Shared Occupancy and Property Tax Arrears*

Wilfred K. Anim-Odame† Precious A. Brenni‡
Damian S. Damianov‡ Dennis Philip‡

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†National Development Planning Commission (retd.), No. 13 Switchback Road, P. O. Box CT 633, Cantonments-Accra, Ghana; E-mail: anim.wao@gmail.com.

‡Durham University Business School, Durham University, Mill Hill Lane, Durham, DH1 3LB, United Kingdom; E-mails: precious.a.brenni@durham.ac.uk; damian.damianov@durham.ac.uk; dennis.philip@durham.ac.uk.

Abstract

Shared occupancy arrangements are on the rise in recent years due to affordability constraints in homeownership. This article examines for the first time the property tax compliance behavior of shared dwellings, where homeowners rent out part of their own homes to tenants. Using administrative property-level data from Ghana, where homeowners are responsible for tax payments, we reveal that shared dwellings, compared to pure owner-occupied homes, are more likely to be in tax arrears. The noncompliance of shared dwellings is more sensitive to property tax hikes than pure owner-occupied homes, and greatest among those in the least affluent geographic areas. These effects are moderated by reciprocity, in that compliance levels are higher in locations closer to public services and amenities. The findings provide new insights for policymakers on the tax compliance effects arising in shared occupancies.

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"I hate paying taxes. But I love the civilization they give me." —Oliver Wendell Holmes

1. Introduction

The motivations for paying taxes have been extensively studied both theoretically and empirically. The theoretical literature alludes to the trade-offs that tax-payers face between the monetary gains from evasion and the costs of being found out and punished (Allingham and Sandmo, 1972). However, empirically tax compliance levels are observed to be much higher than predicted by these theoretical models, even when enforcement measures such as audits and fines are minimal (Frey and Torgler, 2007; Alm, 2019). Thus, alternative explanations related to "tax morale" and more broadly nonpecuniary motivations for paying tax have emerged, including guilt and shame (Andreoni et al., 1998), culture and social norms (Cummings et al., 2009), reciprocity (Fjeldstad and Semboja, 2001; Castro and Scartascini, 2015), intrinsic duty-to-comply preferences (Dwenger et al., 2016), and peer behavior (Hallsworth et al., 2017).

Given these nonpecuniary motives, one expects a higher tax compliance among owners as compared to renters. For instance, owners have more to lose in terms of assets and social connections (Alm et al., 2014; Arbel et al., 2017) and derive more social benefits than renters (Foye et al., 2018). The literature on social capital argues that homeowners are more likely than renters to be "better citizens," who invest in and seek to improve their local communities (see, for instance, DiPasquale and Glaeser, 1999; Hilber, 2010).[1]

In this paper, we examine for the first time the tax compliance behavior of shared occupancy arrangements, where a homeowner lives in the property and rents out part of their own home. Previous studies have ignored such shared housing tenure arrangements, although they have become increasingly popular in recent times, owing to increased housing costs and

[1]The choice of owning a home versus renting depends also on societal culture and behavioral factors, where nonpecuniary motives play a bigger role than the economic and fiscal reasons. Comparing Australia and the United States, Bourassa and Yin (2006) show that the differences in tax and housing subsidy policies alone cannot explain the differences in home ownership rates between the two countries.

economic challenges that limit the prospects of getting onto the property ladder.[2] In developing countries, multihabitation arrangements have become particularly rife over the years, where a house is either occupied by more than one household, usually sharing facilities, or where a household's dwelling space is occupied by the nuclear family and other persons.

A priori, it is unclear whether the owner-and-tenant-occupied dwellings will be more or less tax compliant, as compared to owner-occupied dwellings, in jurisdictions where homeowners are legally liable for property tax payments. On the one hand, the availability of extra rental income suggests that owner-and-tenant-occupied dwellings should be more tax compliant. On the other hand, one of the reasons for deciding to rent out part of their own homes is driven by financial constraints, unlike the case of pure owner-occupiers, which suggests a greater chance of noncompliance due to possible income constraints. Therefore, from a policy perspective, it is a priori unclear whether a homeowner under the owner-and-tenant occupancy arrangement should be regarded as a landlord and taxed more, or considered as an owner-occupier and taxed less, in a bid to encourage homeownership.

To address this important gap in the literature, we develop a theoretical framework in which tax compliance behavior is endogenously determined in a dynamic setting of income uncertainty and a weak regulatory environment. The theoretical framework here builds upon the early literature on dynamic household consumption problems under income uncertainty, including Schechtman (1976), Bewley (1977), Mendelson and Amihud (1982), and Deaton (1991). It allows for self-selection into different occupancy types and accounts for nonpecuniary motives for compliance, which we model as an intrinsic moral cost of noncompliance (Fortin et al., 2007; Traxler, 2010; Alm and Torgler, 2011). We show that if households rent out part of their home due to income constraints (shared occupancy), their rental income

[2] For instance, a survey by SpareRoom.co.uk, reported in 2015, revealed that 45% of "live-in landlords" in the UK could not afford to pay their mortgage without a lodger. "Owner-renting" – owning a house/houses but living in rented property owned by others — exists in large cities in countries such as China, where policies that limit housing purchase and high house prices prevent residents, especially migrants, from purchasing homes in large cities. Thus, there is renting in large cities but homeownership in smaller and more affordable areas (Huang et al., 2021). Arundel and Doling (2017) also note how a deterioration in labor market conditions in Europe is associated with reduced homeownership, especially for young adults.

will not completely offset their financial constraints. Thus, the shared occupancy type of households will be more likely to be noncompliant relative to owner-occupiers. Further, their compliance behavior will be more sensitive to property tax rate changes, and to nonpecuniary motives for compliance.

To test these predictions empirically, we utilize granular administrative property-level data on the occupancy and property tax characteristics of dwelling units observed over the period 2011–2018, obtained from the Accra Metropolitan Assembly (AMA) in Ghana. The AMA is the largest metropolitan assembly in Ghana, with oversight responsibility for the capital city. Our data captures three residential occupancy arrangements: owner-occupancy (where a house is occupied by the homeowner), tenant-occupancy (where a house is occupied by tenants), and shared/owner-and-tenant-occupancy (where a house is jointly occupied by the homeowner and tenants). The data contain individual property-level information on the value of the occupied property, the property tax (rating) zone, the street on which it is located, the annual property tax rate, and the tax amount payable, as well as the property tax arrears.

Our empirical identification focuses on minimum-rate-paying homes, where the rates are determined solely by the budgetary planning of the AMA and do not depend on attributes of the property other than its rating zone. This identification strategy ensures that we capture variation in property taxes, which is exogenous to the property-level characteristics. The final sample comprises 238,140 dwelling unit–year observations.

Our baseline results show that owner-and-tenant-occupied dwellings are significantly more likely to be noncompliant, relative to owner-occupied homes. Their likelihood of failing to pay their property taxes fully is 2.2% higher than that of owner-occupied homes, with the difference being statistically significant. In the case of tenant-occupied dwelling units, we find, in line with previous studies that such dwellings show a greater noncompliance level than either owner-occupied or owner-and-tenant-occupied ones. We exploit further the structure of our data to examine the sources of important heterogeneity in the noncompliance behaviors. The AMA distinguishes location quality by classifying geographical areas into different rating zones. Exploiting these rating zones, we find that shared dwelling units in less wealthy neighborhoods are more likely to be in full or partial arrears, compared with those in the most affluent areas. We also show that, of the three occupancy types, the tenant-occupied dwellings have the highest likelihood of being in arrears, regardless of the affluence levels of their neighborhoods.

Further, we examine response heterogeneity according to building type, based on the type of material used in the construction of the property. In the data, we observe three types of building structure, with the cheapest structures made of wattle and daub, and the most expensive being sandcrete blocks. In terms of tax noncompliance, we find that it is the owner-and-tenant-occupied dwellings, in properties made of the cheapest building material, that are most likely to be in arrears, reflecting the binding income constraints faced by this occupancy type.

Next, we investigate property taxpayers' reactions to exogenous rate shocks seen in the years 2012 and 2018, when relatively large tax rate hikes were observed. We note that annual tax rates are exogenously determined by the AMA in line with budgetary targets. As expected, we find that rate shocks increase the probability of arrears for all three occupancy categories, with the effects being strongest for the shared dwelling units. We also gather data on the geographic coordinates of the properties to assess how proximity to public amenities (suburban police stations and hospitals) affects compliance outcomes. Consistent with the theory of reciprocity, we find a positive relationship between distance to the amenities and noncompliance outcomes. Owner-and-tenant-occupied dwellings that are distant from the amenities are about 3% more likely not to pay their property taxes. This effect is also observed for the other two dwelling types although the magnitudes are smaller. Overall, our administrative data shows evidence for compliance behavior consistent with the theory of reciprocity documented by previous literature relying on field experiments (see, for instance, Castro and Scartascini, 2015; Dwenger et al., 2016; Hallsworth et al., 2017). Additionally, although prior studies have analyzed how distance to public amenities affects property values through capitalization effects (see, for instance, Chin and Foong, 2006; Dubé et al., 2013; Dronyk-Trosper, 2017), we are the first, to our knowledge, to explore how distance to amenities affects property tax compliance depending on residential occupancy types.

The findings in the paper have several policy implications in developing economies, particularly with trends toward increased decentralization of public service delivery to local governments, who then rely on property taxes as a major source of government revenue to fund local needs and reduce poverty levels (see, for example, Bardhan and Mookherjee, 2006; Tang et al., 2011; Ramírez et al., 2017). Our findings suggest that policy interventions aimed at enhancing local property tax revenues should take into account the composition of habitation in dwelling units. We document that multihabitation dwelling units are more sensitive to changes in property taxes and more susceptible to delinquency. Therefore, treating homeowners in shared occupancy as pure landlords for taxation purposes is likely to be detrimental to tax revenue, since shared dwelling units are exposed to more severe affordability constraints than the pure owner category. Thus, from a public policy perspective, the findings of this paper bring into debate for the first time whether or not owners renting out sections of their home to tenants should be considered as pure landlords and be subject to similar taxation policies – our evidence suggests a more targeted tax scheme toward this occupancy type could increase tax compliance.

The remainder of this paper is structured as follows. Section 2 presents a theoretical framework of the relationship between occupancy status and property tax arrears. Section 3 gives a brief overview of property tax administration in Ghana. The data and variables are discussed in Section 4. Section 5 details our empirical analysis. Section 6 presents robustness checks and additional analyses. Section 7 concludes the paper.

2. Theoretical predictions

In this section, we develop a housing occupancy model in which housing consumption (and corresponding tenure choice) and property tax compliance are determined endogenously. In accordance with the structure of our data, we consider three types of property. An "owner" property is a property that is solely occupied by its owner, who is also liable for the property tax payment. A "tenant" property is one that is occupied solely by tenants. The landlord does not live in the property but is solely liable for the property tax payment. An "owner-and-tenant" property is one in which the owner shares the property with a tenant (in exchange for rental income) but is solely liable for the property tax payment.

To capture the affordability constraint of households, we consider a classical dynamic household consumption problem under income uncertainty (see, for example, Schechtman, 1976, Bewley, 1977, and Mendelson and Amihud, 1982).[3] In this framework, we embed a choice of housing consumption and property tax compliance. The model posits that affordability considerations and social pressure – defined as the cost of noncompliance – are driving both tenure choice and tax compliance behavior. As we will show, in this model, the affordability-constrained households choose to live in a shared occupancy arrangement. They are renting out part of their home to generate additional income, yet this rental income does not fully relax their affordability constraint. We demonstrate that the owner-and-tenant-occupied properties are more likely to be non-compliant than the owner-occupied properties (Proposition 1). We also find that the owner-occupied properties could be more or less compliant than the tenant-occupied properties (Proposition 2). While landlords receive rental income and can afford to pay their property tax, they do not live in the property and face less compliance pressure. These two effects work in opposite directions and the comparison depends on which effect dominates. Furthermore, within this theoretical framework, we provide a ranking of the compliance sensitivity of the three property types to shocks to property

[3] An overview of the early theoretical results on optimal consumption and precautionary savings of liquidity-constrained households can be found in Deaton (1991). Further extensions and more recent advancements of the literature on the buffer-stock theory of savings are described by Carroll (1997).

tax rates and income, as well as to change in social pressure (Proposition 3). We illustrate these results with a numerical example.

2.1 Model setup

Consider an infinitely lived homeowner who receives at the beginning of each period t stochastic labor income given by

$$\widetilde{y}_t = \mu + \varepsilon_t, \tag{1}$$

where ε_t is a stationary random variable with a mean of zero and support $[\varepsilon_l, \varepsilon_h]$. We denote the cumulative distribution function of labor income by $F(y)$ and assume that the lower bound of its support is nonnegative; i.e., $\mu + \varepsilon_l \geq 0$.

2.1.1 Owner- and owner-and-tenant-occupied properties

The owner of a home of size $H > 0$ makes a long-term decision to either occupy the entire property by choosing housing consumption level $h = H$ (i.e., the housing unit belongs to the owner category) or occupy the space $h \in [0, H)$ and rent out the remaining space to a tenant (i.e., the housing unit belongs to the owner-and-tenant category).[4] In the latter case, the homeowner receives rental revenue of $k(H - h)$ per period, where $k > 0$ is the rental price per unit of space. Further, in each period t, the homeowner chooses the level of nonhousing consumption c_t and decides whether to default on or to pay the property tax τ.

A property tax–compliant household consumes the amount $c_t - \tau$. A noncompliant household consumes c_t, but incurs noncompliance cost. Following the "tax morale" literature (cf. Gordon, 1989; Fortin et al., 2007; Traxler, 2010; Alm and Torgler, 2011), we assume that this implicit (psychological, moral, or social) cost is represented by the function $g(c_t, \tau, \alpha)$,

[4] Rental contracts in Ghana span multiple years, and hence, the decision to rent (part of) their homes can be viewed as a long-term decision for homeowners. In this shared arrangement, owners share a dwelling unit with a tenant for a fixed payment, usually paid in advance, often up to several years of rent. This type of shared arrangement differs from caretaker arrangements also found in Ghana (Gough and Yankson, 2011).

whereby $\alpha \geq 0$ is the coefficient of compliance pressure in the residential area.

The cost of noncompliance is assumed to be increasing in the consumption level c_t and the compliance pressure α and decreasing in the amount of tax τ. A major source of compliance pressure is the relationship between the taxpayer and the state. When the household enjoys a higher level of public services provided by the state, it is more likely to be compliant. This relationship underlies the concept of "reciprocity" introduced in the recent literature on tax morale (Luttmer and Singhal, 2014). In the empirical analysis, we consider proximity to local amenities as a source of compliance pressure.

We assume that the contemporaneous utility of nonhousing consumption $u(c_t)$ is strictly increasing and concave. Thus, the expenditure threshold level $\bar{c} = \bar{c}(\tau, \alpha)$, below which the homeowner becomes noncompliant, is determined by the solution to the equation

$$u(c_t) - g(c_t, \tau, \alpha) = u(c_t - \tau), \tag{2}$$

where the left-hand side denotes the utility of noncompliance and the right-hand side the utility of compliance.[5] Given this optimal choice, the instantaneous (sub)utility of nonhousing consumption can be expressed as

$$U(c_t) = \begin{cases} u(c_t) - g(c_t, \tau, \alpha) & \text{for} \quad c_t < \bar{c}(\tau, \alpha), \\ u(c_t - \tau) & \text{for} \quad c_t \geq \bar{c}(\tau, \alpha). \end{cases} \tag{3}$$

where $\bar{c}(\tau, \alpha)$ is the solution of equation (2). We assume that $U(c_t)$ is strictly increasing and concave. Further, we denote the instantaneous utility of housing consumption by $v(h)$ and assume that it is also strictly increasing and concave. The household maximizes its

[5] The equation can be rearranged as $u(c_t) - u(c_t - \tau) = g(c_t, \tau, \alpha)$ and from the concavity of $u(c_t)$ it follows that the left-hand side is strictly decreasing in c_t while the right-hand side is increasing. Hence the equation has a unique solution.

intertemporal expected utility given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \big[U(c_t) + v(h)\big] \tag{4}$$

under the budget constraint

$$A_{t+1} = (1+r)[A_t + \widetilde{y}_t + k(H-h) - c_t]. \tag{5}$$

The parameter β denotes the household's personal discount factor r is the interest rate, and A_t denotes the savings of the household. We focus on the scenario $\beta(1+r) < 1$, which ensures that the household is impatient enough so as not to have an incentive to accumulate savings indefinitely (see, for example, Deaton, 1991 or Carroll, 1997). We consider both the baseline case where saving and borrowing is not allowed ($A_t = 0$) and the case where saving is allowed but borrowing is not (i.e., $A_t \geq 0$).

2.1.2 Tenant-occupied properties

The tenant category represents a landlord who is responsible for paying the property tax of a property that is occupied by tenants. The landlord lives in another location in a property of size H. Thus the tenant category, by assumption, faces a lower compliance pressure α relative to the owner category but enjoys an extra rental income of kH. Thus, the tenant maximizes the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \big[U(c_t) + v(H)\big] \tag{6}$$

under the budget constraint

$$A_{t+1} = (1+r)[A_t + \widetilde{y}_t + kH - c_t]. \tag{7}$$

2.2 Equilibrium

2.2.1 Owner- vs owner-and-tenant-occupied properties

We denote the "cash on hand" in each period t by the amount of savings, labor income, and rental income available for spending in this period as follows:

$$x_t = A_t + \widetilde{y}_t + k(H - h). \tag{8}$$

We first consider the baseline case in which saving is not allowed, i.e., $A_t = 0$. In this case all cash on hand consists of labor and rental income and is spent in each period; i.e., $c_t = x_t = \widetilde{y}_t + k(H - h)$. The housing consumption decision is determined by the first-order condition

$$\frac{k}{1-\beta} \cdot v'(h) = E_0 \sum_{t=0}^{\infty} \beta^t \big[u'(x_t)\big], \tag{9}$$

which can be reduced to

$$k \cdot v'(h) = Eu'(x_t). \tag{10}$$

When the solution to this equation is $h < H$, the optimal housing consumption is $h^* = h$ and the dwelling unit belongs to the owner-and-tenant category. When the solution to the equation is $h \geq H$, the optimal housing consumption is $h^* = H$ and the dwelling unit belongs to the owner category. Further, when $c_t < \bar{c}(\alpha, \tau)$, the homeowner defaults on their property tax payment and when $c_t \geq \bar{c}(\alpha, \tau)$, the household is compliant.

Next, we consider the case in which households can build precautionary savings, $A_t \geq 0$. This problem has a unique solution given by a stationary consumption policy function $c_t = f(x_t)$ (see, for example, Deaton, 1991). This policy function determines the portion of the cash on hand that will be consumed ($f(x_t)$) and the portion that will be carried forward

$(x_t - f(x_t))$. We denote the associated marginal utility of money by:

$$p(x_t) = u'(f(x_t)).$$

The corresponding Euler equation is given by $u'(c_t) = \max[u'(x_t), \beta(1+r)E_t(u'(c_t))]$. Expressed in terms of cash on hand $x = x_t$, this Euler equation yields the following stationary equilibrium condition:

$$p(x) = \max\big[u'(x), \beta(1+r)\int p\{(1+r)(x - f(x) + k(H-h) + y\}dF(y)\big]. \tag{11}$$

This equation states that the equilibrium marginal utility today should be equal to the maximum value of the marginal utility in the current period or the discounted expected value of the utility in the next period. The solution $f(x)$ and the corresponding $p(x)$ are unique and have the following properties:[6]

(i) When realized labor income y is so low that cash on hand x is below a critical level x^*, all cash on hand is consumed $f(x) = x$, and when $x > x^*$, the household saves $f(x) < x$.

(ii) The marginal utility of money $p(x)$ is decreasing in x.

(iii) When $x_t - f(x_t) > 0$, the marginal utility is a martingale; i.e., $E_t p(x_{t+1}) = \frac{1}{\beta(1+r)} p(x_t)$. When $x_t - f(x_t) = 0$, the process loses memory and the marginal utility is constant: $E_t p(x_{t+1}) = E(p(y + k(H-h)))$.

With these preliminaries, the optimal level of housing consumption is determined by the first order condition

$$\frac{k}{1-\beta} \cdot v'(h) = E_0 \sum_{t=0}^{\infty} \beta^t \big[p(x_t)\big]. \tag{12}$$

[6] See Deaton (1991) for an overview of equilibrium analysis of stochastic income fluctuation problems.

As in the baseline case, when the solution to this equation is $h < H$, the optimal housing consumption is $h^* = h$ and the dwelling unit belongs to the owner-and-tenant category. When the solution to the equation is $h \geq H$, the optimal housing consumption is $h^* = H$ and the dwelling unit belongs to the owner category. The household defaults in period t when its cash on hand falls below the critical level given by the condition $x_t < \overline{x} = f^{-1}(\overline{c}(\alpha, \tau))$.

2.2.2 Tenant-occupied properties

The tenant category of households occupies a house of size H and chooses only the level of nonhousing consumption c_t. Their consumption problem is thus a standard stochastic income fluctuation problem and their optimal policy function is given by equation (11).

2.3 Compliance behavior

We next compare the equilibrium compliance behavior of an owner-occupied unit with that of an owner-and-tenant-occupied unit.

2.3.1 Owner- vs owner-and-tenant-occupied properties

Let us assume that two neighbors have homes of equal size and identical consumption preferences, and face the same property tax compliance pressure pertinent to their neighborhood. The difference in their housing consumption is determined by the differences in their labor income distributions. If the optimal choice of one of them is to sacrifice part of their housing consumption in exchange for rental income, as we will show, this homeowner must have a lower labor income. Further, we establish that the additional rental income of the owner of the dwelling unit with a tenant is not sufficient to compensate for the initial difference in labor incomes. This means that the owner-and-tenant household has, on average, a lower amount to spend on property tax payments and nonhousing consumption. That is, the model generates the following theoretical prediction:

Proposition 1. *The owner-and-tenant-occupied property is more likely to be noncompliant than the owner-occupied property.*

The proof is in Appendix A. The analysis shows that the homeowner with a lower income rents out part of their home to subsidize nonhousing consumption and property tax expenditure. While this additional income serves to lower noncompliance rates, in equilibrium, the rental income does not entirely compensate for the lower initial labor income. We further investigate how changes in property taxes and compliance pressure affect the compliance of these two household categories.

2.3.2 Owner- vs tenant-occupied properties

The owner and the tenant categories of households both occupy a home of size H. While the owner category receives an income of $\widetilde{y}_t$, the tenant category receives addition rental income, or a total income of $\widetilde{y}_t + kH$. We denote the compliance pressure parameter of the tenant by α_{TEN} and that of the owner by α_{OWN}, assuming that the tenant faces lower compliance pressure, $\alpha_{TEN} < \alpha_{OWN}$. The compliance cost satisfies $g(c_t, \tau, \alpha_{TEN}) < g(c_t, \tau, \alpha_{OWN})$ and hence the compliance income thresholds satisfy the inequality $\overline{c}(\tau, \alpha_{OWN}) < \overline{c}(\tau, \alpha_{TEN})$. Let f_{OWN} and f_{TEN} denote the optimal policy functions of the owner and tenant categories, respectively. The critical levels of cash on hand below which the two categories of households default can be derived from the policy functions and are given by $\overline{x_{OWN}} = f^{-1}_{OWN}(\overline{c}(\alpha_{OWN}, \tau))$ and $\overline{x_{TEN}} = f^{-1}_{TEN}(\overline{c}(\alpha_{TEN}, \tau))$. Solving the optimal dynamic consumption problems of the two households yields the stationary equilibrium cumulative distribution functions of the cash on hand. Let us denote these distributions by G_{OWN} and G_{TEN} for the owner and the tenant, respectively. Thus, the compliance of the tenant relative to that of the owner depends on whether the additional income compensates for the lack of compliance pressure, as stated in the next proposition.

Proposition 2. *The owner-occupied property is more tax compliant than the tenant-occupied* *property when $G_{OWN}(\overline{x_{OWN}}) < G_{TEN}(\overline{x_{TEN}})$. When the reverse inequality holds, the owner-occupied property is less tax compliant.*

2.3.3 Sensitivity to tax, income, and social pressure

We further investigate how shocks to property taxes and income as well as changes in social pressure affect compliance. The sensitivity ranking of the three property types is presented in the following proposition.

Proposition 3. *Let $F_{OWN}(y)$, $F_{OWN-TEN}(y)$, and $F_{TEN}(y)$ be the income distribution function of the owner-occupied property, owner-and-tenant-occupied property, and the tenant-occupied property, respectively. Let these functions be convex in an open neighborhood around the income level y. The following relationships apply regarding the noncompliance probabilities of these property units:*

a) ***Affordability.*** *The change in the probability of compliance due to an increase in the tax rate (or a decrease in income) is greater for the owner-and-tenant-occupied property than the owner-occupied property, followed by the tenant-occupied property:*

$$\frac{\partial F_{OWN-TEN}(\overline{x}(\tau,\alpha))}{\partial \tau} > \frac{\partial F_{OWN}(\overline{x}(\tau,\alpha))}{\partial \tau} > \frac{\partial F_{TEN}(\overline{x}(\tau,\alpha))}{\partial \tau}.$$

b) ***Compliance pressure.*** *The change in the probability of compliance due to a change in the compliance pressure parameter is greater for the owner-and-tenant-occupied property than for the owner-occupied property followed by the tenant-occupied property:*

$$\frac{\partial F_{OWN-TEN}(\overline{x}(\tau,\alpha))}{\partial \alpha} < \frac{\partial F_{OWN}(\overline{x}(\tau,\alpha))}{\partial \alpha} < \frac{\partial F_{TEN}(\overline{x}(\tau,\alpha))}{\partial \alpha}.$$

The proof is in Appendix A. We note that this result is based on the assumption that the income distribution function is convex at least in a neighborhood around the critical income level. While we are not aware of any studies estimating income uncertainty in Ghana, extant research on the income distribution in the US implies convexity of the labor income distribution for the part of the cumulative distribution function below the mean (see, for example, Carroll, 1997).[7]

In the next section, we will illustrate these results with a numerical example. Then, the empirical analysis section will test the validity of these predictions in the data by examining the compliance behavior sensitivities of the various occupancy categories to tax rate hikes and location features, such as the proximity to local amenities as a source of compliance pressure and reciprocity.

2.4 Numerical example

We provide an illustration of the compliance behavior of owner-occupied and owner-and-tenant-occupied dwellings by numerically solving the considered stochastic dynamic optimization problem for specific homeowner preferences and labor income distribution. In particular, we consider a homeowner exhibiting constant relative risk aversion; i.e., $U(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$ and $v(h) = 4 \cdot \frac{h^{1-\gamma}}{1-\gamma}$, where $\gamma = 2$. We set the discount factor to $\beta = 0.95$ and the interest rate to $r = 0.03$. Further, we normalize the size of the house to $H = 1$ and the rent to $k = 1$ monetary units. In the considered example, labor income follows a normal distribution with a mean of $\mu_i \in [1, 3]$ monetary units and standard deviation of $\sigma_i = 0.2$. Starting from $\mu_i = 1$ we incrementally increase the average income of the household using steps of 0.01 and for each step solve the household tenure choice problem.[8]

Figure 1 represents the expected labor income (dashed line) and the expected total income (solid line) of households. The solid line shows that a household with an expected labor income of 1 monetary unit attains a total income of about 1.37 monetary units. That is,

[7] Assuming that the income distribution is log-normal, Carroll (1997) estimates a coefficient of less than 0.2. The distribution for parameters below 1.0 implies convex distribution for all income levels y below the average income.

[8] We adapt a Matlab code originally developed by Greg Kaplan in 2017 and provided by Benjamin Moll at `http://benjaminmoll.com/ha_codes` for the solution of a standard income fluctuation problem. The program implements a value function iteration algorithm to calculate the policy function numerically. The distribution of savings is obtained by simulating $50,000$ random draws of the income distribution for 600 periods. We iterate over each income level and solve for the optimal housing consumption h of the household.

this household finds it optimal to rent out 37% of its property and be an owner-and-tenant occupied dwelling. Similarly, a household with an expected labor income of 1.5 has a total income of about 1.72 monetary units and hence rents out only 22% of their home. By contrast, households with incomes exceeding 2.16 occupy their entire property and belong to the owner category.

[Insert Figure 1 about here]

We next consider two levels of compliance pressure. Households exposed to low compliance pressure default when their cash on hand is below 2 monetary units, while households exposed to a high compliance pressure default when their cash on hand falls below 1.8. These results are illustrated in Figure 2.

[Insert Figure 2 about here]

As can be observed in the figure, the default probability functions are decreasing in the expected total income and are generally steeper for lower income levels. Hence, the default behavior of owner-and-tenant properties is more sensitive to income shocks (Proposition 2). Furthermore, we can also conclude that, within the group of owner-and-tenant properties and within the group of owner properties, the individuals with lower income will be less tax compliant. We will test this additional hypothesis in our empirical analysis.

In this numerical example, a landlord generates a rental income of 1 monetary unit. The compliance pressure parameters control how far apart the two default functions in Figure 2 are positioned relative to each other. If the difference in compliance pressure is sufficiently large, the tenant category would be less compliant (Proposition 2). Conversely, if the compliance pressure is similar, the tenant category would be more compliant as its higher income overcompensates for the lower compliance pressure.

3. Property tax administration in Ghana

This section presents the institutional background surrounding the practice of property taxation in Ghana. The information discussed in this section is gathered from policy documents and based on interviews with senior officials and officers of the Accra Metropolitan Assembly.[9]

Structure and legal framework

Property taxes are raised at the local level in Ghana through local authorities known collectively as Metropolitan, Municipal, and District Assemblies (MMDAs). The MMDAs are created based on the main criterion of population size. District Assemblies and Municipal Assemblies oversee areas with a minimum population of 75,000 and 95,000, respectively. Metropolitan Assemblies, such as the AMA, have oversight of a metropolis with a minimum population of 250,000 people. Consideration is also given to the geographical contiguity and economic prospects of the area in the MMDA-creating decision. New MMDAs are formed by splitting or carving them out of an already existing one. They can also be formed by an upgrade in status, for example, from a Municipal Assembly to a Metropolitan Assembly. As of the end of 2018, there were 6 Metropolitan Assemblies, 109 Municipal Assemblies, and 145 District Assemblies in Ghana. To provide even greater decentralization, the MMDA structure includes the establishment of subunits, namely the Sub-Metropolitan District Councils, Urban Councils, Town or Area Councils, and Unit Committees, to correspond with the area of authority for each MMDA. This results in four tiers of local governance for Metropolitan Assemblies and three tiers for both Municipal and District Assemblies. Figure A1 in the Online Appendix graphically illustrates this tiered local governance structure in Ghana.

The current regulatory framework within which the MMDAs operate dictates that the MMDAs bear direct responsibility for the overall development of respective districts, while empowering them to generate their own revenues, with a key source coming from property

[9]Detailed summary of the interview conducted with the AMA tax administration authorities is available upon request.

rates. In the following subsections, we explain the institutional setting related to the collection of the property tax, along with relevant legal terminology.

Ratable values

Ratable values are the monetary values of properties which form the tax base for calculating the property tax in Ghana. They are determined by the Lands Commission of Ghana, a parastatal, which is tasked with the creation of a valuation list for every MMDA. The Lands Commission uses a depreciated replacement cost (DRC) method of property valuation. The DRC works by estimating the cost of the building as though it were new and then allowing for depreciation and improvements. However, owing to the huge outlay, these valuations are only infrequently carried out. The ratable value shall not exceed 50% of the replacement cost for owner-occupied properties and not be less than 75% of the replacement cost for any other occupancy arrangement.

Property tax rates

Property tax rates (or property rates) are set in the annual publication of the Local Government Bulletin of District Assemblies, as defined by the regulations of the MMDA, in view of their budgetary needs. Section 145(1) of Act 936 specifically states that "[a] District Assembly shall levy sufficient rates to provide for the total estimated expenditure to be incurred by the District Assembly during the period in respect of which the rate is levied."

This suggests that property tax rates and any increases thereof, for any given year, are primarily driven by budgetary considerations of the MMDAs. Specifically for the AMA, the budgeted expenditure for the year is compared with how much revenue is expected to be raised, based on the existing stock of properties and their ratable values. This approach helps to ensure the maintenance of an appropriate balance between the financial requirements of the AMA and the tax burden on property owners. A special decentralized unit, the Rate Assessment Committee, plays a crucial role in this process. It is responsible for examining and deciding on the appropriate rates. The committee is also authorized to investigate and address taxpayer grievances around their ratable values or property tax rates. Once these rates are finalized and approved, they are applied. Property rates are deemed to be levied by the annual publication of notice in its Local Government Bulletin, as defined by the regulations of the MMDA.

The rate impost is the tax rate that is multiplied by the ratable value of the property to determine the annual property tax due in the local currency (Ghana Cedi (GHS)). An MMDA would typically have a rating zone classification, especially for residential property rating purposes. This classification reflects differences in location quality within an MMDA. Thus, properties in a rating zone for prime locations usually attract a higher rate impost than those in other rating zones. Properties within a particular rating zone, however, could attract different rate imposts on account of other building characteristics or factors taken into consideration by the MMDA. To illustrate how this works, we include the 2017 bulletin for the AMA, shown in Figure 3. We see different rating impost ranges for the various rating zones, with 1A, the most affluent residential areas, attracting the highest rates, and 3C, representing the least affluent areas, having the lowest rates. Ignoring the A, B, and C subclassifications, the photographs in Figure A2, in the Online Appendix, show examples of a neighborhood belonging to the most affluent Rating Zone 1 (East Legon), the less affluent Rating Zone 2 (Adabraka), and the least affluent Rating Zone 3 (Nima).

When the rate impost and the ratable value of a property are low, resulting in a low overall property tax amount, the MMDAs set a lower bound on the property tax bill, which is referred to as the minimum rate. Each financial year, the MMDAs set the minimum rates to be imposed on residential properties within the Assembly in view of its budget requirements and revenue stream forecasts for the year. These rates are also published at the beginning of the financial year in its Local Government Bulletin and vary by area. A key distinction between the rate impost and the minimum rate is that with the rate impost, properties within a particular rating zone could face different tax bills, whereas with the minimum rate, all properties within a particular rating zone face the same property tax bill. Minimum rate payers pay a fixed property rate that depends on the rating zone of the residence and is subject to annual updates. Also, in certain instances where properties do not have ratable values, taxpayers are made to pay the minimum rate. At all times, the amounts paid reflect the rating zones in which the properties are located.

We see from Figure 3 that the minimum rate varies by rating zone, with a systematic decline in the minimum rate paid as one moves from the most affluent to the least affluent residential areas. For example, the minimum rates paid by households within the aforementioned neighborhoods of East Legon, Adabraka, and Nima, for the year 2017, were GHS 200, GHS 80, and GHS 60, respectively, as shown in the bulletin.

[Insert Figure 3 about here]

Property tax bill delivery

The main mode of serving property tax bills is manual. Printed copies of property tax bills are hand-delivered to the occupants at their property addresses.[10] Understandably, there are several challenges associated with this tax delivery process, including the absence of bill recipients from home, wrong recipient details, limited accessibility to certain locations, and difficulties in locating properties due to inadequacies in the property address system (see also Dzansi et al., 2022). Additionally, for properties that were fully tenant-occupied, there are some instances where the tenants fail to pass on the bills to the property owners, who are responsible for paying the property tax. For the AMA, however, households covered in its database largely receive their bills because all bill deliveries are tracked in a "service diary." This diary records specific details such as the receipt dates, names of the persons who received the bills, contact phone numbers, and signatures of the recipients. This helps to ensure a comprehensive record of the delivery and receipt of property tax bills.

[10] A new electronic platform for serving and paying property tax bills within the AMA has been trialed and is subsequently under review.

Property tax burden and collection

The property owner has the legal obligation for payment of property taxes. However, there does not appear to be a different tax treatment for the owner in the shared occupancy arrangement, relative to the pure owner-occupier. This is due to there being no clear distinguishing property or household characteristics between the two occupancy types, except for differences in the ratable values, which has a direct bearing on the amount of property tax revenue that can be generated. The MMDAs are expected to appoint suitable persons as revenue collectors, whose job is to collect property rates due at the physical residences of taxpayers, and pay the amounts collected to their respective local authorities. However, for the AMA, there have been instances of revenue collectors embezzling the taxes collected. Therefore, internal monitoring mechanisms have been put in place, including bookkeeping, submission of weekly reports detailing activities of revenue collectors, and unannounced field visits by auditors. For MMDAs like the AMA, property taxes could be paid in cash or by check at the physical location of the AMA, or via direct bank transfer into the accounts of the AMA. These alternative ways of collecting the property taxes provide an additional safeguard against the financial malfeasance associated with the traditional revenue collector approach. In addition to all these measures, penalties exist for rate collectors who embezzle the monies collected or commit other similar offences.

Nonpayment of property taxes

All MMDAs are guided by the legal framework in recovering property tax arrears from defaulting households. The most severe action that could be taken against delinquent parties is the initiation of court proceedings, leading to the sale of their properties to defray the amount owed. For the AMA, the process typically begins with the issuance of a series of warning letters to defaulting taxpayers, prompting them to fulfil their tax payment obligations. If payment is still not received after these warning letters, court proceedings need to be initiated to recoup the outstanding tax. In practice, however, these cases seldom make it to court due to bottlenecks in the system. Thus, the AMA often resorts to its own internal processes to help retrieve arrears, including dialoguing with defaulters in order to understand their reasons for nonpayment and giving them the opportunity to make immediate payments or to pay within a grace period. There is also a "tax force," whose job is to contact defaulters and try to collect payments, especially toward the end of the year. Another method employed, especially for commercial institutions, involves placing a large final notice in a clearly visible location on the property. This is done to evoke nonpecuniary motivations for tax payment, such as guilt and shame, and in the case of commercial institutions to motivate them to settle their outstanding payments in order to avoid loss of reputation and subsequent loss of business.

4. Data and variables

4.1 Data sample

Our analysis is based on administrative panel data obtained from the Accra Metropolitan Assembly (AMA). The AMA is responsible for the Greater-Accra region of Ghana and is one of only six Metropolitan Assemblies in the entire country. It has oversight responsibility for Accra, the capital city, which is the center of economic activity and seat of government in Ghana. The data cover all ten of the AMA's Sub-Metropolitan District Councils for the period 2011–2018. The dataset captures information on property tax arrears, occupancy status, rate imposts, minimum rates, ratable values, street names, and rating zones. It also includes a spatial dimension, detailing the building floor areas and geographical coordinates of properties.

4.2 Minimum rate payers

Our empirical assessment focuses on minimum rate–paying properties, which cover more than 97% of properties in our sample. Minimum rate payers represent a homogeneous group for which the property tax payment liability is determined solely by the budgetary planning of the AMA and does not depend on attributes of the property other than its rating zone. This selection aids our identification to ensure that we capture variation in property taxes, which is exogenous to the property-level characteristics. Our final data sample contains 238,140 property-year observations.

The distribution of annual minimum rates across rating zones for the period 2011–2018 is presented in Table 1.[11] We observe that the minimum rates gradually increase over the 8-year period. Rating Zone 1 attracts the highest rates, followed by Rating Zone 2 and then Rating Zone 3. With the exception of the 2012–2013 and 2015–2016 periods, where the rates remain unchanged, there are hikes to the minimum rates for all the other years. We also see that the greatest increase in the minimum rates occur in the 2017–2018 period. There is also within–rating zone consistency across the A, B, and C subdivisions in terms of the amount, with A always being greater than B, and B always being greater than C.

[Insert Table 1 about here]

4.3 Summary statistics

Table 2 presents summary statistics for the full final data sample and also for each type of housing tenure. There are three housing tenure arrangements: properties occupied solely by their legal owners (Owner); properties rented out to tenants (Tenant); and properties in which the legal owners share the living space with tenants (Owner-Tenant). The majority of the properties (139,830) are of the Owner category, representing 58.72% of all observations.

[11] The USD conversion of these amounts is in Online Appendix Table A1. There is a small number of observations with minimum rates which deviate from the correct values, which were dropped from the analysis.

A sizeable share of the properties are of the Tenant (53,585) and Owner-Tenant (44,725) categories, representing 22.50% and 18.78% of the full sample, respectively.

The annual average amount of property tax unpaid across all observations is GHS 53.73, with properties solely occupied by tenants having the highest arrears estimate (GHS 56.36) compared with the other dwelling unit types. The average property tax payable for a property – which corresponds to the minimum rate – for the overall sample is GHS 68.87, with the median payment amounting to GHS 58.00. Properties with shared occupancy between the legal owner and tenants have the lowest average property tax payable (GHS 63.83). To ascertain the proportion of the property tax bill that is unpaid, we express the annual property tax arrears as a fraction of the property tax payable each year, generating the arrears proportion variable. For all the observations, we see that the annual property tax arrears is on average about 72% of the property taxes expected to be paid, whereas the median household records an arrears proportion of 100%, suggesting that it completely reneges on its property tax obligations. Properties rented out to tenants have the highest arrears proportion among the three housing tenure arrangements (77%). The average building floor area for the entire sample is 157.08 square meters. By housing tenure, quite unsurprisingly, the building floor area is largest for properties in which there is shared occupancy between the owner and tenants (161.02 square meters). The average property value is GHS 24,120.53.[12] Comparing average property values across the three housing tenure arrangements reveals that properties jointly occupied by the owner and tenant have the highest value (GHS 25,382.09).

We construct indicator variables to measure property tax compliance. If the property tax for the year is not paid in full, we record the property as being in arrears (Arrears). Further, we make a distinction between no payment at all (Full arrears) and partial property tax payment (Partial arrears). An average of 78% of the all the households in the overall sample are in arrears, with only 22% being compliant. Of those in arrears, 76% have not made any payment and are in full arrears. In terms of housing tenure, property tax arrears are most

[12]Property value estimates are valuation-based instead of market-based, with valuations carried out infrequently owing to huge outlay.

prevalent for solely tenant-occupied properties (82%), with four-fifths of those in arrears paying none of their property taxes. Overall, these estimates clearly show a high incidence of property tax delinquency within the AMA. The amount of income lost in arrears by the AMA is also non-negligible, given that a large proportion of the property tax revenues are used to provide vital public services within the local assembly. For instance, economic capital expenditure is a main type of expenditure incurred by the AMA, which includes the sub-category expenditures for construction of toilet/bathhouses, rehabilitation/refurbishment of markets, construction of roads/drains, other economic activities, maintenance of roads, maintenance of markets, and maintenance of public toilets.[13]

Properties from the least prime locations within the AMA (Rating Zone 3) are the most represented in the entire sample (62%), with those from the most prime areas (Rating Zone 1) being the least represented (6%). There are also differences among the housing tenure arrangements in terms of distribution within rating zones, with the shared owner and tenant occupancy arrangement being predominant in Rating Zone 3 (73%) and least concentrated in Rating Zone 1 (2%). Information on 2,966 streets is observed in the data sample, which works out to an average of about 80 properties per street.

[Insert Table 2 about here]

In Online Appendix Table A2, we present additional summary statistics on the proportion of properties in arrears by year and rating zone. Rating Zone 1, which is the most affluent zone, has a distinctly lower proportion of properties in arrears, as compared to Rating Zones 2 and 3. Over the sample period, we observe that the proportion of noncompliant properties has not changed significantly for the various rating zones, except for the increase seen for Rating Zone 1 in 2018, closing the gap between the three rating zones.

[13] A back-of-the-envelope calculation using the AMA's 2018 accounting figures indicate that economic capital expenditure in 2018 amounted to GHS 6.8 million, while the total arrears unrecovered from the owner-and-tenant category of properties in the same year was GHS 1.15 million. This means that the revenue lost due to arrears from the owner-and-tenant properties is equivalent to 17% of the total economic capital expenditure of the AMA, which is a significant amount.

5. Empirical analysis

5.1 Baseline specification

As a first step, we analyze how the property tax compliance behavior depends on the occupancy status of dwelling units. Our baseline specification is given by the following model:

$$NonCompliance_{it} = \mu_s + \delta_t + \alpha_1 Owner\text{-}Tenant_i + \alpha_2 Tenant_i + \varphi' X_{it} + \varepsilon_{it}, \qquad (13)$$

where $NonCompliance_{it}$ captures the property tax noncompliance behavior of dwelling unit i in year t. We use four types of noncompliance behavior namely, $Arrears_{it}$, which takes the value of one if dwelling unit i is in arrears in year t, and zero if the property tax for the year t has been paid in full; $Full\ arrears_{it}$, which takes the value of one if dwelling unit i has not made any payment in the year, and zero if the tax has been paid in full; $Partial\ arrears_{it}$, which takes the value of one if dwelling unit i has paid some tax but not the full amount, and zero if the tax has been paid in full; and $Arrears\ proportion_{it}$, which gives the percentage of dwelling unit $i's$ property tax in year t that was not paid for that year. μ_s and δ_t are the street and year fixed effects, respectively. The street fixed effects enables us to control for any persistent differences between neighborhoods. This includes any attributes shared by all streets within a neighborhood, such as the general quality of the neighborhood. *Owner-Tenant* is an indicator variable which takes the value of one if the property belongs to the owner-and-tenant occupancy category, and zero otherwise. The indicator variables for the *Tenant* and *Owner* categories are defined analogously, with the latter as our base category. The vector, X_{it}, captures three property-specific covariates recorded by the AMA – the recorded property value, the building floor area and the property tax payable. We use standard errors clustered at the household level. Detailed definitions of all variables are provided in Appendix B.

Table 3 presents our baseline results. Columns (1)–(3) report linear probability estimates, with Arrears, Full arrears and Partial arrears as the dependent variables, respectively. We observe that properties with shared owner and tenant occupancy, our main dwelling unit of interest, are less compliant relative to those that are solely owner-occupied, with a probability of nonpayment being about 2.2% higher for the former. Tenant-only dwelling units are least compliant in that they are 5.2% less likely to pay their taxes in full relative to solely owner-occupied dwelling units. These differences are highly significant and robust across the four different noncompliance specifications. The coefficients for property value, property tax payable and building floor area are also highly significant and largely have the expected negative signs, indicating that more expensive and bigger properties are less likely to be in arrears.

We perform a number of robustness checks for our results. First, we apply the methodology proposed by Oster (2019) to examine potential bias from unobservable regressors and assess coefficient stability. There are two main ways to ascertain how robust coefficient estimates are using this methodology. One approach involves calculating the coefficient of proportionality, δ, which measures the degree of selection on unobservable covariates, relative to the observable covariates in the regression, required to explain away the estimated effect. In our case, this pertains to the effect of occupancy type. δ is defined as $\frac{\beta_{fm}}{\beta_{lm}-\beta_{fm}} \times \frac{R_{fm}-R_{lm}}{R_{max}-R_{fm}}$, where β_{fm} (β_{lm}) is the coefficient on the occupancy type from the model with (without) the control variables. R_{fm} (R_{lm}) is the r–squared from the model with (without) control variables. R_{max} is the r–squared from a hypothetical regression that includes all regressors, including unobserved control variables. Following Oster (2019), we set $R_{max} = 1.3 \times R_{fm}$. If $\delta = 1$, both observables and unobservables are of equal importance and affect β_{fm} in the same direction. If $0 < \delta < 1$, ($\delta > 1$), the unobserved covariates are less (more) important than the observed covariates.[14] The second approach of establishing the strength of the significance of the occupancy type coefficient involves estimating a bounding set, $[\beta^*, \beta_{fm}]$. β^* is the bias-adjusted effect of occupancy type on arrears outcomes, using specific values of

[14] A negative δ, value can also be realized if the influence of observables on the estimated coefficient is in the opposite direction to the effect of the unobservables.

R_{max} and δ. We follow convention in maintaining the previous R_{max} calculation and setting ($\delta = 1$).[15] The estimated occupancy type effect from the controlled regression is considered robust if the bounding set excludes zero.

Online Appendix Table A3 reports the test results. For both occupancy types, the δ values imply that the impact of any omitted regressors, relative to the included regressors, would need to be extraordinarily large in (absolute terms) to reduce the estimated coefficients to zero across all the model specifications. For instance, where the dependent variable is Arrears, the effect of the unobservables has to be nearly eight times as important as the observables to nullify the occupancy coefficient. However, this scenario is highly improbable, since the regression already incorporates key determinants of property tax arrears outcomes, including the various fixed effects. The results of the coefficient bounding set also demonstrate that none of the identified sets includes zero, further confirming that the estimates are less likely to be strongly influenced by omitted variable bias.

Next, we employ the high-dimensional street times year fixed effects. This allows the street-level fixed effects to vary over time. The advantage of this specification is that we are able to compare households within the same street, and we control for any factors that vary across streets and evolve over time but that affect all properties on the same street in the same year. We also include double-clustered standard errors at the household and year levels in another specification, owing to the potential for error-term correlations in both entity and time dimensions. The results are reported in the Online Appendix Tables A4 and A5, respectively. We observe that the coefficients for shared owner and tenant and the coefficient for solely tenant-occupied properties remain positive and highly statistically significant across all the model specifications.

Overall, the results support the hypothesis that properties jointly occupied by the owner and tenant are more likely to be associated with noncompliant behavior.

[15]Whether β_{fm} serves as the upper or lower bound of the bounding set depends on the direction of the occupancy type effect and the omitted variable bias. If the occupancy type effect is positive, β_{fm} is the lower (upper) bound when there is downward (upward) bias. Conversely, if the occupancy type effect is negative, β_{fm} becomes the upper (lower) bound with upward (downward) bias.

[Insert Table 3 about here]

5.2 Heterogeneity across rating zones

Next, we explore whether differences in compliance behavior are driven by the affluence level of neighborhoods. To this end, we use the multivariate regression model in Equation (13) and examine noncompliance across the three subsamples of the AMA's residential rating zone classifications: Rating Zone 1, Rating Zone 2, and Rating Zone 3. The classification reflects differences in location quality.[16]

The results of the analysis are presented in Table 4. In columns (1)–(3), we examine the probability of nonpayment for Rating Zones 1, 2 and 3, respectively. As shown in column (1), in the most affluent Rating Zone 1, there are no significant differences between the probability of nonpayment for shared owner-and-tenant dwellings relative to the baseline (solely owner-occupied) category. Highly significant differences in compliance, however, emerge in the less affluent Rating Zones 2 and 3, as shown in columns (2) and (3). For tenant-occupied dwellings, compared to the baseline occupancy category, the likelihood of noncompliance increases across all Rating Zones. A similar pattern for owner-and-tenant- and tenant-occupied dwellings is observed for the full nonpayment regression specifications, the results of which are reported in columns (4)–(6), for Rating Zones 1, 2 and 3, respectively. For the partial nonpayment specification, of which the results are reported in columns (7)–(9), for Rating Zones 1, 2 and 3, respectively, significant differences are observed only in the least affluent neighborhoods (Rating Zone 3). This is shown in column (9), where shared owner-and-tenant- and solely tenant-occupied dwelling units are 2.5% and 2.9% respectively more likely to make a partial payment, relative to the solely owner-occupied category. In Online Appendix Table A6, we report results of the heterogeneity analysis with the arrears proportion as the dependent variable. The results confirm the susceptibility to arrears of the shared owner and tenant housing arrangement in less affluent locations, relative to those re-

[16]The A, B, and C rating zone sub-classifications are jointly considered for ease of analysis.

siding in more affluent neighborhoods. The results are largely consistent for tenant-occupied dwellings that are likely to be in full arrears, even in the most affluent areas.

In sum, the results in Table 4 suggest that the property tax compliance outcomes of dwelling units are associated with the affluence levels of the neighborhoods to which they belong. In particular, we see that owner-and-tenant-occupied dwellings in less wealthy neighborhoods are more likely to be in arrears, whether full or partial, compared to those in the most affluent areas. Comparing results across all noncompliance measures and affluence categories for the owner-and-tenant-occupied dwellings, we see that partial nonpayment of property taxes is driven by only those in the least well-off locations. The results indicate that owner-and-tenant-occupied dwellings, our category of interest, may be willing to pay their property taxes, as highlighted by their partial arrears, but may be prevented from doing so owing to financial constraints.

[Insert Table 4 about here]

5.3 Exogenous property rate shocks

It is well established that taxpayers are resistant to property tax rate hikes, particularly in developing countries (Bahl and Wallace, 2008). In this section, we examine how the relative compliance behavior of the three dwelling unit types changes in response to changes in the property tax rates. This analysis presents a test of the prediction derived in Proposition 3a related to the sensitivity of household compliance to affordability. The minimum rates are determined at the discretion of the AMA and are set in view of its budgetary objectives. As illustrated in Figure 4, the minimum rate changes vary from one period to the next. For the 2012–2013 and 2015–2016 periods, there is virtually no year-on-year increase in the minimum rates, while for 2011–2012 and 2017–2018, the minimum rates increase by more than 40%, on average.

[Insert Figure 4 about here]

We analyze how dwelling units in different tenure arrangements respond to these property rate shocks by estimating the following regression:

$$
\begin{aligned}
NonCompliance_{it} = \mu_s + \alpha_1 Owner\text{-}Tenant_i + \alpha_2 Tenant_i + \alpha_3 Rate\ shock_t + \\
\alpha_4 Owner\text{-}Tenant_i \times Rate\ shock_t + \alpha_5 Tenant_i \times Rate\ shock_t \\
+ \varphi' X_{it} + \varepsilon_{it},
\end{aligned}
\tag{14}
$$

where $Rate\ shock_t$ takes the value of one for the years 2012 and 2018, where there has been a large hike in rates, and zero for the years 2013 and 2016, with no rate increases. All the other variables are as previously defined.[17] According to Proposition 3a, the coefficient α_4 should be positive and statistically significant.

Table 5 presents the results of this analysis for the three outcome variables Arrears, Full arrears and Partial arrears, as considered previously. We find that, as expected, dwelling units which experience a property rate shock are significantly more likely to be in arrears in all the regression specifications. In particular, the positive effect of the shock on arrears is greatest for dwelling units that partially default on their property tax obligations (11%). We also see find evidence for Proposition 3a in that the rate shock plays a significant role in worsening the noncompliance probabilities for the shared owner-and-tenant dwellings. That is, homeowners in the shared occupancy arrangement who face a rate shock have a significantly higher probability of not paying their property taxes, relative to the homeowner in the solely owner-occupied category. Interestingly, interacting rate shock with the dwelling units that are solely tenant-occupied reveals that their probability of nonpayment is reduced by the rate shock, although the relationship is weak. Also, the likelihood of full or partial nonpayment for these dwelling units is unaffected by the rate shock.

Overall, the results indicate that the shared owner-and-tenant dwelling type displays greater sensitivity to property rate shocks, which reflects in their increased probabilities of incurring property tax arrears. This is unlike the tenant-occupied dwellings, whose property

[17] Since we are including a dummy variable for the year, we do not include year fixed effects in this model.

tax arrears outcomes are mostly insensitive to the rate shocks.

[Insert Table 5 about here]

5.4 Heterogeneity across building types

In this section, we examine the heterogenous effects in compliance behavior based on the different types of material used in the construction of the property, a proxy of the affordability considerations. As such, the analysis presents a test of the prediction derived in Proposition 3a. We obtain from the Lands Commission of Ghana a restricted data sample in which the building structure information is provided. Based on the sample, we observe three types of building structures, those made of wattle and daub, mass swish, or sandcrete blocks. Wattle and daub buildings are the weakest structures of the three (prone to decay and cracking) and made from wooden frames and clayey soil. Swish buildings are constructed with rammed earth and built in courses. Sandcrete block buildings are made from sand, cement and water, and considered the highest quality. The literature suggests that buildings made of raw earthen materials, such as wattle and daub and mass swish, are likely to appeal to low-income households due to their lower cost (Adegun and Adedeji, 2017). Rammed earth buildings have been found to be 50% to 60% cheaper than sandcrete block buildings (Zami and Lee, 2008; Dabaieh and Sakr, 2015). Therefore, in terms of affordability, properties made of wattle and daub is more likely to be owned by the more income constrained households, while the affluent and less financially constrained households would be able to afford properties made of sandcrete blocks.

We merge the data on the building type with the main AMA database used in the study, retrieving a matched sample of 141,015 household-year observations. For the analysis, we estimate the following regression model:

$$NonCompliance_{it} = \mu_s + \delta_t + \alpha_1 Owner\text{-}Tenant_i + \alpha_2 Tenant_i + \theta_1' Build\,type_i + \theta_2' Build\,type_i \times Owner\text{-}Tenant_i + \theta_3' Build\,type_i \times Tenant_i + \varphi' X_{it} + \varepsilon_{it}, \quad (15)$$

where the vector, $Build\,type_i$, captures the building material types, defined as indicator variables, with sandcrete blocks as the base category. All the other variables are as previously defined. According to Proposition 3a, the coefficient θ_2, for the interaction of the Owner-Tenant category with the Wattle and daub building type, is expected to be the greatest. That is, we expect to see a lower level of compliance among households residing in cheaper building types and those in shared occupancies.

Table 6 reports the regression results for arrears, full arrears and partial arrears. Columns (1), (3) and (5) are the baseline regressions, where we additionally include information on the building type. We observe that the findings drawn previously continue to hold in the presence of these additional controls, whereby owner-and-tenant and tenant categories are significantly more noncompliant than the owner category. When examining the interactions between building types and ownership characteristics, we find that homeowners in the shared housing arrangement living in properties made of wattle and daub, which is the cheapest building type, are significantly more likely not to pay their property taxes (24%), and also to not pay in full (27%).[18] The results, in line with Proposition 3a, indicate that poorer owner-and-tenant-occupied dwelling units are additionally vulnerable to property tax arrears, which reflects the binding income constraints they face. However, none of the interactions between tenant-occupied dwellings and the building material types are statistically significant for property tax arrears, suggesting that affordability does not seem to play a significant role in explaining tax noncompliance.

[18] In the partial arrears regression, one of the interaction coefficients is not estimated, due to no observational data.

[Insert Table 6 about here]

5.5 Reciprocity analysis: Proximity to public amenities

In this section, we examine the relationship between distance to public amenities and the property tax arrears of dwelling units. Theoretically, proximity to local amenities is a source of compliance pressure for households. Previous studies find that people tend to be more tax compliant when they receive a higher quality of public services for their tax payments (Alm et al., 2014). The positive relationship between access to public goods and compliance is at the foundation of the "reciprocity" hypothesis formulated by Luttmer and Singhal (2014). Hence, our empirical tests could be viewed as a test of the "reciprocity" hypothesis.

We exploit geographic coordinate information (latitudes and longitudes) to calculate geodetic distance estimates to two classes of public amenities in Accra: suburban police stations and hospitals. Drawing on Vincenty (1975), the distance estimation approach takes the length of the shortest curve between two points, using an ellipsoidal model of the earth. The methodology is based on the World Geodetic System 1984 (WGS84) datum, which is the same used by Google Maps, Google Earth and GPS gadgets.[19] In addition to the property-level geographic coordinates available in the data, we hand-collect from Google Earth the coordinates for thirty-eight police stations and the three main and best-resourced public hospitals in Accra.[20] We then estimate the distance from each property to each police station and hospital.[21] Finally, for each property, we select the shortest distance estimate among all the police stations and hospitals, treating both amenity classes separately. To ascertain the effect of proximity to amenities on property tax arrears, we estimate the following linear

[19] We use the `geodist` function in Stata for the computation; see Picard (2010) for more details.

[20] Korle-Bu Teaching Hospital, 37 Military Hospital, and Greater Accra Regional Hospital.

[21] The function works by estimating the centroid of each building. The centroid is effectively the geometric center of a building, which in our case is every residential property, police station and hospital, with each building outlined by a polygon.

probability regression model:

$$NonCompliance_{it} = \mu_s + \delta_t + \alpha_1 Owner_i * Distance\ to\ amenities_i + \alpha_2 Owner\text{-}Tenant_i \times Distance\ to\ amenities_i + \alpha_3 Tenant_i \times Distance\ to\ amenities_i + \alpha_4 Owner\text{-}Tenant_i + \alpha_5 Tenant_i + \varphi' X_{it} + \varepsilon_{it}, \tag{16}$$

where *Distance to amenities*$_i$ is the shortest distance to a hospital or police station for any given property. The regressions are run separately for hospitals and police stations. All the other variables are as previously defined.

Panel A of Table 7 reports the summary statistics of the distance estimates to police stations and hospitals. We see that the mean distance from a property to the nearest hospital is 4.42 kilometers, whereas it is only 1.18 kilometers in the case of the police stations. This suggests that on average, the distance to the nearest hospital is greater than the distance to the nearest police station. The estimates are unsurprising, given the greater number of police stations as compared to hospitals, meaning police stations are more likely to be within the immediate precincts of the dwelling units. Proximity to police stations therefore serves as a good proxy as regards the effect of providing public services in a specific local area. Conversely, the smaller number of hospitals suggests that they are not necessarily localized, providing a means to test of the effect of what is generally a more distant amenity on property tax compliance outcomes.

Panel B of Table 7 presents the results based on distance to hospitals. We report estimates for arrears (columns (1) and (2)), full arrears (columns (3) and (4)) and partial arrears (columns (5) and (6)). In columns (1), (3) and (5), we include only the distance to hospital variable as the regressor, but do not control for other factors. We find that for every 1-kilometer increase in distance to the nearest hospital, the probability of arrears increases by about 3% across all the three specifications, as expected. When the interaction terms and the other covariates (columns (2), (4) and (6)) are included, we find that the initial positive relationship between hospital distance and the likelihood of arrears still holds. In particular, we see from the interaction terms that homeowners in all three dwelling unit types, when these are relatively distant from the nearest hospital, are significantly more likely to be property tax–delinquent, with the probabilities also roughly around the 3% level across the regression models.

Panel C of Table 7 displays the results based on distance to police stations. The results are qualitatively similar to those based on the hospital distance estimates. However, the magnitude of the probabilities is comparatively larger for the police-based estimates when accounting for only the distance estimates in the regressions (columns (1), (3) and (5). Also, in the case of partial arrears (column (6)), the coefficient estimate for the distance to police and shared owner-and-tenant-occupancy interaction term (5.4%) bucks the trend of a monotonic decrease in the magnitude of the other two dwelling unit and distance interaction term coefficients, for both hospital (columns (2), (4) and (6)) and police distance–based results (columns (2), (4)). In Online Appendix Table A7 reports results of the reciprocity analysis using arrears proportion as the dependent variable. The results corroborate previous findings by showing that being far away from public amenities significantly increases the percentage of property tax that is left unpaid.

Overall, the results are in line with the concept of reciprocity: spatially disadvantaged dwelling units, as regards the siting of public amenities, are generally more likely to be in arrears.

[Insert Table 7 about here]

6. Additional analyses and robustness checks

In this section, we discuss the additional analyses conducted to examine the robustness of the main findings. The nature of our administrative property-level data is such that we observe several property-level characteristics, but not the demographics of the households living in those properties. This limitation of our data means that we are unable to control for household-level characteristics directly, although street-level fixed effects are controlled for in all the regressions to capture neighborhood characteristics (e.g., education level of the neighborhood), which will be somewhat correlated with the household characteristics. To alleviate further concerns, we replicate the baseline regressions using a propensity score matching (PSM) approach. Using this approach, we are able to create a sample of properties in the treatment group that would be comparable to the sample of properties in the control group. Here, we assume that households with similar characteristics are more likely to live in properties with similar characteristics, while aiming to reduce potential imbalances in the observable covariates between various occupancy categories.

To do this, we perform separate pairwise comparisons for two treatment categories, namely, owner-and-tenant-occupied units and the tenant-only units, against the owner-occupied units, which acts as the control group. The PSM procedure ensures that the data used in the model estimation have a similar empirical distribution between the treated and the untreated units with regard to their covariates. As such, for each treated unit, the counterfactual observation is the nearest neighbor with the closest propensity score, based on property value, property tax payable, and building floor area attributes. The matching is performed with replacement, which has been shown to be more effective in reducing bias (see, for instance, Dehejia and Wahba, 2002). The analysis selects properties with similar characteristics between the treated and comparison properties.

Table A8 in the Online Appendix reports the regression results for the owner-and-tenant-occupied units and the tenant-only units, based on the propensity score–matched samples. We find that the coefficients on the shared and the tenant occupancy categories remain highly significant across the various model specifications and with similar magnitudes to those of the baseline results, thus confirming the robustness of the main findings. We calculate the mean standardized bias before and after the match, showing a significant reduction in bias in the matched sample. Figures A3 and A4 in the Online Appendix display balancing diagnostics for the two propensity-score-matching procedures conducted. The common support graphs presented in Plot (a) of the two figures illustrate that for every treated unit, there is an untreated unit with a similar propensity score, thereby ensuring effective matching. Before the match, the kernel densities of the treated and comparison dwelling units are seen to be significantly different from each other, while they overlap almost entirely following the match, as seen in Plot (b) of the two figures.

Next, we explore the possibility that nonpayment of property taxes may be attributed to the nondelivery of tax bills, particularly in light of the weak property tax administration system (Dzansi et al., 2022). To address this, we conduct an additional regression analysis, excluding dwelling units that never paid their property taxes throughout the sample period. The results of this analysis, reported in Table A9 in the Online Appendix, still indicate an increased likelihood of arrears for shared occupancy and tenant-occupied dwellings, relative to owner-occupied units.

Furthermore, to ensure our results are more representative of the taxpayer profile within the AMA, we conduct a regression analysis after expanding our sample size to include the previously omitted non–minimum rate–paying dwelling units. The results are reported in Table A10 in the Online Appendix. The estimated occupancy coefficients remain positive and strongly statistically significant, as in the case of the baseline results.

Next, we consider potential issues related to model overfitting and multicollinearity arising from the use of highly granular street-level fixed effects in our primary analyses. Given the substantial size of our dataset, these concerns are anticipated to be minimal. Nevertheless, to further validate our findings, we substitute the street-level fixed effects with two broader fixed effect categories: suburb-level and rating zone–level fixed effects. Table A11 in the Online Appendix presents the results. We find that the main results remain robust, indicating that the observed effects are stable and not sensitive to the level of fixed effect granularity.

We explore the heterogeneity in property values to assess whether dwelling unit property tax arrears outcomes vary across different property value brackets. This could also help to infer whether there are any varying economic factors influencing taxpayer behavior. We conduct this investigation by dividing the data into two subsamples based on the median property value for each model specification: high and low property values. Table A12 in the Online Appendix reports the results. We find that the higher likelihood of arrears in both shared occupancy and tenant-occupied units, relative to owner-occupied units, is consistent across both high and low valued properties. This indicates that the relationship between occupancy type and arrears outcomes is stable.

7. Conclusion

Property tax compliance is a topic of much research. The extant literature focuses on the pecuniary and nonpecuniary motives driving the decision-making of owners and renters. In recent years, multihabitation arrangements within dwelling units have become increasingly common, where homeowners rent out part of their home, thus allowing homeowners to utilize the additional rental income to support their financial needs.

This paper examines property tax noncompliance behavior among dwelling units jointly occupied by homeowners and tenants within a tax administration system where owners are responsible for making property tax payments. Using a theoretical framework, we show that the unique constraints and motives of homeowners sharing their space with tenants lead to variations in compliance compared to pure owners and landlords. On the one hand, since homeowners are renting out parts of their home, their compliance levels should be higher than those of pure owners, due to the extra rental income. On the other hand, homeowners normally decide to share their residential space with tenants due to binding income constraints, making them more susceptible to noncompliance than pure owners, and more sensitive to property tax rate increases.

Our empirical investigation draws on detailed administrative property-level data on tax arrears and occupancy characteristics of residential dwelling units in the Accra Metropolitan Assembly (AMA) in Ghana, for the period 2011–2018. We find that shared owner-and-tenant dwellings are more likely to renege on their property tax obligations compared to owner-occupied units, with the likelihood of nonpayment being about 2.2% higher for the former. Further, the property tax compliance outcomes of this occupancy category are associated with the affluence levels of the neighborhoods, with a greater likelihood of default in less affluent locations. The owner-and-tenant category is also more likely to become noncompliant when faced with property tax rate shocks. Moreover, the households living in this occupancy arrangement are influenced more strongly by nonpecuniary motives. In particular, owner-and-tenant-occupied dwellings that are distant from public amenities have a significantly greater probability of property tax delinquency. Finally, utilizing heterogeneity in building types based on the material used to construct the property and ownership characteristics, we observe that poorer homeowners (those living in the cheapest building type) in shared occupancy arrangements are most likely to be in tax arrears, alluding to the binding income constraints they experience. The results for solely tenant-occupied properties presents a contrasting picture. Specifically, compared to owner-occupied dwellings, tenant-occupied properties have a higher likelihood to renege on their property tax obligations, with an increased probability of 4.7%. Such dwellings are also associated with a higher likelihood of being in full arrears, regardless of the affluence levels of their locations. Additionally, unlike owner-and-tenant-occupied dwelling units, tenant-occupied units do not appear to be sensitive to property rate shocks and weakly sensitive to nonpecuniary motives, when it comes to their tax noncompliance behavior.

These findings advance our understanding of how occupancy characteristics are related to residential property tax compliance, especially in developing nations with weak regulatory enforcement. Targeted policy interventions to increase compliance levels should consider the higher sensitivity to tax rate changes and affordability constraints observed in the case of owner-and-tenant-occupied dwellings, as compared to pure owner-occupied units. Specifically, for these owner-and-tenant-occupied dwellings, the application of a tailored tax scheme could significantly enhance tax compliance. Further, since compliance levels are influenced by the benefits derived from public amenities, policymakers should consider reciprocity effects when planning their spatial allocation of public amenities – a balanced spread of benefits derived from public amenities can encourage residents to reciprocate with higher compliance levels in property taxes.

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Figure 1
Labor income and the choice between owner-and-tenant and owner

The dashed line represents the expected labor income. The solid line represents the expected total income which includes the rental income of homeowners who choose to rent out a portion of their home.

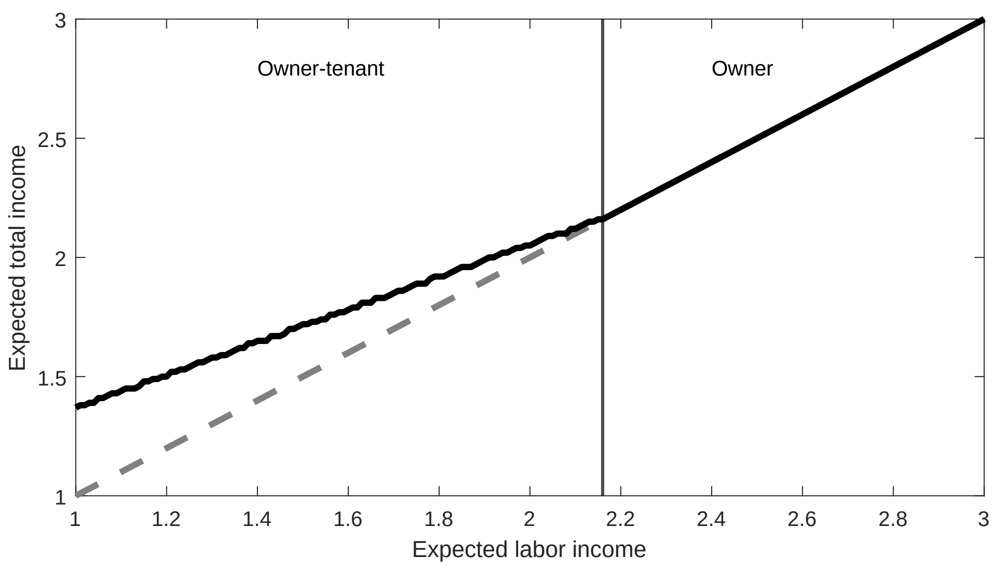


Figure 2
Probability of default under high and low compliance pressure

Default under high and low compliance pressure occurs when the cash on hand of the household falls below the levels of 1.8 and 2.0, respectively.

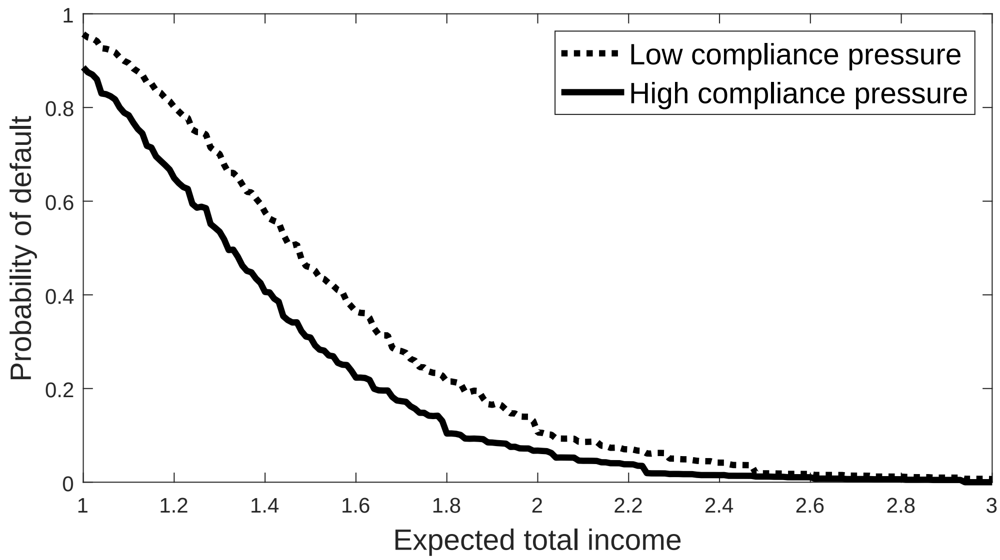
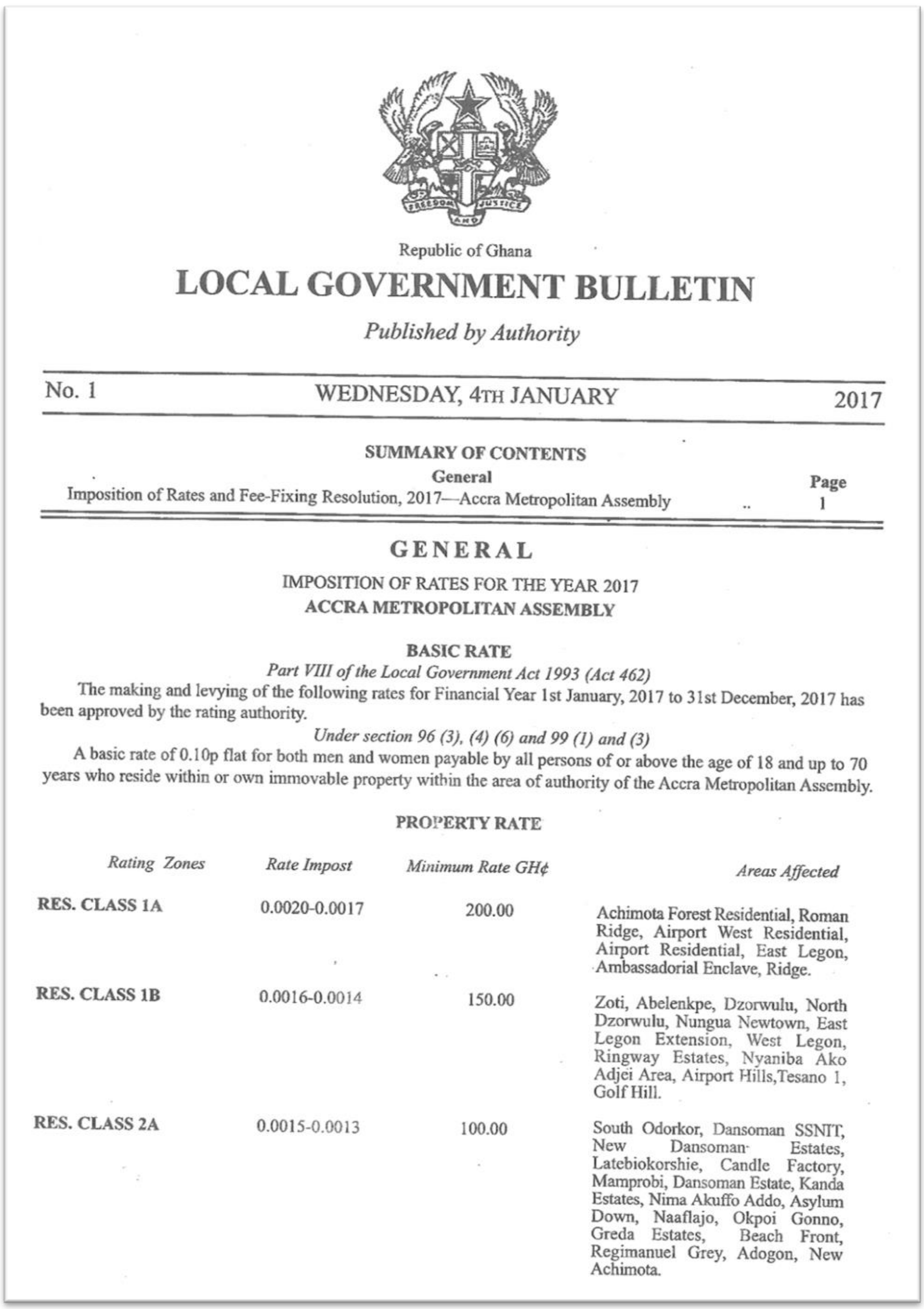


Figure 3
Property rate imposts and minimum rates

This figure presents the first two pages of a sample bulletin (for the year 2017), showing the property rate impost ranges and distribution of minimum rates for locations within the Accra Metropolitan Assembly (AMA), as categorized under residential rating zones.



Republic of Ghana

LOCAL GOVERNMENT BULLETIN

Published by Authority

No. 1 WEDNESDAY, 4TH JANUARY 2017

SUMMARY OF CONTENTS

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GENERAL

IMPOSITION OF RATES FOR THE YEAR 2017

ACCRA METROPOLITAN ASSEMBLY

BASIC RATE

Part VIII of the Local Government Act 1993 (Act 462)

The making and levying of the following rates for Financial Year 1st January, 2017 to 31st December, 2017 has been approved by the rating authority.

Under section 96 (3), (4) (6) and 99 (1) and (3)

A basic rate of 0.10p flat for both men and women payable by all persons of or above the age of 18 and up to 70 years who reside within or own immovable property within the area of authority of the Accra Metropolitan Assembly.

PROPERTY RATE

Rating Zones	*Rate Impost*	*Minimum Rate GH¢*	*Areas Affected*
RES. CLASS 1A	0.0020-0.0017	200.00	Achimota Forest Residential, Roman Ridge, Airport West Residential, Airport Residential, East Legon, Ambassadorial Enclave, Ridge.
RES. CLASS 1B	0.0016-0.0014	150.00	Zoti, Abelenkpe, Dzorwulu, North Dzorwulu, Nungua Newtown, East Legon Extension, West Legon, Ringway Estates, Nyaniba Ako Adjei Area, Airport Hills,Tesano 1, Golf Hill.
RES. CLASS 2A	0.0015-0.0013	100.00	South Odorkor, Dansoman SSNIT, New Dansoman Estates, Latebiokorshie, Candle Factory, Mamprobi, Dansoman Estate, Kanda Estates, Nima Akuffo Addo, Asylum Down, Naaflajo, Okpoi Gonno, Greda Estates, Beach Front, Regimanuel Grey, Adogon, New Achimota.

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Rating Zones	Rate Impost	Minimum Rate	Areas Affected
RES. CLASS 2B	0.0012	80.00	Kwashieman North, Sakaman-Busia, New Dansoman, Mateheko, West Abbosey Okai, Osofo Dadzie, Dansoman Exhibition, Dansoman Sahara, North Alajo, Adabraka, Kaneshie, Awudome Estates, North Kaneshie, North Kaneshie Estates – CFC, Abeka, Fadama, Tesano 2, Akweteman, Apenkwa, Abofu.
RES. CLASS 3A	0.00104-0.0009	70.00	Kwashiebu, Kwashieman, North Odorkor, Odorkor Old Town, Kwashieman Old Town, Odorkor, Stanley Owusu, Banana Inn, Korle Gonno, Mamprobi Sempey, Old Dansoman, Maamobi, Kotobabi Police Station, Kpehe, Aalajo, Kotobabi, James Town, Bubuashie/ Cable and Wireless, New Fadama, Abeka Lapaz, Alogboshie, Kisseman/Christian Village
RES. CLASS 3B	0.0009-00.0008	60.00	Abossey Okai, Sukura, Russia, Town Council Line, Sabon Zongo, Mamponse, Tunga, Nima, Accra New Town, Shiashie Village, Bawleshie Mempeasem, Old Town, Dakuman, Old Bubuashie, North Abeka, Nii Boyeman/Achimota, Anumle.
RES. CLASS 3C	0.0008-0.0007	50.00	Chorkor, Mpoase, Gbegbeise, Shiabu, Luga, Osu Amanfo/Alata

Figure 4
Yearly distribution of average minimum rate change

This figure shows the annual average percentage growth rate in the minimum rate amount that dwelling units were expected to pay. This commences from 2011 and ends in 2018 and is based on the minimum rate figures presented in Table 1.

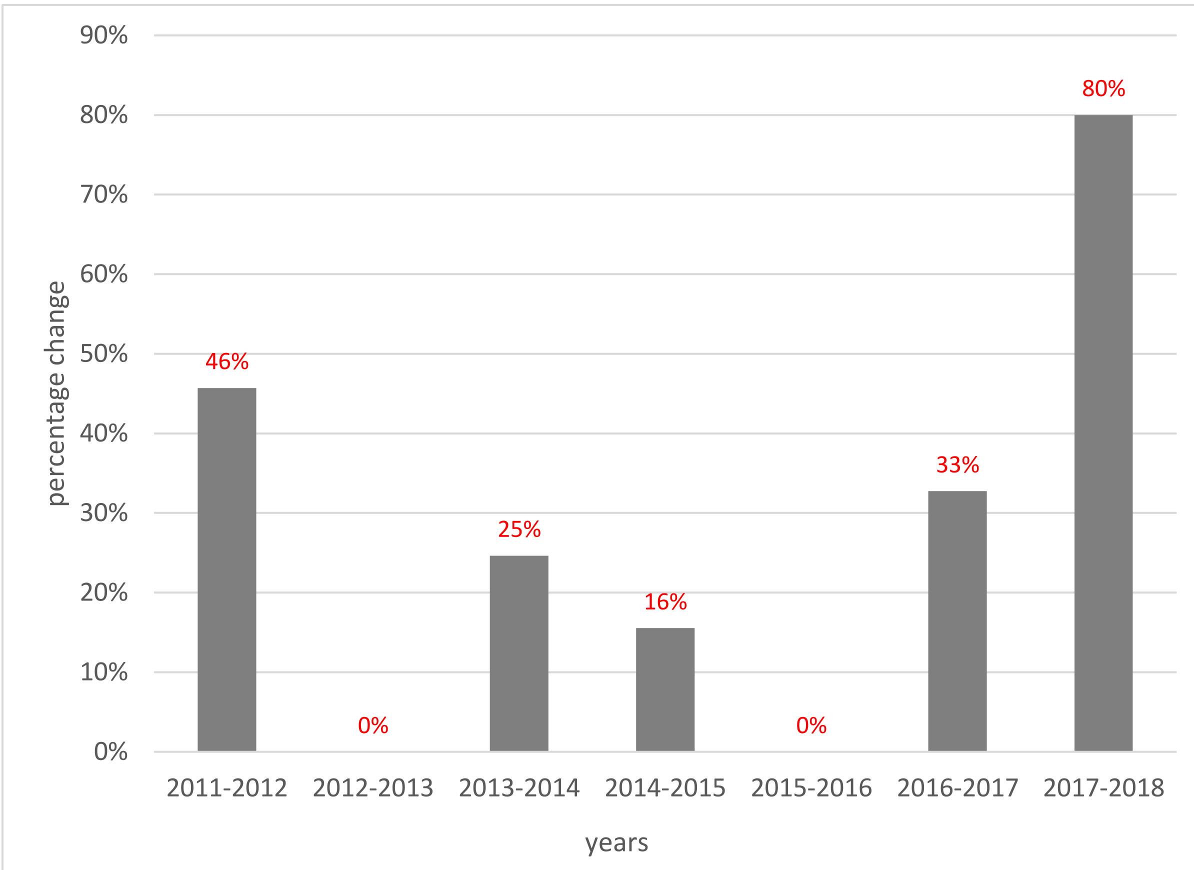


Table 1
Minimum rate distribution across rating zones and years

This table presents the annual minimum rates distributed across an eight-year period, 2011–2018, and the residential rating zone classes of the Accra Metropolitan Assembly (AMA). All amounts are in the local currency – Ghana Cedis (GHS). A, B and C are subdivisions within the rating zone classes, with 1A representing the most prime neighborhoods and 3C the least prime.

Rating zone class		Year							
		2011	2012	2013	2014	2015	2016	2017	2018
1	A	100.00	100.00	100.00	115.00	132.00	132.00	200.00	360.00
	B	50.00	80.00	80.00	90.00	104.00	104.00	150.00	270.00
2	A	40.00	60.00	60.00	70.00	81.00	81.00	100.00	180.00
	B	30.00	50.00	50.00	60.00	69.00	69.00	80.00	144.00
3	A	25.00	40.00	40.00	50.00	58.00	58.00	70.00	126.00
	B	20.00	30.00	30.00	40.00	46.00	46.00	60.00	108.00
	C	15.00	20.00	20.00	30.00	35.00	35.00	50.00	90.00

Table 2
Summary statistics

This table presents the summary statistics (mean, median and standard deviations (SD)) of the variables used in the study, also split by the occupancy categories. Variable definitions are given in Appendix B.

	Full sample			Owner	Owner-Tenant	Tenant
	Mean	Median	SD	Mean	Mean	Mean
Continuous variables:						
Amount unpaid (GHS)	53.73	50.00	47.42	53.74	50.55	56.36
Property tax payable (GHS)	68.87	58.00	40.76	70.50	63.83	68.82
Arrears proportion	0.72	1.00	0.44	0.70	0.72	0.77
Building floor area (sq. m.)	157.08	138.55	111.38	155.34	161.02	158.34
Property value (GHS)	24,120.53	22,148.50	15,560.60	24,343.38	25,382.09	22,486.05
Indicator variables:						
Arrears	0.78			0.76	0.79	0.82
Full arrears	0.76			0.74	0.76	0.80
Partial arrears	0.20			0.19	0.23	0.20
Rating Zone 1	0.06			0.07	0.02	0.07
Rating Zone 2	0.31			0.35	0.25	0.27
Rating Zone 3	0.62			0.58	0.73	0.66
Number of streets	2,966					
Number of observations	238,140			139,830	44,725	53,585

Table 3
Baseline regression results

This table reports regression results for the relationship between property tax arrears and occupancy categories. The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in column (1)), full nonpayment of property taxes (in column (2)), or partial nonpayment of property taxes (in column (3)); and zero if there is no property tax payment outstanding. In column (4), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors are clustered at the household level and given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears (1)	Full arrears (2)	Partial arrears (3)	Arrears proportion (4)
Owner-Tenant	0.022***	0.023***	0.023***	0.024***
	(0.004)	(0.004)	(0.005)	(0.004)
Tenant	0.047***	0.052***	0.021***	0.059***
	(0.003)	(0.004)	(0.005)	(0.004)
Property value	–0.023***	–0.041***	0.111***	–0.060***
	(0.002)	(0.002)	(0.003)	(0.003)
Property tax payable	–0.047***	–0.004**	–0.004**	
	(0.011)	(0.002)	(0.002)	
Building floor area	–0.003**	–0.038***	–0.092***	–0.005**
	(0.002)	(0.012)	(0.017)	(0.002)
Street fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.093	0.106	0.103	0.119
Observations	238,140	216,789	65,922	238,140

Table 4
Heterogeneity across rating zones

This table reports linear probability regression results for the relationship between property tax arrears and occupancy categories for the three rating zone subsamples (Rating Zones 1, 2, and 3). The dependent variable is indicated at the top of the columns, taking the value one if, for a given year, a household has any unpaid property taxes (in columns (1)–(3)), full nonpayment of property taxes (in columns (4)–(6)), or partial nonpayment of property taxes (in columns (7)–(9)); and zero if there is no property tax payment outstanding. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears			Full arrears			Partial arrears		
	Rating Zone 1 (1)	Rating Zone 2 (2)	Rating Zone 3 (3)	Rating Zone 1 (4)	Rating Zone 2 (5)	Rating Zone 3 (6)	Rating Zone 1 (7)	Rating Zone 2 (8)	Rating Zone 3 (9)
Owner-Tenant	0.041	0.019***	0.021***	0.040	0.020***	0.023***	0.042	0.016	0.025***
	(0.029)	(0.007)	(0.004)	(0.031)	(0.007)	(0.005)	(0.032)	(0.010)	(0.006)
Tenant	0.059***	0.047***	0.046***	0.063***	0.052***	0.051***	0.024	0.007	0.029***
	(0.014)	(0.006)	(0.004)	(0.015)	(0.006)	(0.004)	(0.015)	(0.009)	(0.006)
Property value	–0.033***	–0.023***	–0.020***	–0.055***	–0.042***	–0.038***	0.075***	0.132***	0.109***
	(0.010)	(0.004)	(0.003)	(0.011)	(0.004)	(0.003)	(0.013)	(0.007)	(0.004)
Property tax payable	0.084	0.128*	–0.036*	0.088	0.129*	–0.029	0.071	0.161	–0.063*
	(0.159)	(0.073)	(0.021)	(0.167)	(0.078)	(0.022)	(0.167)	(0.156)	(0.037)
Building floor area	–0.019**	–0.003	–0.002	–0.021***	–0.002	–0.003	–0.011	–0.008*	–0.002
	(0.008)	(0.003)	(0.002)	(0.008)	(0.003)	(0.002)	(0.007)	(0.004)	(0.003)
Street fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.099	0.091	0.093	0.111	0.103	0.106	0.055	0.098	0.113
Observations	14,900	74,756	148,483	13,701	68,753	134,332	5,314	20,443	40,141

Table 5
Exogenous rate shock analysis

This table reports linear probability regression results for the relationship between property tax arrears, occupancy categories and rate increases/shocks. The dependent variable is indicated in the first row, taking the value one if, for a given year, a household has any unpaid property taxes (in column (1)), full nonpayment of property taxes (in column (2)), or partial nonpayment of property taxes (in column (3)); and zero if there is no property tax payment outstanding. The key explanatory variables are the occupancy categories, rate shock and their respective interaction terms. Variable definitions are given in Appendix B. Street fixed effects are included. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears (1)	Full arrears (2)	Partial arrears (3)
Owner-Tenant	0.020***	0.021***	0.016**
	(0.005)	(0.006)	(0.008)
Tenant	0.054***	0.058***	0.025***
	(0.005)	(0.005)	(0.007)
Rate shock	0.049***	0.041***	0.111***
	(0.003)	(0.003)	(0.006)
Owner-Tenant × rate shock	0.010*	0.013**	0.035***
	(0.005)	(0.006)	(0.012)
Tenant × rate shock	–0.009*	–0.005	–0.001
	(0.005)	(0.005)	(0.011)
Property value	–0.024***	–0.042***	0.116***
	(0.002)	(0.002)	(0.005)
Property tax payable	0.107***	0.122***	0.109***
	(0.002)	(0.003)	(0.006)
Building floor area	–0.004**	–0.004**	–0.005*
	(0.002)	(0.002)	(0.003)
Street fixed effects	Yes	Yes	Yes
Adjusted R-squared	0.088	0.100	0.117
Observations	132,334	120,009	35,700

Table 6
Analysis by building types

This table reports linear probability regression results for the relationship between property tax arrears, occupancy categories, and the type of building material used (wattle and daub, mass swish, and sandcrete blocks, as the base category). The dependent variable is indicated at the top of the columns, taking the value one if, for a given year, a household has any unpaid property taxes (in columns (1)–(2)), full nonpayment of property taxes (in columns (3)–(4)), or partial nonpayment of property taxes (in columns (5)–(6)); and zero if there is no property tax payment outstanding. The key explanatory variables are the occupancy categories, building material types, and their respective interaction terms. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears		Full arrears		Partial arrears	
	(1)	(2)	(3)	(4)	(5)	(6)
Owner-Tenant	0.030***	0.028***	0.031***	0.029***	0.028***	0.028***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)
Tenant	0.052***	0.053***	0.058***	0.060***	0.021***	0.023***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.007)
Property value	–0.027***	–0.027***	–0.045***	–0.045***	0.116***	0.116***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)
Property tax payable	–0.051***	–0.051***	–0.044***	–0.045***	–0.090***	–0.090***
	(0.012)	(0.012)	(0.013)	(0.013)	(0.021)	(0.021)
Building floor area	–0.005**	–0.005**	–0.005**	–0.005**	–0.007**	–0.007**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Wattle and daub	–0.084	–0.169*	–0.104*	–0.198**	0.185***	0.180***
	(0.053)	(0.086)	(0.057)	(0.095)	(0.047)	(0.062)
Mass swish	–0.053***	–0.054***	–0.053***	–0.052***	–0.007	–0.001
	(0.009)	(0.015)	(0.009)	(0.015)	(0.010)	(0.014)
Wattle and daub × Owner-Tenant		0.237**		0.270**		-
		(0.098)		(0.107)		-
Wattle and daub × Tenant		0.142		0.156		0.013
		(0.109)		(0.118)		(0.094)
Mass swish × Owner-Tenant		0.012		0.010		–0.005
		(0.019)		(0.020)		(0.017)
Mass swish × Tenant		–0.007		–0.012		–0.015
		(0.019)		(0.019)		(0.017)
Street fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.103	0.103	0.116	0.116	0.118	0.118
Observations	141,015	141,015	128,554	128,554	37,230	37,230

Table 7

Reciprocity analysis: Proximity to public amenities and arrears

This table reports linear probability regression results for the relationship between propoerty tax arrears, occupancy categories, and distance to public amenities. Panel A presents the mean, median and standard deviation (SD) distance estimates from the location of each dwelling unit to the nearest hospital and police station. Panels B and C present results based on the distance to hospitals and police stations, respectively. The dependent variable is indicated in the first row of Panels B and C, taking the value one if, for a given year, a household has any unpaid property taxes (in columns (1)–(2)), full nonpayment of property taxes (in columns (3)–(4)), or partial nonpayment of property taxes (in columns (5)–(6)); and zero if there is no property tax payment outstanding. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

Panel A: Summary statistics of distance estimates to public amenities (in km)

	Mean	Median	SD
Hospital	4.42	4.23	2.03
Police station	1.18	1.12	0.57

Panel B: Distance to hospitals

	Arrears		Full arrears		Partial arrears	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to hospital	0.030***		0.032***		0.032***	
	(0.003)		(0.004)		(0.005)	
Distance to hospital × Owner		0.032***		0.034***		0.031***
		(0.004)		(0.004)		(0.005)
Distance to hospital × Owner-Tenant		0.029***		0.031***		0.031***
		(0.004)		(0.004)		(0.005)
Distance to hospital × Tenant		0.026***		0.028***		0.028***
		(0.004)		(0.004)		(0.005)
Owner-Tenant		0.036***		0.036***		0.022**
		(0.009)		(0.010)		(0.011)
Tenant		0.071***		0.077***		0.030***
		(0.009)		(0.010)		(0.011)
Property value		–0.023***		–0.041***		0.111***
		(0.002)		(0.002)		(0.003)
Property tax payable		–0.049***		–0.041***		–0.091***
		(0.011)		(0.012)		(0.017)
Building floor area		–0.003**		–0.004**		–0.004**
		(0.002)		(0.002)		(0.002)
Street fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.091	0.094	0.101	0.107	0.085	0.104
Observations	238,140	238,140	216,789	216,789	65,922	65,922

Panel C: Distance to police stations

	Arrears		Full arrears		Partial arrears	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to police	0.039***		0.041***		0.049***	
	(0.007)		(0.008)		(0.012)	
Distance to police × Owner		0.038***		0.038***		0.043***
		(0.008)		(0.008)		(0.012)
Distance to police × Owner-Tenant		0.030***		0.032***		0.054***
		(0.008)		(0.009)		(0.014)
Distance to police × Tenant		0.022***		0.021**		0.046***
		(0.008)		(0.008)		(0.014)
Owner-Tenant		0.031***		0.030***		0.012
		(0.008)		(0.008)		(0.012)
Tenant		0.067***		0.073***		0.018
		(0.007)		(0.008)		(0.012)
Property value		–0.023***		–0.041***		0.111***
		(0.002)		(0.002)		(0.003)
Property tax payable		–0.040***		–0.031***		–0.084***
		(0.011)		(0.012)		(0.017)
Building floor area		–0.003**		–0.004**		004**
		(0.002)		(0.002)		(0.002)
Street fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.090	0.093	0.101	0.106	0.084	0.103
Observations	238,140	238,140	216,789	216,789	65,922	65,922

Appendix A Theoretical proofs

Proof of Proposition 1. Let dwelling unit i be an owner-occupier with an average labor income of μ_i, and dwelling unit j be an owner-and-tenant-occupier with an average labor income of μ_j and an additional rental income of $k(H-h)$. We consider first the scenario without borrowing and lending.

Case $A_t = 0$. As $v(h)$ is concave, $v'(h) > v'(H)$. From equation (10) it follows that:

$$Eu'(x_t^i) < Eu'(x_t^j).$$

Denoting G_i as the distribution of $x_i = y^i$ and G_j as the distribution of $x_j = y^j + k(H-h^*)$, the above inequality can be represented as:

$$\int u'(x_t^i)dG_i(x_t^i) < \int u'(x_t^j)dG_j(x_t^i). \tag{A1}$$

As $u'(x_t^i)$ is decreasing, from the above inequality and equation (1) it follows that G_i first-order dominates G_j and hence $\mu^i > \mu^j + k(H-h^*)$. Therefore $G_i(\overline{x}) < G_j(\overline{x})$; i.e., dwelling unit i is less likely to default than dwelling unit j.

Case $A_t \geq 0$. From equation (12) it follows that:

$$E_0 \sum_{t=0}^{\infty} \beta^t \big[p(x_t^i)\big] < E_0 \sum_{t=0}^{\infty} \beta^t \big[p(x_t^j)\big]. \tag{A2}$$

We proceed by contradiction. Assume that $\mu^i < \mu^j + k(H-h^*)$ and thus dwelling unit i is more likely to be noncompliant. From the definition of "cash on hand" (see equation (8)) as well as the martingale and memory renewal property of x_t (see property (iii)), it follows that, for each period t, the probability distribution $G_t^j(x_t^j)$ first-order stochastically dominates $G_t^i(x_t^i)$. Since $p(x_t)$ is monotonically decreasing, it follows that for each period t

$$\int p(x_t^i)dG_t^i(x_t^i) > \int p(x_t^j)dG_t^j(x_t^i). \tag{A3}$$

Hence,

$$\sum_{t=0}^{\infty} \beta^t E\big[p(x_t^i)\big] < \sum_{t=0}^{\infty} \beta^t E\big[p(x_t^j)\big], \tag{A4}$$

a contradiction to (A2). □

Proof of Proposition 3. From Proposition 1 and the assumption that the TEN household has a higher income than the OWN household it follows that $F'_{TEN}(y) < F'_{OWN}(y) < F'_{OWN-TEN}(y)$ for $y = \overline{x}(\alpha, \tau)$. Part a) holds because by assumption $\frac{\partial \overline{x}(\tau,\alpha))}{\partial \tau} < 0$ and Part b) holds because $\frac{\partial \overline{x}(\tau,\alpha)}{\partial \alpha} > 0$. □

Appendix B Variable definitions

Variable	Definition
Panel A: Property tax and dwelling unit attributes	
Amount unpaid	Denotes the annual unpaid property tax amount in Ghanaian Cedis (GHS).
Arrears	Equal to one if a dwelling unit has an amount unpaid, and zero if it has no amount unpaid.
Full arrears	Equal to one if a dwelling unit has a full amount unpaid, and zero if it has no amount unpaid.
Partial arrears	Equal to one if a dwelling unit has a partial amount unpaid, and zero if it has no amount unpaid.
Arrears proportion	Denotes the quotient when amount unpaid is divided by property tax payable.
Property value	Denotes the ratable value (valuation-based) of a property, in Ghanaian Cedis (GHS). The variable is normalized by using a natural log transformation.
Property tax payable	Denotes the annual monetary property tax bill, in Ghanaian Cedis (GHS), for a dwelling unit. The variable is normalized by using a natural log transformation.
Building floor area	Denotes the total land area, in square meters (sq. m.), taken up by the external walls of a building.
Owner	Equal to one if a dwelling unit is completely occupied by the homeowner, and zero otherwise.
Owner-Tenant	Equal to one if a dwelling unit is jointly occupied by the homeowner and tenant(s), and zero otherwise.
Tenant	Equal to one if a dwelling unit is completely occupied by tenants, and zero otherwise.
Wattle and daub	Equal to one if a building is made of wattle and daub, and zero otherwise.
Mass swish	Equal to one if a building is made of mass swish, and zero otherwise.
Sandcrete	Equal to one if a building is made of sandcrete blocks, and zero otherwise.
Panel B: Location attributes	
Rating Zone 1	Equal to one if a dwelling unit is in an area designated by the Accra Metropolitan Assembly (AMA) as a residential class 1 rating zone, and zero otherwise. There are two subdivisions, 1A and 1B, which are jointly considered for the purposes of our analyses.
Rating Zone 2	Equal to one if a dwelling unit is in an area designated by the Accra Metropolitan Assembly (AMA) as a residential class 2 rating zone, and zero otherwise. There are two subdivisions, 2A and 2B, which are jointly considered for the purposes of our analyses.
Rating Zone 3	Equal to one if a dwelling unit is in an area designated by the Accra Metropolitan Assembly (AMA) as a residential class 3 rating zone, and zero otherwise. There are three subdivisions, 3A, 3B, and 3C, which are jointly considered for the purposes of our analyses.
Rate shock	Equal to one if year is either 2012 or 2018, and zero if year is either 2013 or 2016. This is based on the annual average percentage changes in the rating zone–based minimum rates, as shown in Figure 4.
Distance to hospitals	Denotes the shortest distance in kilometers from a dwelling unit to the nearest of three public hospitals: Korle-bu Teaching Hospital, Greater Accra Regional Hospital, and 37 Military Hospital. All distances are calculated using Stata's geodist function, which geographically measures the length of the shortest path between two points along the surface of a mathematical model of the earth (see Picard, 2010).
Distance to police	Denotes the shortest distance in kilometers from a dwelling unit to the nearest police station. All distances are calculated using Stata's geodist function, which geographically measures the length of the shortest path between two points along the surface of a mathematical model of the earth (see Picard, 2010).

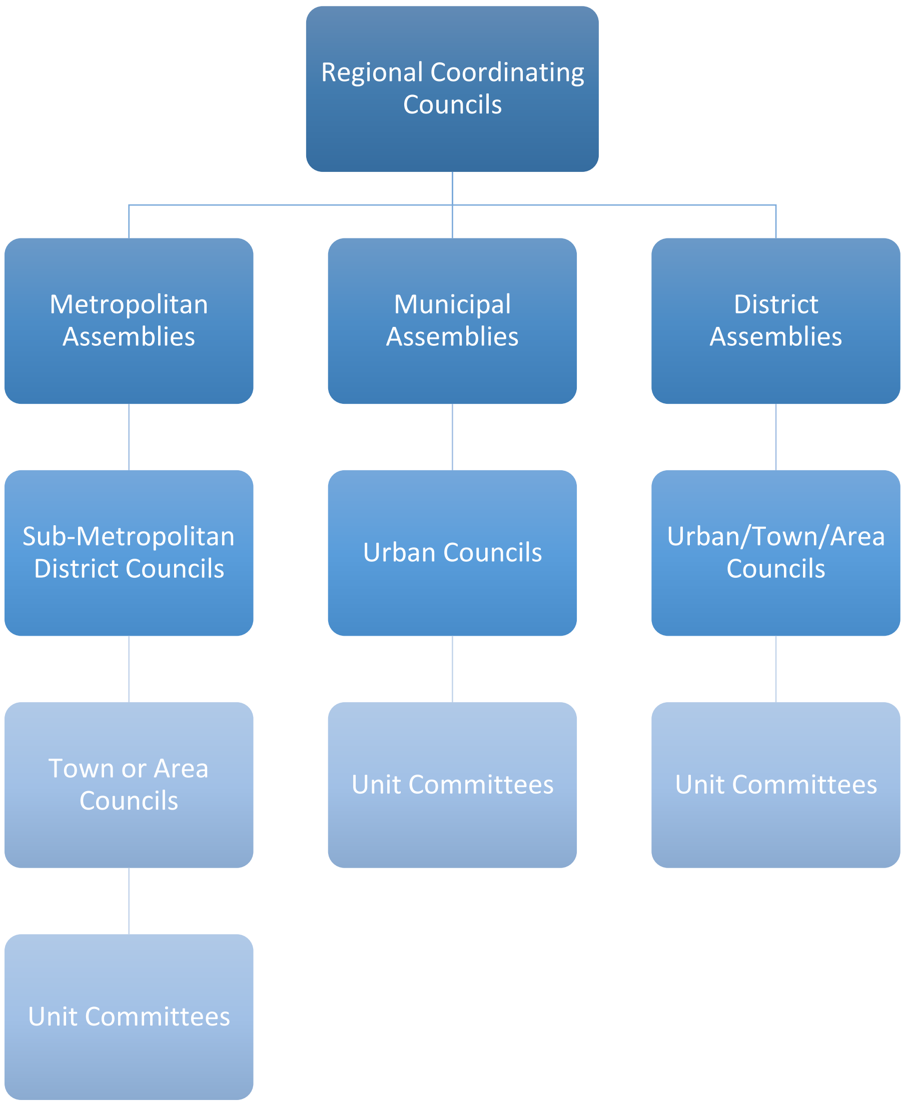
Shared Occupancy and Property Tax Arrears

Online Appendix

January 2025

Figure A1
Structure of the local governance system in Ghana

This figure displays the structure of the local governance in Ghana. It shows a 4-tier setup for Metropolitan Assemblies, and a 3-tier setup for both Municipal and District Assemblies.



Source: Adapted from Institute of Local Government Studies (ILGS), Ghana, 2008.

Figure A2
Residential rating zones

The figures show examples of areas in the three residential rating zones of the Accra Metropolitan Assembly (AMA). The AMA's residential rating zones are: 1A, 1B, 2A, 2B, 3A, 3B, and 3C, with 1A representing the most prime areas and 3C the least prime. To simplify the analysis, the A, B, and C sub-categories are jointly considered. Image Credit: Panel A – https://www.flickr.com/photos/sweggs/534895571; Panel B – https://www.flickr.com/photos/sweggs/510700598; Panel C – https://www.flickr.com/photos/caetie/9035079273 [Accessed November 19, 2020].

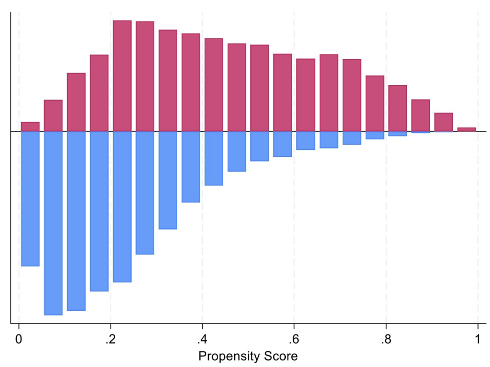
Panel A: East Legon (Zone 1)

Panel B: Adabraka (Zone 2)

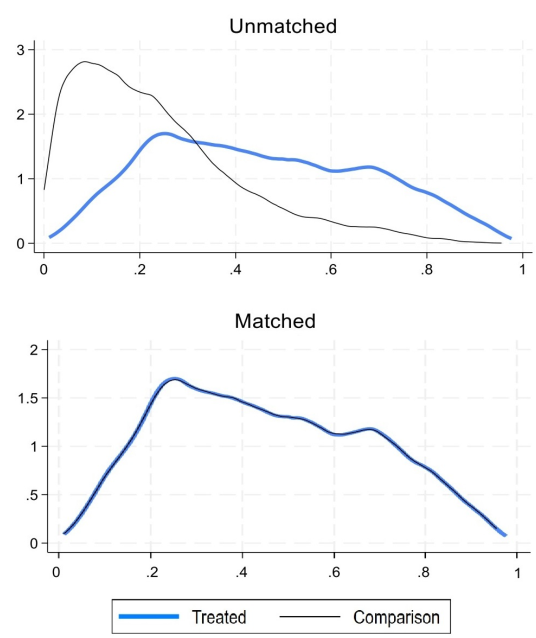
Panel C: Nima (Zone 3)

Figure A3
Propensity score matching diagnostic tests for the treatment group of shared occupancy category

This figure show the propensity score matching diagnostic tests for the treatment group (shared occupancy) and the comparison group (owner occupancy). Plot (a) shows the level of common support for properties in the treated group (in Red) and the comparison group (in Blue). Plot (b) shows the kernel density plots of the propensity scores for the treated and comparison groups before and after the match.



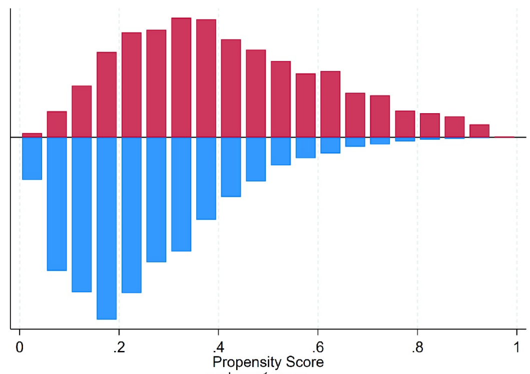
(a) Common support graph



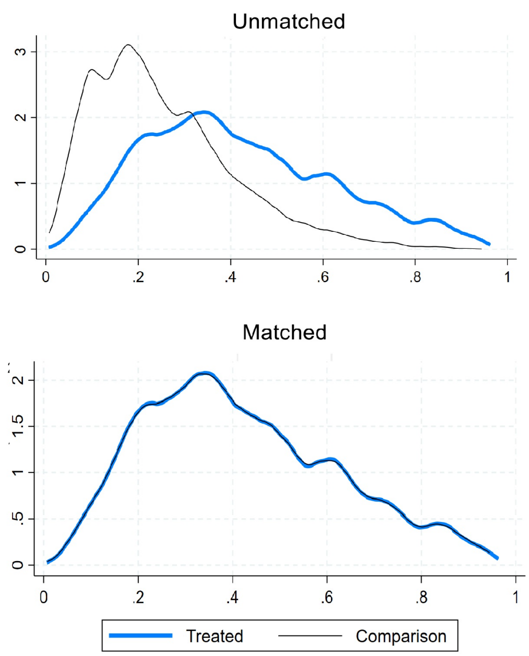
(b) Kernel densities

Figure A4
Propensity score matching diagnostic tests for the treatment group of tenant occupancy category

This figure show the propensity score matching diagnostic tests for the treatment group (tenant occupancy) and the comparison group (owner occupancy). Plot (a) shows the level of common support for properties in the treated group (in Red) and the comparison group (in Blue). Plot (b) shows the kernel density plots of the propensity scores for the treated and comparison groups before and after the match.



(a) Common support graph



(b) Kernel densities

Table A1
Minimum rate distribution across rating zones and years (USD)

The table presents the annual minimum rates (in monetary terms) distributed across an eight-year period, 2011–2018, and the residential rating zones of the Accra Metropolitan Assembly (AMA). A, B and C are subdivisions within the rating zones, with 1A representing the most prime neighborhoods and 3C the least prime. All amounts are converted from the local currency, Ghana Cedis (GHS), into US dollars (USD), using annual USD/GHS exchange rates listed on the World Bank website: https://data.worldbank.org/indicator/PA.NUS.FCRF?locations=GH [Accessed 20 December 2022].

Rating zone		Year							
		2011	2012	2013	2014	2015	2016	2017	2018
1	A	65.76	54.80	50.47	39.70	35.54	33.76	45.97	78.51
	B	32.88	43.84	40.38	31.07	28.00	26.60	34.48	58.88
2	A	26.30	32.88	30.28	24.17	21.81	20.72	22.99	39.26
	B	19.73	27.40	25.24	20.71	18.58	17.65	18.39	31.40
3	A	16.44	21.92	20.19	17.26	15.61	14.83	16.09	27.48
	B	13.15	16.44	15.14	13.81	12.38	11.77	13.79	23.55
	C	9.86	10.96	10.09	10.36	9.42	8.95	11.49	19.63

Table A2
Proportion of properties in arrears by year and rating zone

The table shows the proportion of properties in arrears each year from 2011 to 2018 across three residential rating zones of the Accra Metropolitan Assembly (AMA). The zones are categorized as 1A, 1B, 2A, 2B, 3A, 3B, and 3C, with 1A being the most prime and 3C the least prime. For simplicity, the A, B, and C sub-categories are combined in the analysis.

	Rating Zone 1	Rating Zone 2	Rating Zone 3
2011	0.61	0.70	0.73
2012	0.65	0.74	0.75
2013	0.63	0.75	0.74
2014	0.65	0.76	0.77
2015	0.63	0.73	0.75
2016	0.66	0.76	0.78
2017	0.68	0.82	0.81
2018	0.83	0.89	0.87

Table A3
Robustness of baseline results: assessing the impact of potential omitted variable bias using Oster (2019) test

This table reports results of the Oster (2019) test assessing whether the inclusion of unobserved variables could significantly alter the key coefficient estimates in the main paper Table 3, and how robust the results are to the possible bias arising from omitted variables. δ is given by $\frac{\beta_{fm}}{\beta_{lm}-\beta_{fm}} \times \frac{R_{fm}-R_{lm}}{R_{max}-R_{fm}}$. $\beta_{fm}(\beta_{lm})$ is the Owner-Tenant and Tenant coefficient, from the model with (without) the control variables. R_{max} is the R-squared from a hypothetical regression that includes all regressors, including unobserved control variables. $R_{max} = 1.3 \times R_{fm}$. $R_{fm}(R_{lm})$ is the R-squared from the model with (without) the control variables. The beta bounds encapsulate a bounding set, $[\beta^*, \beta_{fm}]$ or $[\beta_{fm}, \beta^*]$, on β, where β^* is bias-adjusted effect of occupancy type on arrears outcomes.

Dependent variable	Occupancy covariates	δ	Beta bounds
Arrears:	Owner-Tenant	–7.634	[0.022, 0.028]
	Tenant	7.836	[0.046, 0.047]
Full arrears:	Owner-Tenant	–4.356	[0.023, 0.032]
	Tenant	6.502	[0.049, 0.052]
Partial arrears:	Owner-Tenant	2.195	[0.015, 0.023]
	Tenant	–3.369	[0.021, 0.031]
Arrears proportion:	Owner-Tenant	–3.768	[0.024, 0.034]
	Tenant	6.078	[0.055, 0.059]

Table A4
Robustness check of baseline results with street-year fixed effects

This table reports regression results for the relationship between property tax arrears and occupancy categories after controlling for street $\times$ year fixed effects. The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in column (1)), full nonpayment of property taxes (in column (2)), or partial nonpayment of property taxes (in column (3)); and zero if there is no property tax payment outstanding. In column (4), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B of the paper. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears (1)	Full arrears (2)	Partial arrears (3)	Arrears proportion (4)
Owner-Tenant	0.022*** (0.004)	0.023*** (0.004)	0.021*** (0.005)	0.024*** (0.005)
Tenant	0.047*** (0.003)	0.052*** (0.004)	0.017*** (0.005)	0.059*** (0.004)
Property value	–0.023*** (0.002)	–0.041*** (0.002)	0.100*** (0.004)	–0.060*** (0.003)
Property tax payable	–0.048*** (0.013)	–0.039*** (0.014)	–0.104*** (0.020)	
Building floor area	–0.003** (0.002)	–0.004** (0.002)	–0.005** (0.002)	–0.005** (0.002)
Street×year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.104	0.118	0.119	0.122
Observations	235,788	214,346	61,441	235,788

Table A5
Robustness check of baseline results after double clustering standard errors

This table reports regression results for the relationship between property tax arrears and occupancy categories after double clustering standard errors by household and year. The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in column (1)), full nonpayment of property taxes (in column (2)), partial nonpayment of property taxes (in column (3)); and zero if there is no property tax payment outstanding. In column (4), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B of the paper. Street and year fixed effects are included. Statistical significance at the 10, 5, and 1 percent levels are denoted by *, **, and ***, respectively.

	Arrears (1)	Full arrears (2)	Partial arrears (3)	Arrears proportion (4)
Owner-Tenant	0.022*** (0.002)	0.023*** (0.003)	0.023*** (0.005)	0.024*** (0.003)
Tenant	0.047*** (0.002)	0.052*** (0.002)	0.022*** (0.005)	0.059*** (0.002)
Property value	–0.023*** (0.001)	–0.041*** (0.002)	0.111*** (0.003)	–0.060*** (0.001)
Property tax payable	–0.047*** (0.008)	–0.038*** (0.008)	–0.092*** (0.016)	
Building floor area	–0.003*** (0.001)	–0.004*** (0.001)	–0.004** (0.002)	–0.005*** (0.001)
Street fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.093	0.106	0.103	0.119
Observations	238,140	216,789	65,922	238,140

Table A6
Heterogeneity across rating zones with arrears proportion as dependent variable

This table reports regression results for the relationship between property tax arrears and occupancy categories for the three rating zone subsamples (Rating Zones 1, 2, and 3). The dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B of the paper. Street and year fixed effects are included. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears proportion		
	Rating Zone 1 (1)	Rating Zone 2 (2)	Rating Zone 3 (3)
Owner-Tenant	0.055	0.026***	0.021***
	(0.034)	(0.008)	(0.005)
Tenant	0.073***	0.061***	0.056***
	(0.016)	(0.007)	(0.005)
Property value	–0.073***	–0.062***	–0.056***
	(0.012)	(0.005)	(0.003)
Building floor area	–0.020**	–0.004	–0.004
	(0.009)	(0.004)	(0.002)
Street fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Adjusted R-squared	0.124	0.111	0.123
Observations	14,900	74,756	148,483

Table A7
Reciprocity analysis with arrears proportion as dependent variable

This table reports regression results for the relationship between property tax arrears, occupancy categories and distance to amenities (hospitals and police stations). The dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, the distance estimates to public amenities, and their respective interaction terms. Variable definitions are given in Appendix B of the paper. Street and year fixed effects are included. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears proportion			
	Distance to hospitals		Distance to police stations	
	(1)	(2)	(3)	(4)
Distance to hospitals	0.036*** (0.004)			
Distance to police stations			0.049*** (0.009)	
Distance to hospitals × Owner		0.037*** (0.004)		
Distance to police stations × Owner				0.046*** (0.009)
Distance to hospitals × Owner-Tenant		0.036*** (0.004)		
Distance to police stations × Owner-Tenant				0.047*** (0.010)
Distance to hospitals × Tenant		0.031*** (0.004)		
Distance to police stations × Tenant				0.031*** (0.010)
Owner-Tenant		0.030*** (0.011)		0.024** (0.010)
Tenant		0.084*** (0.011)		0.077*** (0.009)
Property value		–0.060*** (0.003)		–0.060*** (0.003)
Building floor area		–0.005** (0.002)		–0.005** (0.002)
Street fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.112	0.120	0.111	0.120
Observations	238,140	238,140	238,140	238,140

Table A8
Propensity score matching approach

This table reports regression results for the relationship between property tax arrears and occupancy categories using a propensity score matching approach. The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in columns (1)–(2)), full nonpayment of property taxes (in column (3)–(4)), or partial nonpayment of property taxes (in columns (5)–(6)); and zero if there is no property tax payment outstanding. In columns (7)–(8), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The even-numbered columns show the results for the shared occupancy treatment group, while the odd-numbered columns show the results for the tenant occupancy treatment groups. The owner occupancy category serves as the comparison group. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors are clustered at the household level and given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears		Full arrears		Partial arrears		Arrears proportion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Owner-Tenant	0.020***		0.022***		0.028***		0.020***	
	(0.005)		(0.005)		(0.007)		(0.006)	
Tenant		0.046***		0.053***		0.020***		0.057***
		(0.004)		(0.004)		(0.006)		(0.005)
Property value	–0.013***	–0.021***	–0.041***	–0.035***	0.115***	0.106***	–0.054***	–0.053***
	(0.005)	(0.003)	(0.005)	(0.004)	(0.008)	(0.007)	(0.006)	(0.004)
Property tax payable	–0.065***	–0.042**	–0.054**	–0.037**	–0.067*	–0.099***	–0.027	–0.016
	(0.021)	(0.017)	(0.023)	(0.018)	(0.037)	(0.033)	(0.025)	(0.020)
Building floor area	–0.005	–0.004	–0.002	–0.007**	–0.004	–0.000	–0.006	–0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.003)
Street fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.103	0.118	0.115	0.126	0.138	0.132	0.128	0.145
Observations	68,271	82,619	61,209	76,284	18,306	18,357	68,271	82,619
Propensity score matching statistics:								
Mean bias % across covariates before match	1.8	1.5	1.8	1.5	2.1	1.8	1.8	1.5
Mean bias % across covariates after match	0.6	0.5	0.6	0.5	1.0	0.9	0.6	0.5

Table A9
Robustness checks after dropping households noncompliant in all years

This table reports regression results for the relationship between property tax arrears and occupancy categories after dropping households who were noncompliant for the entire sample period (2012-2018). The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in column (1)) or full nonpayment of property taxes (in column (2)); and zero if there is no property tax payment outstanding. In column (3), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors are clustered at the household level and given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears (1)	Full arrears (2)	Arrears proportion (3)
Owner-Tenant	0.025*** (0.004)	0.026*** (0.004)	0.027*** (0.005)
Tenant	0.040*** (0.004)	0.045*** (0.004)	0.052*** (0.005)
Property value	0.062*** (0.003)	0.045*** (0.003)	0.028*** (0.003)
Property tax payable	–0.088*** (0.013)	–0.076*** (0.014)	
Building floor area	–0.003* (0.002)	–0.004* (0.002)	–0.005** (0.002)
Street fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Adjusted R-squared	0.091	0.097	0.103
Observations	184,520	163,165	184,520

Table A10
Robustness checks including the sample of non-minimum-rate payers

This table reports regression results for the relationship between property tax arrears and occupancy categories using the full sample of households (minimum-rate and non-minimum-rate payers). The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in column (1)), full nonpayment of property taxes (in column (2)), or partial nonpayment of property taxes (in column (3)); and zero if there is no property tax payment outstanding. In column (4), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors are clustered at the household level and given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears (1)	Full arrears (2)	Partial arrears (3)	Arrears proportion (4)
Owner-Tenant	0.021*** (0.003)	0.023*** (0.004)	0.023*** (0.005)	0.020*** (0.005)
Tenant	0.047*** (0.003)	0.053*** (0.004)	0.022*** (0.005)	0.060*** (0.004)
Property value	–0.017*** (0.002)	–0.040*** (0.002)	0.108*** (0.003)	–0.052*** (0.003)
Property tax payable	–0.003 (0.005)	–0.035*** (0.010)	–0.071*** (0.015)	
Building floor area	–0.003** (0.002)	–0.004** (0.002)	–0.004* (0.002)	–0.005** (0.002)
Street fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.087	0.104	0.100	0.094
Observations	271,572	222,300	67,925	271,572

Table A11
Alternative specifications with suburb and rating zone fixed effects

This table reports regression results for the relationship between property tax arrears and occupancy categories after controlling for suburb and rating zone fixed effects. The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in columns (1)–(2)), full nonpayment of property taxes (in columns (3)–(4)), or partial nonpayment of property taxes (in columns (5)–(6)); and zero if there is no property tax payment outstanding. In columns (7)–(8), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B of the paper. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears		Full arrears		Partial arrears		Arrears proportion	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Owner-Tenant	0.023***	0.026***	0.024***	0.028***	0.026***	0.024***	0.027***	0.030***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)
Tenant	0.047***	0.053***	0.052***	0.059***	0.021***	0.021***	0.061***	0.066***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Property value	–0.027***	–0.035***	–0.046***	–0.055***	0.108***	0.108***	–0.065***	–0.079***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
Property tax payable	–0.056***	–0.132***	–0.049***	–0.134***	–0.115***	–0.137***		
	(0.008)	(0.008)	(0.008)	(0.009)	(0.013)	(0.013)		
Building floor area	–0.003**	–0.000	–0.003**	–0.000	–0.004*	–0.001	–0.005**	–0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Suburb fixed effects	Yes	No	Yes	No	Yes	No	Yes	No
Rating zone fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.068	0.035	0.078	0.042	0.081	0.059	0.083	0.037
Observations	238,177	238,178	216,829	232,779	66,063	58,138	238,177	238,178

Table A12
Heterogeneity across property values

This table reports regression results for the relationship between property tax arrears and occupancy categories for subsamples of high and low property values, determined based on median values. The dependent variable takes the value one if, for a given year, a household has any unpaid property taxes (in columns (1)–(2)), full nonpayment of property taxes (in columns (3)–(4)), or partial nonpayment of property taxes (in columns (5)–(6)); and zero if there is no property tax payment outstanding. In columns (7)–(8), the dependent variable is, for a given year, the ratio of the property tax amount unpaid to the property tax amount expected to be paid. The key explanatory variables are the occupancy categories, with owner-occupiers as the base category. Variable definitions are given in Appendix B. Street and year fixed effects are included. Standard errors clustered at the household level are given in parentheses. Statistical significance at the 10, 5, and 1 percent levels is denoted by *, **, and ***, respectively.

	Arrears		Full arrears		Partial arrears		Arrears proportion	
	Low property value (1)	High property value (2)	Low property value (3)	High property value (4)	Low property value (5)	High property value (6)	Low property value (7)	High property value (8)
Owner-Tenant	0.022***	0.021***	0.023***	0.025***	0.021***	0.013*	0.022***	0.026***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.007)	(0.008)	(0.006)	(0.006)
Tenant	0.039***	0.055***	0.041***	0.063***	0.011*	0.032***	0.046***	0.071***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.008)	(0.005)	(0.006)
Property value	–0.033***	–0.006	–0.041***	–0.019***	0.093***	0.002	–0.050***	–0.046***
	(0.003)	(0.007)	(0.004)	(0.007)	(0.005)	(0.011)	(0.004)	(0.009)
Property tax payable	–0.051***	–0.017	–0.034**	–0.009	–0.099***	–0.056**	–0.013	0.007
	(0.015)	(0.017)	(0.016)	(0.018)	(0.022)	(0.028)	(0.017)	(0.021)
Building floor area	–0.008***	0.000	–0.008***	0.000	–0.006**	–0.005	–0.010***	0.000
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Street fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.112	0.098	0.123	0.109	0.115	0.098	0.136	0.124
Observations	119,066	119,073	108,389	108,392	32,843	32,848	119,066	119,073