Slum-Upgrading in Tanzania: Public Infrastructure and Private Property Rights

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Abstract

This paper seeks to understand the relationship between the provision of public infrastructure and the demand for formal property rights in the unplanned urban settlements of Dar es Salaam, Tanzania. We analyze take-up patterns in two adjacent settlements where residents were offered the opportunity to purchase formal land titles at subsidized prices. Detailed plans for proposed infrastructure investments were drawn up for both settlements, but these infrastructure investments were only implemented in one of the two locations. We exploit this quasi-experiment to show that proximity to actual, but not hypothetical, infrastructure investment significantly increases demand for property rights, and this effect appears to be driven by both increased property values and a dramatically-higher perceived risk of expropriation.

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1 Introduction

Since 2008 the majority of the world's population lives in urban areas, and across both Africa and Asia the urban population is expected to double between 2000 and 2030 (UNFPA, 2007). In line with these global trends Tanzania is urbanizing rapidly, with its urban population currently growing at 4.7% per annum compared to 2.9% for the country as a whole (United Nations, 2012).

As Tanzania's urban centers have grown, access to basic services has declined and urban planning has failed to keep up with rising demand for land and services. This is especially true in Dar es Salaam, where 70% of residents live in unplanned settlements. The share of households in the capital with access to piped drinking water fell dramatically from 93% in 1991 to 61% in 2007, and access to electricity fell from 59% in 2001 to 55% in 2007 (National Bureau of Statistics, 2009).

In this paper we analyze one common policy response to the challenges posed by the growth of unplanned urban settlements: the World Bank's "slum upgrading" model. These projects, implemented in Tanzania and many other countries over the past 25 years, commonly focus on two aspects: improving public infrastructure and formalizing private property rights (Gattoni, 1998). This dual focus finds some justification in the literature on the impact of both land titling in developing countries (Field, 2005; Galiani and Schargrodsky, 2010) and the economic benefits of road and infrastructure upgrading (Mu and van de Walle 2007; Jacoby and Minten 2009; Donaldson, 2010). Critics of the World Bank's slum upgrading approach have argued that, in practice, it is heavily skewed in favor of infrastructure investment over supporting property rights reforms. If formal land tenure is a prerequisite for the poor to fully take advantage of improved services (Werlin 1999), then it merits greater emphasis.

There are potentially other, less felicitous, links between public infrastructure upgrading and the demand for formal property rights. On the supply side, Tanzanian government officials interviewed as part of this study typically viewed the expansion of formal land tenure as an obstacle to in-

frastructure investment for clear logistical reasons. On the demand side, homeowners may be motivated to procure formal property rights as a defensive measure against expropriation, which is commonly associated with public works projects in Tanzania.

To estimate the effect of infrastructure upgrading on the demand for property rights, we exploit the (deliberate) overlap of two separate 'slum upgrading' interventions. Our data spans two unplanned urban settlements that were eligible to purchase land titles at subsidized rates, as part of a separate evaluation described in Ayalew, Collin, Deininger, Dercon, Sandefur, and Zeitlin (2012). The first location, Kigogo Kati, was chosen by the World Bank and the city of Dar es Salaam for infrastructure upgrading prior to this study. The second location, Mburahati Barafu, which is not receiving any planned infrastructure upgrading, was selected by the research team to act as a control group, based on its comparability to Kigogo Kati along a range of observable characteristics, including parcel size and home amenities.

To study the impact of formal property rights on household-level outcomes a land titling program was introduced in both locations in which landowners were provided with subsidies land titles. As part of the planning process for this intervention detailed infrastructure plans were drawn up in both locations, but only implemented in Kigogo Kati. This enables us to observe the precise counterfactual location of proposed infrastructure upgrading in Mburahati Barafu. Thus our empirical strategy relies on within-settlement variation in proximity to local infrastructure, which was only upgraded in one of the two neighborhoods.

We find a significant and robust relationship between proximity to (commenced) infrastructure and demand for titling in Kigogo Kati, the 'treatment' settlement, but no such relationship in Mburahati Barafu where infrastructure was planned but construction never commenced. We explore two potential channels through which this effect may operate: increased property values and the increased risk of government expropriation. These channels are not mutually exclusive, and indeed we find evidence consistent with both. Expropriation risk and property values both increase with proximity to planned infrastructure improvements only in the settlement where

upgrading took place, Kigogo Kati.

The next section provides some context on recent land legislation in Tanzania and describes the experimental setting in which these data were collected. Section 3 describes data employed in the analysis and presents summary statistics. Section 4 presents the empirical strategy and Section 5 covers the main results of the paper. Conclusions are provided in Section 6.

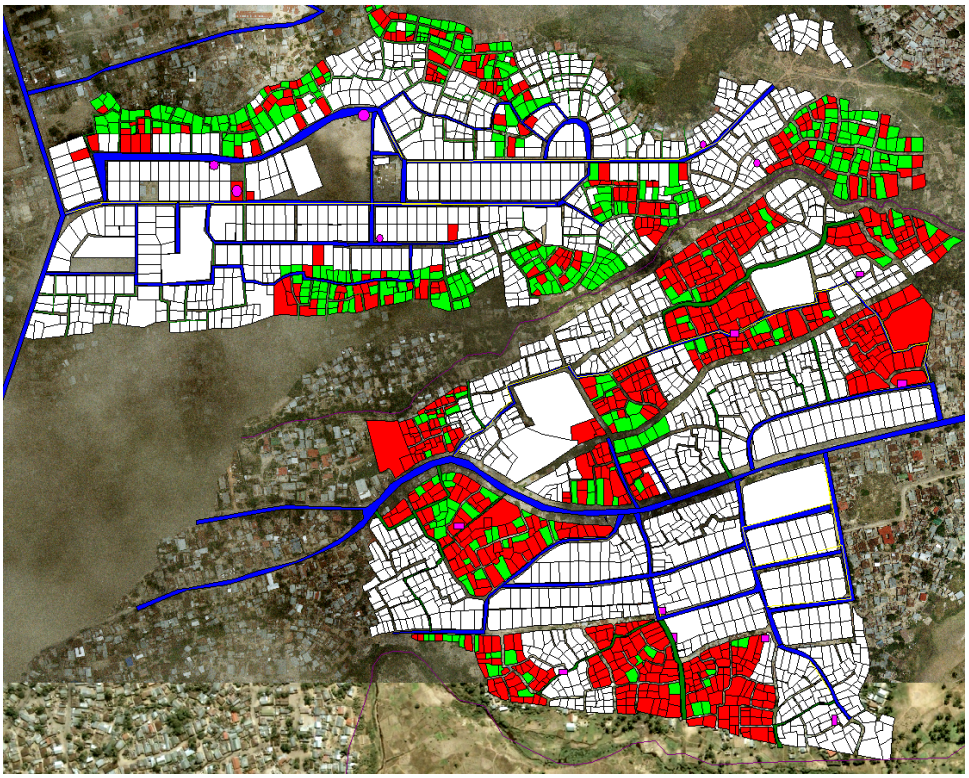
2 Intervention background and land legislation in Tanzania

In Tanzania all land is legally vested in the Office of the President, and formal access to urban land is controlled exclusively by the government (Kironde, 1995). In 1999 the government passed the Land Act (LA) which introduced a new form of land tenure in urban areas called a Certificate of Right of Occupancy (CRO). CROs are long term leaseholds with a duration of 99 years and have characteristics that make them very similar to full land titles: they are fully transferable and are thought to be useful as collateral for gaining access to loans.

The take-up rate for CROs in Dar es Salaam has been extremely low to date. In Kinondoni Municipality, where our survey is based, slightly more than 2,000 CRO applications have been filed, out of a total of 60,000 land parcels. A likely explanation for low take-up is the complex application system for CROs, which imposes large practical and monetary hurdles such as expensive cadastral surveying and application fees (Collin, Dercon, Nielson, Sandefur, and Zeitlin, 2012).

In October 2010 the University of Oxford, jointly with the World Bank, began implementing a land titling program aimed at increasing CRO adoption rates in two adjacent neighborhoods called Mburahati Barafu and Kigogo Kati (map in Figure 1). Both neighborhoods (also known as sub-wards or *mitaa*) are located approximately five kilometers from the city center in the Kinondoni Municipality, the largest of the three municipalities of which Dar es Salaam is composed. The two sub-wards were chosen to be homogeneous

Figure 1: Final take-up and infrastructure placement in Kigogo Kati and Mburahati Barafu



Note: Green cells are parcels in treatment blocks that fully paid for a CRO application. Parcels in treatment blocks that did not apply for a CRO are in red. Control parcels are in white. Prospective road upgradings are in blue, water point in pink and street lighting in yellow.
Source: Authors' GIS elaborations.

in terms of geographical location and economic activities. The programme, implemented in partnership with the Woman's Advancement Trust (WAT), a local NGO specialized in large-scale title programmes, was designed to lower application costs and reduce some of the logistic hurdles that may prevent households from applying for CRO. Full details can be found in Ayalew et al (2012).

At the same time as the property rights experiment was taking place Kigogo Kati was one of the beneficiaries of a Community Infrastructure Upgrading Project (CIUP) implemented by the World Bank in several different settlements in Dar es Salaam. The objectives of the program were to improve access to basic services such as water, sanitation and electricity, as well as to

upgrade road infrastructure in the unplanned and un-serviced settlements of the city.

The two interventions proceeded as follows: prior to launching the land titling program, a local town-planning firm[1] was contracted to draw up a map of the two *mitaa*. In both settlements locations were identified for infrastructural investment, including roads, storm water drainage, water supply, sanitation, electric lines and street lighting. Whilst the infrastructure improvements only actually took place in Kigogo Kati, this mapping exercise was implemented in both communities, providing a precise location of where infrastructure would have been built in the event that Mburahati Barafu was also involved in an infrastructure upgrading project.

At approximately the same time as the infrastructure upgrading took place in Kigogo Kati, the land titling programme was implemented in Mburahati Barafu and then in the following year in Kigogo Kati. The programme began with the identification of parcels and households in each of the communities under study. Parcels were divided into different blocks, and randomly allocated into treatment and control groups. Parcels in treatment blocks were subject to several interventions aimed to facilitate CRO adoption. Firstly, a cadastral survey, demarking parcels boundaries using cement beacons, was implemented in all the parcels in treatment blocks. A cadastral survey is a legal prerequisite for CRO applications. Secondly, all the land owners in treatment blocks were invited to meetings where the benefits of CRO ownership were discussed. During these meetings parcel owners in the treatment blocks were also invited to pay TZS 100,000 (approximately 65 USD) to WAT over a period of five months. In return, WAT would manage their CRO application process and cover all the cadastral survey costs and application fees. Finally, discount vouchers were randomly allocated in treatment blocks through a public lottery in order to identify take-up price elasticity.

In accordance with the program, households in treatment blocks were free to sign up for the CRO application and begin the repayment process to

[1] A firm independently contracted by CIUP was hired to produce a town plan for Kigogo Kati, with some assistance from the Ministry of Lands. In Barafu another town planner was contracted as part of the experimental CRO intervention.

WAT over a period of five months. The municipal government in charge of collecting applications agreed to accept applications from treated households only if they were submitted by the NGO. In contrast households in control blocks were free to obtain CROs directly through the municipality following the official procedure at the regular cost. An investigation in the municipality archives showed that none of the households in control blocks seems to have applied for a CRO to date. At the time of writing the project is still underway, with no land titles having been issued yet. Some applications have been submitted via WAT, and are awaiting municipal government action.

3 Data and summary statistics

Our analysis employs three main sources of data: the first is parcel-level data taken from WAT project records, which induces information on signed applications and fully completed CRO repayments. In the months following the general meeting each land owner had to decide whether to join the program, meaning signing up for a CRO and subsequently starting the repayment process for administrative costs to the NGO. These records identify individuals who signed-up and fully paid for the CRO application.

The second source of data is a complete census of parcels in Kigogo Kati and Mburahati Barafu collected during the summer of 2010, before the beginning of the land titling program. These data provide information regarding self-reported house values, self-reported expropriation risk and other control variables. It should be emphasized that construction work in Kigogo Kati began *before* the implementation of the survey, but by the time of the survey construction works were not yet completed. While we expect self-reported house values and expropriation risk to be based on full knowledge of the infrastructure upgrading project, household characteristics are not likely to have been affected at the time of the survey, given that infrastructure improvements were still underway.

The third source of data is geographic information service (GIS) data on the location of individual land parcels, as well as on the location of actual and planned infrastructure improvements in Kigogo Kati and Mburahati Barafu,

respectively. This enables us to create measures of parcel distance from the location of planned and implemented infrastructure upgrades. Given that no households in control blocks applied for a CRO (i.e., defiance was nil in the land-titling intervention), this analysis is based on treatment blocks only. Moreover, we exclude households for which a survey plan was already available before the implementation of the programme.

Table 1 reports summary statistics for the outcome variables employed in the analysis, divided by geographical location. Our dependent variable of interest is participation in the land titling programe. The sign-up rate to the land titling programme is significantly higher in Mburahati Barafu, where 60% of the parcels in treatment blocks signed up, compared with Kigogo Kati where only 16% decided to participate. It should be noted that during December of 2011, Dar es Salaam was subject to one of the biggest floods in the last 60 years, which particularly affected Kigogo Kati. As a consequence of this, households were subject to a shortfall in income, potentially leading to a depression of CRO applications. Given this exceptional circumstance, the process of collecting repayment has suffered a substantial delay in Kigogo Kati. Therefore, results concerning payments should be considered with caution until final data on take-up become available. However, it should be noted that since the analysis is based on a difference-in-differences strategy that compares across *mitaa* the relationship between distance to infrastructure and demand for title, any pure differences in levels of take-up rate among the two settlements should not be a source of concern.

Table 1 also reports average values and standard deviations for self-reported property values and self-reported expropriation risk collected during a land owners' plot census. Self-reported house values are on average higher in Kigogo Kati than in Mburahati Barafu. On average a property in Kigogo Kati is estimated to be worth more than TZS 61,000,000 while the equivalent in Mburahati Barafu is almost TZS 37,000,000. Moreover, as expected, self-reported house values are higher under the hypothetical scenario of holding a CRO.[2] Average house values in the case where the plot held a CRO is TZS

[2]Landowners were asked to condition their self-reported values on the hypothetical scenario where they held no title and when they held a CRO. The order in which these

Table 1: Summary statistics: dependents by geographical area

	Kati	Barafu	Diff
1[Fully completed CRO application]	0.16	0.60	-0.44***
	(0.37)	(0.49)	(0.03)
Self-reported property value in '000'000 TZS - without CRO	61.61	36.94	24.67***
	(88.71)	(46.06)	(4.75)
Self-reported property value in '000'000 TZS - with CRO	72.94	44.77	28.17***
	(101.34)	(56.70)	(5.48)
Expropriation risk	39.97	45.16	-5.19**
	(32.63)	(33.70)	(2.09)
Number of parcels outside Mtaa owned by household	0.17	0.16	0.01
	(0.43)	(0.42)	(0.03)
N	459	682	

Source: project records and landlords plot survey.
Note: Treatment blocks only.

72,940,000 in Kigogo Kati and TZS 44,770,000 in Mburahati Barafu. By the time of the survey, people from Kigogo Kati were aware of the infrastructure investments planned in the sub-ward. Therefore, we expect that landowners in Kigogo Kati will have already adjusted their expectations, incorporating the expected impacts of the infrastructure provision in their self-reported value. Self-reported expropriation risk is a measure from 0 to 100, where 0 indicates a 0% chance of losing one's land in the next five years and 100 represents absolutely certainty of being expropriated. This perceived risk is significantly higher in Mburahati Barafu than in Kigogo Kati. Finally, Table 1 includes a placebo variable, the number of parcels outside the *mtaa* which are owned by the head of the household, which should be unaffected by the provision of infrastructure. We we will use this variable as a robustness check for the validity of our estimation strategy.

Table 2 summarizes geographical information on parcel location and planned infrastructure location to provide average distances between these in Kigogo Kati and Mburahati Barafu. These data are based on distances from infrastructure planned by the CIUP plan in Kigogo Kati and planned—but not implemented—developments in Mburahati Barafu. On average, households in Kigogo Kati are closer to infrastructure than those in Mburahati Barafu, although for roads this difference is small (approximately 9m over a total

questions was asked was randomized to avoid priming effects.

Table 2: Summary statistics: distances from infrastructure by geographical area

	Kati	Barafu	Diff
Distance from road, water or light, in meters	41.05	56.81	-15.77***
	(35.26)	(47.05)	(2.44)
Distance from roads, in meters	50.89	59.72	-8.84***
	(41.21)	(50.85)	(2.74)
Distance from water supply, in meters	87.55	132.61	-45.05***
	(55.81)	(59.46)	(3.46)
Distance from street lighting, in meters	68.82	113.59	-44.77***
	(40.94)	(43.37)	(2.53)
N	459	682	

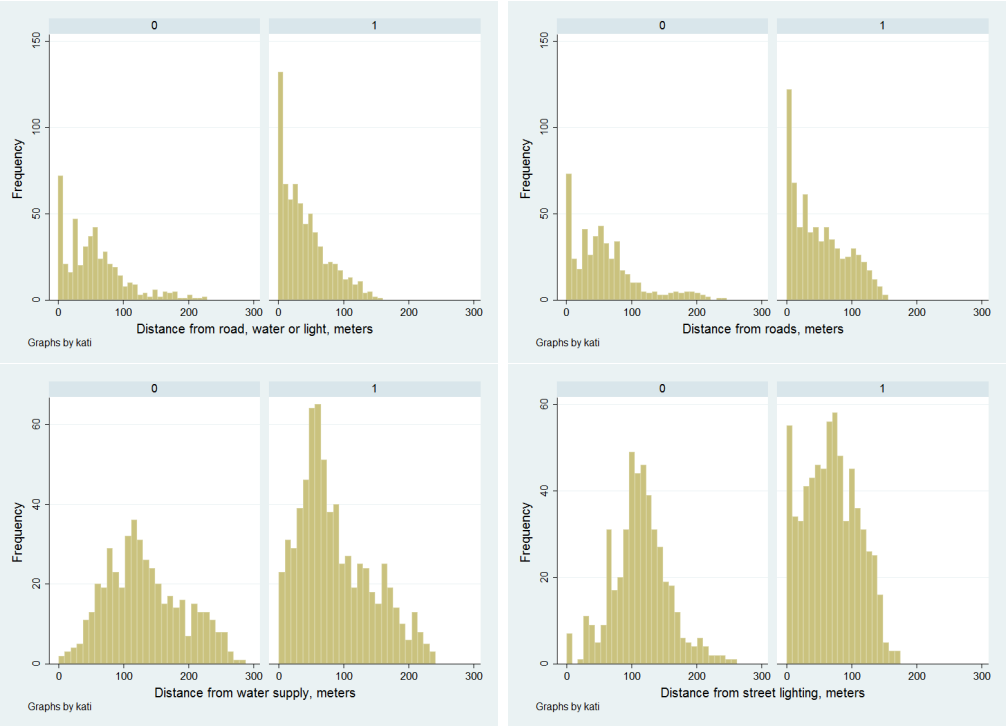
Source: GIS data.
Note: Treatment blocks only.

area of approximately $1Km^2$).

Considered together, Figures 1 and 2 and Table 2 provide an accurate idea of how infrastructure and plots are distributed in the area under analysis. Figure 1 shows the map of Kigogo Kati (the south settlement) and Mburahati Barafu (north settlement) with the program take-up outlined. Green cells are parcels in the treatment group that sign up for a CRO and completed the payment process. Red cells indicate parcels in the treatment group that did not sign up or completed the CRO payment process. White cells are parcels in control blocks. Planned roads are expressed in blue, whereas street lighting is in yellow and water pumps are pink dots or pink squares. Figure 2 provides frequency histograms for distances for each parcel from the road and from any infrastructure feature including roads, water supply and street lightning, with Mburahati Barafu presented on the left of each graph and Kigogo Kati on the right. Frequency distributions for the two *mitaa* are very similar, although Kigogo Kati shows signs of being skewed to the right.

Lastly, Table 3 reports average values and standard deviations for control variables employed in the forthcoming analysis, divided by geographical area. The third column reports unconditional differences between Kigogo Kati and Mburahati Barafu. The two geographical areas are homogeneous and do not report significant differences in terms of all the considered characteristics, with a few exceptions: number of buildings per parcel and household asset

Figure 2: Histogram distances in Mburahati Barafu and Kigogo Kati



Note: Histogram distribution for distances from roads and infrastructure features.
Source: Authors' GIS elaborations.

Table 3: Summary statistics: other controls by geographical area

	Kati	Barafu	Diff
1[Attended the meeting]	0.60	0.61	-0.01
	(0.49)	(0.49)	(0.03)
Amount voucher (TZS '000)	53.20	53.86	-0.66
	(25.59)	(24.68)	(1.53)
log(parcel area)	5.12	5.10	0.02
	(0.61)	(0.52)	(0.03)
Year of Acquisition	1992.74	1992.12	0.63
	(13.60)	(11.79)	(0.81)
1[Parcel rented out]	0.38	0.40	-0.02
	(0.49)	(0.49)	(0.03)
1[Electricity Connection]	0.39	0.41	-0.01
	(0.49)	(0.49)	(0.03)
Number of buildings on parcel	1.26	1.33	-0.07*
	(0.59)	(0.54)	(0.04)
1[Any investment in the last 12 months]	0.24	0.17	0.06**
	(0.43)	(0.38)	(0.03)
Household monthly income (TZS '000)	410.41	356.35	54.06
	(767.17)	(445.14)	(41.46)
Household asset stock (TZS '000)	3275.63	4140.88	-865.26**
	(4603.63)	(6567.07)	(347.22)
Landlord's years of schooling	12.18	12.26	-0.08
	(2.82)	(2.67)	(0.17)
Landlord household size	5.27	4.72	0.56***
	(2.68)	(2.40)	(0.16)
N	459	682	

Note: Treatment blocks only. *Source*: landlords plot survey.

stock are higher in Mburahati Barafu, and household size and investment in the last 12 months prior to the baseline are higher in Kigogo Kati.

4 Empirical Strategy

Our goal is to estimate the effect of infrastructure upgrading on the demand for property rights, requiring us to construct a credible counterfactual for demand in the absence of the World Bank's infrastructure investment. Rather than simply comparing outcomes between the two settlements, our empirical strategy relies on within-settlement variation in proximity to the proposed infrastructure upgrading. We compare differences in the relationship between proximity to infrastructure and demand for titling across settlements where infrastructure did or did not take place.

Even though infrastructure upgrading never took place in the control settlement, Mburahati Barafu, a novel advantage of our data is that detailed plans and maps for possible future infrastructure investment were drawn up for the settlement as part of this project by a team of professional town planners and land surveyors. Thus we know exactly where infrastructure upgrading *would* have occurred in the counterfactual scenario that Mburahati Barafu had been treated by the upgrading intervention. We use this detailed household-level information on the distance between parcel and "counterfactual infrastructure" in the control settlement in the analysis below.

In order to estimate the effect of infrastructure on the probability of CRO take-up we estimate the following linear probability model (LPM):

$$\begin{aligned} T_{it} = \alpha + \beta_1 TreatmentSettlement_i + \beta_2 DistanceInfrastructure_i \\ + \beta_3 (DistanceInfrastructure_i * TreatmentSettlement_i) + \delta X_{t-1}^{'} + \varepsilon \end{aligned} \tag{1}$$

Where T_{it}, a binary dependent variable equal to one if parcel i fully paid for a CRO application, is used as measure for title adoption. $TreatmentSettlements_i$ is a binary variable equal to one if parcel i is located within Kigogo Kati. $DistanceInfrastructure_i$ is a continuous variable representing the distance,

expressed in meters, from plot i to the closest infrastructure feature. The parameter β_2 provides the effect of increasing distance from infrastructure on the probability of take-up of a CRO in the control settlement. The same effect in the treatment settlement is given by the sum of $\beta_2 + \beta_3$. The third term is the interaction between $DistanceInfrastructure_i$ and the dummy variable $TreatmentSettlements_i$. The estimated parameter β_3 measures the difference in 'distance effect' on the probability of CRO take-up between treatment and control settlements. Finally, X' is a vector of control variables[3] collected during the baseline.

In this analysis we are primarily interested in testing two hypotheses. The first hypothesis is testing whether distance from infrastructure is a determinant in the CRO take-up decision process for households residing near infrastructure upgrading activities. This implies testing whether or not we can reject the hypothesis that $\beta_2 + \beta_3 = 0$. Since the correlation between distance and demand in infrastructure-treated parcels may reflect both the effect of upgrading *per se* and differences in demand for title attributable to market access or other, fixed geographic factors, the second hypothesis worth investigating is that the 'distance effect' on the probability of take-up is the same for treatment and control settlement: that $\beta_3 = 0$. Since Kigogo Kati actually received the infrastructure upgrading programme, we are expecting the effect in the treatment settlement to be statistically different from the control, though the sign of this difference is theoretically ambiguous: while rising property values may increase the demand for a property title, changes in policy-induced uncertainty over possible land clearance may or may not offset this effect.

We are also interested in the channels through which infrastructure proximity affects take up. We may expect that proximity from infrastructure

[3]These variables are: a dummy variable equal to one if the household attended the meeting where the application process was explained; amount of the voucher received from the lottery system within the experimental design; logarithm of parcel area; year of plot acquisition; dummy variable taking value equal to one if the plot is rented out; dummy equal to one if the plot is connected with electricity; number of buildings in the parcel; dummy equal to one if there has been any investment in the plot in the last 12 months; household monthly income and household asset stock; landlord's final year of schooling; and finally household size.

increases the probability of CRO take-up since it may be seen as a profitable investment for the house (i.e. the value of titling increases in the parcel's sale price). However, proximity to new infrastructure investments, such as roads, may increase a household's perceived expropriation risk, given that upgrading may require the bulldozing of buildings in some parcels. In order to investigate which channels are most salient in the decision process we estimate the following equation:

$$Y_{it-1} = \alpha + \beta_1 TreatmentSettlement_i + \beta_2 DistanceInfrastructure_i + \beta_3(DistanceInfrastructure_i * TreatmentSettlement_i) + \delta X_{t-1}^{'} + \varepsilon \quad (2)$$

where Y_{it-1} takes on several different outcome measures: the natural log of the household's self-reported land value, conditional of having and not having a CRO; self-reported expropriation risk; and finally, a placebo variable represented by number of parcels outside the *mtaa* owned by the head of the household.

While these models are initially estimated where $DistanceInfrastructure_i$ is defined as distance from any form of infrastructure, we will subsequently present a robustness check in which we restrict our infrastructure measure to roads.

5 Results

Results in Table 4 suggest that distance from infrastructure upgrading is a significant determinant of land title adoption only where upgrading took place. The first and second columns report estimates of equation 1 using distance from the nearest infrastructure feature, without and then with additional parcel-level controls. In both specifications, the probability of participating in the land titling project in Kigogo Kati (the treatment settlement) decreases as distance from infrastructure increases. The point estimate implies that a parcel located 100m farther from upgraded infrastructure is 10% less likely to purchase a land title. In Mburahati Barafu, where infrastruc-

ture upgrading did not take place, this negative point estimate on distance is closer to, and insignificantly different from, zero.

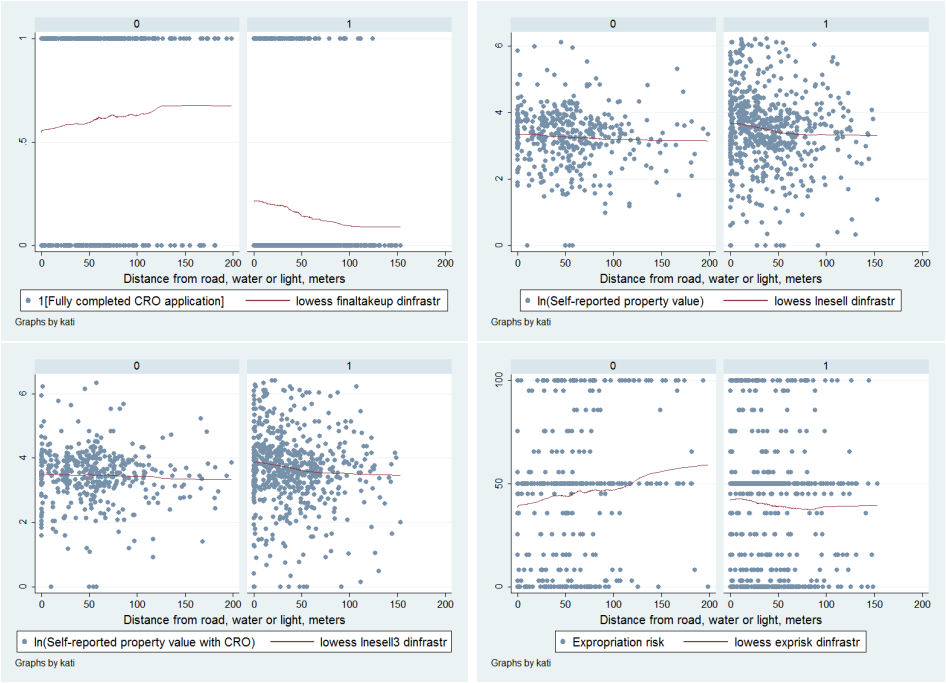
Given these results, why is infrastructure upgrading associated with higher demand for property formalization? We test two alternative (though not mutually-exclusive) channels. The first is that higher take-up is driven by an increase in land value, itself determined by proximity to new infrastructure. The second is that demand is induced by a rise in perceived expropriation risk, driven by the introduction of infrastructure upgrading.

The third and fourth columns in Table 4 report estimates of equation 2 using as the dependent variable the logarithm of property value. Columns five and six report the results using the log of self-reported property values under the hypothetical case of owning a CRO. The results suggest that in Kigogo Kati there is some indication that increasing distance from infrastructure decreases self-reported property value conditional on having a CRO. Although point estimates are suggestive, these estimates are unable to reject the hypothesis of an equal relationship between distance to potential infrastructure and property values across *mitaa*.

Columns seven and eight in Table 4 report estimates for equation 2 using perceived expropriation risk as the dependent variable. Results suggest a divergence in the relationship between infrastructure proximity and expropriation risk in the two locations. Being near infrastructure in the treatment settlement is perceived as being riskier than in the control. These results are consistent with the idea that individuals living in Kigogo Kati consider the possibility of being bulldozed to make space for infrastructure a concrete reality. Individuals living in Mburahati Barafu, where upgrading is not likely in the near future, do not report a higher probability of expropriation if living close to potential infrastructure projects. Figure 3 presents these relationships graphically for both Kigogo Kati and Mburahati Barafu.

Finally, columns nine and ten in Table 4 report estimations for equation 2 using the number of parcels owned by the household outside the *mtaa* as the dependent variable. We interpret this as a placebo test, since we have no reason to believe this measure of household wealth at baseline will be effected by infrastructure upgrading. As anticipated, none of the variables

Figure 3: Scatterplots and locally weighted scatterplot smoothing regression of distance from infrastructure and dependent variables in Mburahati Barafu and Kigogo Kati



Note: Graph shows scatterplot and LOWESS running-mean smoothing for the dependent variables employed in the analysis and distance from infrastructure

in equation 2 are significantly associated with the number of parcels.

In conclusion, we find evidence that, for proximity to infrastructure, we have a positive effect on the probability of applying for a land title. The results suggest that this operates mainly through two mechanisms. First, through higher expropriation risk that induces individuals to seek protection for their parcels. In Kigogo Kati, our treatment location, being close to infrastructure is perceived as being relatively riskier than in Mburahati Barafu. Second, we find suggestive evidence that proximity to potential infrastructure projects is more strongly associated with property values in Kigogo Kati, although this result is not robust to the inclusion of a full set of household control variables.

6 Robustness checks

As a robustness check on the results above, we re-estimate equation 2 using an alternative measure of infrastructure: distance from the nearest road instead of distance from general infrastructure including roads. These estimates, reported in Table 5, follow the same structure as in Table 4.

The first and second columns in Table 5 confirm the results from the previous section. Parcels further away from the road in Kigogo Kati are less likely to apply for a CRO. In Mburahati Barafu, where upgrading did not take place, there is no significant correlation between distance to a road and the probability of applying for a land title.

The third and fourth columns regress self-reported property values on distance from the nearest road and interaction terms. While the results in column three are qualitatively similar to findings in the previous section, when control variables are included we fail to find a significant difference between Mburahati Barafu and Kigogo Kati in either parameter of interest (column four). Columns seven and eight report self-reported expropriation risk as the dependent variable. Results are again consistent with Table 5. Finally, as expected, column five repeats the placebo test described above and fails to find any relationship between the distance to a road and a baseline household wealth measure.

In summary, the relationship between infrastructure and demand for property rights appears robust to alternative measures of the definition of infrastructure, though the relationship between infrastructure and house values is somewhat weaker in this second set of estimates.

7 Conclusion

In the face of Tanzania's rapid urbanization and the unchecked growth of unplanned, informal settlements, research into the link between two standard policy responses, infrastructure upgrading and land tenure formalization, is more crucial than ever.

This paper exploits the partial overlap of an infrastructure upgrading program and a land titling experiment to investigate the impact of public infrastructure investments on the demand for private property rights in Dar es Salaam, Tanzania. The analysis uses GIS data on infrastructure upgrading that was planned but not implemented, in the control site to construct a reasonable counterfactual for infrastructure investments.

Results suggest that infrastructure upgrading has a positive effect on the probability of applying for a land title certificate. This seems to operate primarily through two mechanisms. First, infrastructure upgrading results in higher perceived expropriation risk by landowners in the settlement. Second, improved infrastructure results in higher self-reported property values for those who are located close to the sites of improvement. These mechanisms suggest a potentially important, complementary, role for land titling alongside infrastructure projects, as a means for households both to capitalize gains from infrastructure investments, as well as to address uncertainty inherent in the growth process of a rapidly urbanizing environment.

Table 4: Regression: distance from the nearest infrastructure feature

	CRO Application		ln(Self-reported value)		ln(Self-reported value|CRO)		Expropriation Risk		N parcels outside Mataa	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treatment settlement	-0.353***	-0.368***	0.301***	0.260***	0.326***	0.277***	4.431	3.186	0.025	0.008
	(0.043)	(0.044)	(0.101)	(0.096)	(0.101)	(0.096)	(3.200)	(3.250)	(0.042)	(0.041)
Distance to infrastructure	0.001	0.001	-0.001	-0.001	-0.001	-0.001	0.140***	0.122***	-0.000	-0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.034)	(0.033)	(0.000)	(0.000)
Treatment X Distance infrastructure	-0.002***	-0.002***	-0.003*	-0.001	-0.003**	-0.002	-0.183***	-0.190***	-0.000	-0.000
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.052)	(0.051)	(0.001)	(0.001)
constant	0.568***	2.815	3.339***	7.480	3.521***	7.369	37.261***	-326.425**	0.178***	0.758
	(0.037)	(2.123)	(0.067)	(5.692)	(0.068)	(5.502)	(2.431)	(157.772)	(0.032)	(2.036)
N	1141	1033	1015	1013	1015	1013	1035	1033	1035	1033
$\beta_2 + \beta_3$	-0.001***	-0.001***	-0.004***	-0.002*	-0.004***	-0.002*	-0.044	-0.069*	-0.001	-0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.039)	(0.039)	(0.000)	(0.000)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Controls: a dummy variable equal to one if the household attended the meeting where the application process was explained; amount of the conditional and unconditional voucher received from the lottery system within the experimental design; logarithm of parcel area; year of plot acquisition; dummy variable taking value equal to one if the plot is rented out; dummy equal to one if the plot is connected with electricity; number of buildings in the parcel; dummy equal to one if there has been any investment in the plot in the last 12 months; household monthly income and household asset stock; landlord's final year of schooling; and finally household size.
Note: Values for $\beta_2 + \beta_3$ are estimates for *Distance to infrastructure* using the same specification in terms of control settlement rather than treatment settlement.
Standard Errors in parenthesis. * p>0.10, ** p>0.05, *** p>0.01.

Table 5: Regression: distance from the nearest road

	CRO Application		ln(Self-reported value)		ln(Self-reported value|CRO)		Expropriation Risk		N parcels outside Mataa	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treatment settlement	-0.371***	-0.383***	0.293***	0.261***	0.298***	0.256***	5.069	3.605	0.008	-0.010
	(0.043)	(0.044)	(0.103)	(0.098)	(0.104)	(0.098)	(3.249)	(3.313)	(0.042)	(0.041)
Distance to road	0.000	0.000	-0.001	-0.001	-0.001	-0.001	0.130***	0.113***	-0.000	-0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.031)	(0.031)	(0.000)	(0.000)
Treatment X Distance road	-0.001**	-0.001**	-0.002	-0.001	-0.002	-0.001	-0.182***	-0.180***	-0.000	0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.046)	(0.046)	(0.001)	(0.001)
constant	0.583***	2.877	3.330***	7.897	3.520***	7.870	37.459***	-318.946**	0.180***	0.936
	(0.036)	(2.122)	(0.067)	(5.706)	(0.068)	(5.532)	(2.392)	(158.005)	(0.032)	(2.027)
N	1141	1033	1015	1013	1015	1013	1035	1033	1035	1033
$\beta_2 + \beta_3$	-0.001***	-0.001***	-0.003**	-0.002	-0.003**	-0.001	-0.053	-0.068**	-0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.034)	(0.035)	(0.000)	(0.000)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Controls: a dummy variable equal to one if the household attended the meeting where the application process was explained; amount of the conditional and unconditional voucher received from the lottery system within the experimental design; logarithm of parcel area; year of plot acquisition; dummy variable taking value equal to one if the plot is rented out; dummy equal to one if the plot is connected with electricity; number of buildings in the parcel; dummy equal to one if there has been any investment in the plot in the last 12 months; household monthly income and household asset stock; landlord's final year of schooling; and finally household size.
Note: Values for $\beta_2 + \beta_3$ are estimates for *Distance to road* using the same specification in terms of control settlement rather than treatment settlement.
Standard Errors in parenthesis. * p>0.10, ** p>0.05, *** p>0.01.

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