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There Is No Free House: Ethnic Patronage in a Kenyan Slum†

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Using unique data from one of Africa's largest informal settlements, the Kibera slum in Nairobi, we provide evidence of ethnic patronage in the determination of rental prices and investments. Slum residents pay higher rents and live in lower quality housing (measured via satellite pictures) when the landlord and the locality chief belong to the same ethnicity. Conversely, rental prices are lower, and investments higher when residents and chiefs are co-ethnics. Our identification relies on the exogenous appointment of chiefs and is supported by several tests, including a regression discontinuity design. (*JEL* J15, O15, O17, O18, R21, R31)

Informal settlements, or slums, accommodate a growing fraction of the world's poor. According to the United Nations (UN), there were 881 million slum dwellers in developing countries in 2015, and at least 59 percent of sub-Saharan Africa's urban population are estimated to live in informal settlements (UN-Habitat 2015).[1] Considering the expansion of cities globally, the UN estimates that at least 450 million new housing units are needed to accommodate slum populations in direct need of shelter (UN-Habitat 2012). Yet there remains little empirical evidence on the economic livelihoods of slum residents. These areas pose particular challenges for standard data collection and economic research: direct measurement of economic indicators in slums (in particular housing-related characteristics and land prices) is practically difficult, expensive, and therefore carried out infrequently. In this paper, we report on a unique effort to study the livelihoods of residents in one of Africa's

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[1] Slums are generally defined as overcrowded urban areas with poor-quality housing, a lack of public services, and large numbers of informal residents (UN-Habitat 2006).

largest informal settlements, the Kibera slum in Nairobi, and we provide an in-depth study of the rental market in this slum. We focus on one particular form of market distortion—we show that ethnic patronage affects the determination of rental rates and housing quality.

Our data collection combined a large-scale survey of approximately 30,000 slum dwellers across Kibera with high resolution satellite imagery captured over the slum between 2009 and 2012. We use the satellite data to corroborate and augment our findings on the ground. Nighttime satellite luminosity is regularly used as a proxy for economic activity (Chen and Nordhaus 2011; Henderson, Storeygard, and Weil 2012),[2] but the nighttime data is not well suited to measuring economic outcomes at a very fine level of aggregation as the low resolution of nighttime images and the diffusion (or "bleeding") of light across pixels cause local economic activity to be poorly measured. In this paper, we construct a proxy for housing quality using daytime satellite images with a resolution of 0.5 meters. We measure the luminosity reflected by corrugated iron roofs, and we show in the online Appendix that these measures correlate with various measures of socioeconomic welfare. Over the past decade, satellite remote sensing has increasingly been used in GIS applications to detect and classify slum settlements (Kohli et al. 2012; Kohli, Stein, and Sliuzas 2016; and Duque, Patino, and Betancourt 2017) and to measure the value of housing and quality of life in urban areas (see Patino and Duque 2013 for a review and Jiao et al. 2017 and Kuffer et al. 2017 for recent applications in emerging countries). To our knowledge, this paper is the first to combine the use of satellite imagery with detailed survey data on rental prices and housing quality in a slum setting.

One major characteristic of informal settlements is their high level of ethnic diversity, yet the impact of such diversity in poor urban contexts is not well understood. A recent exception is Collin (2013), who shows that local ethnic homogeneity reduces demand for land formalization in Tanzanian slums. Outside informal urban settings, a large literature documents the negative relationship between ethnic diversity and economic performance (see Alesina and La Ferrara 2005 for a review). There is also a long tradition of studying racial discrimination in the housing market in the United States (e.g., Becker 1957; Cutler and Glaeser 1997; Cutler, Glaeser, and Vigdor 1999; and Bayer et al. 2012). Kain and Quigley (1975) and Collins (2004), in particular, provide evidence that African Americans in US ghettos paid more than other ethnicities for similar-quality housing (reviews of this literature can be found in Collins 2004 and Ross 2005). To understand how ethnic bias affects transactions in the rental market and the price of housing in Kibera, we look at the interaction between local authorities (in this environment, location chiefs),[3] landlords, and tenants. To identify these effects, we exploit the fact that the Provincial Administration exogenously appoints chiefs to their positions within Nairobi, and that chiefs are regularly rotated around the city. We look at ethnicity as a factor that potentially mediates the rent-seeking behavior of chiefs.

[2] In economics, Burchfield et al. (2006) and Burgess et al. (2012) also use remote sensing data to construct measures of urban sprawl and deforestation, respectively.

[3] Chiefs in the context of our study are not traditional ethnic leaders imposed by local custom (as in Michalopoulos and Papaioannou 2015), but employees of the administration locally recognized as chiefs.

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 tenants paying between 6 percent and 11 percent more to rent their dwelling (we use the terms "tribe" and "ethnicity" interchangeably throughout the paper). Conversely, we find that having a co-ethnic chief leads tenants to pay lower rents, by a similar order of magnitude. We argue that these effects arise when chiefs are called upon to arbitrate rent-related disputes, and accordingly side with a co-ethnic. This interpretation is consistent with the anecdotal evidence we collected in the field, and qualitative accounts on the role ethnic networks play in the governance of Kibera.[4] 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 tenant and the chief belong to the same tribe. We measure investments by looking at a measure of the quality of a tenant's roof, using the roof's luminosity (brightness) from high resolution satellite images of the slum. These effects are estimated from a tenant-level panel specification that only exploits variation from the change in chiefs across the slum between periods, and uses roof luminosity data from the satellite imagery between 2009 and 2012 as the outcome of interest. Rental prices adjusted for luminosity are also higher for residents whose landlord is of the same tribe as the chief, and lower when the chief is of their own tribe.

We conduct three separate checks to defend our identification assumption that the appointment of chiefs is exogenous to characteristics of the slum dwellers. First, we show that a variety of socioeconomic characteristics of residents measured in 2009 do not predict ethnic alignments in 2012, even though they do correlate strongly with rental prices. If residents were sorting based on underlying characteristics, we would have expected at least some of the variables observed in 2009 to predict whether a resident and a chief are of the same ethnicity in 2012. Second, we show that the match between the resident's and the chief's ethnicity and the match between the landlord's and the chief's ethnicity are not correlated with various measures of the ethnic composition of the locality. Third, we use the idea that residents are very similar along observable and unobservable characteristics across the internal administrative boundaries of the slum to design a regression discontinuity (RD) test. For the subsample of residents who have a co-ethnic chief operating in the slum, for whom we can construct this RD design, we show that our results hold within very small bandwidths around the internal (location) boundaries of the slum.[5]

These results suggest that ethnic patronage surrounding rental prices have both distributional effects and consequences on welfare in the slum. The effects we find amount to a transfer from tenants with an adversarial landlord-chief match toward tenants with a co-ethnic chief. The magnitude of our estimates suggests that this

[4] In particular, Joireman and Vanderpoel (2011) documents that a chief will generally side with co-ethnic tenants in cases of rent disputes involving different ethnicities. They also highlight how permissions are needed from the chief to upgrade housing structures, interactions that often involve bribery and where ethnicity also plays a key role.

[5] Our data supports the notion that the mobility of residents within the slum is limited. Residents have lived in the same structure and with the same landlords for long periods of time (the averages of these variables in our sample are 8 and 7 years, respectively), much longer than the typical tenure of a chief within the slum, which averages 23 months in our data.

transfer is approximately welfare-neutral in terms of slum living costs, but the existence of frictions in the determination of rents and investments suggests that slum residents incur additional welfare costs. First, tenants pay a cost in terms of consumption volatility, and bargaining costs as rents become potentially renegotiable with every change in the ethnicity of the chief. Second, given the dynamics, the existence of *any* friction in investment decisions will imply a departure from optimality: the effects we find on roof luminosity arise from the fact that chiefs intervene in decisions to upgrade private dwellings, a feature that would not exist in an efficient housing market. Third, the ethnic discrimination in rents for residents whose landlord and chief belong to the same tribe may exacerbate an existing, but separate market failure: the fact that landlords have local monopoly power. Overall, the results we present imply that the lack of public arbitration of land disputes is a major market failure in slum settings, and that city authorities should play a much more direct role in settling these disputes, since delegating this role to local chiefs creates extensive opportunities for rent-seeking.

Our findings contribute to a growing empirical literature on the economic consequences of ethnic favoritism (e.g., Franck and Rainer 2012, Burgess et al. 2015). In this paper, we make two contributions to this literature. First, we show that ethnic favoritism does not only affect public goods provision, but also equilibrium prices in a (housing) market setting, and we look at the economic consequences of these distortions. Few studies have looked at ethnic favoritism in private markets in developing countries (exceptions include Fafchamps 2000, Hjort 2014, and Michelitch 2015). We note, nevertheless, that these effects in our context are still mediated by the provision of a public good (arbitration of land disputes). Second, and relatedly, we show that the ethnicity of local arbitrators matters in these private markets. Arbitrators in our setup are chiefs appointed by the administration whose responsibility it is to mediate rent-related disputes in the slums. There is a literature in the United States focusing on the ethnicity of arbitrators (examples include Anwar, Bayer, and Hjalmarsson 2012; Abrams, Bertrand, and Mulainathan 2012; Shayo and Zussman 2011; and Price and Wolfers 2010), but no studies have looked at their role in developing economies.[6]

The rest of the paper is structured as follows. Section I provides relevant background on Kibera. Section II describes the data we collected and our estimates of roof quality based on high-resolution satellite imagery. Section III describes our empirical framework. Section IV provides our main results, including identification and robustness checks. Section V concludes.

I. Background: The Kibera Slum

The Kibera colony was established in 1912 to accommodate veteran Sudanese soldiers from the British colonial army. The official estimate of its population in the 2009

[6] Our paper also adds to a large literature on the adverse effects of weak property rights on economic performance (e.g., Besley 1995; Banerjee, Gertler, and Ghatak 2002; Goldstein and Udry 2008; and Hornbeck 2010), including a more recent literature documenting the importance of strengthening property rights in informal urban areas (Field 2007; Galiani and Schargrodsky 2010; Lanjouw and Levy 2002).

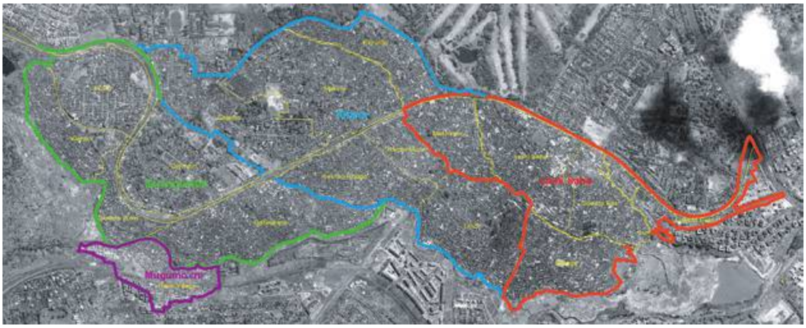

Figure 1. Map of Kibera

Notes: This figure shows a map and satellite image of the Kibera area. Location boundaries are outlined in red, blue, green, and purple, and villages inside Kibera are outlined and labeled in yellow.

national census was 170,000 residents. Figure 1 shows a map of the Kibera slum, which nowadays spans approximately 8 square kilometers in the center of Nairobi.

Tenancy rights in Kibera have been ambiguous since the colony's creation. Sudanese settlers were the only residents legally recognized until 1969, when the Kenyan government revoked their claims on the land (de Smedt 2011). However, a de facto housing market had already developed in which long-term residents of the settlement rented structures to newcomers (Temple 1974). Starting in 1974, new land titles were illegally allocated by local chiefs and bureaucrats in the Provincial Administration, engendering the creation of new structures and a demographic explosion (Amis 1984). Today, Kibera land formally remains the government's property, but the housing market is effectively controlled by slum landlords. From our data, there are, in fact, at least several hundred different landlords in Kibera.[7] A 2002 survey of Kibera landlords reported on in Joireman and Vanderpoel (2011) concluded that more than 80 percent of landlords lived outside of the slum and 57 percent were public officials. Our survey data also suggests that most landlords (55 percent) are Kikuyus or Nubis living in estates outside Kibera.[8] The remaining half of landlords is predominantly Luo (17 percent), Luhya (11 percent), and Kamba (8 percent). Figure 2 shows the distribution of landlord tribes across the slum.

A densely populated and diverse area, Kibera has experienced many episodes of interethnic violence in the past. The ethnic makeup of Kibera is not representative of Kenya, since Luos, Luhyas, and Kambas, in that order, are the tribes most represented in the slum (representing 36 percent, 27 percent, and 15 percent of the slum population, respectively), while Kikuyus (the most prevalent tribe in the country) represent only 6 percent. Kenyans of Sudanese (Nubian) origin, who were the original settlers of Kibera, constitute only a small fraction of its current population. Figure 3 shows the distribution of resident tribes across the slum.

[7] Our data unfortunately does not allow us to calculate the exact number of landlords in the slum, since most tenants declined to provide the full name of their landlord.

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

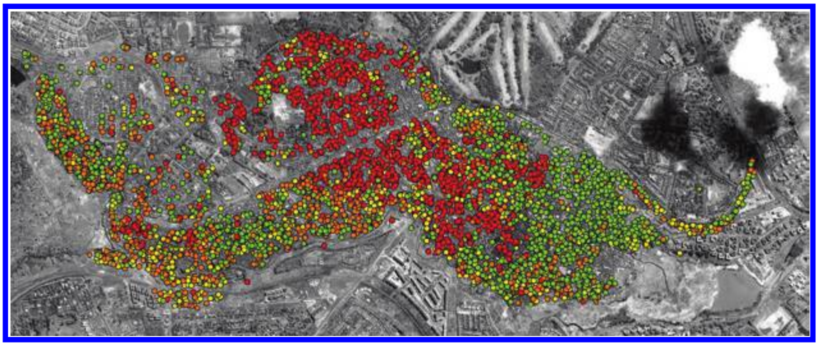

Figure 2. Distribution of Landlord Tribes in Kibera

Note: For confidentiality reasons and under IRB requirements, we do not provide a key as to which color is which tribe.

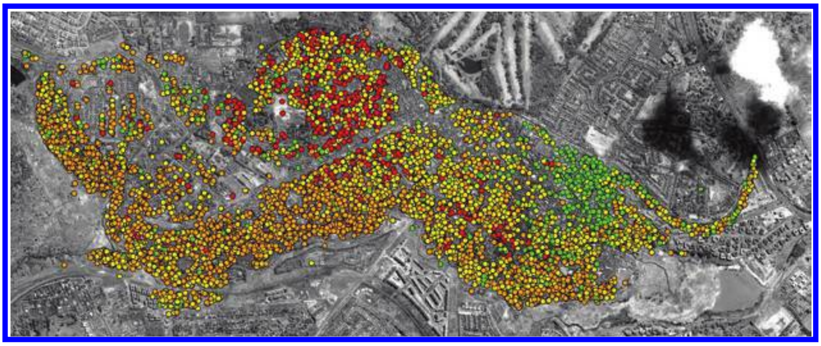

Figure 3. Distribution of Household Tribes in Kibera

Note: For confidentiality reasons and under IRB requirements, we do not provide a key as to which color is which tribe.

II. Data

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

A. *Listing* (*Census*) *and Household Survey Data*, 2012

Our survey data was collected between February and December 2012. To constitute a sampling frame of slum dwellers within Kibera, we first listed 31,765 resident households over the 9 sublocations that constitute the slum area.[9] The listing involved two rounds of visits in each sector of the slum. GPS coordinates were collected for all inhabited structures, resulting in 9,728 unique sets of coordinates and hence

[9] Since the average household size in our listing is 3.65, our listing covered approximately 115,942 individuals or 68 percent of the 2009 slum population based on the 2009 census data.

Table 1A—Survey Summary Statistics

	Mean	SD	Observations
Listing (census) data			
Household size	3.65	2.109	31,717
Rent, census sample (Kshs)	1,678.5	2,105.9	18,679
Kalenjin tribe	0.013	0.115	28,890
Kamba tribe	0.155	0.362	28,890
Kikuyu tribe	0.059	0.235	28,890
Kisii tribe	0.064	0.244	28,890
Luhya tribe	0.269	0.444	28,890
Luo tribe	0.365	0.481	28,890
Nubi tribe	0.054	0.226	28,890
Other tribe	0.021	0.145	28,890
Ethnic fractionalization, zone	0.674	0.069	31,765
Resident survey data			
Tenant pays rent	0.916	0.277	17,251
Amount paid in rent (Kshs)	1,715.3	1,784.1	15,473
Change in rent, census to survey (Kshs)	101.6	1,210.0	11,019
Household ever evicted in Kibera	0.106	0.324	17,216
Roof renovated	0.233	0.423	17,196
Roof renovated in 2 years	0.18	0.384	17,196
Roof renovated in 5 years	0.21	0.407	17,196
Landlord Kalenjin tribe	0.004	0.064	15,620
Landlord Kamba tribe	0.082	0.275	15,620
Landlord Kikuyu tribe	0.333	0.471	15,620
Landlord Kisii tribe	0.052	0.223	15,620
Landlord Luhya tribe	0.106	0.307	15,620
Landlord Luo tribe	0.167	0.373	15,620
Landlord Nubi tribe	0.218	0.413	15,620
Number of years in Kibera	15.55	11.123	17,067
Years with the same landlord	6.915	6.821	15,884
Years in the same structure	8.471	8.969	17,153
Ethnic matches			
Landlord-chief (LC) tribe match	0.218	0.413	15,620
Tenant-chief (TC) tribe match	0.137	0.344	17,742
Landlord-tenant (LT) tribe match	0.281	0.449	14,814
All tribes match (ALL)	0.047	0.211	14,814

Notes: The household survey is a stratified random sample taken from the census data. Resident tribes were collected in the census data. Landlord tribes were collected in the household survey data. Chief tribes come from the administrative history of chief lineage. The exchange rate at the time of the household survey was 80 KShs to the US dollar.

structures. For each structure we also collected the number of households residing in the structure. The household size in our sample was approximately 3.7 individuals per household, with just over 2 adults. Sixty-five percent of household heads gave us valid phone numbers. Table 1A shows summary statistics from this listing data.

Based on this listing of Kibera residents (households), we conducted a phone survey starting in July 2012. The survey itself collected data on the tribe of landlords, rental prices, renovation of dwellings (roofs), and previous evictions within the slum. To construct this sample, we stratified the listing by whether the residents reported a phone number. We attempted to contact all residents that reported a phone number and reached 79 percent or 16,314 of them on the phone. Of the 21 percent that could not be reached by phone, we sampled 20 percent (888 resident households) and collected these surveys in person in the slum. Finally, of the 35 percent of residents that did not provide a phone number, we randomly sampled 14 percent (1,595) and conducted the survey in person. Throughout our analysis, we re-weight the data to create a sample of surveys that is representative of the whole 31,765 resident households initially listed. This sampling strategy gave us a total target sample size of $N = 18{,}797$,[10] of which we reached 18,254 (97 percent), giving us an attrition rate of 11 percent (weighting attrition by survey sampling weights). Table 1A shows summary statistics from our resident survey, and online Appendix 1 shows that survey attrition is not driving our empirical results.

As can be seen in Table 1A, approximately 92 percent of residents pay rent and average monthly rents are approximately KShs 1,700 (US$20). About 11 percent report having ever been evicted from their houses in Kibera. The most common reasons for evictions are residents not paying rents (45 percent) or refusing to pay higher rents (10 percent), a unilateral decision from the landlord (19 percent), or the structure being demolished (9 percent). Twenty-three percent of residents have had their roofs renovated since they moved in and 18 percent in the last two years. Finally, residents 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, 22 percent of residents have a landlord with the same tribe as the chief. About 14 percent of residents have a co-ethnic chief and 28 percent have a co-ethnic landlord. Only 5 percent of residents have both a co-ethnic chief and a co-ethnic landlord.

B. *Chief and Elder Surveys*

In addition to the listing and resident surveys, we reconstructed the history of chiefs who served in Kibera since 1950. The settlement was originally governed by one chief appointed by the Provincial Administration, assisted by community elders who represent the most basic level of informal authority in the slum and are responsible for small areas called "zones."[11] In 2002, the slum area and its surroundings were divided into four locations, each governed by a chief and nine sublocations, each governed by an assistant chief who reports to the location chief.[12] The nine sublocations are divided into villages, which are relevant for the purpose of customary governance but are not part of the provincial administration. In total, there are 17 villages, of which the 5 largest ones are split into zones.

We also conducted surveys of all current chiefs and community elders who accepted to be interviewed. Our sample of respondents was composed of 3 location chiefs, 7 assistant chiefs,[13] and 45 community elders. All the chiefs and assistant chiefs we surveyed mentioned a version of "maintaining law and order" as their main responsibility. Two chiefs cited "arbitration" and "peace-building and conflict management" as their second most important responsibility. Furthermore, eight out

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

[11] Community elders are appointed by chiefs and are generally chosen amongst people well-known to the community. They tend to serve much longer than the chiefs themselves (14.6 years on average in our survey data).

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

[13] The one location chief and two sublocation chiefs we missed were all operating in the same location (Sarangombe location). These individuals, as well as the elders in that village, all declined to be interviewed.

of ten respondents claimed to know most or approximately half of residents in their area of responsibility, and seven out of ten claimed to know most or half of landlords in their area. Finally, when asked how often chiefs receive requests from residents to pay lower rents, three out of ten respondents answered "several times daily" or "several times a week," suggesting rent-related disputes do occur on a frequent basis. Thus, there is some evidence that chiefs spend a substantial fraction of their time arbitrating such disputes.

We also visited various chiefs' offices to obtain, wherever possible, administrative records on the amount of rent-related disputes, and the way in which disputes are typically settled by chiefs. Unfortunately, since consistent records of these disputes are not being kept, we cannot provide exact statistics on the number and the outcomes of these disputes. The anecdotal figures we could obtain are the following. In the Sarangombe location (one of the four locations in our data), over a one-week period in February 2014, 16 rent-related cases were reported to the chief and settled by him. All cases were initiated by the landlord as a result of tenants not paying their rents. Out of these 16 cases, 3 ended with the tenant vacating the dwelling, 11 resulted in a rent increase with payment of some arrears, and 2 ended with the tenant agreeing to pay the rent but arrears were forgiven. Over a three-day period in April 2014, 6 out of 11 cases also resulted in the chief summoning tenants to pay their rents and arrears over a given time frame. In the Kibera location, over a one-week period in March 2014, 55 out of 58 cases were settled by the chief, with the remaining 3 being settled in courts. The outcome of these disputes was not reported. In the Langata location, we could find a large number of rent-related disputes having been reported to the chief and documented (158 and 413 over two different time periods, the length of which is undocumented). Again, the outcome of these disputes is unknown.

The surveys conducted with community elders also provided us with data on local public goods and amenities, which we use as controls in our main analysis. These include the numbers of street lights, clinics, schools, kiosks (small retailer shops), and M-PESA (mobile money) agents in the zone. Summary statistics for these variables are presented in Table 1B. Finally, 96 percent of elders report that permission is needed to upgrade the housing in the slum, in particular, to upgrade roofs, and 77 percent of the time, the permission of one of the chiefs is needed.

C. *Kenya National Bureau of Statistics Census Data*, 2009

In addition to our survey data, we use 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.[14] In 2009, the slum was divided into 643 Enumeration Areas (EAs), encompassing 64,588 households, of which 576 EAs (57,804 households) were listed as informal settlements. We digitized EA maps

[14] The Kibera Division is split into 7 locations and a further 16 sub-locations. Of these, the Kibera slum spreads across four locations and nine sub-locations. From the 1999 census, there were a total of 2,427 locations and 6,612 sub-locations in Kenya.

Table 1B—Summary Statistics: Other Data

	Mean	SD	Observations
2009 Census data, EA level			
Age of household head	35.43	2.11	608
Household head works for pay	0.676	0.163	608
Household head owns a business	0.152	0.125	608
Head works for private sector	0.407	0.209	608
Household head has no education	0.036	0.043	608
Head has secondary education	0.425	0.101	608
Head, years of education	9.29	1.44	608
Head, hours worked in seven days	55.68	9.08	608
TV	0.422	0.2	608
Radio	0.761	0.096	608
Mobile phone	0.827	0.104	608
Bicycle	0.06	0.066	608
EA within 15 m of road	0.247	0.209	616
EA listed as informal (slum)	0.919	0.272	608
Walls are made of mud/wood	0.293	0.3	608
Floor is made of earth	0.366	0.287	608
Main water source water vendor	0.234	0.386	608
Main waste uncovered pit	0.224	0.337	608
Main cooking fuel is paraffin	0.525	0.207	608
Main light source is electricity	0.516	0.292	608
Fraction youth unemployed	0.171	0.122	608
Wealth index (principal components)	0	2.26	608
Extreme poverty ($1.25/day)	0.143	0.078	608
Poverty ($2/day)	0.424	0.14	608
Zone-level variables			
Number of street lights in zone	4.697	5.844	33
Number of clinics in zone	1.242	1.714	33
Number of schools in zone	3.061	3.517	33
Number of kiosks in zone	81.47	94.17	32
Number of M-PESA agents in zone	10.30	12.58	33
Ethnic fractionalization, zone	0.69	0.071	33
Visit by government official	0.667	0.479	33
Satellite data			
Luminosity, roof level	307.33	70.11	75,062
Luminosity, household level	304.69	78.70	75,188
Luminosity, roof level, trimmed	304.23	51.39	73,663
HH luminosity, trim	301.23	57.19	73,782
Luminosity change, roof level	20.12	85.88	56,293
Roof luminosity, change, trim	20.55	56.93	55,208
HH luminosity, change, trim	19.91	64.23	55,331

Notes: Luminosity data is from satellite images for July 2009, January 2011, December 2011, and August 2012. The trimmed luminosity data drop the top 1 percent and the bottom 1 percent of observations.

from KNBS to map the 2009 census data to the EA level, and 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 high-rise buildings along two edge areas of the slum. We therefore use data for the 608 EAs covered during our 2012 listing.

In Table 1B, we show summary statistics from the KNBS census data aggregated at the level of the EA. We show the rates of youth unemployment (defined both within households and within EAs as the fraction of individuals aged 16–25 without a job), which we use in the online Appendix as a proxy for the local presence of youth gangs. The EA-level average of these two measures is 17 percent. As measures of economic activity, about 4 percent of household heads have no education, 42 percent have some secondary education, and household heads have 9 years of education on average (a year longer than primary school completion). To provide some context, we also report measures of asset ownership and wealth. For example, 36 percent of households have water piped into their dwelling, and about 8 percent of households report owning their house.

D. *Satellite Imagery*

Overview.—To study investments in slum structures in Kibera, we develop a methodology that uses the luminosity reflected by metal roofs in high-resolution daytime satellite pictures of the area (we describe our cross-validation of the methodology in online Appendix 2). A recent literature uses satellite luminosity data to proxy for economic activity.[15] Two limitations of the nighttime data are its low resolution[16] and the lack of data variation in areas of the world that are not well electrified. For example, Henderson, Storeygard, and Weil (2012) reports that over 99 percent of the territories of Mozambique and Madagascar are completely unlit at night over the period 1992–2008. Although useful as a proxy for aggregate activity, the nighttime data is inadequate for measuring economic activity at the household level. Using daytime pictures of Kibera with a panchromatic resolution of 0.5 meters, we are able to use the satellite data at a disaggregated level of analysis, down to the level of a dwelling. Our satellite images span a period of three years between 2009 and 2012.

Our analysis uses the fact that metal roofing quality is a useful variable to understand the investment behavior of households in the slum; 96 percent of slum residents have corrugated iron roofs. There is little variation in the quality of floors and walls of these households. Most slum inhabitants live a subsistence lifestyle, work in the informal sector, and own few assets. Households with higher quality roofs are likely to be those with more savings, more secure 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. Online 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 decaying and rusting over the period. Though we have survey data on roof renovations, there are two reasons we use satellite images as well. First, self-reports of roof renovations involve some measurement error—residents may not remember exactly when their roofs were replaced. Second, the satellite images provide a short-term panel on what happens over a two-year period, with detailed variation in the quality of the roof, not just the replacement of the roof.

[15] Examples of studies using nighttime data include Bleakley and Lin (2012) and Michalopoulos and Papaioannou (2013).

[16] 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 km at the equator.

Data Description.—We use four high-resolution (0.5 m) 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 0.5 m and one with a multispectral resolution of 2 m, over an area of interest (AOI) comprised between $-1.298°$ and $-1.324°$ latitude and $36.77°$ and $36.89°$ longitude. This AOI covers about 35 km² within the city of Nairobi. To optimize the accuracy of the geo-positioning and the superposition of the pictures over time, the raw data was ortho-rectified by the consultant using regional geo-reference points and a shapefile of land use in Nairobi made publicly available 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 $-1.305°$ and $-1.321°$ latitude and $36.77°$ and $36.81°$ longitude (approximately 7.91 km²).

Data Processing.—To extract luminosity data from the satellite pictures, we use the Zonal Statistics (Spatial Analyst) (ZS) 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 gray 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 resident household) at which we compute the luminosity data.

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.[17] 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 own 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 of roofs. The appropriate values of the parameters of interest were

[17] 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.

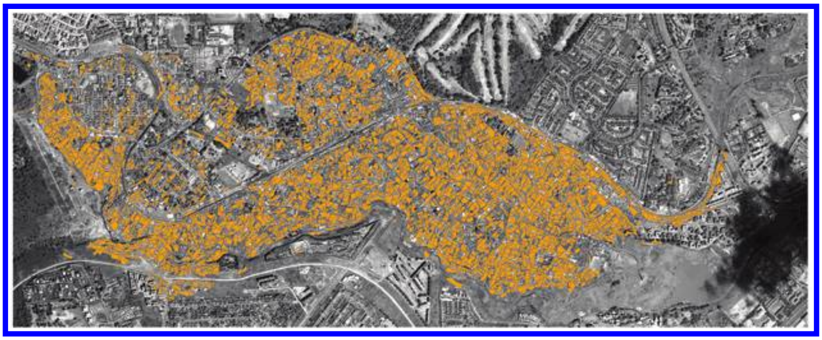

Figure 4. Roofs from Satellite Images in Kibera (January 2011)

Notes: This figure shows a satellite image of the Kibera area. Roofs in our sample are indicated in orange. See online Appendix for methods.

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 manually rectified the roof objects in ArcGIS based on simple visual checks. Figure 4 shows our resulting map of roofs across the entire Kibera slum. The mean surface of a roof is 466 m^2, and 11.2 households on average live under one roof.

In addition to the roof-level analysis, we present the luminosity data reflected by the roof surface situated just above the resident 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 (also using the ArcGIS's ZS tool) within a one-meter radius of the household's GPS coordinates. 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 full 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 in our pictures of the slum. Table 1B shows summary statistics on the luminosity variables extracted from these satellite images. In the online Appendix, we provide some empirical validation that the 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 measures of income and wealth.

III. Empirical Framework

This section describes the empirical framework we use to test our hypotheses. We first discuss the theory that underpins our main research question: do ethnic matches between chiefs, landlords, and tenants affect rental prices and investments in the slum? We then describe the main specification we use in our empirical analysis. Finally, we defend the identification assumptions needed for our estimates to be interpreted as causal. We also present a number of robustness checks to support our main results.

A. *Research Question*

We are interested in understanding how two specific forms of ethnic collusion—the tenant and the location chief belonging to the same tribe, or the landlord and the chief belonging to the same tribe—affects rental prices and investments in the slum. As we discuss below, our identification strategy is based on the fact that chiefs are exogenously assigned and regularly transferred by the Provincial Administration.

There are several reasons to expect that the ethnicity of the chief would affect the rental prices paid by tenants, in a context where tenancy rights are weak and rents are regularly renegotiated (recall that tenant evictions are frequent events in Kibera). First, chiefs may have a "taste" for favoring individuals from their own tribe. This would lead them to side with co-ethnic landlords against non–co-ethnic tenants, and with co-ethnic tenants against non–co-ethnic landlords in rent-related disputes, regardless of any bribes received. Second, both tenants and landlords may be able to obtain more favorable settlements from a co-ethnic chief because of lower bargaining costs or communication frictions. There is a large literature documenting the relationship between co-ethnicity (i.e., ethnic homogeneity) and productivity (Alesina and La Ferrara 2005 provide a review of this literature). Third, ethnicity could mediate the rent-seeking behavior of chiefs in their role as arbitrators. There is widespread qualitative evidence that chiefs use rent-related disputes as an opportunity to extract rents: for example, Joireman and Vanderpoel (2011) describes Kibera chiefs as "bureaucratic entrepreneurs, exhibiting rent-seeking behavior in exploiting their formal office to secure personal gain." They further argue that:

> *Since structure owners have a higher socioeconomic status than tenants, they can pay more, giving chiefs an incentive to decide in favor of a structure owner. An alternative outcome is possible if the chief and tenant are of the same ethnic group and the structure owners' tribe is perceived as adversarial. For example, a Luo chief would generally side with a Luo tenant against a Kikuyu structure owner despite the smaller payment offered by the tenant.*
>
> —(Joireman and Vanderpoel 2011, 140–42).

Thus, while chiefs use rent disputes to extract bribes from landlords and tenants, they will typically request lower bribes from co-ethnics than from outsiders. Again, this differential treatment could arise from preferences, bargaining costs, or from intragroup norms (i.e., chiefs may be disciplined by norms within their own ethnic group: for example, a Luo chief is accountable to the Luo hierarchy outside of Kibera). Note that all these effects could take place with or without a direct involvement of the chief. For example, a Kikuyu landlord dealing with a Luo tenant in a Luo-governed area may cater to the tenant's request to lower the rent just to avoid a direct mediation involving the chief.

In our analysis, we also look at whether these relationships have longer term effects by constraining investments in the housing infrastructure. Anecdotal evidence supported by our data indicates that permission from chiefs is needed for any investments in housing quality, including any upgrading of roofs, an interaction that involves rent seeking and can therefore also be subject to ethnic patronage. Alternatively, as the quality of housing degrades, the tenant is likely to demand improvements and fixes for leaky roofs. Some of these will generate disputes, which are then resolved by the chief, with the chief siding with the landlord or the tenant depending on the specific ethnic configuration, following the same logic as the one discussed above. We test for these investment effects using satellite data to proxy for roof quality.

B. *Main Specification*

We first outline our baseline specification. We start with a simple regression that illustrates the hypotheses we are interested in, as follows:

$$(1) \qquad y_{ij} = \alpha + \beta^{lc} m_{ij}^{lc} + \beta^{tc} m_{ij}^{tc} + \beta^{lt} m_{ij}^{lt} + \gamma_l + \gamma_t + \gamma_c + \Omega X_{ij} + \delta_j + \epsilon_{ij},$$

where y_{ij} is our outcome measure of interest (rental prices or roof luminosity) for resident i in village j; m^{lc} is a dummy variable that takes value one if the tribes of the landlord and the location chief match (henceforth, LC) and is zero otherwise; m^{tc} is a dummy variable for the tribes of the tenant and the chief matching (TC); m^{lt} is a dummy for a landlord-tenant tribe match (LT); the γ_l, γ_t, and γ_c are main effects for the tribes of the landlord, the tenant, and the chief, respectively; X_{ij} are a set of hedonic controls; and δ_j are village fixed effects.

C. *Identification*

We now discuss identification for the two main coefficients of interest, β^{lc} and β^{tc}. In equation (1) above, the identification assumption is that $\text{cov}\left(m_{ij}^{lc}, \epsilon_{ij} \mid W_{ij}\right) = 0$ and $\text{cov}\left(m_{ij}^{tc}, \epsilon_{ij} \mid W_{ij}\right) = 0$, where W_{ij} includes all the controls and fixed effects in equation (1). Conditional on the covariates, village fixed effects, and all the relevant tribe main effects, the matching of the landlord-chief and the tenant-chief tribes should be exogenous to unobserved tenant characteristics that determine rental prices.

To defend this assumption, we provide some background on the appointments of chiefs as well as a number of empirical checks using the characteristics of tenants 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 propose three empirical checks that support our identification assumptions.

Exogenous Appointments of Chiefs.—Between 2002 and 2012, 18 different chiefs (each responsible for 1 of 4 locations) served in Kibera. In Nairobi, appointments are advertised by the Provincial Administration and made by the Office of the President of Kenya, or by the Provincial Administration through the Provincial Commissioner, subsequent to an interview process. In addition, the chiefs are rotated through the entire province at the discretion of the administration approximately every two years. Formally, this appointment process implies that chiefs cannot sort across parts of the slum based on local characteristics of the residents or the landlords. At the time of data collection in August 2012, the current chiefs in Kibera had been active for an average of 18.8 months, though based on our data on chief tenures, the average tenure for a chief has been 23 months: since 2002, 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.

Figure 5 describes the amount of variation we have in the tribes of chiefs, landlords, and tenants over the period covered in the panel (2009–2012). In the bottom-right panel, we also show the fraction of ethnic matches we have along each dimension in the 2012 cross section. While there are only four chiefs in this cross section, in the panel we have one change in the tribe of the chief in every location. Under the assumption of exogeneity of the tribe of the chief, the specification we run is thus analogous to a difference-in-differences specification (we check the validity of this assumption below). In addition, note that in our setup, treatment is not defined at the level of a chief, but at the level of a chief-landlord-tenant combination (and there are two treatments: the TC match and the LC match). There are 224 such combinations in our data.[18] For any given chief (i.e., in every location), individual treatment status will vary depending on the ethnicity of landlords and residents: for a chief from ethnicity K governing location A, there will be both treated and untreated tenants along the TC dimension, and treated and untreated tenants along the LC dimension. This setup is similar to that of studies that look at changes in the ethnicity of political leaders over time to estimate the effects of ethnic patronage (e.g., Burgess et al. 2015).

Identification Checks.—The main concern with estimating a specification such as equation (1) involves sorting. Tenants could sort into areas with a co-ethnic chief, or alternatively try to avoid housing where the landlord is of the same tribe as the chief. This sorting behavior would be a problem for our identification if it correlates with other observables and unobservables that also affect rental prices and investment.

We believe this type of behavior is unlikely to occur because mobility within the slum is limited (residents stay in the same structure and with the same landlord 8 and 7 years, respectively, on average) and anecdotal evidence suggests that finding arrangements for new housing in the slum is difficult. Nevertheless, we address these concerns by providing three sets of empirical checks. First, to test for the exogeneity of chief appointments, we look at a range of characteristics of residents 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

[18] Consistent with this logic, this is also the level at which we cluster our standard errors (see Section IV).

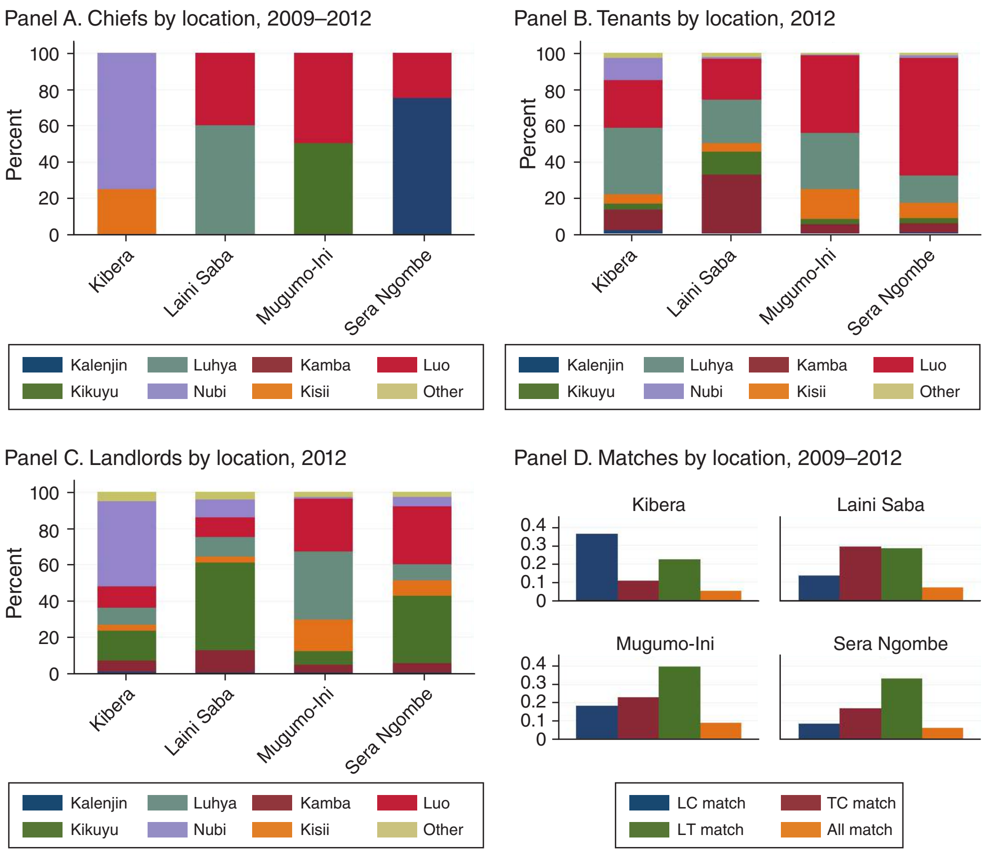

Figure 5. Tribes by Location

Notes: Panels A, B, and C show the fractions of chiefs, tenants, and landlords belonging to each tribe in each location. Tenant and landlord tribes were collected in 2012. Chief tribes were collected retrospectively for the period 2009–2012. Panel D shows the fraction of residents experiencing a LC, a TC, a LT, or a triple match between 2009–2012 in each location.

part of which locations to be posted in. Second, we show these matches are largely uncorrelated with various measures of the ethnic composition of the locality.

Third, we construct a regression discontinuity (RD) test in which we look at residents living within a small distance of the internal location boundaries of the slum. We assume that residents and local area characteristics are continuous across these boundaries, while the ethnicity of the location chief (who has the power to interfere with rents) changes discretely at the boundary. We use a standard RD design to look at whether rental prices and investments show a change across these internal location boundaries of the slum.

Note that we often also show the estimate for the tenant-landlord tribe match variable. It may be relevant to control for this variable, but we do not interpret this effect as being causal. Our identification strategy is based on the tribe of the chief being exogenous to characteristics of the tenants and landlords. The tribe match of the tenants and landlords does not have any exogenous variation that allows us to interpret this effect as causal. In most specifications, the coefficient on this variable is very small in magnitude and statistically not significant. In addition, we report some specifications where we do not include this variable—the results are unchanged.

IV. Results

We first report on our identification checks, and then present our main results from equation (1) using measures of rental prices and roof luminosity as outcomes. Finally, we present results from the RD specification.

A. *Correlates of Ethnic Matches*

In this section we present two sets of checks to support our identification assumptions.[19] In our first set of checks, we analyze whether our tribe match variables are correlated with observables from the 2009 census data. Our match variables come from data collected in 2012 and all the chiefs serving in 2012 were appointed after 2009. This allows us to check if chiefs were sorting into locations based on the 2009 socioeconomic characteristics of the slum residents. Since these measures were collected in 2009—before any of the current chiefs began their terms—we use them as a measure of "baseline" data. This data is aggregated at the level of an EA because the census data is de-identified. Table 2A reports the results. Each cell in the table represents a separate regression where the dependent variable is a tribe match dummy. We show results for 24 different right-hand side variables, correlating each with the relevant match dummy. We control for village fixed effects, main effects of the tribes, and we cluster the regressions at the EA level. Column 1 reports the mean of each variable. Column 2 uses the dummy for a landlord-chief tribe match (m^{lc} in our notation) as the dependent variable, column 3 uses the dummy for the tenant-chief tribe match (m^{tc}), column 4 the dummy for the tenant-landlord tribe match (m^{tl}), and column 5, log rents.

In column 2, 3 of the 24 variables predict a match between the landlord and chief tribes (significant at the 5 percent level). In column 3, we find only one significant predictor of the match between tenant and chief tribes. In column 4, four variables predict the tenant-landlord match: the dummies for whether the resident household head works for pay, owns a business, or works for the private sector, as well as the poverty rate. It seems that residents 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 variables. Finally, in column 5 of Table 2A, we test whether the 2009 characteristics are correlated with rents in 2012. This is analogous to running a hedonic regression to predict rental prices. We find that a number of housing and area characteristics are significantly correlated with rents: these include (among others) informal status, floor and wall quality, water and electricity access, as well as asset ownership and education levels of the resident household.

[19] In the online Appendix, we also show that our results are robust to survey attrition.

Table 2A—How Do Observables Correlate with Ethnic Matches and Rents?

	Mean	LC	TC	LT	Rent
Roof size	0.631	−0.0034 [0.0074]	−0.0043 [0.0054]	0.0074 [0.008]	−0.0244 [0.0156]
How many HHs in this structure?	8.98	−0.0007 [0.0008]	0.0005 [0.0005]	0.0004 [0.0007]	−0.0029 [0.0014]
EA listed as informal (slum)	0.939	0.006 [0.1092]	0.0051 [0.0217]	0.0794 [0.1]	−0.2741 [0.1346]
Walls are made of mud/wood	0.282	0.0078 [0.0217]	0.012 [0.0145]	−0.0108 [0.017]	−0.0714 [0.0294]
Floor is made of earth	0.334	0.0001 [0.029]	−0.0008 [0.0209]	0.0086 [0.0223]	−0.2211 [0.0382]
Main water source water vendor	0.243	−0.0216 [0.0149]	−0.0014 [0.0092]	−0.0124 [0.0137]	0.048 [0.023]
Main waste uncovered pit	0.219	0.0098 [0.0181]	0.003 [0.0104]	0.007 [0.0143]	0.0121 [0.0245]
Main cooking fuel is paraffin	0.516	−0.0852 [0.0377]	−0.0272 [0.0219]	0.0272 [0.0264]	−0.0578 [0.055]
Main light source is electricity	0.538	0.0211 [0.0327]	−0.0152 [0.0195]	−0.0158 [0.0255]	0.2847 [0.0437]
Age of household head	35.2	−0.0024 [0.0033]	0.0021 [0.0022]	0.0006 [0.003]	−0.0019 [0.006]
Household head works for pay	0.673	−0.0226 [0.0393]	−0.0181 [0.0222]	−0.0841 [0.0303]	−0.1296 [0.0689]
Household head owns a business	0.155	0.0054 [0.0483]	0.0138 [0.0267]	0.0741 [0.0382]	0.1438 [0.0961]
Head works for private sector	0.400	0.0264 [0.0284]	0.0062 [0.0186]	−0.0531 [0.0247]	0.0336 [0.0388]
Household head has no education	0.037	0.0516 [0.1634]	0.0497 [0.075]	0.0495 [0.1182]	-0.3254 [0.1812]
Head has secondary education	0.430	−0.0864 [0.0626]	−0.024 [0.0414]	−0.0098 [0.0606]	0.2165 [0.1094]
Head, years of education	9.22	−0.0041 [0.0078]	−0.0096 [0.0039]	0.0004 [0.0064]	0.0681 [0.0121]
Head, hours worked in 7 days	55.94	−0.0007 [0.0008]	−0.0002 [0.0004]	0.0004 [0.0006]	0.0023 [0.0011]
TV	0.425	0.0943 [0.0545]	−0.0078 [0.0321]	0.0175 [0.0456]	0.5084 [0.0746]
Radio	0.758	0.1112 [0.075]	−0.0406 [0.0435]	0.0725 [0.0531]	0.2201 [0.0908]
Mobile phone	0.827	0.0265 [0.0676]	−0.07 [0.0555]	0.0161 [0.0499]	0.4311 [0.088]
Bicycle	0.059	0.1386 [0.083]	0.0029 [0.0444]	0.0796 [0.0646]	0.0316 [0.1213]
Wealth index	0.019	0.004 [0.0048]	−0.0027 [0.0031]	0.002 [0.0041]	0.0503 [0.0064]
Poverty	0.433	−0.0862 [0.0555]	0.0472 [0.0356]	−0.0861 [0.0458]	−0.5288 [0.0903]
R^2		0.205	0.034	0.019	0.311

Notes: Standard errors are clustered at the EA level (reported in brackets). This table checks whether ethnic match variables correlate with observables from the 2009 census data. LC, TC, and LT refer to landlord-chief, tenant-chief, and landlord-tenant ethnic matches, respectively. Each cell is from a separate regression of the match dummy on a census characteristic of slum residents (aggregated to the EA), controlling for village fixed effects and tribe dummies. R^2 values are computed without the village and tribe dummies.

Table 2B—Ethnic Matches and Local Tribe Composition

	Majority tribe, EA (1)	Majority tribe, zone (2)	Majority tribe, village (3)	Diversity, EA (4)	Diversity, zone (5)
Landlord-chief (LC) tribe match	0.025	0.006	−0.033	0.006	0.004
	[0.095]	[0.087]	[0.100]	[0.012]	[0.005]
Tenant-chief (TC) tribe match	−0.114	−0.006	−0.163	0.013	0.008
	[0.128]	[0.124]	[0.145]	[0.009]	[0.004]
Landlord-tenant (LT) tribe match	0.140	0.108	0.071	−0.024	−0.004
	[0.059]	[0.062]	[0.068]	[0.006]	[0.003]
Dependent variable mean	0.545	0.497	0.491	0.610	0.689
R^2	0.246	0.309	0.336	0.428	0.588
Observations	14,766	14,766	14,766	14,766	12,390

Notes: Standard errors are clustered at the location-tenant tribe-landlord tribe level (reported in brackets). Standard errors in column 5 are clustered at the zone level. This table checks whether tribe match variables correlate with measures of local ethnic composition. "Majority tribe" indicates whether the resident belongs to the majority tribe in the relevant area (EA/zone/village). "Diversity" is a Herfindahl index of ethnic diversity in the relevant area (EA/zone). A high value of the index indicates high diversity.

As a second check, in Table 2B, we look at whether the tribe match variables correlate with measures of local ethnic composition. Here we regress ethnic composition variables on the tribe match dummies and tribe main effects. In columns 1, 2, and 3, we look at a dummy for whether the resident belongs to the majority tribe. Majority is defined at the EA level in column 1, at the zone level in column 2, and at the village level in column 3. In all three columns, the landlord-chief and household-chief tribe matches do not correlate with whether the resident is part of the majority tribe (while the landlord-resident match does). Similarly, in columns 4 and 5, we look at a measure of ethnic diversity, measured at the EA and zone levels. Again, the landlord-chief tribe match does not correlate with local ethnic diversity. The resident-chief tribe match exhibits a correlation when diversity is measured at the zone level. However, we should note that we do not correct for multiple comparisons in this table, so we would expect one of the ten coefficients to be significant.

B. *Rental Prices*

For clarity of exposition, we rewrite equation (1):[20]

$$y_{ij} \;=\; \alpha + \beta^{lc} m_{ij}^{lc} + \beta^{tc} m_{ij}^{tc} + \beta^{lt} m_{ij}^{lt} + \gamma_l + \gamma_t + \Omega X_{ij} + \delta_j + \epsilon_{ij}.$$

Tables 3A and 3B show the results from this regression where log rental prices and quality-adjusted rental prices are the outcomes of interest, and for a range of specifications where we progressively add more controls. We should note that the number of observations in these specifications is not the number of residents surveyed, but the number of tenants for whom we have complete ethnicity data. Overall, we surveyed 18,254 residents, of which approximately 10 percent did not report

[20] Here the chief tribe dummies, γ_c, are omitted since they are absorbed by the village fixed effects.

either their own tribe or their landlord's tribe. This leaves us with a sample of 16,262 residents, of which just over 14,300 pay rent. In the remainder of this section, we refer to these residents as "tenants." Throughout (unless otherwise specified) we cluster our standard errors at the level of location-tenant tribe-landlord tribe, i.e., at the level of the three tribe (chief, tenant, and landlord) combinations. In addition, we report the test statistic from an F-test for the null hypothesis that $\beta^{lc} + \beta^{tc} = 0$.

Before we report results, it is useful to comment on the variation in the two match variables of interest. Twenty-two percent of tenants have a landlord who is a co-ethnic of the chief. Fourteen percent of tenants belong to the same ethnicity as the chief themselves, and 5 percent of tenants belong to the same ethnicity as both their landlord and the chief. This implies that there is a lot of variation in the landlord-chief and tenant-chief matches that does not imply that all three of the landlord, tenant, and chief are co-ethnics. The correlation between the landlord-chief and the tenant-chief matches is only 0.14.

In column 1 of Table 3A, we report results without any controls and without village fixed effects (chief tribe dummies are included in that specification). Tenants whose landlords are of the same tribe as the chiefs (LC match) pay 11 percent higher rents. The coefficient on the tenant-chief tribe match (TC match) is negative, but not significant. The coefficient on the tenant-landlord tribe match (LT match) is small in magnitude and insignificant.

In column 2 of Table 3A, we add village fixed effects to capture unobservable differences in the desirability of housing across various areas of the slum, and several controls for housing quality measured at the EA level from the 2009 KNBS census: namely dummies averaged at the EA level for whether the walls of the dwelling are made of mud and wood, whether the floor of the dwelling is made of earth, whether the tenants' main source of water is a water vendor, whether the tenant's toilet is an uncovered pit latrine, whether the tenant's main cooking fuel is paraffin and whether the tenants' main source of light is electricity. In addition, we control for roof size (computed from our satellite pictures), the number of resident households in each structure (collected from the listing data), and a dummy for whether the enumeration area was coded as informal in the 2009 KNBS census. The results are statistically unchanged after adding these controls.

In column 3 of Table 3A, we add controls for a set of local public amenities measured at the zone level, namely the numbers of street lights, clinics, schools, kiosks (small retailer shops), and M-PESA (mobile money) agents in the zone, as well as the fraction of the enumeration area that falls within 15 m of a road (to proxy for accessibility of the dwelling).[21] The zone-level controls were collected from the elder survey, and the accessibility variable was computed in ArcGIS. In column 4 of Table 3A, we further add a number of demographic controls at the tenant level and at the EA level.[22] In column 5, we add a dummy for whether all three of the tenant, the

[21] Since some elders refused to be interviewed, estimates with zone-level controls (from column 3 onward) have only about 11,600 observations. In addition to the results reported in this table, our results are also robust to estimation on this subsample without any of the zone-level controls (results not reported).

[22] These are: from our own listing census, the number of adults and total household size for each resident household; and from the 2009 KNBS census, the average age and education levels (in years) of heads of household in the EA; dummies for the head having no education, and for having some secondary education; dummies for whether

Table 3A—Rents

	Dependent variable is log rent						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Landlord-chief (LC) tribe match	0.108	0.066	0.058	0.053	0.079	0.056	0.046
	[0.040]	[0.027]	[0.029]	[0.029]	[0.026]	[0.032]	[0.027]
Tenant-chief (TC) tribe match	−0.047	−0.081	−0.070	−0.064	−0.041	−0.061	−0.061
	[0.041]	[0.028]	[0.027]	[0.027]	[0.023]	[0.028]	[0.026]
Landlord-tenant (LT) tribe match	−0.034	0.008	0.021	0.020	0.034	0.023	0.018
	[0.026]	[0.020]	[0.022]	[0.021]	[0.022]	[0.021]	[0.020]
All tribes match (ALL)					−0.089		
					[0.058]		
Landlord-elder (LE) tribe match						−0.028	
						[0.023]	
Tenant-elder (TE) tribe match						−0.015	
						[0.025]	
Chief-elder (CE) tribe match						0.132	
						[0.092]	
F-stat for LC + TC = 0	0.943	0.112	0.072	0.060	0.967	0.013	0.120
p-value	0.333	0.738	0.789	0.807	0.326	0.911	0.730
Dependent variable mean	7.255	7.248	7.306	7.306	7.306	7.306	7.306
Village fixed effects		X	X	X	X	X	X
Housing controls		X	X	X	X	X	X
Amenities controls			X	X	X	X	X
Other controls				X	X	X	X
Zone tribe controls							X
R^2	0.09	0.4	0.303	0.319	0.319	0.321	0.323
Observations	14,311	14,051	11,599	11,577	11,577	11,577	11,577

Notes: Standard errors are clustered at the location-tenant tribe-landlord tribe level (reported in brackets). Rents are monthly. Observations vary across columns due to missing observations for various covariates. Results are identical when the sample is restricted to observations with non-missing data. Housing controls: roof area, number of tenants in structure, EA-level housing characteristics from the census. Amenities controls: fraction of the EA close to roads and zone-level controls from the elder survey. Other controls: demographic controls from the resident survey and economic EA controls from the census.

landlord, and the chief have the same tribe. The results on the landlord-chief tribe match remain significant with a coefficient of 8 percent as does the coefficient on the tenant and the chief belonging to the same tribe (−4 percent). The coefficient on all three tribes matching is fairly large in magnitude but not statistically significant. In column 6, we include our data on the tribes of community elders. In particular, we control for dummies for an elder-landlord tribe match as well as an elder-tenant tribe match. Since elders are not exogenously rotated in the same way that chiefs are, we do not interpret these effects as causal, but we show them for comparison. In column 7 of Table 3A, we also include village dummies interacted with the fraction of the most common tribe in the zone.

Finally, in Table 3B, we use as our main outcome a measure of quality-adjusted rental prices—this measure is the log of rental price divided by roof luminosity. The controls are the same as those in column 6 of Table 3A; namely, we include

the head works, runs a business, works for the private sector; and dummies for whether the household owns each of a number of assets (TV, radio, phone, bicycle) (all these variables are averaged at the EA level).

Table 3B—Quality Adjusted Rents

	Quality adjusted rent		
	(1)	(2)	(3)
Landlord-chief (LC) tribe match	0.058	0.082	0.061
	[0.029]	[0.028]	[0.033]
Tenant-chief (TC) tribe match	−0.065	−0.044	−0.063
	[0.026]	[0.023]	[0.028]
Landlord-tenant (LT) tribe match	0.014	0.027	0.017
	[0.021]	[0.022]	[0.021]
All tribes match (ALL)		−0.083	
		[0.055]	
Landlord-elder (LE) tribe match			−0.028
			[0.022]
Tenant-elder (TE) tribe match			−0.013
			[0.023]
Chief-elder (CE) tribe match			0.145
			[0.092]
F-stat for LC + TC = 0	0.032	0.937	0.002
p-value	0.858	0.334	0.968
Dependent variable mean	1.501	1.501	1.501
Village fixed effects	X	X	X
Housing controls	X	X	X
Amenities controls	X	X	X
Other controls	X	X	X
Zone tribe controls			
R^2	0.311	0.312	0.313
Observations	11,577	11,577	11,577

Notes: Standard errors are clustered at the location-tenant tribe-landlord tribe level. For explanations of controls, see notes for Table 3A. Quality adjusted rent is rent adjusted by luminosity at the roof level.

all the hedonic, amenities, and demographic controls. In column 2 of Table 3B, we include the dummy for a tenant-landlord-chief tribe match, and in column 3 we include the same elder-level tribe dummies as in column 6 of Table 3A. Across those three columns, results are similar to those obtained with log rents: a landlord-chief tribe match increases quality-adjusted rents, while a tenant-chief tribe match has the opposite effect.

Based on these results, a back-of-the-envelope calculation suggests that, absent any ethnic matches between tenants and chiefs (TC) and between landlords and chiefs (LC), the total amount of monthly rents paid in the slum would be approximately Kshs 54.46 million (or US$630,000 in 2012 dollars). We obtain this number by multiplying our total sample size (31,765) with the weighted average amount paid in rent by tenants with no TC match and no LC match (Kshs 1,714.5 or US$19.8 in 2012 dollars). This figure is almost exactly the same as the total amount of monthly rents paid in the actual sample (Kshs 54.49 million). This is intuitive since the effect of the TC match and that of the LC match have comparable magnitudes and because the fractions of the sample with a TC or an LC match are also similar (14 percent of tenants have a TC match and 22 percent have an LC match in our 2012 census).

Thus, because the effects of TC matches almost offset the effects of LC matches on rents, the net aggregate effect of ethnic patronage on the cost of living in the slum is small in magnitude. The effects of ethnic matches are primarily redistributive in nature: ethnic patronage implies a transfer from tenants with an "adverse" LC match to tenants with a "favorable" TC match.

C. *Investments*

In Tables 4A and 4B, we focus on the roof luminosity data as our outcome. As described in Section IID, the luminosity data provides a proxy for housing quality that varies across residents in the slum, and correlates with various socioeconomic characteristics including housing rents. Here we look at three different specifications, and in each case we report results for the two different measures of luminosity (see Section IID for a description of these two measures). The first specification is a resident-level panel specification that only exploits exogenous variation from the rotation of chiefs across time (we report estimates from a similar specification in Figure 6, as described below). The second specification looks at luminosity levels in a specification analogous to equation (1) now estimated over four time periods, and the third specification looks at changes in luminosity across periods.

Recall from Section IID that there are four periods in the satellite data spanning July 2009 to August 2012. In this analysis, we implicitly assume that residents stay in the same structure and with the same landlord within the period considered. This is consistent with the data we collected on duration of residence (residents in our sample have lived in the same structure for 8 years, and with the same landlord for 7 years on average). We make this assumption as we do not have panel data on structures to capture how tribes change within a given structure.[23] However, note that the tribe of the chief changes over time, so the match variables are now time varying and given by $m_{ij\tau}^{lc}$ and $m_{ij\tau}^{tc}$.

In columns 1 through 4 of Table 4A, we take advantage of the panel nature of our data and report results from the following resident fixed effects specification:

$$L_{ij\tau} = \alpha_i + \beta^{lc} m_{ij\tau}^{lc} + \beta^{tc} m_{ij\tau}^{tc} + \gamma_c + \mu_\tau + \epsilon_{ij\tau}, \quad (2)$$

where $L_{ij\tau}$ is the level of luminosity for resident i in village j measured in period τ; α_i is a resident fixed effect; and μ_τ is a period fixed effect. We present results for the full sample (columns 2 and 4) as well as the sample excluding one village, Laini Saba (columns 1 and 3), for which the luminosity data is extremely different (there is a very high within-roof standard deviation in the luminosity measures for this village). We do not control for a tenant-landlord match in this specification since this effect is not identified in the panel (as the tribes of the tenant and landlord do not change over time). Equation (2) is identified from the tribes of the chiefs changing over time as they rotate in and out of locations in the slum. The chiefs do not rotate at the same time in each location—the rotations are staggered. Thus, the panel

[23] All the results presented in Tables 4A and 4B are robust to dropping residents that have lived in the same structure for less than two years (results not reported, available upon request).

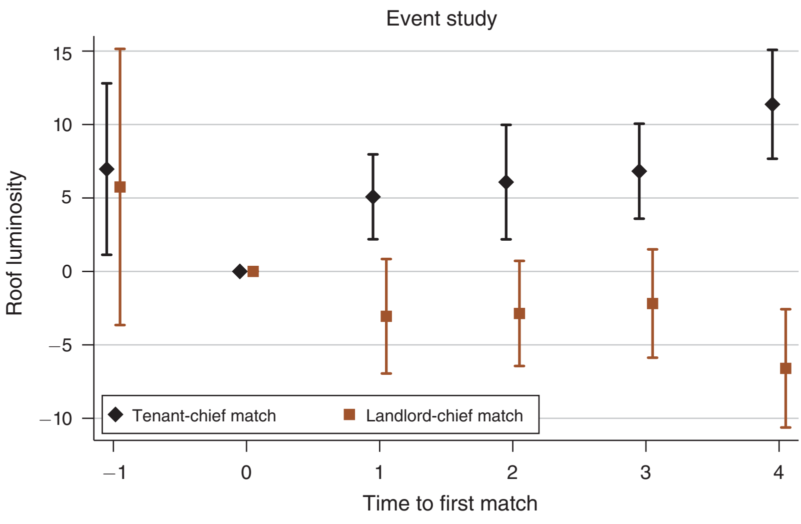

Figure 6. Effects of Ethnic Matches on Roof Luminosity

Notes: This figure reports coefficients from an event study specification with the level of luminosity as the dependent variable. The event (separately for the first TC match and the first LC match) occurs at time $t = 1$ in the graph, not necessarily the first period in the data. *Tenant-chief match* is a dummy variable equal to 1 if a tenant experiences her first ethnic match with the chief at time $t = 1$. *Landlord-chief match* is a dummy variable equal to 1 if a resident experiences the first ethnic match between her landlord and the chief at time $t = 1$. The specification includes resident fixed effects, chief tribe fixed effects, and period fixed effects. Standard errors are two-way clustered at the tribe combination and at the longitude-latitude level. The bars indicate 90 percent confidence intervals.

Table 4A—Investments in the Slum: Roof Luminosity

	Luminosity, panel regression			
	Roof measure	Roof measure	Resident measure	Resident measure
	(1)	(2)	(3)	(4)
Landlord-chief (LC) tribe match	−0.671	−0.779	−1.752	−1.177
	[1.134]	[1.454]	[1.472]	[1.847]
Tenant-chief (TC) tribe match	2.890	2.166	2.867	1.902
	[1.036]	[1.125]	[1.248]	[1.521]
Landlord-tenant (LT) tribe match				
All tribes match (ALL)		1.209		0.485
		[1.825]		[1.669]
Test statistic LC + TC = 0	3.354	0.527	0.472	0.103
p-value	0.068	0.469	0.493	0.748
Dependent variable mean	303.342	303.626	300.748	300.817
Drop Laini Saba	X		X	
GPS clustering			X	X
Tribe clustering	X	X	X	X
Tenant fixed effects	X	X	X	X
R^2	0.635	0.633	0.611	0.615
Observations	54,992	58,087	55,006	58,076

Notes: Standard errors are clustered at the levels indicated in the table. Columns 1–4 show panel regressions (controlling for tenant fixed effects). All specifications also control for period fixed effects and GPS coordinates. Luminosity data is extracted from satellite images for July 2009, January 2011, December 2011, and August 2012. All results use the trimmed luminosity data (top and bottom percentiles removed). Regressions cannot be clustered at the roof level as roofs cannot be matched across pictures.

allows us to measure the effect of at least one change of chief in each location during the period considered.

In columns 1 and 2 of Table 4A, we focus on luminosity measured at the roof level. In column 1, we find that roof quality is significantly higher when the resident and the chief are of the same tribe. The coefficient on the landlord-chief tribe match is negative but not significant. In columns 3 and 4, we report similar results for our second measure of luminosity, the resident-level measure. Here the regressions are two-way clustered at the tribe combination and at the longitude-latitude level (the latter to account for multiple households with the same set of GPS coordinates). Our estimates have the expected sign and are significant only in the case of a resident-chief match, in column 3.

The effects we find in columns 3–4 of Table 4A are further illustrated by the event study plot presented in Figure 6. Here, we report regression estimates from the following specification:

$$(3) \qquad L_{ij\tau} = \alpha_i + \sum_{t=-1,t\neq 0}^{t=4} \beta^{lc} d_{ijt}^{lc} + \sum_{t=-1,t\neq 0}^{t=4} \beta^{tc} d_{ijt}^{tc} + \gamma_c + \mu_\tau + \epsilon_{ij\tau},$$

where luminosity $L_{ij\tau}$ is still measured in levels, d_{ijt}^{lc} is a dummy equal to 1 if resident i in village j experiences her first LC match at time t, and $d_{ijt}^{tc} = 1$ if i experiences her first TC match at time t (the dummies d_{ij0}^{lc} and d_{ij0}^{tc} are the omitted group). As in columns 3–4 of Table 4A, standard errors are two-way clustered at the tribe combination and at the longitude-latitude level. We find in Figure 6 that roof luminosity increases monotonically after the first TC match and decreases after the first LC match, with no clear evidence of pre-trends. However, we have limited power to estimate pre-trends since no resident in the data experiences their first match in the fourth period (August 2012), and few residents experience their first treatment in the third period (December 2011). Overall, the estimates displayed in Figure 6 are consistent with those reported in Table 4A.

In columns 1 through 4 of Table 4B, we look at a different DGP for luminosity. We use the change in luminosity as a measure of investment in the housing infrastructure. Specifically, we use this change measured between every pair of periods as our outcome and look at whether our ethnic match variables affect this measure of investment in the following specification:

$$(4) \quad DL_{ij\tau} = \alpha + \beta^{lc} m_{ij\tau}^{lc} + \beta^{tc} m_{ij\tau}^{tc} + \beta^{lt} m_{ij}^{lt} + \gamma_c + \gamma_l + \gamma_t + \Omega X_{ij} + \delta_j + \mu_\tau + \epsilon_{ij\tau},$$

where $DL_{ij\tau}$ is the change in luminosity for resident i in village j measured between period τ and period $(\tau - 1)$. In columns 1 and 3, we again exclude Laini Saba village from the sample. We find similar results: the resident-chief tribe match has large positive effects on luminosity, significant in two out of the four specifications. The coefficient on the landlord-chief tribe match is significant in only one specification (column 3). Comparing columns 1 and 2, we can see the role Laini Saba plays—the coefficients change, although the sample size only falls by about 5 percent. In column 3, we find that the two tribe match variables of interest have

Table 4B—Investments in the Slum: Roof Luminosity

	Change in luminosity, OLS				Luminosity level, OLS			
	Roof (1)	Roof (2)	Res (3)	Res (4)	Roof (5)	Roof (6)	Res (7)	Res (8)
Landlord-chief (LC) tribe match	−1.462	0.825	−4.109	1.906	−1.190	−0.624	−1.480	−0.832
	[1.729]	[1.891]	[1.448]	[2.883]	[1.428]	[1.526]	[1.657]	[1.864]
Tenant-chief (TC) tribe match	3.581	3.156	5.007	3.492	2.857	3.141	3.161	2.573
	[2.090]	[1.939]	[1.925]	[2.320]	[1.199]	[1.189]	[1.256]	[1.228]
Landlord-tenant (LT) tribe match	−0.387	0.246	−0.453	0.741	1.576	1.906	2.262	1.958
	[0.295]	[0.623]	[0.541]	[0.772]	[0.883]	[0.949]	[1.134]	[1.127]
All tribes match (ALL)		−1.781		−5.102		0.085		0.287
		[2.585]		[2.784]		[1.823]		[2.458]
Test statistic LC + TC = 0	0.664	1.960	0.206	2.667	1.280	1.826	0.786	0.685
p-value	0.415	0.161	0.650	0.102	0.258	0.177	0.375	0.408
Dependent variable mean	20.513	20.363	20.465	20.261	304.085	304.275	301.574	301.568
Drop Laini Saba	X		X		X		X	
Roof clustering	X	X			X	X		
GPS clustering			X	X			X	X
Tribe clustering	X	X	X	X	X	X	X	X
All controls	X	X	X	X	X	X	X	X
R^2	0.186	0.183	0.157	0.155	0.382	0.371	0.311	0.307
Observations	33,539	35,522	33,551	35,559	44,654	47,356	44,689	47,376

Notes: Standard errors are clustered at the levels indicated in the table (reported in brackets). Columns 1–4: dependent variable is the change in luminosity from one period to the next. Columns 5–8: dependent variable is the level of roof luminosity. All controls: village fixed effects, housing, amenities, and other controls. All specifications also control for period fixed effects and GPS coordinates. Luminosity data is extracted from satellite images for July 2009, January 2011, December 2011, and August 2012. All results for luminosity use the trimmed luminosity data (top and bottom one percentiles removed). Roof refers to roof level measure of luminosity, Res the resident measure. See text for details.

significant effects on investments: when the chief and the tenant belong to the same tribe, investments are higher and when the chief and the landlord belong to the same tribe, investments are lower.

In columns 5 through 8 of Table 4B, we look at the following regression specification:

$$(5)\quad L_{ij\tau} = \alpha + \beta^{lc} m^{lc}_{ij\tau} + \beta^{tc} m^{tc}_{ij\tau} + \beta^{lt} m^{lt}_{ij} + \gamma_c + \gamma_l + \gamma_t + \Omega X_{ij} + \delta_j + \mu_\tau + \epsilon_{ij\tau},$$

where the γ_c are dummies for the tribes of the chiefs (in this specification, we have multiple years of data so the village dummies do not subsume the chief tribe dummies). We include the complete set of controls used in Tables 3A and 3B, as well as the GPS coordinates of residents (latitude and longitude) to capture other relevant spatial characteristics of the dwelling. The results in columns 5 through 8 are very similar to the panel estimates. We find strong effects of the resident-chief tribe match on luminosity throughout. For the landlord-chief tribe match, we consistently find negative effects, though these are not significant.

In Tables 5A and 5B, we use self-reported measures of roof renovations to corroborate our results on investments. In columns 1 through 8, we show that renovations

Table 5A—Investments in the Slum: Roof Luminosity

	Dependent variable is luminosity							
	Roof (1)	Res (2)	Roof (3)	Res (4)	Roof (5)	Res (6)	Roof (7)	Res (8)
Roof renovated	2.083	2.264						
	[1.160]	[1.045]						
Roof renovated in two years			1.457	1.999				
			[0.960]	[1.151]				
Roof renovated in five years					1.043	1.880		
					[0.871]	[1.069]		
log years since last renovation							1.487	0.457
							[1.395]	[1.254]
Dep. var. mean	332.357	329.581	332.357	329.581	332.357	329.581	332.273	329.250
Roof clustering	X		X		X		X	
GPS clustering		X		X		X		X
All controls	X	X	X	X	X	X	X	X
R^2	0.135	0.091	0.134	0.091	0.134	0.091	0.233	0.159
Observations	14,056	14,058	14,056	14,058	14,056	14,058	2,157	2,154

Notes: Standard errors are clustered at the levels indicated in the table (reported in brackets). All controls: village fixed effects, housing, amenities, and other controls. All specifications also control for period fixed effects and GPS coordinates. Luminosity data is extracted from satellite images for July 2009, January 2011, December 2011, and August 2012. All results for luminosity use the trimmed luminosity data (top and bottom one percentiles removed). Roof refers to the roof level measure of luminosity and Res the resident measure. See text for details. In columns 7 and 8, the sample is restricted to those who report ever having renovated their roofs.

Table 5B—Investments in the Slum: Self-Reported Renovations

	Dependent variable is roof renovated		
	Ever (1)	In last two years (2)	In last five years (3)
Landlord-chief (LC) tribe match	−0.035	−0.031	−0.034
	[0.015]	[0.014]	[0.015]
Tenant-chief (TC) tribe match	−0.002	−0.000	−0.003
	[0.015]	[0.015]	[0.014]
Landlord-tenant (LT) tribe match	0.014	0.001	0.004
	[0.012]	[0.012]	[0.012]
Dependent variable mean	0.227	0.182	0.210
Tribe clustering	X	X	X
All controls	X	X	X
R^2	0.025	0.024	0.023
Observations	12,047	12,047	12,047

Notes: Standard errors are clustered at the levels indicated in the table. For explanations of controls, see notes for Table 5A. For explanations of luminosity data, see notes for Table 5A.

reported by tenants predict the luminosity variables used in Tables 4A and 4B.[24] We include our regular controls and GPS coordinates, and report results for the two different measures of luminosity. In all specifications, luminosity correlates positively with the self-reported measures of renovations. In Table 5B in columns 1 through 3, we run our main specification (equation (2)) using self-reported renovations as the outcome. The sign of the estimate on the landlord-chief match is, as in our main results, negative and significant. The estimate on the resident-chief match is close to zero and not significant.

D. *Regression Discontinuity Specification*

As an additional check, we look at a regression discontinuity (RD) specification where a resident-chief tribe match represents the "treatment," and the distance to a location boundary represents the running variable—the distance to the treatment cutoff. The identifying assumption behind this RD design is that residents living on either side of a location boundary are indistinguishable along observable and unobservable characteristics. In particular, resident and local area characteristics (including accessibility and public goods or amenities) should be continuous across internal boundaries of the slum, while the ethnicity of chiefs who can interfere in rent disputes in favor of co-ethnic tenants changes discretely at these boundaries.

To implement the RD, we limit the sample to the set of residents who can explicitly benefit from living in certain areas of the slum, namely areas governed by a co-ethnic chief. The relevant sample for this exercise is thus composed of all residents who have at least one co-ethnic individual active as chief: in 2012, Kalenjins, Luos, Luhyas, and Nubis. We exclude residents who do not have a co-ethnic chief anywhere in Kibera since we cannot construct the running variable of the RD for these residents. Of 31,765 residents visited in the listing exercise, our sample for the RD analysis contains 20,271 of them. Then, for any given tribe, the relevant "cutoff" is the boundary of the only location that is governed by a co-ethnic chief.[25]

For this restricted sample of tenants, we use both a local linear and a polynomial specification. The RD specification is

$$(6)\quad y_{ij} = \alpha + \beta m_{ij}^{tc} + \beta^R m_{ij}^{tc} \times D_{ij} + \beta^L\left(1 - m_{ij}^{tc}\right) \times D_{ij} + \gamma_l + \gamma_t + \Omega X_{ij} + \rho_j + \epsilon_{ij},$$

where y_{ij} is either rent or luminosity for resident i, and D_{ij} is the distance from the resident to the relevant location boundary. Here we do not include village fixed effects or chief tribe dummies (which are not separately identified from the ethnic

[24] Households in our survey sample were asked when the roof of their dwelling was last renovated. We use this to construct a set of dummy variables indicating whether the household had a roof renovation since they moved in, in the past two years (since 2010), and in the past five years (since 2007).

[25] Within the slum, tenants from tribe 1 have on average a distance of 495 m to the boundary of location A, and 14 percent of all tribe 1 tenants are "treated" (i.e., they live in location A)(we omit location names for confidentiality purposes). Tenants from tribe 2 have an average distance of 530 m to the location governed by a tribe 2 chief (location B), and 26 percent of all tribe 2 tenants live in location B. Tenants from tribe 3 live on average 811 m away from the location governed by a tribe 3 chief (location C), and 5 percent of tribe 3 tenants live there. Tribe 4 tenants live on average 321 m away from the boundary of location D, the one governed by a tribe 4 chief, and 89 percent of all tenants from this tribe live there.

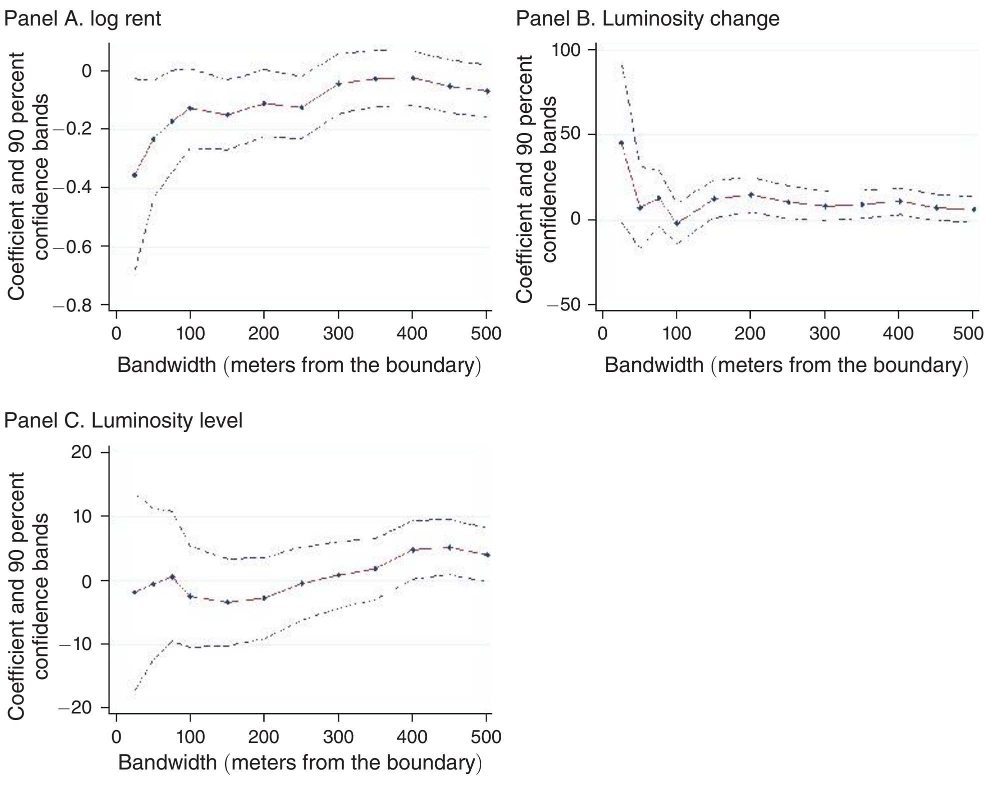

Figure 7. RD Graphs for log Rent and Luminosity: Local Linear RD Estimate across Various Bandwidths

Notes: This figure reports local linear RD coefficients on the tenant-chief ethnic match variable across different bandwidth values. The running variable is the distance to the boundary of the nearest location governed by a co-ethnic chief, interacted separately on each side of the boundary. The optimal bandwidth from Calonico, Cattaneo, and Titiunik (2014) is approximately 200 m on each side of the boundary.

match dummies in the RD sample), but we include fixed effects for small geographic clusters that cut across the location boundaries (denoted as ρ_j in equation (6)). This is similar to using fixed effects for cross-state border county pairs in border discontinuity designs (a recent example in this literature is Allegretto et al. 2013). We construct these clusters by rounding the GPS coordinates of residents to the third decimal point, and include fixed effects for each combination of latitude-longitude rounded to the third decimal point. In the ΩX_{ij} here, we also control for the resident-landlord and the landlord-chief match dummies. For the local linear specification, we rely on the optimal bandwidth from Calonico, Cattaneo, and Titiunik (2014), which is 200 m on each side, and we show graphically how the RD estimate varies across bandwidths in Figure 7. In addition, we look at a polynomial specification that allows for up to fourth-order polynomials in the distance, and their interactions with the TC match dummy.[26]

[26] We do not include weights in these specifications as the weights are not applicable in the RD specification given the different sample.

Table 6—Rents and Luminosity for Residents Close to Internal Boundaries: RD Specification

	log rent			Roof luminosity change			Roof luminosity level		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TC match	−0.110	−0.024	−0.093	15.086	11.272	13.863	−2.770	4.812	−1.274
	[0.068]	[0.055]	[0.047]	[6.197]	[4.671]	[4.501]	[3.798]	[2.751]	[2.558]
Bandwidth	CCT	2 × CCT	Polynomial	CCT	2 × CCT	Polynomial	CCT	2 × CCT	Polynomial
Dep. var. mean	7.291	7.313	7.286	2.960	1.969	−0.027	335.295	332.670	331.934
All controls	X	X	X	X	X	X	X	X	X
R^2	0.38	0.42	0.41	0.19	0.2	0.16	0.35	0.3	0.25
Observations	1,812	3,071	7,591	1,888	3,216	7,853	1,893	3,234	7,939

Notes: Robust standard errors are reported in brackets. CCT refers to the optimal bandwidth from Calonico, Cattaneo, and Titiunik (2014), which is (approximately) 200 m. 2 × CCT refers to a 400 m bandwidth. The polynomial specification includes fourth-order polynomials, estimated separately on either side of the boundary. Controls include housing characteristics, amenities, and other controls, but not village fixed effects. All specifications control for landlord-chief and landlord-tenant tribe matches and tenant tribe dummies. All specifications also include fixed effects for geographic blocks across the boundary constructed using GPS coordinates.

Since the slum is overcrowded and the same amenities are used by all local residents (e.g., water access, waste disposal sites), public goods and amenities are unlikely to vary at these boundaries.[27] Nevertheless, we address this concern before proceeding to the RD analysis. In online Appendix Table A6, we show that housing characteristics and amenities are broadly balanced across internal boundaries of the slum, by regressing these variables on the same RD (local linear and polynomial) specification as the one above. Out of 69 coefficients we look at, 13 appear statistically significant (including 2 at 1 percent and 6 at 5 percent). To address any remaining concerns about balance across boundaries, in all our RD specifications we control for all the variables included in this table.

Table 6 reports the main results from this specification. We look at log rental prices in columns 1–3, at the changes in roof luminosity between 2011 and 2012 in columns 4–6, and at luminosity levels in columns 7–9. For each dependent variable, we report results from the local linear (using two bandwidths, 200 m and 400 m) and from the polynomial specification. Consistent with the results in Table 3, we find negative coefficients on the tenant-chief match, though this coefficient is only significant in the polynomial specification (column 3). The left panel of Figure 7 suggests that the negative effect on rents is driven primarily by residents who live close to location boundaries—the RD estimate is largest in magnitude for bandwidth values under 300 m. In columns 4–6, we find positive, significant effects on the change in roof luminosity in both the local linear and the polynomial specification, in line with our earlier results reported in Table 4. Finally, in columns 7 through 9, we find that the TC match at the border has no consistent effect on luminosity levels. For luminosity levels and changes, Figure 7 suggests that RD estimates are noisy for smaller bandwidth values, and become positive when we use larger bandwidths. Overall, the RD provides some support of our earlier results: having a co-ethnic chief allows tenants to pay lower rents and to improve the quality of their housing.

[27] In addition, location chiefs do not have executive control over the allocation of local public goods.

E. *Robustness Checks*

In online Appendix Table A3A and A3B, we show additional results and robustness checks on rental prices. In these two tables, odd-numbered columns report specifications without any controls (other than village fixed effects) and even-numbered columns report specifications with the full set of controls used in Table 3. In Table A3A, columns 1–2 show the unweighted results; columns 3–4 show results with non-clustered, robust standard errors; columns 5–6 report results for a sample obtained after trimming the top percentile of rents; columns 7–8 report results obtained after dropping one village (Laini Saba) from the sample; and column 9 shows results where we do not include the LT tribe match. The results in this table are robust and similar to those in Table 3.

Appendix Table A3B looks at alternative measures of rents and on the extensive margin of the rental market. Columns 1–2 look at unconditional levels of rental prices (instead of logs) as our outcome. The rental price is set to zero if the resident does not pay any rent. Columns 3–4 look at rents collected during the listing exercise for a (nonrandom) subsample of about 11,000 residents.[28] In columns 5 and 6, we look at the difference between the rental prices collected in the listing exercise and those collected during the survey, using the same subsample. Rents increased significantly (by 126 KShs on average) over the five-month period between the listing and the survey, and the correlation between the two rent measures is high (0.76). The sign of our estimates in columns 5–6 are consistent with our previous results: tenants facing a landlord-chief match report a higher increase in rent, and tenants with a co-ethnic chief report a decrease (nonsignificant).

In columns 7–8 of Appendix Table A3B, we look at the extensive margin of rents by analyzing the effect of our tribe matches on whether the resident pays any rent. Residents who do not pay any rent for their dwelling could be homeowners, squatters, or simply residents who have been allowed to stay in the structure but do not pay any rent. These columns exclude the landlord-chief match since for the subset of households that do not pay rent, we do not observe the landlord's tribe. The results are consistent with our earlier findings, though not significant: residents with a co-ethnic chief are 3 percent less likely to pay rent.[29]

V. Conclusion

This paper provides the first in-depth quantitative study of a rental market in a slum setting. We study how ethnic diversity, discrimination, and patronage lead to distortions in the determination of housing prices and quality. We find that ethnicity plays an important role in determining rental prices: tenants pay higher rents when the area chief is of the same tribe as their landlord, and lower rents when the chief

[28] Rent data was only collected during the second wave of the listing exercise from approximately 18,600 residents, and during the survey. Of these 18,600, approximately 11,000 were also reached in the survey, and 10,000 provided the rent amount they pay in both exercises.

[29] As an additional check, we do not find any significant effects of the TC match on rents when we restrict the sample to residents who do not pay any rent (results not reported, available upon request). This constitutes only 8 percent of our original sample, so we do not have much power to implement this test.

is a co-ethnic. In addition, we find that ethnic relationships affect longer term outcomes in the slum via their impact on investments. We use high-resolution satellite imagery to compute measures of daytime roof luminosity, which proxy for investments in housing quality. We show that the landlord-chief ethnic match variable is associated with lower roof luminosity, while the tenant-chief variable is associated with higher luminosity.

The primary responsibility of Kibera chiefs is to arbitrate conflicts in the slum, a large fraction of which are rent-related disputes. Our findings provide suggestive evidence that these chiefs engage in rent-seeking as part of their role as arbitrators. This implies that the lack of proper arbitration mechanisms for land and other disputes may be among the key market failures occuring in slum settings, and that city authorities should play a much more active and direct role in settling these disputes, perhaps by strengthening the role of local courts. To our knowledge, the existing literature on slums has largely ignored this particular market failure. This finding is consistent with Henderson, Regan, and Venables (2017), who quantify the impact of institutional frictions on welfare using data from the entire city of Nairobi. However, the friction they focus on is of a different nature: they look at the costs of land formalization, while we look at frictions in the settlement of private disputes in areas where property rights are weak or inappropriately defined.

The data we collected does not allow us to accurately estimate the welfare impacts of ethnic patronage, but we think our main results have two main implications for welfare. First, the effects of ethnic patronage are primarily distributional—they imply a transfer from tenants with adversarial ethnic matches to tenants with favorable matches—and have only a small effect on average slum living costs. Second, tenants subject to the effects we describe incur costs in terms of consumption volatility and bargaining costs, which are almost certainly welfare-reducing. Third, the investment frictions caused by ethnic matches are also likely to reduce welfare since they contribute to prevent improvements in housing quality over time.

The results we present have important implications for our understanding of urban poverty across the developing world. The ethnic fragmentation and extensive systems of informal land rights prevalent in Kenyan slums are also prevalent in other slum settings. This paper shows that such typical dimensions of urban slum living give rise to extensive systems of rent extraction that have important implications for investment, welfare, and the functioning of markets. A more rigorous understanding of market failures specific to slum settings will be necessary to design effective policies to tackle urban poverty.

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