Public Roads on Private Lands: Land Costs and Optimal Road Improvements in Urban Uganda

Jeanne Sorin*

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Abstract

Despite the need for transportation infrastructure investments in developing cities, empirical evidence on their net returns is lacking due to data constraints and the common oversight of land acquisition costs. In this paper, I collect novel data to estimate the net returns of 140 km of road improvements in Kampala, Uganda, since 2017, accounting for both benefits and land acquisition costs. Using new surveys with real estate brokers and landowners, I exploit variation in the timing of improvements to estimate local benefits. I develop a quantitative spatial model to capture the city-level impacts of the policy, accounting for general equilibrium effects and heterogeneous land acquisition costs. Leveraging the coexistence of three property rights regimes in the city, I show that weak property rights are associated with lower land acquisition costs. I find that the net welfare gains from the realized road improvements were equivalent to a 119 USD transfer per resident, but would have been negative if land had been acquired at market value, as legally mandated under eminent domain, due to the high cost of raising domestic funds. Finally, I solve for the optimal road improvements under different institutional settings and demonstrate the importance of accounting for land costs when designing, funding, and evaluating transportation infrastructure projects, particularly in low- and middle-income countries where land acquisition relies on fragile land and financial institutions.

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1 Introduction

Infrastructure is crucial for economic development and African cities face a severe deficit in transportation infrastructure, with only one third of roads paved (Kumar and Barrett 2008). Yet, investments to tackle this infrastructure deficit are still insufficient (World Bank 2019), potentially suggesting low net returns.

Estimating the net returns to these investments is challenging. Despite research linking urban mobility with economic development (Akbar et al. 2023), data scarcity has limited empirical evidence on the benefits of specific transportation infrastructure projects. In addition, measuring benefits is particularly complex, as transportation infrastructure improvements have both local and citywide impacts, through the rerouting of traffic patterns, and the location decisions of residents and firms in equilibrium. Furthermore, in addition to construction costs, mostly funded by international agencies, governments are often required to formally acquire the land on which these roads are built from private landowners against fair compensation (Collier and Venables 2016). These costs have been largely overlooked by the literature, despite their significant impact on the net returns of implemented projects (World Bank 1996) - because of especially high costs of raising domestic funds in low- and middle-income countries (Besley and Persson 2014) - as well as their influence on the optimal location and amount of investments.

This paper addresses the gap in the literature by estimating the benefits, land costs, and net returns to several road improvement projects undertaken in Kampala, Uganda over the period starting in 2017. I conduct two novel surveys with real estate brokers and landowners, and leverage the coexistence of three property right regimes in the city (Bird and Venables 2020) to analyze how property rights affect land acquisition costs. I estimate the local reduced-form benefits of these projects by using variation in their timing, along with data on commuting patterns from a local ride sharing company, and traffic data from Google Maps. Next, to measure the city-level net returns of these road improvements, I build and estimate a quantitative spatial model that accounts for equilibrium changes in traffic flows, the relocation of residents, and heterogeneous land costs. Finally, I solve the model for the road improvements made by a central planner maximizing city-level welfare, under different institutional frameworks. I evaluate how heterogeneous property rights and other institutional constraints affect the allocation and returns of these optimal investments.

By collecting the most comprehensive data on both the benefits and land costs of road improvements in a Sub-Saharan African city, I show that despite large benefits, high net returns from road improvements in Kampala are enabled only because weak property rights reduce land acquisition costs. In addition, in Kampala, areas with large benefits from road improvements often coincide with those that have strong property right regimes, shifting welfare-maximizing investments away from high-benefit but high-cost locations. These findings are consistent with theoretical work on the tension between private property rights and public goods provision (Acemoglu and Robinson 2012, Posner and Weyl 2017) and have important implications for both academic research and policy. They emphasize the importance of accounting for both land costs and city-level benefits when designing, funding, and evaluating transportation infrastructure projects, especially in low- and middle-income countries where land acquisition relies on fragile land and financial institutions.

I start by characterizing the state of Kampala's transportation infrastructures. With less than 45% of

its major roads paved, Kampala's road network is typical to Sub-Saharan African cities. To improve urban mobility in the city, about 140 km of road improvements have been rolled out between 2017 and 2024. Upgrading road networks commonly requires additional land, but, in most projects, construction is primarily funded by international agencies, while the domestic government is responsible for acquiring the underlying land from private landowners. Yet, the government expressed concerns that acquiring land at market value, as mandated under the eminent domain legal framework, would lead to high costs, jeopardizing the project's implementation (World Bank 2023), and instead encouraged owners to cede small portions of their land without compensation.

I then present six main results.

First, I estimate the land acquisition costs and show that they depend on the different property right regimes in the city. I collect a novel survey with 377 real estate brokers, which includes a retrospective panel of transactions. I show that if the government were to pay the market value of residential properties, as required under the legal eminent domain framework, land costs would sum up to 80% of construction costs. However, from interviewing 548 landowners whose properties border the upgraded roads in Kampala, I find that 80% of landowners consented to forfeit their land without compensation, averaging 73 square meters (786 square feet) of land per property. These interviews reveal that consent is partly motivated by the high cost of negotiating with the government and the challenges associated with obtaining official copies of ownership documents. These challenges are heterogeneous along the lines of Kampala's three main property right regimes: *leasehold*, *freehold* as well as *mailo*. Leasehold land features limited term ownership with a strong record of property titles. Freehold land features perpetual ownership but land titles are poorly tracked. Mailo land is characterized by double legal rights - landowner and legal occupant - over a single plot of land (Bird and Venables 2020). I find that leasehold landowners, who report the lowest cost of getting a copy of their ownership documents, are 55% more likely to negotiate than mailo owners, and 75% more likely to negotiate than freehold owners. Consequently, this *voluntary land take approach* decreases overall land costs for the government, but ties them, and therefore the likelihood of road improvements, to the different property right regimes in the city.

Second, I estimate the local benefits of these road improvement projects. I start by calculating the impact of road improvements on traffic speed by leveraging information from Google Maps queries. I exploit variation in the timing of the policy and compare traffic speeds on the roads upgraded at the start and end of the policy. I estimate that the intervention increased uncongested local traffic speeds by 4.1 km/h (16% faster than baseline speed). Consistent with this increase in local speed, I find that trips between pairs of neighborhoods became more likely to take upgraded roads over time.

I show that road improvements also increased local property values. Using the appraisal of a standardized hypothetical property from the broker survey, I estimate that the assessed sales price of a residential property increases by 25% if the road in its immediate vicinity is improved. Extrapolating to all properties that border upgraded roads implies a total increase in local property values of 76 million USD, less than the 80 million USD of road construction costs, implying that the project would not have positive net returns if benefits were only local. I also estimate this effect using a retrospective panel of transactions from the same survey and I find that improving roads in a parish (neighborhood) leads to a 19% increase

in the sale price of local properties.

While informative, these local reduced-form estimates do not capture the full net returns of the implemented policy. Indeed, road improvements also have benefits in distant locations through the rerouting of traffic patterns, and the location decisions of residents and firms in equilibrium. In addition, using residential land for roads has an opportunity cost, as it strains the stock of valuable residential land and increases prices. To capture these effects, I build a static quantitative spatial model of a closed city. This model includes standard elements as workers freely choose residential and workplace locations trading off between high commuting costs and high rents (Redding and Rossi-Hansberg 2017, Allen and Arkolakis 2022). In addition, I explicitly model the competition for land between residential and road uses and assume that residential land is owned by immobile private landowners.

Third, I estimate key parameters of the model needed to compute the benefits and land costs of road improvements. To estimate the elasticity of commuting flows on commuting times, I partnered with a local prominent ride hailing company with more than 160,000 monthly users. Using the universe of rides (flows) by users of the app for a random sample of weeks from 2019 to 2024, I estimate that the number of commuters between two locations decreases by 0.33 percent for every one percent increase in commuting times. This elasticity is in the bottom half of existing estimates in middle- and high-income country settings and consistent with the few existing estimates in low-income country (LIC) cities (Balboni et al. 2020, Kreindler and Miyauchi 2023). I use my reduced-form estimates to recover the elasticity of road speed on road infrastructure and owners' negotiation costs and I calibrate the rest of the parameters using public data for Kampala or from the literature.[1]

Fourth, equipped with this model and the parameters described above, I find large city-level benefits of road improvements implemented in Kampala since 2017. I solve for workers' new equilibrium residential and workplace locations and estimate that workers' average commuting time decreased by 6.6%, and that total property values in the city increased by 1.36%, compared to the period before road improvements. I solve for the compensating differential transfer that would need to be made to each resident to reach the same level of welfare gains realized by the road upgrades. Abstracting from land payments, I estimate that this one time transfer is equal to 306 USD, or 208% of the average monthly wage of a worker in Kampala. Summing over all residents, this implies 265 million USD net welfare gains in the absence of land payments (but accounting for construction costs). Comparing this number to the 66 million USD increase in local property values from the brokers' appraisal exercise highlights the importance of accounting for city-level benefits and general equilibrium effects when assessing the welfare impacts of road improvements.

Fifth, I leverage the model to investigate the mechanisms through which land acquisition affect the projects' net returns. Payments for land may decrease the net welfare gains from road improvements in the presence of large costs of levying taxes to raise domestic funds. I solve for the wedge on tax revenues rationalizing the government's claim that acquiring land at market value would threaten the viability of the project (World Bank 2023). I find that acquiring all land at market value would lead to negative net welfare gains of the realized road upgrades if the tax revenue wedge was above 0.51. This number is consistent with Regan

[1] I estimate that increasing road width by 1% decreases average trip time by 0.39%. This estimated elasticity of travel time on road infrastructure is on the upper end of existing estimates, all of them in high or middle income countries (Couture et al. 2018, Fajgelbaum and Schaal 2020, Bordeu 2024).

and Manwaring (2024), who find that for every 1 dollar due in property taxes, the Kampala capital city government recovers only 39 cents, or a wedge of 0.61. Under this high tax revenue wedge, the net welfare gains of the policy under the existing voluntary land take approach are equivalent to a one time 119 USD transfer to all Kampala residents. Importantly, I find a positive correlation between the location of the realized upgrades and the corresponding net welfare gains from specific link-level improvements predicted by my model, consistent with the realized improvements being relatively well allocated given the existing costs and benefits. I also find a negative correlation between local land costs and road upgrades, consistent with the model capturing property right regimes as a relevant feature of the city government's decision.

Sixth, I use the model to study how land institutions impact the allocation and welfare gains of road improvements by conducting counterfactual exercises with alternative land cost structures. I fix the maximum total kilometers of roads improved to match the policy and I solve for the optimal road improvements chosen by a utilitarian central planner maximizing residents' welfare. Under compensation at market value, I estimate net welfare gains equivalent to a one-time transfer to each resident of 153 USD, or 104% of the median monthly wage. Under the voluntary land take approach, net welfare gains of the optimal policy would instead be equivalent to a 500 USD transfer per resident. Weak property rights decrease the probability that owners get compensated, enabling the government to improve more high benefit roads and reach higher welfare gains than under market value compensation, as road improvements have positive externalities not internalized by private landowners. Yet, this voluntary land take approach also ties land payments to spatially heterogeneous property rights, affecting the spatial distribution of optimal investments. In turn, the optimal road improvements under uniform property rights set at the weakest regime in the city would yield 563 USD per resident. 30% of this increase comes from a lower fiscal burden and 70% comes from a better allocation, as improvements would be allocated towards the highest benefit locations, leading to a larger decrease in commuting times and larger increase in property values.

Given the key role played by the tax revenue wedge in driving these results, I also investigate the impact of a policy removing existing restrictions on the use of external funds. Currently, the city government can only use funds from the World Bank and the African Development Bank for road construction, not for land acquisition. I solve for the optimal improvements removing this restriction. I find that under the voluntary land take approach in place, the net welfare gains would be 12% larger in the absence of fund use restrictions than under the existing restrictions. Under compensation at market value, the net welfare gains would be 56% larger in the absence of fund use restrictions than under the existing ones. Both results hold despite fewer roads being improved, as some external funds are instead being used for land acquisition. The existing restrictions are likely driven by corruption concerns, which are outside the scope of this paper. Yet, given the World Bank's stated objective to ensure that owners are *"provided prompt and effective compensation [...] for losses of assets attributable directly to the project."* (World Bank OP 4.12), these numbers should be used to benchmark whether the anticorruption benefits outweigh the potential benefits in terms of better compensating affected owners, and allocating improvements towards higher benefit locations.

Related Literature and Contributions My work contributes to a growing literature at the intersection of development and urban economics.[2]

First, my paper is the first to measure the net returns to road improvements in a LIC city, accounting for both benefits and land costs. On the benefits side, I find that road improvements had large impacts on local speed and local property values, as well as on city-level average commuting time and property values through general equilibrium effects. Existing evidence on the impact of road quality on speed is either in the United-States (US) (Duranton and Turner 2011, Currier et al. 2023) or across cities worldwide (Akbar et al. 2023). One of the few within-city studies on the benefits of road paving in low or middle income country cities comes from Gonzalez-Navarro and Quintana-Domeque (2016), who randomize the rollout of road paving in Acayucan, Mexico and study the impact on local property values, but do not account for the city-level impacts. Instead, I build on a literature that has developed quantitative spatial models (Ahlfeldt et al. 2015, Allen and Li 2015, Redding and Rossi-Hansberg 2017, Monte et al. 2018, Heblich et al. 2020, Severen 2023, Almagro et al. 2024) to study the benefits of improved transportation infrastructure, and I add competition between private and public land use, while papers usually model competition between residential and business land uses (Lucas and Rossi-Hansberg 2002). Within-city studies using quantitative spatial models in low and middle income countries have focused on the impact of Bus Rapid Transit (BRTs) (Majid et al. 2018, Balboni et al. 2020, Tsivanidis 2023, Zarate 2024, Kreindler et al. 2023), and very few estimates of these models' key elasticities exist in LIC cities (Kreindler and Miyauchi 2023).[3] In Kampala, as in the majority of LIC cities, road is the only transportation mode, so that the improvements will be experienced by all commuters.[4]

On the costs side, I show that land costs affect both the net returns of existing improvements in Kampala, and the optimal location of road improvements. High land costs have been shown to have increased the costs of transportation infrastructure since 1960s in the US (Brooks and Liscow 2023), and a few policy reports have discussed their role in LICs (World Bank 1996). Collier and Venables (2016) also discuss the cost of land use for LIC infrastructures but I am the first to formalize and quantify this mechanism through my quantitative spatial model of optimal road improvements, building on the recent methodologies developed by Allen and Arkolakis (2022), Fajgelbaum and Schaal (2020) and Bordeu (2024). I micro-found land cost heterogeneity in Kampala's historical property right regimes under the voluntary land take approach, and show how it affects the optimal location of road investments by shifting the distribution of relative costs.

Second, I provide new evidence on the relationship between property rights and efficiency of investments, through the channel of public good provision. Unclear property rights yield higher risks of expropriation, associated with lower economic development (North 1990, Acemoglu et al. 2001, Besley and Ghatak

[2]Collier and Venables (2016) and Glaeser and Henderson (2017) highlight that this intersection has historically been overlooked by both development and urban economists, partly to the absence of detailed data needed to estimate quantitative spatial models.

[3]Works on between-city and rural impact of road paving in LIC countries include Storeygard (2016), Aggarwal (2018) Gertler et al. (2024a), Graff (2024).

[4]Most existing studies on road improvements in LIC countries focus on rural or cross-city infrastructure (Baum-Snow et al. 2017, Asher and Novosad 2020, Alder et al. 2022, Balboni 2023, Gertler et al. 2024b, Morten and Oliveira 2024, Herzog et al. 2024). There are also several studies on the impact of railroad development on across-city transportation costs and migration, including Gollin and Rogerson (2010), Faber (2014), Ghani et al. (2016), Jedwab and Moradi (2016), Donaldson (2018) and Bryan and Morten (2019).

2010), including in Kampala (Bird and Venables 2020). However, in the context of public goods provision, I show that clear property rights can have large negative welfare gains, by preventing budget constrained governments from seizing land that could be used more efficiently for the public good because there are positive externalities of road improvements on the whole city that owners do not internalize. As in Holland (2023), who studies the role of strong property rights in shaping opportunistic behavior by private owners in Colombia, I find that payments are increasing with the strength of owners' property rights. My contribution is to show how this relationship can affect the optimal amount of high benefit infrastructure improvements and, in the presence of spatially heterogeneous property rights, shift their location away from the highest benefit areas. I build on existing literature that acknowledges the tension between strong private property rights and public interests (Acemoglu and Robinson 2012, Posner and Weyl 2017), which is traditionally used to justify eminent domain (Munch 1976, Shavell 2010, Jeong et al. 2016) for public purposes.

I further show how, however, in LICs, eminent domain may lead to suboptimal investments, given the high costs of raising public funds. I estimate that any tax revenue wedge above 0.51 would lead to negative net welfare gains from road improvements if land was acquired at market value, as mandated by eminent domain. This number is in line with estimates for Kampala by Regan and Manwaring (2024) and consistent with a dense literature on the widespread challenges faced by LICs to levy domestic and property taxes (Traxler 2010, Besley and Persson 2014, Knebelmann 2019, Bergeron et al. 2023, Brockmeyer et al. 2023).

The rest of the paper is organized as follows. Section 2 describes the context and the data I collected. Section 3 details how I estimate the reduced-form benefits and land costs of road improvements. In Section 4, I build a quantitative spatial model to study the city-level impacts of these improvements and the welfare effects of spatially heterogeneous land costs. In Section 5, I estimate the model on Kampala and characterize the net returns of the road improvements. In Section 6, I solve for the optimal road improvements to quantify the welfare consequences of the existing property right regime, land acquisition rule and fund use restrictions. Section 7 concludes.

2 Context and Data

2.1 Context

2.1.1 Road Improvements in Kampala

Kampala, Uganda's capital, is a fast growing city, with approximately 1.9 million inhabitants in 2024. While Kampala hosts an increasing share of Uganda's population and GDP, its road infrastructure is of low quality: out of 4,622 km of roads and paths recorded by Open Street Map (OSM), only 742 km (16%) are major roads, and less than 43% of these major roads are paved (7% of all roads).[5]

In the past decade, relatively large amounts have been invested to improve the quality of the existing road network. In addition to some domestic investments, most funds come from the World Bank (WB) and the African Development Bank (AfDB), under the umbrella of two projects, the Second Kampala Institutional

[5] Akbar et al. (2023) define major roads as roads falling under the motorway, primary, secondary or tertiary road classes on OSM. For reference the mean lane km of major urban road in US MSAs in 2008 was 14,000 km (Couture et al. 2018).