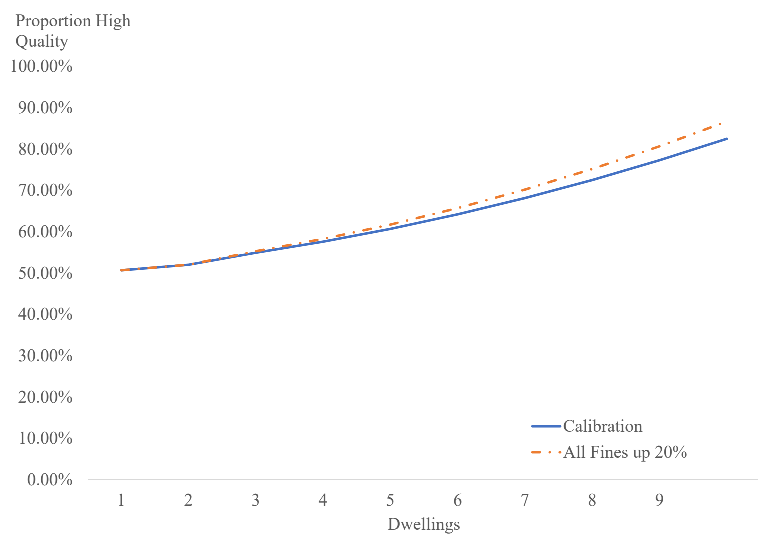
[28] Since fines are relatively small in the unregulated sector, the results are quite similar to adjusting fines in just the regulated sector.

[29] We are grateful to an astute referee for helping us see this link.

Figure 7: Impact of Increased Fines on Vacancy and Quality Housing



(Panel A) Vacancy Rate by Property Size



(Panel B) High-Quality Rate by Property Size

6.3 Additional Sensitivity Analysis

Given our baseline calibration comes from data from Baltimore, we explore the sensitivity of our analysis to a variety of additional scenarios in order to ensure the results are applicable to other cities. This section presents three different sensitivities: 1) an increase in the supply of single family rentals, 2) an increase in high-quality rents in order to explore more unequal housing markets, and 3) an increase in the cost parameter for low-quality housing units α to analyze cities with more equal carrying costs between low- and high-quality units. Table 3 provides the parameters for the additional sensitivity analysis, while the results of each of these sensitivities can be found in Table 4. Figure 8 presents the change in vacancies and supply of low-quality and high-quality housing for each scenario in comparison to our baseline calibration, whereas Figure 9 does the same for high and low-quality rents.

Table 3: Parameters for Additional Sensitivity Analysis

	Baseline	Single Family Rentals Increased 5%	High-Quality Rent Increased 40%	α Increased 20%
Single Family Home l(1)	51,991	54,591	51,991	51,991
α	0.722	0.722	0.722	0.866
$\bar{\lambda}$	0.743	0.743	0.783	0.743
$\underline{\lambda}$	0.647	0.647	0.645	0.647

Note: The parameter values for d_p, D, Θ, K, c, ϕ, f, f_N, and μ remain the same as in the baseline calibration (Table 2).

Table 4: Additional Sensitivity Analysis

	Baseline	Single Family Rentals Increased 5%	High-Quality Rent Increased 40%	α Increased 20%
Rents				
Low-Quality Rent	\$14,256	\$13,133	\$14,256	\$16,050
High-Quality Rent	\$18,313	\$17,056	\$25,638	\$19,965
Supply				
Vacancies	5,055	5,436	5,055	10,542
Low-Quality Dwellings	31,815	32,775	32,588	23,684
High-Quality Dwellings	41,117	42,377	40,345	43,761
Total Supply	72,933	75,152	72,933	67,446

Figure 8: Change in Vacancies, High-Quality and Low-Quality Units

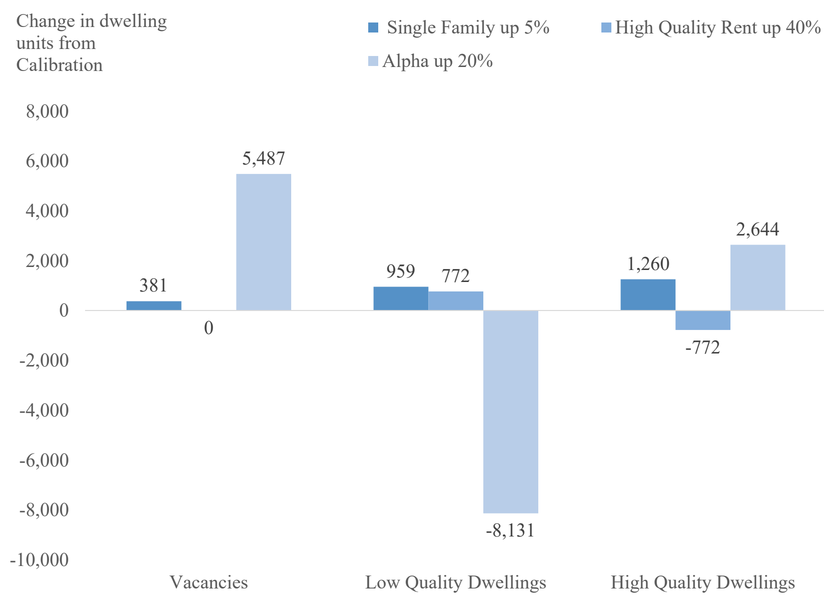
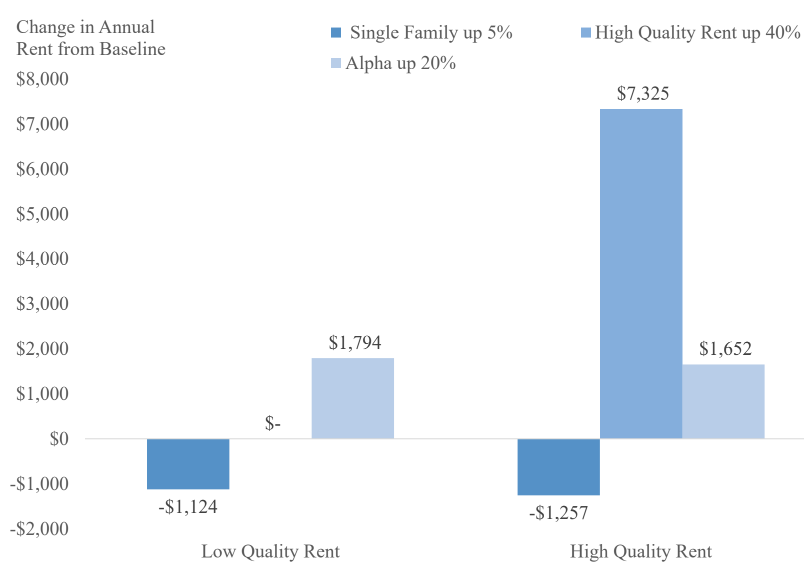


Figure 9: Changes in High and Low Quality Rents



6.3.1 Increase in the Single Family Home Rental Market

We first explore the impact of an exogenous increase in the supply of single family rentals. There was a significant increase in single family rentals following the financial and home foreclosure crisis related to the 2008 - 2009 Great Recession. While we lack pre-2009 data to specifically measure the increase in this market in Baltimore, we simulate its effects by examining how the market would change if there was a 5% increase in single family rentals. This translates into an increase of 2,599 new single rental family homes. In addition to exploring the impact of single family rentals, this alternative scenario may also be more applicable to cities with lower density than Baltimore.

As one might expect, the increase in supply of single family homes lowers rent in both the high- and low-quality sectors compared to the baseline results. In the low-quality sector, the decline is $1,124, or a fall of 7.9%, suggesting a price elasticity of -1.6 with respect to an increase in single family homes. In the high-quality sector, the decline in rents is also economically significant as rents for high-quality units fall by $1,257, or 6.9%, implying an elasticity of -1.4. As a result of the increase in single family homes, there is an increase of more than 1,200 high-quality units. However, the decline in rents results in many landlords deciding to simply leave their units vacant, resulting in an offsetting reduction in housing supply of almost 400 units. Thus, the increase in single rental family homes that occurred as a result of the home foreclosure crisis may have crowded out some landlords of small properties.

6.3.2 More Unequal Rents

Our next scenario looks at how the results would change for a city with more unequal rents between high and low-quality units. To accomplish this we recalibrate the model assuming that high-quality rents were 40% higher. This is equivalent to increasing $\bar{\lambda}$ from 0.743 to 0.783 and decreasing $\underline{\lambda}$ from 0.647 to 0.645 (Table 3). This has a very intuitive impact on the change in the equilibrium quantity supplied. Higher rents among high-quality dwellings reduces the quantity demanded such that people substitute into low-quality housing. We find the reduction in high-quality units is more than 700 units, or about 2%. While this represents a seemingly large number of units, it actually implies that supply is fairly inelastic. However, we caution that this should be interpreted as a short-run elasticity as our model does not allow for newly constructed units that may be attracted by higher rents.

6.3.3 Increased Cost of Low-Quality Housing

In this scenario we examine the sensitivity of our analysis to a change in α, the cost parameter for low-quality units. This scenario allows us to explore how the results would differ for cities where the cost of maintaining low- and high-quality units is more similar than our calibration implies for Baltimore. We accomplish this by keeping the calibrated parameters and increasing α by 20% from 0.722 to 0.866.

Again, the results are quite intuitive. Increasing the costs to maintain a low-quality unit shifts the supply of low-quality housing to the left, leading to an increase in low-quality rents of $1,794 (or 12.6%) and a decrease in supply by 8,131 units (or 25.6%), of which 5,487 are units that are left vacant. The increase in the price of a substitute leads to higher demand for high-quality units. This results in an increase in rents of high-quality units of $1,652 (or 9.0%) and 2,644 more high-quality units (or 7.5%).

7 Conclusion

An ongoing debate in the economics of regulation is whether licensing benefits or harms welfare. Although licensing can raise housing quality, it can reduce welfare by preventing consumers from purchasing lower quality housing at a lower cost. On the supply side, it creates not only scope for an underground economy, but could potentially cause some firms to exit the market (or never enter the industry). Thus, understanding the impact of licensing is an important question for regulators.

Our paper studies these issues within the context of rental licensing. To do so, we develop a theoretical model that mirrors the licensing policy of rental properties in Baltimore. A key set of theoretical findings are that increasing the threshold at which a property must be licensed has an ambiguous effect on the quantity and price of high-quality housing (Results 3 and 5 of Proposition 3) and on the quantity of low-quality housing (Result 4 of Proposition 3). Similarly, we find that increasing the fines on low-quality properties has an ambiguous effect on rents (Proposition 2).

These theoretical results (Propositions 2 and 3) contribute to the important and long-standing debate regarding the impact of landlord regulations on rental affordability. The existing literature generally assumes or finds that raising regulations increases rents. Our analysis identifies two limitations of these papers. First, none of these papers identify the substitution between the formal and the informal sector. When this effect is incorporated into a more general equilibrium framework, then the effect of raising regulations (by increasing the fine or lowering the regulatory threshold) on rent is ambiguous. Second, the impact of regulations depends on the type of regulations; specifically, whether regulations are tightened by raising fines as characterized in Proposition 2 (which is closer to the regulations identified in Hirsch et al., 1975)) or by changing the regulatory threshold (Proposition 3).[30]

By ignoring these issues, the existing literature may not completely characterize the relationship between regulations and rental affordability. For example, Ambrose and Diop (2018) finds that raising regulations results in more tenant screening by landlords. But, this theoretical result assumes that regulations raise rents. However, we show that increasing the fines (which can be viewed as increasing regulations) raises only low-quality rents and may not raise rents of high-quality dwellings. Thus, regulations may only increase tenant

[30] It is worth noting that if regulations were to increase c, the cost of becoming high-quality, then rents would rise and our findings would be closer to those identified in Hirsch et al. (1975).

screening among low-quality dwellings, but may not occur among high-quality dwellings. Furthermore, since the effects of changing the regulatory threshold are not identical to the effect of raising the fines, it is not clear which type of regulation would result in more tenant screening. Thus, to summarize, our paper shows that the existing literature may be mischaracterizing some of the impact of rental regulations because they not only ignore demand-side substitution between the formal and informal sector but also they focus solely on one type of regulation.

The specific direction and magnitude of these theoretical predictions depends on the particular parameters chosen. We therefore pin down these parameters using a unique data set from Baltimore City that allows us to observe unlicensed rentals directly. Our calibration of this model shows that lowering the threshold (increasing the scope of regulation) has only modest negative effects on affordability rents and homelessness, while increasing the quality of housing. Similarly, we find that increasing the fines on underground rentals (to deter such rentals) increases rents modestly. Although these findings are consistent with previous empirical findings on regulation and affordability (e.g. Ambrose and Diop, 2018), we find that the impact on rents is much smaller. We believe that this is attributable to the substitution between high- and low-quality housing (formal and informal rentals), which these papers overlook. Thus, although we derive our results from a calibration specific to the rental market in Baltimore, we believe that our findings are likely generalizable to other cities given the consistency of our findings.

Our calibration also allows us to answer an important question concerning regulatory thresholds. Specifically, what is the regulatory threshold (above which units must be licensed) that maximizes overall quality after accounting for the presence of an informal sector?[31] Our theoretical findings show that there is a non-monotonic relationship between overall housing quality in the market and this licensing threshold, the shape of which depends on the landlords' cost of complying with licensing and other market parameters. By calibrating our model, we are able to identify whether the regulatory threshold is set too high or too low for the specific costs and market conditions. For Baltimore, we find that lowering the threshold raised rents only modestly, while also raising quality, suggesting that increasing regulation likely benefited this city. Such exercises could be utilized in other cities or industries that are regulated in similar fashion.

We believe that these findings concerning licensing's impact on housing quality and rental markets are especially important in light of "stay at home orders" prevalent across the U.S. due to the COVID-19 pandemic. Specifically, lower quality housing can make it more challenging for individuals who are required to stay at home.[32] But if housing is low-quality,

[31] In some sense, this is a question concerning the scale of production above which a firm should be regulated. As others have observed (e.g. Schneider and Buehn, 2013), smaller scale production tends to be produced informally.

[32] Indeed, some descriptive evidence find those in lower income neighborhoods are less likely to be able to "stay at home" (Valentino-DeVries et al., 2020). This finding could be explained by the fact that individuals have less incentive comply with these orders if their residence is low-quality.

then those who do comply may face other risks to their health and safety by staying home. For example, children forced to stay at home may be exposed to other risks if their homes possess unsafe conditions or high levels of lead. Thus, maintaining housing quality through licensing may be particularly important during this time. However, cities must also recognize the costs that these regulations impose. If such regulations also reduce the overall supply of housing (and price out individuals), families without housing may be exposed to other health risks. Thus, understanding the extent to which licensing raises quality while also reducing supply is a critical policy question today.

Our findings have several implications for regulation and the informal sector that go beyond rental housing. First, our model is the first to provide an analysis of markets in which some firms are regulated and others are not. As we noted, there are many other industries in which licensing regulations depends on the scale of the firm Schneider and Buehn (2013). For example, many daycare centers in the U.S. need to be licensed if they care for more than a specific number of children. Our findings suggest that the interaction between regulated and unregulated sector can have important implications for the effectiveness of licensing policies. Accordingly, the threshold for licensing business must be chosen carefully by regulators. Second, with regards to the informal sector, our model and calibration suggest that it is important to recognize the demand-side effects of informality. Specifically, the rental market in our framework need not be fully covered in equilibrium unlike much of the literature on the informal sector (Ahlin and Pinaki, 2006; Choi and Thum, 2005; Cuff et al., 2011). Our calibration exercises suggest that these effects are economically significant. Hence, future analysis of regulation and the informal sector must consider both the demand-side and supply-side effects.

Finally, we conclude by discussing some of the limitations of our model as well as extensions for future work. In this paper we limit our analysis to just two levels of quality. A model that allows for more discrete levels of quality, or even a continuous measure of quality, may be able to analyze if "bunching" in the quality level of units occurs at the minimum standards of a license. Also, the degree that underground units reduce the quality below the minimum standards could also be explored in future work. Finally, we find the work on tenant screening in Ambrose and Diop (2018) to be particularly insightful, and it would be interesting to examine whether more tenant screening occurs in formal or underground rentals.

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