The Political Economy of Ethnicity and Property Rights in Slums: Evidence from Kenya

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Draft version

Abstract

We show that ethnic patronage and informal property rights provide an avenue for rent extraction in Kenyan slums. As is common across slums in the developing world, most households in our area of study have a landlord and pay a rent for their dwelling. Our identification relies on the exogenous appointment of local chiefs governing the area. We find that rents are higher, and investments lower, when the landlord and the chief belong to the same tribe, and the opposite when the tenant and the chief belong to the same tribe. These effects are stronger for households in areas with arguably weaker property rights. We interpret this as evidence that ethnic networks interact with the nature of property rights in the slum to determine rents and investment. A landlord and a chief are more likely to collude and extract rents from tenants if they belong to the same tribe, and a chief is more likely to side with a tenant against a landlord if he and the tenant belong to the same tribe. We provide several robustness checks to support these results.

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1 Introduction

Institutions surrounding property rights have been shown to critically affect long-run economic development. There is widespread evidence that strong property rights increase agricultural productivity (Besley 1995; Banerjee, Gertler and Ghatak 2002; Goldstein and Udry 2008; Hornbeck 2010), private sector investments (Johnson, McMillan and Woodruff 2002), as well as financial development and economic growth (Acemoglu and Johnson 2005). Individuals with insecure tenancy rights will not invest in their assets for fear of future expropriation (Jacoby, Li and Rozelle 2002), or alternatively they must commit sizeable resources to protecting the safety of these assets (Field 2007).

In the development economics literature, the emphasis has generally been on studies of property rights on the agricultural side. In this paper, we study poor urban environments, where property rights on the land may also affect investments and welfare in a variety of ways. Land rights issues are, for example, put forth as an explanation for the persistence of slums: without formal titles to the land they occupy, the urban poor do not have any incentive to upgrade their dwellings. This has motivated a push for land titling programs in slums since formal titles would provide collateral and free up resources for all types of household investments (an argument popularized by de Soto (2000)).[1]

However, this approach has also led much of the literature to overlook the role informal property rights play in determining the allocation of housing in slum settlements.[2] Although most slums are located on nominally vacant land, widespread anecdotal evidence indeed suggests that a large fraction of slum residents are rent-paying tenants, rather than squatters. These rents are usually paid to private individuals referred to as "landlords", whose informal rights over the slums are strongly enforced locally. In this paper, we analyze how property rights are governed in one of the world's largest informal settlements: the Kibera slum in Nairobi, Kenya.

To understand how informality affects institutions in the housing market and the price of housing, we look at the interaction between local authorities (in this environment, chiefs), landlords and tenants. Our identification strategy uses the fact that the Provincial Administration exogenously appoints chiefs to their positions within Nairobi, and that chiefs are regularly rotated around the city. Because the chiefs are frequently transferred, they have limited time to form relationships with local stakeholders and to establish rent extraction mechanisms. We look at ethnicity as a factor that potentially facilitates the establishment of such mechanisms.

"Chiefs" in the context of our study are not traditional ethnic leaders imposed by local custom (as documented in Acemoglu, Reed and Robinson (2012) in the context of Sierra Leone, or

[1]Several studies have looked at the impact of urban land titling on the investment decisions made by households, but there is little rigorous empirical work on slums (exceptions include Field 2007; Galiani and Schargrodksy 2010).

[2]An exception is Lanjouw and Levy (2002) who show that informal rights could effectively substitute for formal rights in a slum context, using data from Ecuador.

Michalopoulos and Papaionnou (2013) in the African context more broadly), but employees of the administration locally recognized as chiefs. Here we argue that although the power of chiefs in urban areas is of a slightly different nature than rural chiefs studied in the literature,[3] some attributes of chief authority - the ability to transact ethnic capital and to settle tribal disputes - may persist in urban areas.

Our main results can be summarized as follows. First, we find that a match between the tribe of the chief and that of the landlord results in higher rents paid by tenants, by approximately 7%. We interpret this as evidence that chiefs and landlords, when they belong to the same tribe (but the tenant does not), "collude" to extract higher rents from tenants. A match between the tribe of the chief and that of the tenants is correlated with lower rents paid by tenants (by the same order of magnitude), implying a chief will side with a co-ethnic tenant in cases of rents disputes. In addition, surprisingly, we find that a tribal match between households and landlords has little impact on rents. Unbundling the mechanisms behind these effects is crucial to understand the economic constraints faced by slum residents: given the high prevalence of poverty in the slum, small variations in rents may have a large impact on households' livelihoods.

Second, we find that investments in the housing infrastructure are lower (though not significantly so) when a landlord and the chief belong to the same tribe, and significantly higher when the household and the chief belong to the same tribe. We measure investments by looking at the age of a household's roof, as measured by the roof's luminosity (brightness) from high resolution satellite images of the slum.[4] This evidence seems to reinforce our previous results: quality-adjusted rents are even worse for households whose landlord is of the same tribe as the chief, and similarly better when the chief is of their own tribe. Crucially, these results also suggest that ethnic patronage surrounding housing rents have longer term effects on investments and welfare in slum neighborhoods.

Finally, looking at the heterogeneity in our effects on rents, we find that the effects of ethnic matches are stronger (more positive and more negative, respectively) in areas where residents have no ownership over the land, and where there is no investment in the quality of the dwellings made by residents. In other words, market distorsions in the form of ethnic patronage are more salient in areas where formal property rights are more weakly defined.

To interpret these results, we draw on a variety of qualitative accounts on the key role ethnic networks play in the governance of Kibera. In particular, Joireman (2011) documented that a chief will generally side with members of the same ethnic group in cases of rent disputes

[3] Michalopoulos and Papaioannou (2013) provide a comprehensive review of this literature. Using Afrobarometer data, they also show that ethnic leaders do not have much control over public goods allocation, but that they play a major role in local dispute resolution and property rights allocation.

[4] The satellite imagery allows us to measure the luminosity reflected by roofs during daytime. 96% of roofs in the slum are made of corrugated iron, which is shiny when new, but rusts, degrades and hence darkens over time. In the Appendix, we show that our measure of roof quality based on the satellite data is consistent with the survey data collected on the ground, and correlates with other types of self-reported housing investments.

involving different ethnicities.[5] She also documented how permissions are needed from the chief to upgrade housing structures, interactions that often involve rent-seeking and bribery.[6]

Based on extensive survey data we collected in Kibera, we provide evidence to defend our main identification assumption that the appointment of chiefs is exogenous to people in the slum. One concern would be that households sort into slum areas based on the ethnicity of chiefs. This sorting would imply that housing rents are driven by unobservables, such as the level of public goods access in the areas that households move into. An additional concern could be that richer households occupy better-quality housing in areas where the landlord and the chief are of the same tribe. This could have resulted, for example, from the fact that landlords are better able to invest in their structures where the competent chief is of the same tribe (though this latter case is ruled out by our investment results).

We conduct two main identification checks and find little evidence to support these concerns. First, using the 2009 census data for the slum, we show that *ex ante* socioeconomic characteristics of households do not predict ethnic matches in 2012. On the contrary, these socioeconomic characteristics do correlate strongly with the rents paid by households. If households were sorting based on underlying characteristics, we would have expected at least some of the variables observed in 2009 to predict the ethnicity match variables in 2012. Second, we use a regression discontinuity (RD) specification to show that our results hold, and are in fact stronger, within very small bandwidths around the administrative boundaries within the slum, where the costs for households migrating across boundaries are presumably the lowest. In fact, our data supports the notion that the mobility of households within the slum is limited. Households have lived in the same structure and with the same landlords for long periods of time (8 and 7 years, respectively), much longer than the typical tenure of a chief within the slum, which averages 23 months in our data.

The paper is structured as follows. Section 2 provides historical and institutional background on land tenure issues in the Kibera slum. Section 3 describes the data collected in the field as well as the methodology used to construct estimates of roof quality based on high-resolution satellite imagery. Section 4 describes our empirical framework. Section 5 provides our main results, including our identification and robustness checks. Section 6 concludes.

[5]Ethnic groups are commonly referred to as tribes in Kenya. We indifferently use the two terms in this paper.

[6]These mechanisms are also consistent with earlier findings that ethnic favoritism influences the allocation of public goods in Kenya (Burgess et al. 2011; Kramon and Posner 2012) and elsewhere in Sub-Saharan Africa (Franck and Rainer 2012).

2 Background

2.1 A Brief History of Kibera

The history of Kibera is closely intertwined with that of Nairobi, a city that was founded *ex nihilo* by the British as a railway depot in 1899 and soon after chosen to become the capital of Kenya. Kibera was established nearby the new colony a decade later, in 1912, to accommodate veteran Sudanese soldiers from the King's African Rifles (KAR), a contingent of the British colonial army. For several decades, the KAR veterans and their families were the only Kibera residents with formal land permits that exempted them from hut taxes; but the settlement also soon became a refuge for Kenyan rural migrants as Nairobi expanded to 120,000 inhabitants by the end of World War II. By that time, only a small fraction of the 3,000 Kibera residents were relatives of the initial Sudanese (also referred to as Nubian) settlers (Parsons 1997). The British authorities never recognized Kibera as a legal settlement, but failed to evict its inhabitants until Kenya's independence in 1963.

After independence, the Kenyan government formally reclaimed property over the Kibera area and tried to discourage new settlements. In spite of this, the population of slum dwellers continued to increase steadily, from 17,000 in 1972 to 62,000 in 1979 (Amis 1984) and probably several hundred thousands in the 1990s. Current estimates range between 170,000, the official census number released in 2009, to more than one million according to unofficial sources (Map Kibera Project 2008). Figure 1 shows a map of the Kibera area, which nowadays spans slightly less than 10 square kilometers in the center of Nairobi.

A densely populated and ethnically diverse area, Kibera has experienced many episodes of inter-ethnic violence in the past, and was amongst the areas heavily affected by the post-election violence in early 2008. The ethnic makeup of Kibera is not reflective of that of Kenya, since Luos, Luhyas and Kambas, in that order, are the tribes most represented in the slum (representing 36%, 27% and 15% of the slum population, respectively), while Kikuyus (the most prevalent tribe in the country) represent only 6% based on our listing data. Luo immigration increased from the 1970s onwards when the slum became a safe haven from members of this tribe fleeing ethnic violence in rural areas (Joireman 2011). Kenyans of Nubian origin constitute only a small fraction of Kibera's current population, yet they remain well represented amongst the local administration and land title holders, as described below. Figure 2 shows the distribution of household tribes across the slum.

2.2 Land Issues and Landlords in Kibera

Land ownership and tenancy rights in Kibera have been ambiguous ever since the establishment of the settlement. Throughout the colonial period, the entirety of Kibera's land remained the property of the British Crown.[7] The original Nubian settlers, legally considered "Tenants of the Crown", remained the slum's only residents with permits that allowed them construction and settlement (Joireman 2011; de Smedt 2011). This *de jure* status perpetuated itself until 1969, when the post-colonial Government officially revoked the Nubian claims on the land.

In the meantime, however, a *de facto* housing market had developed in which so-called "landlords", usually long-term residents of the settlement, allocated or rented structures to newcomers (Amis 1984; Temple 1974). Starting in 1974, new land titles were (illegally) re-allocated by local chiefs and bureaucrats in the provincial administration, engendering the creation of 1,400 new structures and a tripling of the Kibera population in less than a decade (Amis 1984). These political favors resulted in the current situation where Kibera land formally remains the Government's property, but the housing market is effectively controlled by private landlords. From our data, it seems that there are, in fact, at least several hundred different landlords in Kibera.[8] These landlords mostly do not have official property rights on land in the slum,[9] but were allowed (often by the District Officer (de Smedt 2011)) to build, to buy and to rent out habitable structures.

Since independence, the majority of landlords in Kibera have been members of either the Kikuyu or the Nubi tribe (Amis 1984; Joireman 2011), although Kikuyus and Nubis never represented a sizeable fraction of the Kibera population after World War II. These two groups may have been better able to obtain land titles from the administration (a claim made by Amis (1984)) and appeared to always have been mostly well-to-do, absentee landlords. Syagga et al (2002) reported on a survey of Kibera landlords where more than 80% of landlords lived outside of the slum and 57% were public officials (Joireman 2011). These landlords seem to be entrenched, as most residents have had the same landlord for many years (7 years in our sample). Our own survey data also suggests that the majority of landlords (55%) are Kikuyus or Nubis living in estates outside Kibera.[10] The remaining half of landlords is predominantly Luo (17%), Luhya (11%), Kamba (8%) and Kisii (5%). Figure 3 displays the distribution of landlord tribes across the slum.

In our data, about 8% of resident households report owning their housing, irrespective of whether they have a title or not. In the 2009 census for the slum, 87% of households reported renting from a private individual, 6% reported owning after having purchased their house, 3% reported owning after having constructed their house and 2% reported owning after inheriting

[7]This was under the Crowns Land Ordinance of 1902.

[8]Our data does not allow us to calculate the exact number of landlords, since some households did not provide us with the full name of their landlord.

[9]The Nubi landlords claim official property rights based on the permits allocated by the British to their ancestors in the early days of Kibera. According to most sources, these permits have all expired or been revoked since Kenyan independence.

[10]In our survey data, 33% of households reported dealing with a Kikuyu landlord and 22% with a Nubi landlord. The proportion reported by Amis (1984) in the early 1980s was 66% and 22% for the Kikuyus and Nubis, respectively.

their house. We use these measures later to look at heterogeneity in our main effects in areas which have varying degrees of owner occupation and hence property rights.

2.3 Chiefs and Elders in Kibera

Kibera is administered through multiple layers of local government, mixing traditional and formal authorities. Between 1950 and 1987, Kibera was governed by one chief appointed by the Provincial Administration, assisted by village elders.[11] In 1987, the administration added one layer of government below the chief - the assistant chief. In 2002, the administrative structure of the slum was redefined into its present format: the slum area and its surroundings were divided into 4 locations, each governed by a chief and 9 sublocations, each governed by an assistant chief who reports to the location chief.[12] Our listing data in the slum (described in detail below) includes 4,331 households on average per sublocation.

Since 2002, 18 different chiefs (each responsible for one of the 4 locations) and 21 different assistant chiefs (each responsible for one of the 9 sublocations) have operated in Kibera. The appointment of chiefs is made at the provincial level. In Nairobi, appointments are advertised and made subsequent to an interview process. In addition, specifically in Nairobi, the chiefs are rotated through the entire province approximately every two years. These transfers are made entirely at the discretion of the Provincial Administration. Sometimes, although rarely, Kibera chiefs serve multiple times in Kibera over their career.[13] At the time of data collection in August 2012, the current chiefs and assistant chiefs in Kibera had been active for an average of 18.8 months and 36.9 months, respectively, though based on our data on chief tenures, the average tenure for a chief has been 23 months.

Based on our surveys of chiefs, assistant chiefs and village elders on the ground in Kibera (described in detail below), the role of the chiefs is primarily to support the administration in a variety of ways, including maintaining law and order and resolving disputes, primarily rent and domestic disputes. The chiefs are also responsible for appointing village elders, although these elders are always chosen amongst people well known to the community and tend to stay much longer than the chiefs and assistant chiefs (elders report having served 14.6 years on average in our survey data). Elders play a role in dispute resolution in the slum, primarily with domestic disputes, and only occasionally with rent disputes, as those are usually transferred to the location chief. In our surveys of chiefs, all respondents mention conflict resolution and arbitration as one of their three most important responsibilities.

[11] The village elders represent the most basic of local (informal) authority in the slum. Their area of responsibility usually encompasses a village or a zone.

[12] The 4 locations are Kibera, Laini Saba, Sarangombe and Mugumo-ini. The 9 sublocations are Kibera, Lindi, Makina, Silanga, Laini Saba, Nyao Highrise/Soweto East, Bomas, Gatwikira, and Olympic.

[13] In our data, 4 Kibera chiefs were active during at least 2 different periods of time since 2002.

3 Data

Our main analysis combines household-level data collected in Kibera with high resolution satellite data captured over the slum area. We also use data from the 2009 Population and Housing Census and draw on surveys we conducted with current village elders, chiefs and assistant chiefs.

3.1 Listing and Household Survey Data, 2012

Our survey data was collected between February and December 2012. To constitute a sampling frame of households within Kibera, we first listed 31,765 households over the 9 sublocations that compose the slum area.[14] The listing involved two rounds of visits in each sector of the slum. GPS coordinates were also collected for all structures inhabited by the households, resulting in 9,728 unique sets of coordinates and hence structures. For each structure we also collected the current number of households inhabiting the structure.[15] The household size in our sample was approximately 3.7 individuals per household, with just over 2 adults. 65% of household heads provided us with valid phone numbers. Table 1a shows some summary statistics from this listing data. Luos, Luhyas and Kambas are the most prevalent tribes in the slum. The three tribes combined represent approximately 78% of the household population in our listing data.

Based on this listing of Kibera households, we conducted a survey starting in July 2012, targeting a total of 18,797 households. The survey itself collected data on the tribe of landlords, rents, renovation of roofs, and previous evictions within the slum. To construct this sample, we stratified the listing by whether the household reported a phone number. We attempted to contact all households that reported a phone number and reached 79% or 16,314 households on the phone. Of the 21% of households that could not be reached by phone, we sampled approximately 20% (888 households) and collected these surveys in person in the slum. Finally, of the 35% of households that did not provide a phone number, we randomly sampled about 14% (1,595 households) and also conducted the survey in person. Throughout our analysis, we re-weight the data to create a sample of surveys for the slum that is representative of the whole 31,765 households listed in our listing. This sampling strategy gave us a total target sample size of 18,797 households,[16] of which we reached 18,254 (97%), giving us a weighted attrition rate of 11%. Table 1a shows summary statistics from our household survey.

As can be seen in Table 1a, approximately 92% of households pay rent and average monthly rents are KShs 1,715 (US$ 20). About 11% of households report having ever been evicted from

[14] Since the average household size in our listing is 3.65, our listing covered approximately 115,942 individuals or 68% of the 2009 slum population based on the 2009 Census data. Since 2009 there has been some formalization on the edges of the slum so it is unclear what the true population of the slum for 2012 should be.

[15] The average number of households per structure was 6.7.

[16] The details of the sampling strategy are described in Appendix Figure A1.

their houses in Kibera. The most common reasons for evictions are households not paying rents (45%) or refusing to pay higher rents (10%), a unilateral decision from the landlord (19%), the structure being demolished (9%) or a change of landlord in only 4% of cases. 21% of households have had their roofs renovated since they moved in and for about a third of these, the tenants were responsible for the renovations. Finally, households have spent on average 16 years in Kibera, 8 years in the same structure, and 7 years with the same landlord.

Looking at the ethnic match variables that are the focus of this paper, 22% of households have a landlord that shares the same tribe as the chief. About 14% of households share the same tribe as the chief and about 28% belong to the same tribe as their landlord. Only in 5% of households do all three tribes (household, landlord and chief) match.

3.2 Chief and Elder Surveys

In addition to the listing and household surveys, we obtained the history of chiefs and assistant chiefs having served in Kibera since 1950 from the Provincial Administration. We also conducted surveys of all current location chiefs, sublocation chiefs, and community elders who accepted to be interviewed.[17] Our sample of respondents was composed of 3 location chiefs, 7 sublocation chiefs (assistant chiefs)[18] and 45 community elders. The 9 sublocations in our sample are divided into villages, which are relevant for the purpose of customary governance but are not part of the provincial administration. Some villages are larger than others and are therefore split into zones. In total, there are 17 villages, of which 5 are split into zones.

Chiefs and assistant chiefs report earning approximately KShs 18,000 monthly (US$ 228), which is low by Nairobi standards even though 7 of the 10 officials we surveyed had college education. Eight out of 10 respondents lived outside of Kibera. Half of them said they sided with the landlord in most instances of rent disputes, and 20% reported siding with the tenants. All officials surveyed cited the tenants' inability to pay the rent agreed upon as the most common reason for rent disputes, and 60% gave rent increases as the second most common reason.

The data collected from community elders (village elders and zone leaders) included information on individual careers and backgrounds, public goods in the respondent's area of responsibility, the role of landlords, and governance systems. A majority of the 45 village or zone elders we surveyed belonged to the Luo (31%), the Kikuyu (24%), the Nubi (20%) or the Kamba tribe (13%). 84% were appointed (in most instances, by the location chief) while the remaining 16% were elected. 42% of elders reported there was no primary health unit (or dispensary) in

[17]We used two different survey instruments for administrative chiefs and community elders in order to capture the different sets of responsibilities assigned to each.

[18]The one location chief and two sublocation chiefs we missed were all operating in the same location (Sarangombe location), which is comprised of two sublocations. These individuals, as well as the elders in that village all refused to be interviewed. It is one of the more unsafe locations in the slum and is notorious for having a big gang operating in one of the sublocations.

their area of responsibility and 16% reported there was no school. Finally, as mentioned above, 96% of elders report that permission is needed to upgrade the housing in the slum, in particular, to upgrade roofs. In most of these cases (77%), the permission of one of the chiefs is needed.

3.3 Satellite Pictures

To study investments in slum structures in Kibera, we develop a new methodology that uses the luminosity reflected by metal roofs on daytime satellite pictures of the area. A recent literature uses the luminosity data from nighttime satellite images to gauge economic activity, showing that nighttime luminosity correlates with GDP and other economic indicators across the world (Chen and Nordhaus 2011; Henderson, Storeygard and Weil 2012). This nighttime data has been increasingly used as a proxy for development, trade or political outcomes. Recent works using nighttime data include Bleakley and Lin (2012) and Michalopoulos and Papaioannou (2012).

Two limitations of the nighttime data are its low resolution[19] and the lack of data variation in areas of the world that are not well-electrified. For example, Henderson, Storeygard and Weil (2012) report that over 99% of the territories of Mozambique and Madagascar are completely unlit at night over the 1992-2008 period. Although useful as a proxy for aggregate activity, the currently available nighttime data is therefore inadequate for measuring economic activity at the household level. Other recent papers, including Burgess et al. (2012), use daytime satellite imagery for economic analysis, but their level of analysis remains too large for the measurement of individual outcomes. Using daytime pictures of the Kibera area[20] with a panchromatic resolution of 0.5 meters, we are able to use the satellite data at a much more disaggregated level of analysis, down to the level of a dwelling. Our satellite images span a period of three years between July 2009 and August 2012. An example of the dwelling level roofs identified from the satellite images is given in Figure 4 for January 2011.

Our analysis uses the fact that investments in metal roofing are a useful measure for understanding the investment behavior of households in the slum (96% of slum residents have corrugated iron roofs in our data). Most slum inhabitants live a subsistence lifestyle, work in the informal sector and own few assets. Households with higher-quality roofs are therefore likely to be those with more savings, more secure land tenure, and/or who can afford to replace their roofs when needed or pay the higher rents associated with better shelter. Metal roofs are shiny when new or recently renovated, and become dull with age through degradation and rust. Appendix Figure A2 shows two pictures of the same area of Kibera at two different dates (July 2009 and August 2012) with sections highlighted that illustrate roofs getting upgraded, or

[19] This data is provided by the Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) and is a six-bit measure (ranging from 0 to 63) captured for every 30 arc-second pixel on the surface of the earth - approximately 0.86 square kilometers at the equator.

[20] We provide a detailed description of this imagery in the Appendix.

decaying and rusting over these three years.

Throughout our analysis, we extract the luminosity data from the panchromatic pictures using the *Zonal Statistics (Spatial Analyst)* tool of the ESRI ArcGIS software. The data is analyzed and presented at two different levels - at the level of a roof, and at the level of a household. For the roof-level analysis, we extract luminosity reflected by roofs in our sample. This process involved segmenting the satellite pictures into roofs inhabited by households in our data, as shown in Figure 4.[21] The mean surface of a roof is 466 square meters, and 11.2 households on average live under one roof. For the household analysis, we extract luminosity values within a one-meter radius of the household. We use these two different methods for robustness purposes as both involve some measurement error. In the first case, the roofs cannot be recognized with 100% accuracy (in spite of the high resolution of the pictures); and in the second case, measurement error in the collection of GPS coordinates may result in a slightly incorrect positioning of the household on our pictures of the slum. Table 1b shows summary statistics on the luminosity variables extracted from these satellite images. In the Appendix, we provide some empirical validation that this luminosity data can be used as a proxy for the quality of housing. In particular, we show that these measures of luminosity are correlated with various measures of income and dwelling characteristics.

3.4 KNBS Census data, 2009

In addition to our survey data, we use individual-level data from the National Population Census conducted by the Kenya National Bureau of Statistics (KNBS) in August 2009. The data we have covers an entire Division (an administrative unit) that is itself called Kibera, where the Kibera slum is located.

Kibera Division covers a total of 108,998 households. It is split into 7 locations and a further 16 sublocations.[22] Of these, the Kibera slum spreads across 4 locations and 9 sublocations. In 2009, the slum was divided into 643 Enumeration Areas (EAs), each of which is the equivalent of a census tract. The slum area had a total of 64,588 households based on this census data. Of these, 576 EAs (57,804 households) were listed as informal settlements. We were able to access EA maps from KNBS (hand-digitized by us) which allow us to map the 2009 census data to the EA level, as well as to match our own survey data to EAs. Since the 2009 census, there have been a number of changes to the geographic extent of the slum, the most important being the construction of highrise buildings along two edge areas of the slum.[23] We therefore use data only for about 608 EAs, which are the EAs covered during our 2012 listing.

[21] The segmentation was done using a software designed for object-level picture segmentation, eCognition Developer. We provide more details on this segmentation process in Appendix A4.

[22] From the 1999 Census, there were a total of 2,427 locations and 6,612 sublocations in Kenya.

[23] These constructions (as well as the destruction of the informal structures that previously existed on these sites) are visible on our satellite pictures of the Kibera area.

In Table 1b, we show some summary statistics from the KNBS census data aggregated at the level of the EA. As measures of economic activity, we report dummies for whether the household head worked for pay (68% did), whether the household head owned a business (15% did) and whether the household head worked for the private sector (41% did). About 4% of household heads had no education, 42% had some secondary education, and household heads had 9 years of education on average (a year longer than primary school completion). In addition, we report measures of asset ownership and wealth. For example, 36% of households had water piped into their dwelling.

Finally, about 8% of households reported owning their house, via one of two means: purchase or inheritance (6% and 2% via purchase and inheritance, respectively).[24] We use the fraction of households that owned their housing via purchase or inheritance as a measure of more formal ownership in the EA. In particular, we will use a dummy for whether an EA had 0% resident ownership to look at how the existence of more formal property rights in the area affects our main results. Based on this variable, about 17% of EAs have no resident ownership.

4 Empirical Framework

4.1 Overview

This section describes the empirical framework we use to test our hypotheses. We are primarily interested in understanding how a specific form of ethnic patronage - the tenant, the landlord, and/or the chief belonging to the same tribe - affects rents in the slum. In addition, we look at whether these relationships have longer term effects by constraining investments in the housing infrastructure. Anecdotal evidence supported by data from our surveys of village elders indicates that households need permission from chiefs to invest in their houses and upgrade their roofs, an interaction that involves rent seeking and can therefore also be impacted by ethnicities. We test for these investment effects using satellite data to proxy for roof quality.

Our identification strategy is based on the fact that chiefs are exogenously assigned (by the Provincial Administration) to their position within the slum. As mentioned above, chiefs employed by the Provincial Administration are regularly transferred across locations and neighborhoods. Because they have limited time to form local relationships, chiefs may rely on other forms of social capital, such as ethnicity, to establish clientelistic and loyalty networks. In the bargaining between landlords and tenants that determines amounts paid in rent and investments, a chief may be more likely to side with a landlord if he belongs to the same tribe and the tenant does not. This collusion, if it occurs, will lead to more rent extraction at the expense of the tenant. Conversely, a chief might protect a tenant of the same tribe against a landlord belonging

[24]The data also includes whether households owned their house via construction.

to a different tribe, leading to the tenant paying a lower rent. This second mechanism may or may not offset the impact of the first for the slum population as a whole.

In the empirical section below, we are mainly interested in testing these two hypotheses. We start by describing our main specification. Then, we describe and defend the identification assumptions needed for these effects to be interpreted as causal. Finally, we propose a number of robustness checks to support the main results.

4.2 Main Specification

We first begin by outlining our baseline specification. We start with a very simple regression that illustrates the two hypotheses we are interested in, as follows:

$$y_{ij} = \alpha + \beta^{lc} m_{lc} + \beta^{hc} m_{hc} + \beta^{hl} m_{hl} + \gamma_c + \gamma_l + \gamma_h + \Omega X_{ij} + \delta_j + \epsilon_{ij} \tag{1}$$

where y_{ij} is our outcome measure of interest (such as housing rents or luminosity) for household i in village j; m_{lc} is a dummy variable that takes the value of one if the tribes of the landlord and the location chief match (henceforth LC) and is zero otherwise; m_{hc} is similarly a dummy variable for the tribe of the household and the chief matching (HC); m_{hl} a dummy for a household-landlord tribe match (HL); the γ_c, γ_l and γ_h are a set of dummies for the tribes of the chiefs, landlords and households, respectively; X_{ij} are a set of controls; and the δ_j are a set of village fixed effects. For completeness, we include the household-landlord dummy throughout although it is not of primary interest to us - we discuss this in more detail below.

We focus on two main sets of outcomes throughout the paper. The first is the rent paid by households in the slum. 92% of households in the slum pay housing rents. In addition to rents, we report results for the probability that a household pays any rent. Our second set of outcomes is based on the luminosity measures computed from the satellite images of the slum.

4.3 Identification

We now discuss identification for the two main coefficients of interest, β^{lc} and β^{hc}. In equation (1) above, the identification assumption is that $Cov(\mu_{lc}, \epsilon_{ij}|W_{ij}) = 0$ and $Cov(\mu_{hc}, \epsilon_{ij}|W_{ij}) = 0$, where W_{ij} includes the set of controls in X_{ij} as well as all the dummy variables that are included in equation (1). This basically implies that conditional on the covariates, village fixed effects and all the relevant tribe main effects, the matching of the landlord-chief and the household-chief tribes is exogenous to unobserved household characteristics that determine rents.

To defend this assumption, we provide some relevant history and background on the appointments of chiefs and on the characteristics of households and landlords in the area. We first discuss how chiefs are assigned to their positions, and the way in which they get transferred within Nairobi. We then describe the low mobility of residents and landlords within the slum. Finally, we propose some empirical checks that support our identification assumptions.

The chiefs operating in Kibera are employees of the Nairobi Provincial Administration and as such get assigned by their administration to their area of responsibility. Once appointed to a given location, these chiefs have an average tenure of approximately two years before they get moved to another area in Nairobi. This transfer process is entirely determined by the Provincial Administration. Appointments are made directly by the Office of the President, or by the Provincial Administration through the Provincial Commissioner. Formally, this recruitment and appointment process (whereby chiefs are vetted by the administration) implies that chiefs cannot sort across parts of the slum based on the characteristics of the residents or the landlords in any given location in the slum. Of course, this part of the process is not entirely verifiable. The data we collected (which comprises all location and sublocation chiefs having been active in Kibera) shows that chiefs in Kibera are indeed frequently transferred. On average, since 2002, each of the chiefs spends 23 months on average as a chief of a given location in the slum: 3 chiefs stayed 3 months or less, 9 chiefs stayed for a period between 3 months and 2 years, and 5 chiefs stayed longer than 2 years. At the time of data collection in August 2012, the location chiefs currently active (not included in this calculation) had been appointed in June 2010, August 2010, May 2011 and October 2011, respectively.

One set of concerns with estimating a specification such as equation (1) involves sorting. Households could sort into areas with chiefs of their tribe, or alternatively choose housing where the landlord is of the same tribe as the chief. For example, an individual might get better access to public goods in areas governed by a chief belonging to the same tribe. Moving would then improve the household's welfare, but it may also come with lower quality housing, if the only housing available in the area is low-quality. This could explain a negative coefficient on the household-chief tribe match. Similarly, landlords might be able to invest in their structures more easily when the chief is the same tribe as them, so that the housing they own is, in fact, of better quality (which would explain higher rents when landlords and chiefs are of the same tribe). As we show below, this seems counter to the investment effects we find. Looking at luminosity, we find that housing quality seems, in fact, lower when the tribe of the landlord and that of the chief match (although this estimate is not significant), and higher when the tribes of the household and the chief match.

We look more systematically at these types of concerns by providing two additional empirical checks. First, we look at a range of characteristics of households in 2009 (from the KNBS census) and test whether a wide variety of education, wealth and employment measures predict our 2012 ethnic match variables. Given the tenure of the chiefs is about 23 months on average, we would expect these 2009 variables to predict matches if there was sorting by the chiefs or any choice on their part of which locations to be posted in.

Second, we construct a regression discontinuity (RD) test in which we look at households living within a small distance of the internal location boundaries of the slum. We believe that the costs of moving (to a different location and hence to a different chief jurisdiction) would be smallest for households in these areas, and hence that this sample would be more subject to sorting concerns. We use standard RD methods to look at whether rents and investments show a change across these internal boundaries of the slum.

Throughout our analysis, we also show our estimate for the household-landlord tribe match variable. We believe that it is relevant to control for this variable as the level of rents may be affected by the pairing of households with landlords. However, we do not believe that our identification strategy (which is based on the exogenous appointment of chiefs) allows us to interpret the effects of this variable causally. Regardless, in most specifications, the coefficients on this variable are, surprisingly, small in magnitude and insignificant.

5 Results

We now present our main results, starting with the results from the baseline specification in equation (1) using various measures of rents and luminosity as outcomes. We also look at heterogeneity in these effects by measures of the strength of property rights in the slum, measures of ethnic diversity and various measures of wealth (education of the household head, a wealth index and poverty rates). We then present results from our identification and robustness checks.

5.1 Main Results

For clarity of exposition, we rewrite equation (1):

$$y_{ij} = \alpha + \beta^{lc} m_{lc} + \beta^{hc} m_{hc} + \beta^{hl} m_{hl} + \gamma_c + \gamma_l + \gamma_h + \Omega X_{ij} + \delta_j + \epsilon_{ij}$$

Table 2a shows the results from this regression where log household rent is the outcome of interest, and for a range of specifications where we progressively add more controls. In addition, we report the test statistic from an F test for the null hypothesis that $\beta^{lc} + \beta^{hc} = 0$. We should note that the number of observations in these specifications is different from the number of households surveyed. Overall, we surveyed 18,254 households, of which approximately 10% did not report either their own tribe or their landlord's tribe. This leaves us with a sample of 16,380 households, of which about 14,300 pay rent. In addition, throughout (unless otherwise specified) we cluster our standard errors at the level of location-household tribe-landlord tribe, i.e. at the level of the three tribe (chief, household and landlord) combinations. There are 224 such clusters in our data.

In column (1) of Table 2a, we report results without any controls and without village fixed effects. Households whose landlords are of the same tribe as the chiefs (LC match) pay about 11% higher rents. The coefficient on the household-chief tribe match (HC match) is negative, but not significant in column (1). The magnitude of the household-landlord tribe match (HL match) is small in magnitude and insignificant. In column (2), we add village fixed effects. The coefficient on the landlord-chief tribe match falls to about 7%, although this coefficient is not significantly different from the estimate in column (1). The coefficient on the household-chief match is now about 8% (negative) and significantly different from zero, while that on the landlord-household match is extremely small and not statistically significant. In column (3) we add a set of household-level controls, in particular, controls for the demographic composition of the household (i.e. the number of adults and household size). The results are unchanged.

In column (4) we add a number of EA level controls from aggregating the 2009 census data to the EA level, in particular: whether the EA was listed as a slum (informal) settlement, the EA means of the average age of the household head, whether the household head works, whether the household head runs a business, whether the household head works for the private sector, the years of education of the household head, a dummy variable for the household head having no education, a dummy variable for the household head having some secondary education, whether the household owns each of a number of assets (TV, radio, phone, bicycle), dummies for whether the walls of the house are made of mud and wood, whether the floor of the house is made of earth, whether the households main source of water is a water vendor, whether the households main waste disposal is an uncovered pit latrine, whether the households main cooking fuel is paraffin and whether the households main source of light is electricity. Adding these controls does not change our results (columns (4) and (5)).

In column (6), we add a dummy variable for all three of the household, the landlord and the resident having the same tribe. The results on the landlord-chief tribe match remain significant with a coefficient of 8% as does the coefficient on the household and the chief belonging to the same tribe (-6%). The coefficient on all three tribes matching is small and not significant. In the lower panel, we test whether $\beta^{lc} + \beta^{hc} + \beta^{hl} + \beta^{all} = 0$ and cannot reject this hypothesis.

In column (7), we include our data on the tribes of community elders (village elders and zone leaders). In particular, we control for dummies for a village elder-landlord tribe match as well as a village elder-household tribe match. Once again, we do not interpret these effects as causal. Village elders are not exogenously appointed by the Provincial Administration, but instead are chosen by location chiefs amongst influential and well-connected individuals in the community. The elders we surveyed reported having occupied their position for about 15 years on average. Since we expect these tribal match variables to be the outcome of unobservables, sorting and choice on the part of households and landlords, we do not interpret these coefficients as causal. We show these interactions for comparison - as seen in column (6), these two match variables have no statistically significant effects on rents. Also note that since some elders refused to participate in that survey, column (7) has only about 11,800 observations. In column (8), we include village dummies interacted with the fractions of the most common tribe in the zone. Our results are mostly robust to the addition of all these controls.

In Table 2b, we show some additional results on rents. In columns (1) and (2), we show the unweighted results, without and with controls. The results from Table 2a are unchanged. In columns (3) and (4), we show similar results where we do not cluster the standard errors. In columns (5) and (6), we report results for a sample obtained after trimming the top percentile of rents. Finally, in columns (7) and (8) we report results from the data on rents we collected during the listing exercise. These were only collected for a sub-sample of about 11,000 households, As can be seen from these various specifications, the results in Table 2a are robust to a variety of alternative specifications.

In Table 3, we provide even further evidence on rents, looking at both the extensive and intensive margins of the rental market. This table excludes the landlord-chief match as we are interested in whether households pay any rent for their dwelling (hence for the subset of households that do not pay rent, we do not observe a landlord tribe variable). The first column of Table 3 replicates results from Table 2a, without the landlord-chief tribe match. The coefficient on the household-chief match is similar in magnitude to those in Table 2a. In column (2), we add the household-elder tribe match - the estimated coefficient is small, negative and not significant. In columns (3) and (4) we look at the extensive margin of rents by looking at the effect of our tribe match dummies on whether the household pays any housing rent. The results are consistent with our earlier findings, though not significant. Households belonging to the same tribe as the chief seem less likely to pay any rent by approximately 3%. The results for the household-elder match (which, again, we do not interpret as causal) are also consistent with this in terms of sign, and significant at the 10% level in column (4) after adding controls. In columns (5) through (8), we report results for the levels of rents (instead of logs). The estimates have the expected sign and are significant at the 5% level.

5.2 Investments

In Table 4, we focus on the luminosity data from satellite images of the slum as our outcome variable. There is no simple way to measure housing investments and quality in a slum environment. In our sample, based on the 2009 census data, 96% of households have roofs made of corrugated iron and 79% have their walls made of mud (mixed with either wood or cement). Only 21% of our survey respondents reported that their dwelling roof had been renovated since they moved in, and 15% reported the last renovation took place in 2011 or 2012. This implies little variation in the quality of housing based on observables that are typically collected in survey data. The luminosity data therefore provides a proxy for housing quality that varies across households in the slum, and correlates with important socioeconomic characteristics such as housing rental rates. The main rationale for looking at these measures is to test whether the (positive) effect of the landlord-chief tribe match on rents is driven by differences in housing quality. Similarly, the lower rents in the case of a household-chief tribe match could result from inferior housing quality.

For luminosity, we look at three different specifications. The DGP for luminosity is not clear so we first look at a specification for the changes in luminosity over time as a measure of investments in the housing infrastructure. In particular, we use this change between every pair of periods as our outcome and look at whether our match variables affect this measure of investment. We compute the change in luminosity for the two different measures of luminosity we extracted from the satellite images. Table 4 reports these results. Throughout the table we report specifications for the full sample as well as without one village, Laini Saba, for which the luminosity data is extremely different (there is a very high within-roof standard deviation in the luminosity measures for this village).

In columns (1) through (4), we use the measures of the change in luminosity as our dependent variable in the following regression specification:

$$DL_{ijt} = \alpha + \beta^{lc} m_{lc} + \beta^{hc} m_{hc} + \beta^{hl} m_{hl} + \gamma_c + \gamma_l + \gamma_h + \Omega X_{ij} + \delta_j + \mu_t + \epsilon_{ijt} \tag{2}$$

where DL_{ijt} is the change in luminosity for household i in vilage j measured between period t and period $(t-1)$. We include our regular set of controls, as well as the GPS coordinates of households (latitude and longitude) to capture other relevant spatial characteristics of the dwelling. We use four periods of data spanning July 2009 to August 2012, with therefore three periods of data for the changes in luminosity. Over this timeframe, we assume the household stays in the same structure and with the same landlord. We make this assumption as we do not have panel data on structures to capture how tribes change within a given structure over this period. Our data supports this assumption as households live in the same structure for an average of 8 years and have the same landlord for 7 years. Our results are robust to dropping households that have lived in the same structure for 3 years or less.

In columns (1) and (2), we use the roof level measure of the change in luminosity. These regressions are two-way clustered at the roof and tribe combinations levels, the former to account for the luminosity being measured at the roof level. In column (1), we find that investments are significantly higher when the household and the chief are of the same tribe. The magnitude of this effect is fairly large, approximately 18% of the mean. The coefficient on the landlord-chief tribe match is negative but not significant. In column (2), we can see the role Laini Saba plays - the coefficients change, even though the sample size only falls by about 5%.

In columns (3) and (4), we report similar results for our second measure of luminosity, the household measure. Here we cluster at the level of the tribe combinations only. In column (3), we find that the two tribe match variables of interest have significant effects on investments - when the chief and the household belong to the same tribe, investments are higher and when the chief and the landlord belong to the same tribe, investments are lower. From Table 2a, we know that rents are higher when the chief and the landlord are of the same tribe. There is therefore no evidence that the households with landlords and chiefs belonging to the same tribe live in better housing - in fact, the quality of their housing seems, if anything, a little poorer. Similarly, for households who share a tribe with the chief, investments are higher (with lower rents). The coefficients have the same sign but are not significant in column (4), where we include Laini Saba.

In columns (5) through (8), we look at a different DGP for luminosity. We focus on the levels of luminosity (again across our two different measures) in the same way as we did for rents above. The regression specification is:

$$L_{ijt} = \alpha + \beta^{lc} m_{lc} + \beta^{hc} m_{hc} + \beta^{hl} m_{hl} + \gamma_c + \gamma_l + \gamma_h + \Omega X_{ij} + \delta_j + \mu_t + \epsilon_{ijt} \quad (3)$$

where L_{ijt} is the level of luminosity for household i in vilage j from period t. Again, we present results for the full sample as well as the sample excluding Laini Saba. We find very similar results - the household-chief tribe match has large and significant positive effects on luminosity. The coefficient on the landlord-chief tribe match is negative throughout, though not significant.

In columns (9) through (12), we take advantage of the panel nature of our data and report results from the following household fixed effects specification:

$$L_{ijt} = \alpha + \beta^{lc} m_{lc} + \beta^{hc} m_{hc} + \gamma_c + \mu_t + \delta_i + \epsilon_{ijt} \quad (4)$$

where δ_i is a household fixed effect. Note that β^{hl} is not identified in this specification as the tribes of the household and the landlord do not change over time. This specification is identified from the tribes of the chiefs changing over time as they rotate in and out of different locations in the slum. As mentioned above, the chiefs do not rotate at the same time in each location - the rotations happen to be staggered. Our panel of satellite pictures (which begins in July 2009) allows us to measure the effect of at least one change of chief in each location during the period considered. The results in columns (9) through (12) are very similar to the OLS specifications. We find strong effects of the household-chief tribe match on luminosity throughout. For the landlord-chief tribe match, we consistently find negative effects, though these are not significant.

In summary, we find the results for investments and luminosity to be consistent with those in Table 2a: investments in housing are lower (though not significantly so) when there is a landlord-chief tribe match, and are significantly higher when there is a household-chief tribe match. This is consistent with the evidence in Joireman (2011) and with our own survey data -

the community elders we surveyed reported that housing improvements required the permission of the chief and therefore may involve some form of rent extraction.

5.3 Heterogeneous Effects: Property Rights, Ethnic Diversity and Wealth

In Table 5a, we look at the heterogeneity in our effects along two dimensions that proxy for the strength of property rights. In columns (1) and (2), we show heterogeneity along a measure of housing ownership in the EA. We look at EAs where no residents report owning their dwelling.[25] As can be seen from columns (1) and (2), we find that the effects of a landlord-chief tribe match are stronger in EAs with no resident homeowners. Similarly, the gains to a household having a chief of the same tribe are larger in EAs with no ownership. These results are mostly robust to the inclusion of controls, although we lose significance on the estimate for the landlord-chief match.

In columns (3) and (4), we look at a second measure of property rights - investments in a durable and non-portable improvement of the dwelling. The fact that households make such investments may indicate stronger property rights. Unfortunately most of the assets enumerated in the 2009 census are portable (such as a TV, radio, bicycle and mobile phone), and other measures of housing quality (such as the floor and walls materials) are more likely to reflect investments by the landlord. Hence we opt to use a variable indicating whether water is piped into the dwelling, which is more likely to be a private investment made by residents. For the interaction, we use a dummy for whether there are any households with piped water into their dwelling in the EA. The estimates presented in Table 5a indicate that the effects of the landlord-chief match are offset where private investment and property rights are stronger, using this particular metric. These results are robust to the inclusion of controls. The coefficients on the interaction with the HC match in columns (3) and (4) have the expected sign but are not significant.

Finally, in columns (5) and (6), we look at whether the visit of a government official has effects on the rental market. This is not necessarily a direct measure of property rights. However, it is well-known that government officials exert a strong influence over the governance and institutions of the slum, and sometimes directly own property in the area. For example, Syagga et al (2002) report that 57% of landlords for Kibera are public officials. A lof of government officials also visit the slum to garner votes or popular support, often through electoral promises surrounding rents and tenancy rights. We find that the rent extraction by landlords and chiefs (as measured by the coefficient on the landlord-chief tribe match) is lower if a government offi-

[25]This statistic comes from the 2009 KNBS census, in which households owning their houses were asked whether this ownership had been inherited, purchased, or whether households had constructed the house themselves. Here we only look at households whose ownership was inherited or purchased, although our results are very similar if we include ownership via construction.

cial has visited the area. The coefficient on this match variable is approximately halved (though still significant) in the areas where a government official has visited.

In Table 5b, we look at the heterogeneity in our estimated effects along measures of ethnic diversity and wealth. In columns (1), we interact our two main variables of interest with a dummy for whether the household belongs to the majority tribe. We define the majority tribe to be the most prevalent tribe amongst the households living in a given location. The non-majority tribes are all other tribes represented in that location. We find that the effects of our ethnic matches are mostly offset for households belonging to the majority tribe: they seem less affected by the landlord-chief type of rent extraction (LC match), but they may also have less bargaining power to lobby for lower rents (HC match). In column (2), we look at a measure of ethnic concentration, computed using a Hirschman-Herfindahl index (HHI) of the form: $H = \Sigma_{i=1}^{N} s_i^2$ where s_i is the fraction of the village population belonging to tribe i. We compute this index at the village level and then split the sample by the median value of this index. A high index implies an HHI value greater than or equal to 0.285, while a low index implies an HHI value less than 0.285. We interact this dummy for high index with the ethnic match variables of interest. We find that in areas that are more ethnically concentrated (have a high index), residents where the landlord and the chief share a tribe pay rents about 17% higher. Similarly, looking at the coefficient on the household-chief tribe match, these effects are most salient in the low index (more diverse) areas.

In columns (3) through (5) of Table 5b, we look at three measures of welfare: education, a weath index and a poverty rate. All three of these are measured at the EA level from the 2009 census data. For education, we look at the average years of education of the household head. For wealth, we use a principal components analysis for the asset and economic variables from the 2009 census to create a wealth index. For poverty, we use the poverty mapping methodology in Elbers, Lanjouw and Lanjouw (2003) to create EA level poverty rates, in this case the fraction of households in the EA that live on less than $2 a day. For ease of interpretation, the variable we use for the interaction is a dummy for the relevant variable being greater than the median value in the sample. All three sets of results are very consistent, but we sometimes lack the statistical power to obtain significant estimates. The effect on rents of both the household-chief and the landlord-chief tribe match seems larger for wealthier households.

5.4 Identification Checks: Predicting the ethnic matches

We now discuss the first of our two main identification or robustness checks where we analyze whether our tribe match variables are correlated with observables from the 2009 census data. Our match variables all come from data collected in 2012. Since the average tenure of a chief is about 23 months, we can look at whether any of our 2009 observables (a wide range of demographic, economic and wealth measures) predict a match between the tribe of a household and a chief, or a match between the tribe of the landlord and the chief, in 2012.

Table 6 reports these results. Since the census data is de-identified, we aggregate it to the level of an EA.[26] We control for village fixed effects, main effects of the tribes and we cluster the regressions at the EA level. Each cell in the table represents a separate regression. We show results for 19 different variables, correlating each with the relevant match dummy. The first column reports the mean of each independent variable. The second column uses the dummy for a landlord-chief tribe match (m_{lc} in our notation) as the dependent variable, the third column uses the dummy for the household-chief tribe match (m_{hc}), the fourth column the dummy for the household-landlord tribe match (m_{hl}) and the final column, log rents.

Looking at column (2), we see that only three of the 19 variables predicts a match between the landlord and chief tribes (one is significant at the 5% level and two at the 10% level). Looking at column (3), we find only one significant predictor of the match between household and chief tribes. In column (4), we see that the results are quite different for the case of the household-landlord tribe match. A number of variables predict this match, in particular whether the household head works for pay, whether the household head owns a business, and whether the household works for the private sector, with the first of these significant at the 1% level. This seems to imply that households may be able to sort into the landlord of their choice at least to some extent, and that this sorting is based on tribe as well as socioeconomic (observable and probably unobservable) variables. In our earlier results, we actually found that the match between the tribes of a landlord and a household has no effect on the rent. Finally, in column (5) of Table 6, we test whether the 2009 characteristics are correlated with rents and find that a large number of them are indeed significantly correlated with rents. Overall, the 2009 KNBS variables do have some predictive power since they correlate strongly with housing rents. We interpret the fact that they do not predict the LC and HC tribe match dummies as evidence against sorting.

5.5 Regression Discontinuity Specification

As a second robustness check, we look at a regression discontinuity (RD) specification where a household-chief tribe match represents the "treatment" and the distance to a location boudary represents the running variable - the distance to the treatment cutoff. Households seeking to move into a different location may be more likely to do so if they live relatively close to the relevant location boundary. In the limit, consistently with the assumptions of RD, we believe that households living on either side of a location boundary are indistinguishable in terms of both observables and unobservables, especially when they already belong to the same tribe. Here we only focus on the effect of the household-chief tribe match because we do not have a comparable specification for the landlord-chief tribe match. We know how households can

[26]On average, in the 2009 census, there were 100 households per EA.

move to take advantage of the tribe of a given chief, but we do not know how households would sort to undo a landlord-chief match.

We first restrict the sample to the set of households for whom this RD setup is relevant. Households can only sort into areas to select a co-ethnic chief if there is an area within Kibera that is governed by a co-ethnic chief, and they have the ability to move into that area. Hence the ethnic groups who can potentially engage in such sorting behavior are groups who have at least one member active as chief - in 2012, Kalenjins, Luos, Luhyas and Nubis. We therefore exclude households who do not have a chief of their tribe anywhere in the entirety of Kibera (i.e. all households belonging to the Kamba, the Kikuyu or the Kisii tribe, as well as any other tribe). Our sample for the RD analysis contains exactly 20,271 households (before attrition), all belonging to the Kalenjin, the Luhya, the Luo or the Nubi tribe.

Then, for any given tribe, the relevant "cutoff" is the boundary of the only location that is governed by a co-ethnic chief. For example, for Kalenjins, the relevant boundary is the border of the Sarangombe location (which is governed by a Kalenjin), and the score is the distance to that particular boundary. Within the slum, Kalenjins have an average a distance of 495 meters to the boundary of Sarangombe location, and 14% of all Kalenjins are "treated" (i.e., they live within Sarangombe location). Luhyas have an average distance of 530 meters to the location governed by a Luhya (Laini Saba), and 26% of all Luhyas live within Laini Saba. Luos live on average 811 meters away from the only location governed by a Luo (Mugumo-ini), and 5% of Luos live within that location. Nubis live on average 321 meters away from the boundary of Kibera location, the only one governed by a Nubi, and 89% of all Nubis live within that location.

Using this sample, we construct a set of RD specifications. Consistently with the state-of-the-art in the RD literature, we report results for a variety of bandwidths in a local linear specification as well as a polynomial specification on the full sample. In particular, we use the following specification:

$$y_{ij} = \gamma_0 + \gamma m_{hc} + \gamma_R m_{hc} * D_{ij} + \gamma_L (1 - m_{hc}) * D_{ij} + \Omega X_{ij} + \delta_j + \epsilon_{ij} \quad (5)$$

where y_{ii} is either rent or luminosity for household i in village j, D_{ij} is the distance from the household to the location boundary, and m_{hc} is our match dummy for the household being of the same tribe as the chief. We include our regular set of controls, including village fixed effects, and we cluster our standard errors as described above for our main specification.

The specification in equation (2) allows for a local linear specification, where we allow the distance to have a different linear effect on either side of the boundary. For the local linear specifications, we look at four different bandwidths: 75m, 100m, 125m and 150m from the boundary. In addition, we look at a polynomial specification that allows for polynomials in the distance and in its interaction with the match dummy. We use a fourth order polynomial, but get similar results with the third order.[27]

Table 7 reports these results. In columns (1) through (4), we look at local linear specifications for our four bandwidths. We do not include weights in these specifications as the weights are not really applicable in this specification. We find negative coefficients on the household-chief match variable, consistent with the results in Tables 2 and 3. In column (5), we look at the polynomial specification and find similar results. If anything, the magnitude of these differences is larger than those in Table 2a. In columns (6) and (7), we show results for the smallest bandwidth and the polynomial specifications where we include weights, purely for comparison. The results are extremely similar. Finally, in columns (8) through (11), we present results for the change in luminosity for the smallest bandwidth and the polynomial specifications but we restrict the analysis to just one period of data. Columns (8) and (9) report results at the roof level, while columns (10) and (11) report results at the household level. We find similar results - with coefficients much larger than those in Table 4.

5.6 Attrition

The survey we use had some attrition, especially among those who could not be reached by phone and those households who did not provide us with any phone number during our initial listing exercise. Here, we provide two checks on attrition, both of which illustrate that attrition does not seem to play an important role.

The attrition in our survey comes from the households that could not be reached by phone and those that did not have phones. In particular, of the households that could not be reached by phone, we sampled 20% and focused on finding this subset of households in the field to complete the survey. We were able to locate 80% of target respondents in this subsample. In addition, of the households without phone numbers, we sampled 14% to conduct field surveys and were able to find 77% of these. As shown in Appendix Figure A1, the total target sample size was 18,797 households, and the number of households we reached was 18,254, giving us an unweighted attrition rate of 3% and a weighted attrition rate of 11% (sampling weights are used throughout all of our analysis).[28]

These attrition rates are obviously not negligible, although they are not strikingly high for urban areas (for example, Jack and Suri (2012) find higher attrition rates in Nairobi). The context of Kibera makes tracking households harder for a number of reasons. First, we conducted our surveys during weekends, but not in the evenings because of safety concerns for our staff. Households living the slum are often out looking for work or travelling long distances for work

[27]See Imbens and Lemieux (2007) and Lee and Lemieux (2010) for excellent reviews on RD methods.

[28]By definition of our sampling strategy, attrition was null in the subsample of households that we surveyed by phone. Attrition is therefore highest in the subset of households without phone, and the subset of households who could not be reached on their phones, which also have the largest sampling weights by way of the sampling strategy.

and therefore not easily available during the day, including on weekends. Second, even though our surveys were conducted shortly (6 months) after the initial listing exercise, there are reasonably high mortality rates in Kibera which arguably made it more difficult to locate our entire target sample. In our survey data, 4% of respondents reported that at least one member of their household died in the past 6 months. Admittedly, since this does not explain all the attrition in the sample, we present two checks to show that attrition is not driving our results, which we report in Table 8. The first check is a specification where we drop the higher attrition EAs. We keep the EAs that have attrition rates of 5% or less. Results for our two main specifications are reported in columns (1) and (2) of Table 8. As can be seen, our results are robust to dropping the higher attrition EAs. The second check we conduct is to weight the regressions as proposed by Fitzgerald, Gottschalk and Moffitt (1998). Once again, our results are mostly robust to this re-weighting as seen in columns (3) and (4).

6 Conclusion

Informal property rights are not well understood in the context of developing economies. In this paper, we study two outcomes of an entrenched system of informal property rights in a Kenyan slum - housing rents, and investments in the housing infrastructure. Although there are no formal property rights in the slum, 92% of households pay a rent to private individuals, implying that these private individuals not only hold property rights over the slums, but also that these rights are secure enough for them to rent out the slum structures. In this context, we analyze the extent to which ethnic patronage affects housing rents.

We find that ethnicity plays an important role in determining the level of rents in our area of study. Households pay higher rents when the area chief is of the same tribe as the landlord. However, some of this effect is offset when the household is of the same tribe as the chief - in that case, rents are actually lower. The primary responsibility of the chiefs is to arbitrate conflicts in the slum and a large fraction of these are rent disputes. Our findings therefore reflect how chiefs side with landlords in these conflicts when belonging to the same tribe, and conversely with households when they share their tribe with the latter.

In addition, we find that ethnic relationships affects longer term outcomes in the slum via their impact on investments. We use satellite image data to compute measures of roof luminosity which proxy for investments in housing quality. We show that the landlord-chief match variable is not positively correlated with luminosity (as we would expect as rents are high for these cases), but, in fact, negatively correlated (though not significantly). Similarly, the household-chief match is not negatively correlated with luminosity, but in fact has positive effects on investments. This implies that chiefs and landlords also create constraints on investment in the slum. In addition, we find that these results are stronger in areas with weaker property rights and for richer households.

To identify these effects we draw on the institutional context of Kibera. Local chiefs are appointed by the Provincial Administration and are frequently rotated across different locations. We use this rotation to argue that the match between a chief's tribe and that of the landlords and households in the location under his jurisdiction is exogenous to socioeconomic characteristics and other household-level unobservables.

Empirically, we provide some evidence in support of this identification assumption. In particular, we show that a wide variety of *ex ante* socioeconomic characteristics (measured in 2009) do not predict these match variables in 2012. Second, we use a RD specification to look at the sample of households within narrow boundaries of administrative divisions within the slum. Across a variety of local linear and polynomial RD specifications, we find similar results. These RD results indicate that household sorting may be less of a concern, since moving would be easiest and probably cheapest for households closest to the location boundaries.

These results have important implications for our understanding of urban poverty across the developing world. The extensive systems of informal land rights prevalent in Kenyan slums are also common to other slums. These facts highlight the fluidity of property rights in slum environments and question the relevance of land titling programs as the main policy instrument to fight urban poverty. Land titling might not fundamentally alter the existing informal ownership arrangements[29] and hence not have the desired impact on the investment decisions made by slum dwellers. In addition, there are extensive systems of rent extraction in slums that have important implications for investment and welfare. A more rigorous understanding of these informal property mechanisms and the extractive institutions that accompany them will be necessary to design effective policies to tackle urban poverty.

[29] Woodruff (2001) pointed this out in his review of de Soto's *Mystery of Capital*.

Appendix: Geospatial Methods and Satellite Imagery Analysis

A1. Data collection

Our initial listing exercise in Kibera involved collecting GPS coordinates for every household in our sample. Coordinates were received and recorded at the center of each dwelling using Garmin GPS receivers, which are usually accurate within 15 meters or less (`http://www8.garmin.com/aboutGPS/`). Households whose coordinates could not be placed within Kibera after data cleaning were dropped from our sample. To improve the geo-positioning of our satellite pictures, we also collected GPS coordinates for all major installations in Kibera (schools, churches, etc.) and major arteries and boundaries, including the railway that cuts through the slum through a West-East axis.

A2. Mapping of Kibera

After the end of the first wave of listing, we used various sources of information to create our own map of the Kibera area, including location, sublocation, village and enumeration area boundaries. The villages are the finest level of governance we could map with accuracy (some villages are divided into zones, but our data does not allow us to precisely demarcate these zones). Kibera is divided into 17 villages, which are not administrative entities but whose boundaries are well-known by residents of the slum. To construct the map of villages, we used the information reported by households (who were asked to name their village and zone in the listing exercise), a land use shapefile made publicly available by the Center for Sustainable Urban Development (CSUD) at Columbia University, various maps created by the Map Kibera project (`http://mapkibera.org/`), our GPS coordinates of major installations in Kibera, and our own satellite pictures of the area which helped us determine relevant boundaries when those are marked by a street or a river. The Enumeration Area boundaries (drawn as part of the 2009 Population Census) were manually digitized from maps given to us in paper format by the Kenyan National Bureau of Statistics.

A3. Description of the Luminosity Data

We use four high-resolution (0.5 meters) panchromatic pictures captured over the Kibera area in July 2009, January 2011, December 2011 and August 2012. The imagery was acquired from two different remote sensing operators, GeoEye and DigitalGlobe, and processed through an independent remote sensing/GIS consultant. For each date of acquisition, the raw data generally consisted of two pictures, one with a panchromatic resolution of .5 meters and one with a multi-spectral resolution of 2 meters, over an area of interest (AOI) comprised between 36.77 and 36.89 longitude and -1.298 and -1.324 latitude. This AOI covers about 35 square kilometers within the city of Nairobi. To optimize the accuracy of the geo-positioning and the superposition of the pictures over time, the consultant ortho-rectified the raw data using regional geo-reference points and a shapefile of land use in Nairobi released to the public by the Center for Sustainable Urban Development at Columbia University. The pictures were later trimmed to fit the boundaries of the Kibera area, comprised between 36.77 and 36.81 longitude and -1.305 and -1.321 latitude (approximately 7.91 square kilometers).

To extract luminosity data from the satellite pictures, we use the *Zonal Statistics (Spatial Analyst)* tool provided by ESRI ArcGIS. The ZS tool extracts statistics over areas defined by a zone dataset, based on the underlying value in the image or raster dataset. On our pictures, the dynamic range of the luminosity data (the value raster dataset) is 11-bit radiometric (2,048 levels). This roughly corresponds to a grey scale with 2,048 unique values, where low values correspond to dark areas and high values to bright areas. The statistics computed through the ZS tool include the mean, median, standard deviation, minimum, and maximum luminosity (pixel value) over any given area of interest. Since all of our pictures have a different average luminosity (corresponding mostly to different levels of solar radiation), all of our specifications that span different periods include picture fixed effects. Below we describe the two different levels (roof and household) at which we compute the luminosity data.

A4. Extraction of the luminosity data at the roof level

To demarcate dwelling roofs on our pictures, we used a different software specifically designed for picture segmentation, eCognition Developer 8 (Trimble). eCognition segments pictures into homogenous objects by aggregating neighboring pixels with similar values on the radiometric scale, yielding objects that can be as small as one pixel. The user can alter the segmentation algorithm by entering values for three different parameters: a scale parameter, a shape parameter and a compactness parameter. The scale parameter defines the maximum color gap between objects produced by the segmentation algorithm. A higher scale parameter will result in the segmentation producing larger objects, and vice versa. The shape parameter determines how much the shape of objects (as opposed to color) influences the segmentation process. The compactness defines how compact (as opposed to smooth) the produced objects will be. The output of the eCognition algorithm can be exported into ArcGIS in the form of a shapefile.

Our delimitation of roofs was done in three steps. First, we segmented the pictures into objects corresponding to the 17 Kibera villages, using the Chessboard Segmentation tool of eCognition with our shapefile of village boundaries as the underlying thematic layer. Second, we used the Multi-Resolution Segmentation (MRS) algorithm to segment these objects into roofs or blocks or roofs. The appropriate values of the parameters of interest were determined through trial-and-error - we compared the segmented pictures obtained after defining different parameter values, and chose the unique combination of parameter values that produced the best segmentation. We use a scale parameter of 50, a shape parameter of 0.8, and a color parameter of 0.2. Third, we exported the shapefiles into ArcGIS and manually rectified the roof objects based on simple visual checks.

A5. Extraction of the luminosity data at the household level

In addition to the roof-level analysis, we present the luminosity data reflected by the roof surface situated just above the households in our sample. The main goal of this particular method is to obtain a measure that is specific to each household. One advantage of this technique is that it reduces noise due to large roofs accommodating multiple households. We do this by computing, for each household, the same set of luminosity statistics as above, but this time only over an area comprised within one meter of each household. Since our GPS devices are not accurate within one meter, we expect some measurement error in this computation.

A6. Empirical validation of the methodology

We now provide evidence that the data from our satellite images are indeed correlated with a range of socioeconomic outcomes and housing characteristics. We show that luminosity measured from these images correlates with a set of individual demographic, education and occupation characteristics for heads of households in the slum, using data from the 2009 census. Since EAs are the geographical unit of reference in the KNBS census, all the luminosity data available at a 0.5 meters resolution is aggregated at the level of the EA for this empirical validation. Throughout all specifications, we use the sample of only informal EAs (576 out of 643 EAs), we weight the regression by the size of the EA, and we control for sublocation fixed effects.

Our first specification looks at the correlation between luminosity and a variety of individual level demographic, education and occupation characteristics (aggregated by EA). The regression takes the following form:

$$L_{ij} = \alpha + \beta_w WP_{ij} + \beta_b B_{ij} + \beta_s Sec_{ij} + \beta_u Univ_{ij} + \beta_a Age_{ij} + \eta_j + \epsilon_{ij}$$

where L_{ij} is the mean luminosity reflected by EA i in sublocation (administrative unit) j, WP_{ij} is the average fraction of household members working for pay in the EA, B_{ij} is the average fraction of household members running a business, Sec_{ij} is the fraction of household heads that have some secondary education, $Univ_{ij}$ is the fraction of household heads that have some university education, Age_{ij} is the average age of the household head, η_j is a set of eight sublocation fixed effects, and the coefficients of interest are the five β coefficients.

We report the results of this specification in the first column of Appendix Table A1. We find that higher luminosity is associated with higher secondary education and (not significantly) with higher university education. It is also highly correlated with the fraction of household heads that run a business and with the fraction who report having some form of paid employment.

We then report on a specification that includes a number of standard wealth measures:[30]

$$L_{ij} = \alpha + \beta_m WM_{ij} + \beta_f F_{ij} + \beta_c C_{ij} + \beta_a WA_{ij} + \beta_e E_{ij} + \eta_j + \epsilon_{ij}$$

where WM_{ij} is the fraction of households in the EA with walls made of mud mixed with cement, F_{ij} is the fraction of households with floors made of cement, C_{ij} is the fraction of households whose main cooking fuel is charcoal, WA_{ij} is the fraction of households whose main water source is a water vendor, and E_{ij} is the fraction of households whose main light source is electricity.

Appendix Table A1, column (2) reports the results from this specification. Luminosity correlates significantly and positively with the floor being made of cement (the highest-quality floor material) and with the main source of drinking water being a water vendor.[31] Luminosity is also significantly negatively associated with a mix of mud and cement being used as the material to construct their walls and with charcoal being used as cooking fuel - two indicators of relative deprivation within the slum. The coefficient on access to electricity is insignificant and negative - possibly because segments of the slum are illegally connected to the city electricity grid.

Finally, we look at correlations of luminosity with measures of household expenditures and poverty. The census does not collect these measures, instead we estimate them using a standard method in poverty mapping, as developed by Elbers et al. (2003). We look at household expenditures and two different measures of poverty: the fraction of households in the EA that live on less than $1.25 (PPP) a day and the fraction that live on less than $2 (PPP) a day. Since these are generated regressors, we report bootstrap standard errors. In addition, we look at correlations of luminosity with retailer presence and road access in the EA. Since these five variables are highly correlated with each other, Appendix Table A1, column (3) reports coefficients from separate regressions of each of these variables on luminosity. This specification is therefore of the form:

$$L_{ij} = \alpha + \beta_x X_{ij} + \eta_j + \epsilon_{ij}$$

where X_{ij} is one of the economic variables of interest, i.e. one of the following: (i) the fraction of households living on less than $1.25/capita/day; (ii) the fraction of households living on less than $2/capita/day; (iii) average per capita consumption (expenditure) in the EA; (iv) whether there is a retail business in the EA; and (v) the fraction of the area of the EA that is within 15 meters of a road.

[30] These measures are those used in the poverty mapping literature (Elbers et al. (2003)) and in Demographic and Health Surveys (DHS) conducted across the developing world.

[31] These households typically pay for clean water, as opposed to using poorer quality sources such as public pumps.

We find that the EA luminosity correlates positively with estimated household expenditures and negatively with the two poverty measures. These correlations are significant at the 1% level. Appendix Figure A2 presents a visual analysis of these results, comparing average luminosity and average consumption across EAs. To further support these results, we find that EAs with higher luminosity are more likely to have a retail business and are likely to be closer to roads.

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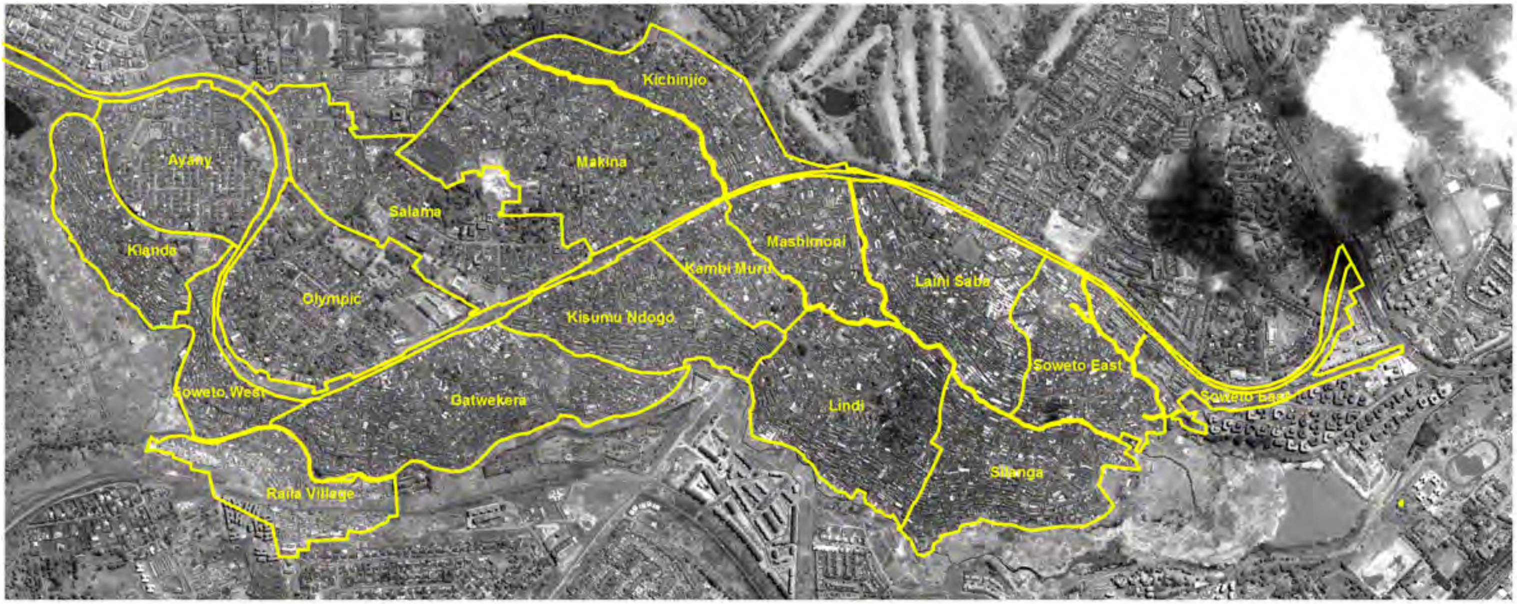
Figure 1: Map of Kibera



Note: This figure shows a map and satellite image of the Kibera area. The villages in Kibera are outlined and labelled in yellow.

Figure 2: Distribution of Household Tribes in Kibera

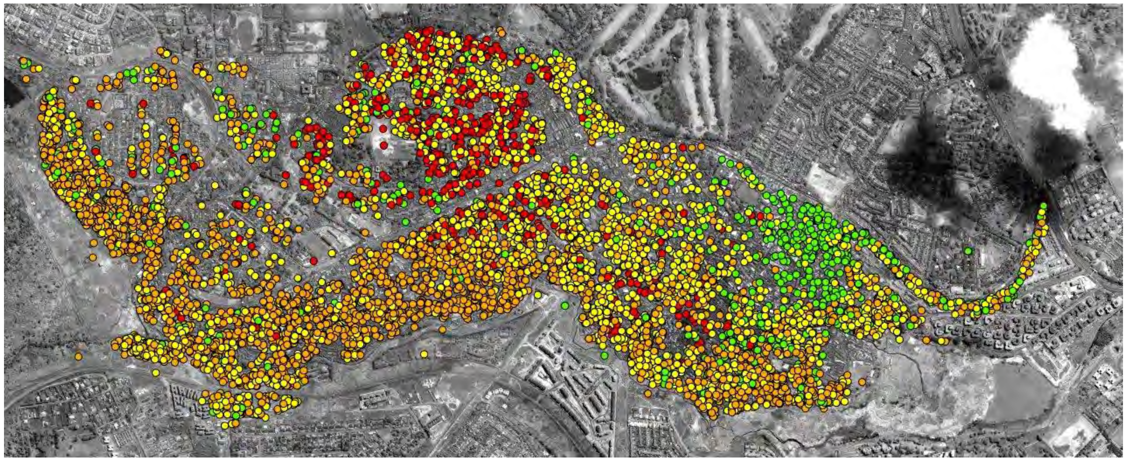
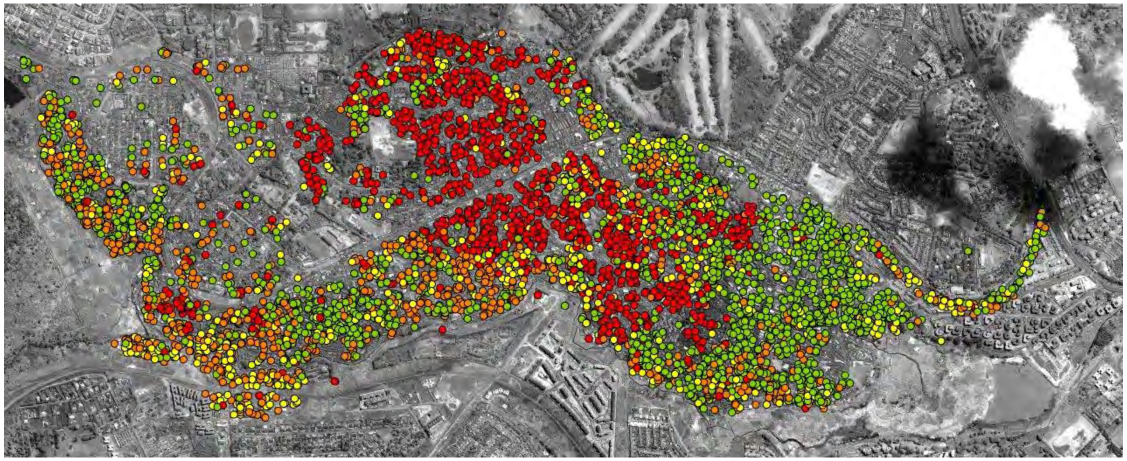
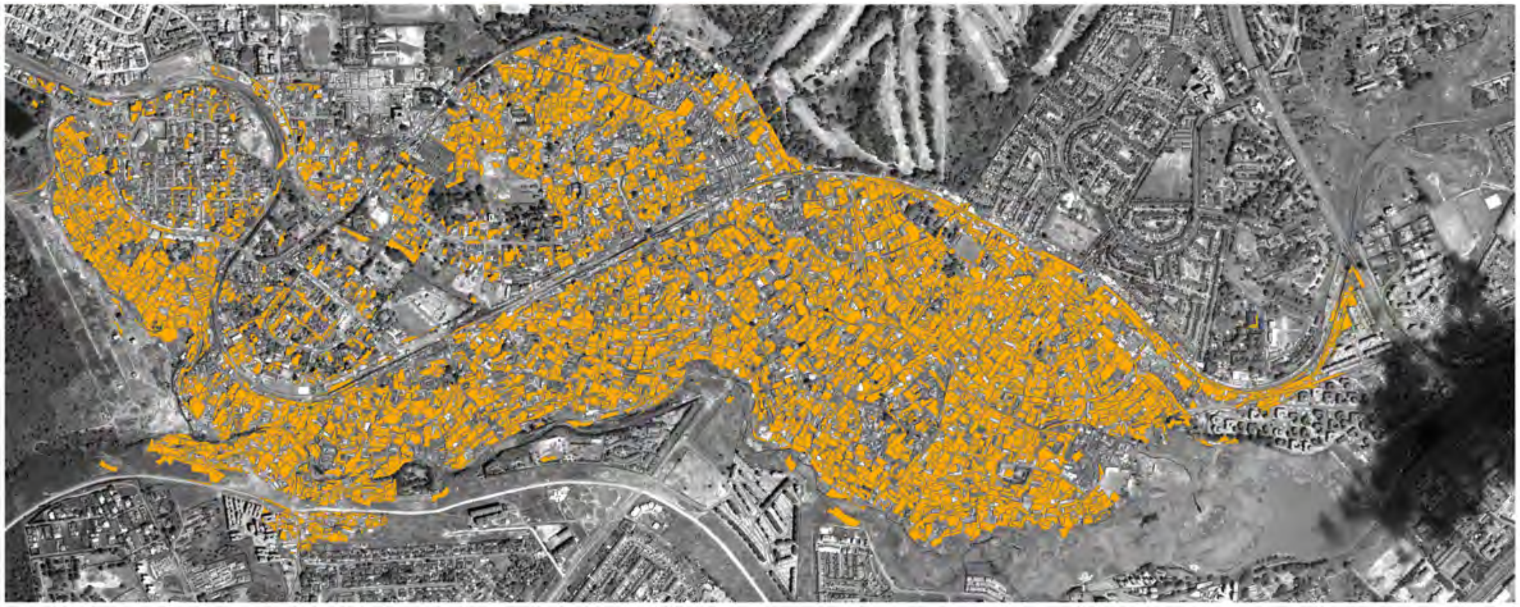


Figure 3: Distribution of Landlord Tribes in Kibera



Note: These figures show the distribution of household (Figure 2) and landlord (Figure 3) tribes in Kibera overlaid on satellite images. For confidentiality reasons and under IRB requirements, we do not provide a key as to which color is which tribe.

Figure 4: Roofs from Satellite Images in Kibera (January 2011)



Note: This figure shows a satellite image of the Kibera area. Roofs inhabited by households in our sample are indicated in orange. Details on the identification of roofs are given in the Appendix.

Table 1a: Survey Summary Statistics

	Mean	SD	N
Census Data			
Number of adults in the household	2.16	2.03	31718
Household size (adults and children)	3.65	2.11	31717
Kalenjin tribe	0.01	0.12	28890
Kamba tribe	0.15	0.36	28890
Kikuyu tribe	0.06	0.23	28890
Kisii tribe	0.06	0.24	28890
Luhya tribe	0.27	0.44	28890
Luo tribe	0.36	0.48	28890
Nubi tribe	0.05	0.23	28890
Household Survey Data			
Household pays rent	0.92	0.28	17251
Amount paid in rent (levels)	1715.30	1784.06	15473
Household ever evicted in Kibera	0.11	0.32	17216
Roof has been renovated since the tenant moved in	0.21	0.41	18254
Tenant was involved in the roof renovation	0.33	0.47	4813
Landlord Kalenjin tribe	0.00	0.06	15677
Landlord Kamba tribe	0.08	0.27	15677
Landlord Kikuyu tribe	0.33	0.47	15677
Landlord Kisii tribe	0.05	0.22	15677
Landlord Luhya tribe	0.11	0.31	15677
Landlord Luo tribe	0.17	0.37	15677
Landlord Nubi tribe	0.22	0.41	15677
Number of years in Kibera	15.55	11.12	17067
Number of years with the same landlord	6.91	6.82	15884
Number of years in the same structure	8.47	8.97	17153
Tribe Match Variables			
Landlord-Chief (LC) tribe match	0.22	0.41	15677
Household-Chief (HC) tribe match	0.14	0.34	17742
Landlord-Household (LH) tribe match	0.28	0.45	14871
All tribes match (ALL)	0.05	0.21	14871

Note: The only census data we use throughout the paper is the tribe of the household.
The household survey is a stratified random sample taken from the census data.
The data on the tribe of the landlord is collected in the household survey data.
The tribe of the chief comes from the history of chief lineage from Provincial administrators.
The exchange rate at the time of the household survey was 80 KShs to the US dollar.

Table 1b: Summary Statistics: Other Data

	Mean	SD	N
Satellite Data			
Luminosity, roof level	307.33	70.11	75062
Luminosity, household level	304.69	78.71	75188
Luminosity, roof level, trimmed	304.23	51.39	73663
Luminosity, household level, trimmed	301.23	57.19	73782
Luminosity change, roof level	20.12	85.88	56293
Luminosity change, roof level, trimmed	20.55	56.93	55208
Luminosity change, household level, trimmed	19.91	64.23	55331
EA Level Census Data, 2009			
EA listed as informal (slum)	0.92	0.27	608
Age of HH head	35.43	2.11	608
HH head works for pay	0.68	0.16	608
HH head owns a business	0.15	0.13	608
HH head works for private sector	0.41	0.21	608
HH head, no education	0.04	0.04	608
HH head, some secondary	0.42	0.10	608
HH head, yrs of education	9.29	1.44	608
HH head, hours worked	55.68	9.08	608
TV	0.42	0.20	608
Radio	0.76	0.10	608
Mobile Phone	0.83	0.10	608
Bicycle	0.06	0.07	608
Walls are made of mud/wood	0.29	0.30	608
Floor is made of earth	0.37	0.29	608
Water source, vendor	0.23	0.39	608
Waste, uncovered pit	0.22	0.34	608
Main cooking fuel is paraffin	0.53	0.21	608
Main light source is electricity	0.52	0.29	608
Tenure is individual	0.87	0.21	608
Tenure is purchased	0.06	0.17	608
Tenure is inherited	0.02	0.06	608
Household owns housing (purchase or inherit)	0.08	0.18	608
Dummy for no ownership	0.16	0.36	608
Household has piped water into its dwelling	0.36	0.48	608
Village Elder Survey Data			
Was the area visited by a government official	0.67	0.48	33

Note: The luminosity data comes from satellite images of the Kibera slum.
The images cover four periods: July 2009, January 2011, December 2011, August 2012.
See text for details on the computation of roof and household level luminosity.
The trimmed luminosity data drop the top 1% and the bottom 1% of observations.
The EA level census data comes from the 2009 micro census data for the Kibera slum.

Table 2a: Rents

	(1) Log Rent	(2) Log Rent	(3) Log Rent	(4) Log Rent	(5) Log Rent	(6) Log Rent	(7) Log Rent	(8) Log Rent
Landlord-Chief (LC) tribe match	0.108***	0.071***	0.070***	0.069**	0.067**	0.078***	0.084**	0.060**
	[0.040]	[0.026]	[0.026]	[0.027]	[0.026]	[0.025]	[0.033]	[0.028]
Household-Chief (HC) tribe match	-0.047	-0.081***	-0.081***	-0.074***	-0.074***	-0.064***	-0.069**	-0.067***
	[0.041]	[0.027]	[0.026]	[0.026]	[0.025]	[0.022]	[0.028]	[0.025]
Landlord-Household (LH) tribe match	-0.033	0.007	0.007	0.006	0.006	0.012	0.020	0.014
	[0.026]	[0.019]	[0.019]	[0.019]	[0.018]	[0.019]	[0.021]	[0.021]
All tribes match (ALL)						-0.038		
						[0.057]		
Landlord-Elder (LE) tribe match							-0.024	
							[0.020]	
Household-Elder (HE) tribe match							-0.020	
							[0.024]	
Test Stat for LC+HC=0	0.061	-0.010	-0.011	-0.005	-0.007	0.014	0.014	-0.007
SE	[0.063]	[0.043]	[0.042]	[0.042]	[0.041]	[0.037]	[0.049]	[0.043]
Test Stat for LC+HC+LH+ALL=0						-0.013		
SE						[0.055]		
Dependent Variable Mean	7.255	7.255	7.255	7.254	7.254	7.254	7.313	7.313
Village FE		X	X	X	X	X	X	X
HH Controls			X		X	X	X	X
EA Controls				X	X	X	X	X
Zone Tribe Controls								X
R-squared	.09	.4	.405	.418	.425	.426	.328	.332
Observations	14324	14324	14290	14249	14215	14215	11833	11833

Note: Standard errors clustered at the location-household tribe-landlord tribe level (reported in brackets).
* p<0.1, ** p<0.05, *** p<0.01
Rents are monthly rents paid. Observations vary across columns due to occasional missing observations for the various covariates.
All elders in one village refused to be interviewed - specifications with zone controls or elder matches therefore have less observations.
Results are identical when the sample is restricted to the observations with non-missing data.
Throughout the paper, data on rents and household controls are from the household survey.
EA controls are from the 2009 census data. The zone dummies and elder match variables are from the elder survey.

Table 2b: Rents: Alternative Specifications

	(1) Log Rent	(2) Log Rent	(3) Log Rent	(4) Log Rent	(5) Log Rent	(6) Log Rent	(7) Log Rent	(8) Log Rent
Landlord-Chief (LC) tribe match	0.066***	0.064***	0.071***	0.067***	0.076***	0.072***	0.053**	0.049**
	[0.020]	[0.019]	[0.021]	[0.020]	[0.027]	[0.027]	[0.022]	[0.022]
Household-Chief (HC) tribe match	-0.073***	-0.069***	-0.081***	-0.074***	-0.076***	-0.070**	-0.073***	-0.067**
	[0.019]	[0.018]	[0.021]	[0.020]	[0.028]	[0.027]	[0.026]	[0.026]
Landlord-Household (LH) tribe match	-0.007	-0.004	0.007	0.006	0.013	0.013	-0.003	-0.002
	[0.015]	[0.014]	[0.015]	[0.015]	[0.020]	[0.019]	[0.018]	[0.017]
Test Stat for LC+HC=0	-0.008	-0.004	-0.010	-0.007	-0.000	0.002	-0.020	-0.018
SE	[0.026]	[0.026]	[0.028]	[0.027]	[0.045]	[0.043]	[0.038]	[0.038]
Dependent Variable Mean	7.255	7.254	7.255	7.254	7.231	7.231	7.248	7.247
Village FE	X	X	X	X	X	X	X	X
HH Controls		X		X		X		X
EA Controls		X		X		X		X
No Weights	X	X						
No Clustering			X	X				
Trim Top Percentile					X	X		
Drop Laini Saba							X	X
R-squared	.39	.42	.4	.425	.36	.388	.409	.435
Observations	14324	14215	14324	14215	14186	14077	13525	13419

Note: Standard errors clustered at the location-household tribe-landlord tribe level (reported in brackets).
The standard errors reported in columns (3) and (4) are heteroskedasticity robust standard errors.
* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 3: Other Measures of Rents

	(1) Log Rent	(2) Log Rent	(3) Pay Rent Dummy	(4) Pay Rent Dummy	(5) Rent	(6) Rent	(7) Rent	(8) Rent
Household-Chief (HC) tribe match	-0.069**	-0.063**	-0.033	-0.025	-130.766***	-117.192***	-97.516**	-92.609**
	[0.026]	[0.029]	[0.023]	[0.021]	[39.052]	[40.180]	[42.840]	[44.267]
Household-Elder (HE) tribe match		-0.027		-0.022*			-123.780*	-103.227*
		[0.034]		[0.013]			[64.343]	[55.364]
Dependent Variable Mean	7.259	7.316	0.924	0.923	1510.458	1509.448	0.920	0.920
Village FE	X	X	X	X	X	X	X	X
HH Controls	X	X	X	X		X		X
EA Controls	X	X	X	X		X		X
R-squared	.431	.333	.155	.163	.276	.295	.255	.273
Observations	14544	12107	16262	13618	15724	15606	13124	13036

Note: Standard errors clustered at the location-household tribe level (reported in brackets).

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Rent levels (columns (5)-(8)) are measured in Kenyan Shillings (KShs 80 to the dollar). The top percentile of rents is trimmed.

The pay rent dummy (columns (3)-(4)) indicates whether the household paid any rent.

Table 4: Investments in the Slum: Luminosity Specifications

	Luminosity Change				Luminosity Level, OLS				Luminosity Level, Panel			
	(1) Roof	(2) Roof	(3) HH	(4) HH	(5) Roof	(6) Roof	(7) HH	(8) HH	(9) Roof	(10) Roof	(11) HH	(12) HH
LC tribe match	-0.302	1.164	-3.850***	-0.339	-1.174	-0.811	-1.959	-1.485	-0.726	-0.386	-1.684	-0.915
	[1.538]	[1.482]	[1.202]	[1.672]	[1.475]	[1.341]	[1.564]	[1.458]	[1.136]	[1.097]	[1.275]	[1.377]
HC tribe match	3.635**	2.122	4.541***	1.683	2.224**	2.146**	2.391**	1.912*	2.917***	2.532**	2.898**	2.104
	[1.716]	[1.500]	[1.729]	[2.076]	[1.010]	[0.888]	[1.201]	[1.126]	[1.029]	[0.983]	[1.291]	[1.362]
LH tribe match	-0.208	0.022	-0.543	-0.244	0.805	1.346	1.715	1.815*				
	[0.205]	[0.238]	[0.536]	[0.527]	[0.851]	[0.870]	[1.092]	[1.077]				
Test Stat LC+HC=0	3.333	3.286	0.691	1.344	1.050	1.335	0.433	0.427	2.191*	2.146*	1.214	1.189
SE	[2.229]	[2.003]	[1.722]	[1.852]	[1.331]	[1.222]	[1.540]	[1.363]	[1.217]	[1.176]	[1.479]	[1.261]
Dep Var Mean	20.379	20.321	20.194	20.038	303.357	303.662	300.765	300.868	303.357	303.662	300.765	300.868
Drop Laini Saba	X		X		X		X		X		X	
Roof Clustering	X	X			X	X						
Tribe Clustering	X	X	X	X	X	X	X	X	X	X	X	X
R-squared	.179	.177	.148	.146	.373	.36	.3	.294	.484	.472	.411	.407
Observations	41157	43449	41422	43741	54813	57925	54884	57975	54813	57925	54884	57975

Note: Standard errors clustered at the levels indicated in the table (reported in brackets).
* $p<0.1$, ** $p<0.05$, *** $p<0.01$
The luminosity data is extracted from satellite images of Kibera for four periods, July 2009, January 2011, December 2011, August 2012.
All results for luminosity use the trimmed luminosity data (top and bottom one percentiles removed).
All specifications control for village FE, period (or picture) FE, household and EA controls.
Roof represents the roof level measure of luminosity and HH represents the household measure. See text for details on how these are computed.
The panel regressions in (9) and (10) cannot be clustered at the roof level since roofs cannot be matched across periods (or pictures).

Table 5a: The Role of Property Rights
Dependent Variable is Log Rent

	(1) No Resident Ownership	(2) No Resident Ownership	(3) Non-Portable Investment	(4) Non-Portable Investment	(5) Visit by Govt Official	(6) Visit by Govt Official
Landlord-Chief (LC) tribe match	0.063**	0.059**	0.094***	0.091***	0.118***	0.105***
	[0.026]	[0.026]	[0.029]	[0.029]	[0.038]	[0.036]
Household-Chief (HC) tribe match	-0.060**	-0.054**	-0.094***	-0.084***	-0.099**	-0.089**
	[0.029]	[0.027]	[0.027]	[0.025]	[0.040]	[0.034]
Landlord-Household (LH) tribe match	0.003	0.006	0.013	0.015	-0.016	-0.021
	[0.019]	[0.017]	[0.021]	[0.021]	[0.044]	[0.040]
LC Match*Relevant Variable	0.065**	0.042	-0.064***	-0.075**	-0.060*	-0.049*
	[0.026]	[0.026]	[0.025]	[0.029]	[0.031]	[0.028]
HC Match*Relevant Variable	-0.132***	-0.127***	0.044	0.036	0.027	0.021
	[0.031]	[0.029]	[0.028]	[0.025]	[0.030]	[0.026]
LH Match*Relevant Variable	0.003	-0.010	-0.019	-0.023	0.050	0.052
	[0.058]	[0.049]	[0.025]	[0.023]	[0.043]	[0.040]
Test Stat for LC+LC Interaction=0	0.128***	0.101***	0.030	0.016	0.058**	0.055**
SE	[0.038]	[0.036]	[0.030]	[0.032]	[0.028]	[0.027]
Test Stat for HC+HC Interaction=0	-0.192***	-0.180***	-0.049	-0.048	-0.072***	-0.068***
SE	[0.033]	[0.030]	[0.036]	[0.033]	[0.024]	[0.024]
Dependent Variable Mean	7.254	7.254	7.254	7.254	7.313	7.313
Village FE	X	X	X	X	X	X
HH Controls		X		X		X
EA Controls		X		X		X
R-squared	.4	.43	.4	.43	.3	.33
Observations	14249	14215	14249	14215	11912	11833

Note: Standard errors clustered at the location-household tribe-landlord tribe level (reported in brackets).
* p<0.1, ** p<0.05, *** p<0.01
Column titles refer to the variable that is interacted with the match dummies.
No resident ownership refers to EAs that have no households residing in the EA reporting ownership of their house.
Non-Portable investment refers to EAs that have any households reporting having piped water into their dwelling.

Table 5b: Tribe Concentrations and Socio Economics
Dependent Variable is Log Rent

	(1) Majority Tribe	(2) Ethnic Concentration	(3) EA Education	(4) EA Wealth	(5) EA Poverty Rate
Landlord-Chief (LC) tribe match	0.087***	-0.004	0.052*	0.050	0.087***
	[0.028]	[0.027]	[0.029]	[0.032]	[0.027]
Household-Chief (HC) tribe match	-0.100***	-0.105***	-0.049	-0.048*	-0.107***
	[0.034]	[0.032]	[0.030]	[0.029]	[0.032]
Landlord-Household (LH) tribe match	-0.012	0.019	0.010	0.012	0.026
	[0.025]	[0.026]	[0.023]	[0.021]	[0.020]
LC Match*Relevant Variable	-0.056**	0.166***	0.034*	0.036	-0.035
	[0.026]	[0.042]	[0.019]	[0.025]	[0.029]
HC Match*Relevant Variable	0.097*	0.081	-0.057*	-0.065*	0.053*
	[0.057]	[0.057]	[0.030]	[0.036]	[0.031]
LH Match*Relevant Variable	0.045	-0.012	-0.006	-0.010	-0.035
	[0.032]	[0.041]	[0.021]	[0.024]	[0.032]
Test Stat for LC+LC Interaction=0	0.032	0.162***	0.086**	0.086**	0.053
SE	[0.027]	[0.040]	[0.027]	[0.026]	[0.032]
Test Stat for HC+HC Interaction=0	-0.003	-0.024	-0.106***	-0.113	-0.054**
SE	[0.039]	[0.049]	[0.030]	[0.035]	[0.027]
Dependent Variable Mean	7.254	7.254	7.254	7.254	7.254
Village FE	X	X	X	X	X
HH Controls	X	X	X	X	X
EA Controls	X	X	X	X	X
R-squared	.426	.428	.43	.43	.43
Observations	14215	14215	14215	14215	14215

Note: Standard errors clustered at the location-household tribe-landlord tribe level (reported in brackets). * $p<0.1$, ** $p<0.05$, *** $p<0.01$
Column titles refer to the variable that is interacted with the match dummies.
Majority tribe refers to the most prevalent tribe in each location. Non-majority tribes are the other tribes in the location.
The interactions in columns (2) to (5) are with dummy variables for the relevant variable being greater than the median in the sample.
The index used in column (2) is a location level Hirschman-Herfindahl Index of ethnic concentration, as defined in the paper.
Education is the EA average of years of education of the HH head. Wealth is an EA level principal components index from the 2009 census data.
The poverty rate is at the EA level and for less than two dollars a day, estimated using the methodology in Elbers, Lanjouw and Lanjouw (2003).

Table 6: How do Observables Correlate with Matches and Rents

	Mean	LC	HC	HL	Log Rent
EA listed as informal (slum)	.9348	.0062	.0082	.0785	-.2736**
		[.108]	[.0237]	[.0987]	[.1294]
Age of household head	35.21	-.0024	.0022	.0003	-.0019
		[.0033]	[.0022]	[.003]	[.006]
Household head works for pay	.6723	-.0221	-.0197	-.0849***	-.1312*
		[.0392]	[.022]	[.0298]	[.0688]
Household head owns a business	.1549	.0034	.0171	.0733*	.1461
		[.048]	[.0262]	[.0375]	[.0957]
Household head works for private sector	.400	.0249	.0044	-.0529**	.0326
		[.0282]	[.0185]	[.0246]	[.0387]
Household head has no education	.0368	.0441	.0542	.0388	-.3242*
		[.1605]	[.0738]	[.1157]	[.1806]
Household head has some secondary	.4302	-.0874	-.0258	-.0142	.2183**
		[.0622]	[.041]	[.0605]	[.1089]
Household head, years of education	9.215	-.004	-.0097**	-.0004	.0681***
		[.0077]	[.0039]	[.0063]	[.0121]
Household head, hours worked	55.94	-.0007	-.0002	.0004	.0022**
		[.0008]	[.0004]	[.0006]	[.0011]
TV	.4251	.0938*	-.0088	.0058	.5083***
		[.0542]	[.0317]	[.0449]	[.0743]
Radio	.7576	.1081	-.0452	.0709	.2178**
		[.0748]	[.0435]	[.0529]	[.0908]
Mobile phone	.8272	.0298	-.0716	.0085	.4276***
		[.067]	[.055]	[.0497]	[.0875]
Bicycle	.0593	.1404*	.0034	.0752	.0332
		[.0826]	[.0444]	[.063]	[.1207]
Walls are made of mud/wood	.2828	.0063	.011	-.009	-.0713**
		[.0214]	[.0143]	[.0167]	[.0294]
Floor is made of earth	.3339	-.0001	-.0004	.0102	-.220***
		[.0288]	[.0208]	[.0221]	[.0382]
Main water source is water vendor	.2434	-.0214	-.0013	-.012	.0485**
		[.0148]	[.0092]	[.0136]	[.023]
Main waste disposal is uncovered pit	.2188	.0088	.0024	.0059	.0128
		[.0179]	[.0104]	[.0142]	[.0244]
Main cooking fuel is paraffin	.5165	-.0847**	-.0285	.0301	-.0567
		[.0376]	[.0218]	[.0262]	[.055]
Main light source is electricity	.5379	.0206	-.0157	-.0176	.2843***
		[.0324]	[.0193]	[.0251]	[.0434]

Note: Standard errors are clustered at the EA level (reported in brackets).
* $p<0.1$, ** $p<0.05$, *** $p<0.01$
Each cell is from a separate regression, controling for village FE and tribe dummies.
The match and rent variables (dependent variables) are from the household surveys.
The independent variables are from the 2009 census aggregated to the EA level.

Table 7: Rents for Households Close to Administrative Boundaries: RD Specification

	(1) Log Rent	(2) Log Rent	(3) Log Rent	(4) Log Rent	(5) Log Rent	(6) Log Rent	(7) Log Rent	(8) Luminosity Change Roof	(9) Luminosity Change Roof	(10) Luminosity Change HH	(11) Luminosity Change HH
HC Match	-0.208**	-0.183**	-0.128**	-0.116**	-0.165***	-0.173	-0.239***	15.290*	18.824***	13.211	12.108**
	[0.083]	[0.077]	[0.059]	[0.047]	[0.042]	[0.110]	[0.054]	[8.251]	[6.089]	[10.289]	[6.017]
Bandwidth	1	2	3	4		1		1		1	
Polynomial					X		X		X		X
Dep Var Mean	7.131	7.155	7.172	7.177	7.218	7.131	7.218	7.131	7.217	7.132	7.217
Village FE	X	X	X	X	X	X	X	X	X	X	X
HH Controls	X	X	X	X	X	X	X				
EA Controls	X	X	X	X	X	X	X				
No Weights	X	X	X	X	X			X	X	X	X
R-squared	.29	.33	.32	.32	.44	.3	.43	.11	.05	.08	.04
Observations	1026	1370	1680	1957	10000	1037	10068	1071	10535	1065	10531

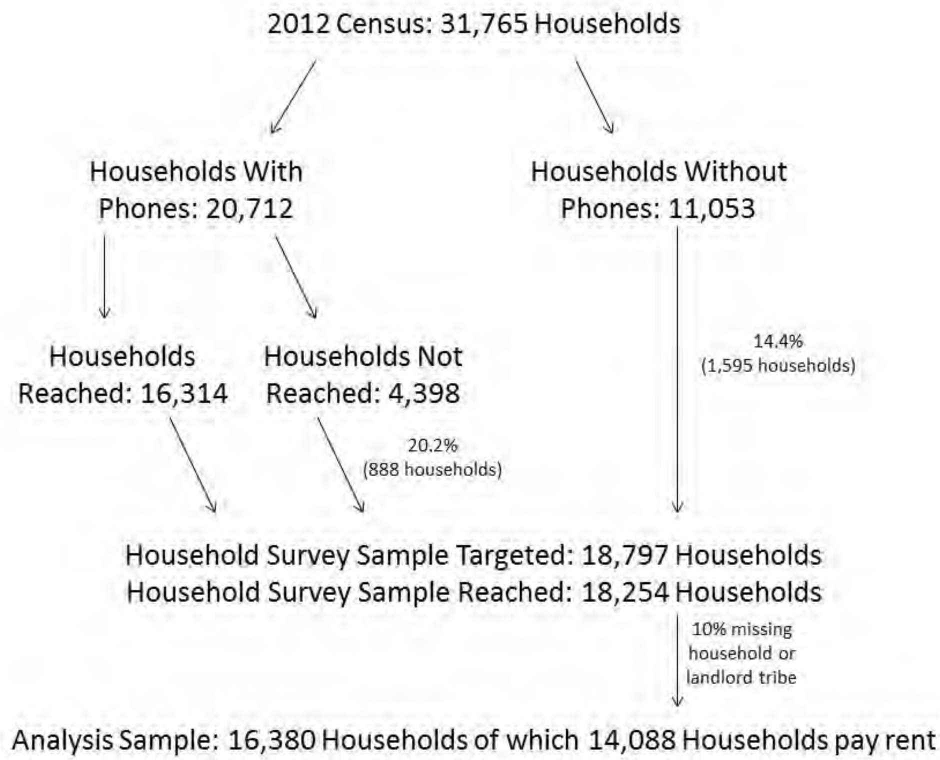
Note: Standard errors clustered at the location-household tribe-landlord tribe level (reported in brackets).
* $p<0.1$, ** $p<0.05$, *** $p<0.01$
All other tribe matches included as controls though not reported.
Bandwidths 1, 2, 3 and 4 are for local linear regressions with bandwidths of 75m, 100m, 125m and 150m respectively.
The polynomial includes fourth order polynomials that are allowed to be different on both sides of the boundaries.
The specifications for luminosity change are based only on the two most recent pictures (i.e it measures the investment between late 2011 and mid 2012).

Table 8: Attrition Checks
Dependent Variable is Log Rent

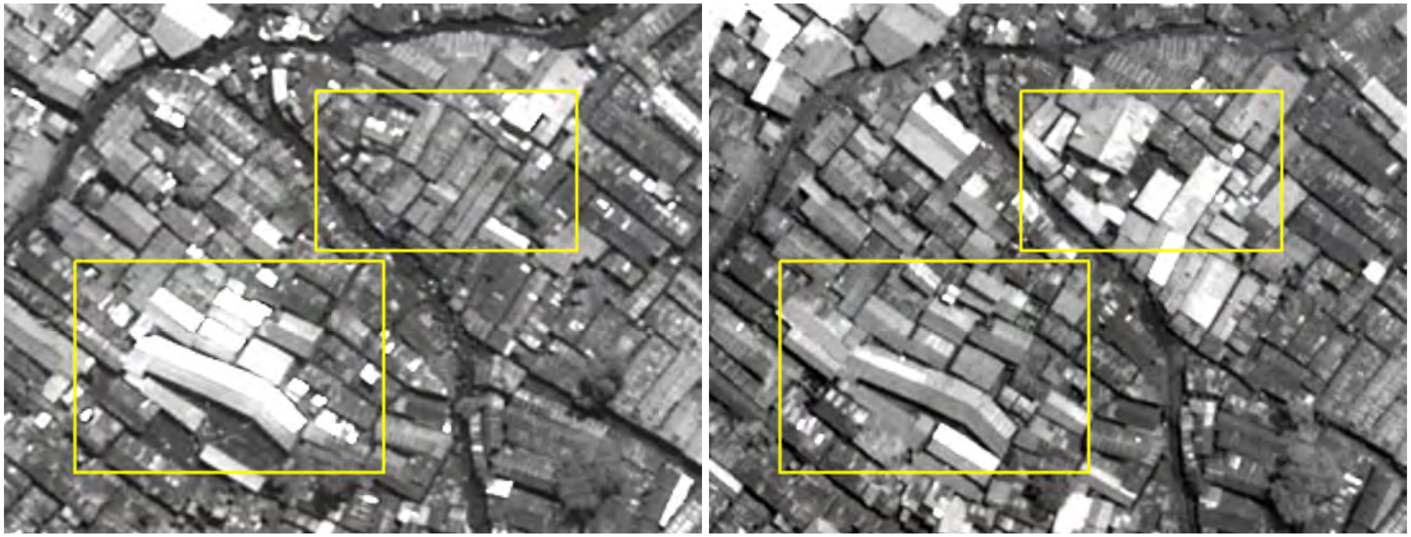
	(1) Low Attrition Sample	(2) Low Attrition Sample	(3) Attrition Weights	(4) Attrition Weights
Landlord-Chief (LC) tribe match	0.094***	0.128***	0.064**	0.080**
	[0.023]	[0.032]	[0.027]	[0.034]
Household-Chief (HC) tribe match	-0.074***	-0.072**	-0.075***	-0.073**
	[0.026]	[0.030]	[0.028]	[0.030]
Landlord-Household (LH) tribe match	-0.007	0.008	0.009	0.020
	[0.019]	[0.023]	[0.019]	[0.022]
Landlord-Elder (LE) tribe match		-0.055**		-0.023
		[0.025]		[0.022]
Household-Elder (HE) tribe match		0.002		-0.009
		[0.029]		[0.026]
Dependent Variable Mean	7.267	7.318	7.247	7.306
Village FE	X	X	X	X
HH Controls	X	X	X	X
EA Controls	X	X	X	X
R-squared	.432	.336	.417	.32
Observations	11246	9381	14003	11641

Note: Standard errors clustered at the location-household tribe-landlord tribe level (reported in brackets).
* $p<0.1$, ** $p<0.05$, *** $p<0.01$
Low attrition sample covers the EAs with a 5% attrition rate or less.
The attrition weights are computed using the methods in Fitzgerald, Gottschalk and Moffitt (1998).

Appendix Figure A1: Household Sampling Strategy

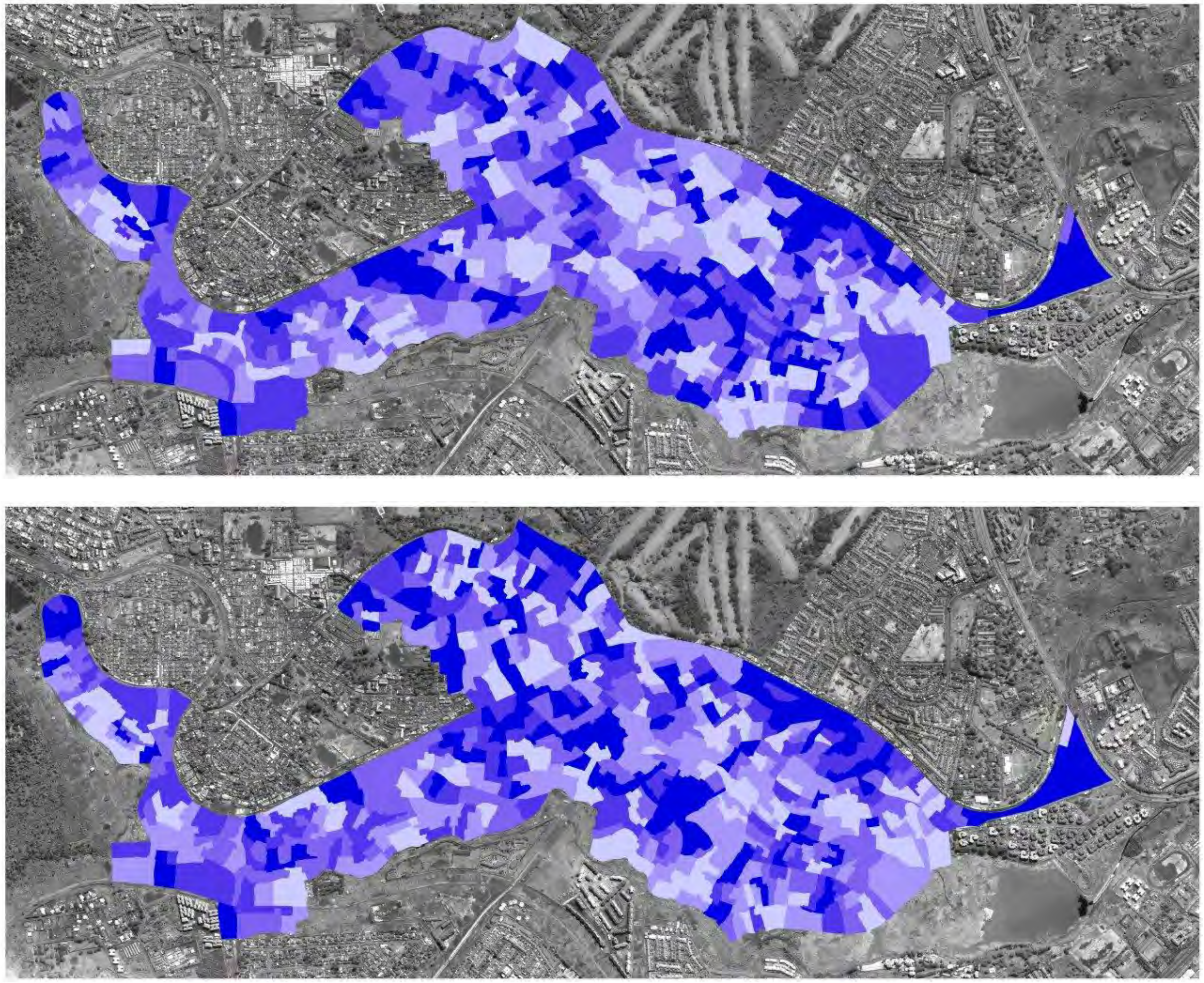


Appendix Figure A2: Old and New Roofs in Kibera



Note: Both pictures are taken over the same area of the slum with the same resolution (0.5 meters panchromatic).
The picture in the left panel was taken in July 2009 and that in the right panel in August 2012.
The yellow rectangles highlight clusters of roofs that markedly evolved over the period.
Roofs highlighted in the bottom rectangle degraded while roofs within the top rectangle were upgraded in the same timeframe.
The picture area is approximately 175 meters long and 140 meters wide.

Appendix Figure A3: Roof Luminosity and Household Consumption Across Kibera



Note: The top panel displays mean luminosity by EA while the bottom panel displays mean (estimated) household consumption by EA. The data used are the residualized values of the variables after accounting for the sublocation fixed effects in a regression framework. The blue color scale is divided into 5 categories (the 20th, 40th, 60th, 80th and 100th percentiles in the data). This picture only includes the 546 EAs listed as informal in the 2009 KNBS census.

Appendix Table A1: Correlations of Luminosity with Wealth, Consumption and Poverty

Relationship with Household Demographics		Relationship with State of Habitat		Relationship with Economic Indicators	
Fraction of HH members working working	16.066** [7.855]	Walls are made of mud or cement	-5.955** [2.507]	Poverty ($1.25 per day)	-50.722** [22.371]
Fraction of HH members in in business	40.025*** [10.327]	Floor is made of cement	16.963*** [3.581]	Poverty ($2 per day)	-37.393*** [8.673]
HH head has some secondary educ	19.697** [8.538]	Main cooking fueld is charcoal	-9.690** [4.061]	Log consumption per capita	22.195*** [3.856]
HH head has some univ educ	15.611 [11.364]	Main water source is vendor	5.863*** [1.943]	% of EA within 15m of road	8.360*** [2.861]
Age of HH head	-1.597 [0.405]	Main light source is electricity	-3.007 [3.759]	Presence of business in EA	2.937** [1.460]
Observations	576		576		576

Note: Heteroskedasticity robust standard errors in brackets.
* p<0.1, ** p<0.05, *** p<0.01
HH stands for household; EA stands for Enumeration Area.
All regressions are weighted by the size of the EA and include eight sublocation fixed effects.
The first two columns are results from one regression of luminosity on the reported variables in the column.
In the third column, each cell reports results from a separate regression as all these variables are extremely highly correlated.