Public Housing Spillovers in a Developing Country*

Benjamin Bradlow
Brown University

Stefano Polloni†
Brown University

William Violette
Federal Trade Commission

This Version: October 1, 2018

Abstract

We estimate economic spillovers from a large public housing program in South Africa using geocoded deeds records and census data. With a differences-in-differences design, we find that public housing projects lead to a 16% decline in nearby formal house prices as well as large increases in the density of nearby informal housing. We attribute this decline prices in the formal market to negative congestion externalities caused by informal housing growth. Our results provide evidence that public housing may interact with nearby informal housing supply producing unintended consequences for local development.

*We are grateful to Matthew Turner, Jesse Shapiro, John Friedman, Andrew Foster, Brian Knight, and Daniel Bjorkegren for their feedback, advice and support. We also thank Adelaide Steedley and the Centre for Affordable Housing and Finance in Africa as well as Geo-Terra Image for generous research guidance and for providing excellent data. Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the the Federal Trade Commission or its Commissioners.

†Department of Economics, Brown University, Box B, Providence, RI 02912 E-mail: stefano_polloni@brown.edu

1. Introduction

In developing countries, 30% of urban populations live in slums where households often suffer from high rates of crime, low access to infrastructure, insecure property rights, and unsanitary conditions (United Nations [2015]). These negative congestion externalities often combine to create poverty traps, preventing long-term economic development (Marx et al. [2013]). Governments have responded by replacing slums with new homes and moving slum dwellers to public housing projects. These policies are intended to provide not only direct health and economic benefits to recipients, but also greater incentives for neighbors to invest in their homes and communities, reducing negative externalities and steering communities away from poverty traps. At the same time, public housing can also attract nearby slum growth by improving access to bulk services like water and sanitation as well as providing undeveloped land within and nearby housing projects. In this way, public housing projects may ultimately exacerbate the same negative externalities that they were designed to remediate.

In this paper, we analyze the impacts of public housing on the development of surrounding neighborhoods. We study a large-scale housing program in South Africa, which has allocated over 4.3 million dwellings and houses over 13% of the total population (Department of Human Settlements [2012,2015]; GHS [2009-2013]). Already one of the largest housing programs in the developing world, this program continues to respond to large backlogs in housing demand with an even mix of upgrading slum areas with new houses as well as constructing stand-alone developments. This program is intended to not only serve as "a key strategy for poverty alleviation" for direct beneficiaries, but also generate community-wide benefits, "leveraging growth in the economy," "combating crime, promoting social cohesion and improving quality of life for the poor," and "utilizing housing as an instrument for the development of sustainable human settlements, in support of spatial restructuring" (Department of Human Settlements [2004]).

We combine administrative records for over 50 completed housing projects with data on property transactions, demographics, and building construction to measure the local impacts of these projects. We estimate a 16% decline in formal residential home prices within 400 meters of a project that persists three years after construction. We find evidence of greater access to services and improved home quality within project areas while surrounding neighborhoods experience substantial growth in informal housing. To interpret these findings, we develop a simple model of residential choice with congestion externalities. We model public housing as a subsidy for construction costs in both the immediate formal housing market as well as surrounding informal housing markets. These subsidies cause growth in nearby informal housing, which exacerbates congestion externalities and generate declines in formal home prices.

To identify these effects, we use a differences-in-differences strategy leveraging both the exact timing of housing project construction as well as the precise geographic proximity of surrounding areas. Like prior studies in the US, the substantial uncertainty in project timing due to difficulties coordinating many stakeholders and sources of funding limits the extent to which local housing markets are able to anticipate these projects (Diamond and McQuade [2016]; Tissington [2011]). To address the potential endogenous placement of housing projects, we use planned but unconstructed projects as counterfactuals and detect no impacts of these projects on local housing markets.

Our negative spillover estimates stand in contrast to a large literature in development that has found positive impacts of public housing on direct recipients. Relying on small-scale experimental designs, previous studies have linked public housing to improvements in employment outcomes (Franklin [2016]), self-reported wellbeing (Galiani et al. [2017]; Devoto et al. [2012]), and child health outcomes (Cattaneo et al. [2009]). Data limitations both in finding a large enough sample of housing projects and in identifying outcomes at a precise spatial scale have prevented previous studies from identifying spillover effects. Taken alongside these previous studies, our findings suggest that policymakers may want to consider weighing direct benefits to recipients against potential negative effects to the local housing neighborhoods in designing future housing policy.

We proceed by first providing background on the South African housing program in Section 2. In Section **??**, we develop a model of residential choice and housing externalities to help to interpret the results. Section 3 describes the data used to measure outcomes and details our approach to identifying housing projects while Section 4 provides descriptive evidence. We present spillover results for residential home prices in Section 5 and demographic outcomes in Section 6. Section 7 includes a discussion of our findings before Section 8 provides some concluding thoughts.

2. Background: Where are houses built?

Between 2000 and 2010, subsidized housing efforts in South Africa have primarily focused on constructing and allocating single-story, two-room (30 to 40 square meter) dwellings to households in groups of 50 to 500 per project. These housing projects are evenly divided between two categories (Department of Human Settlements [2012,2015]):

1. **Greenfield developments** involve the construction of housing projects primarily on undeveloped state-owned land although in some cases, municipalities will work with private developers to purchase inexpensive, undeveloped private land for these projects. Finding undeveloped land often requires policymakers to locate these projects far from city centers and economic opportunities.

2. **In-situ upgradings** replace existing informal settlements with housing developments.[1] Since informal settlements are often located closer to city centers, the resulting housing projects may provide better employment opportunities (Tissington [2011]).

Facing substantial housing demand, the Department of Human Settlements has continued to issue grants to provincial governments to keep the rate of yearly housing allocations roughly constant (Department of Human Settlements [2012,2015]). While the location and types of projects are determined by provincial and municipal governments, construction is subcontracted to private developers who also act as project managers assisting in the allocation of houses to beneficiaries (Durojaye et al. [2013]).

[1]While in some cases these programs refer simply to the provision of land titles and municipal services (water, electricity, etc.), this paper focuses on cases where informal settlements are replaced by fully-serviced, single-story houses.

Since housing projects require coordination between many stakeholders, these projects often face unanticipated delays and cancellations due to labor and land procurement issues, difficulties gaining support from local government agencies, environmental impact assessments, and inadequate bulk infrastructure provision (Department of Human Settlements [2012,2015]). In one example, political disagreements with local stakeholders led to the abandonment of a large project near Johannesburg (Dlmini [2017]).

2.1. Background: Who are the beneficiaries?

The National Department of Human Settlements issues guidelines for eligibility and maintains an official waiting list for eligible households for greenfield developments. Eligibility requires citizenship, no previous property ownership, being married or having financial dependents, and having a monthly household income below R3,500 (Durojaye et al. [2013]).[2] The share of households reporting at least one member on the waiting list has remained stable at over 13% from 2009 to 2013.[3] Before construction, each project is assigned beneficiaries in a first-come, first-served basis according to the waiting list in their province or municipality. For in-situ upgrading projects, previous inhabitants of informal settlements receive renovated houses while any remaining houses are allocated according to the housing waiting list.

In practice, these guidelines are only loosely followed. Recent reports point to cases of corruption in the allocation of houses while in some instances, housing projects are organized with the assistance of local community groups who ultimately select the beneficiaries (Durojaye et al. [2013]; Mathoho [2010]). Research suggests that beneficiaries are often selected over the course of project construction and sometimes even after construction has finished (Durojaye et al. [2013]).

Beneficiaries are expected to pay a small one-time payment in order to receive title for their houses. Guidelines also prevent beneficiaries from reselling their houses within their first 7 years of ownership. Despite these guidelines, only 82% of project houses are reported being still occupied

[2] The Gauteng Province has implemented their own waiting list since 2008 in order to exert greater control over the allocation process.

[3] This figure is calculated from the General Household Surveys from 2009 to 2013

by their original beneficiaries within five years of construction.[4] Anecdotal evidence suggests that project managers are aware of active secondary markets but have difficulty policing these transactions (Matsena [2018]).

3. Data

Understanding the spillover impacts of public housing requires (1) outcome measures at high spatial and geographic resolutions as well as (2) a precise measure of the location, timing, and size of housing projects.

We locate housing projects using administrative maps compiled by the Gauteng City Regional Observatory. These records include 192 planned housing projects as well as notes on their completion status.[5]

To measure formal housing market impacts, we analyze over 500,000 housing transactions from the South African National Deeds Office covering the universe of transactions for suburbs in the bottom 20% of the housing market between 2003 and 2011 in the Gauteng Province (including the Johannesburg metro area). The bottom 20% suburbs were selected relative to prices in 2003 and followed every year from 2003 to 2011. These data were provided by the Affordable Land and Housing Data Centre, which tracks affordable housing markets. These data include the price, exact location, plot size, buyer name, and seller name for each transaction. To isolate spillover effects, we focus on transactions occurring within 2 kilometers of a housing project. We also only include

bringing the final sample to around transactions. We exclude the top 1% of prices as well as prices below 2,500 Rand, which are likely composed of measurement error or the exchange of property title between family members.

Since it is unlikely that government deeds records capture informal housing markets, we also include a building census of all structures in the Gauteng Province in 2001 and 2011. Using a combination of high-resolution satellite imagery and local field teams, these data record the precise

[4]This figure is calculated from the General Household Surveys from 2009 to 2013

[5]Since this data comes in the form of overlapping shapefiles, we use the intersection of the shapes excluding tiny shapes below 0.50 square kilometers.

location of each structure, identifying structures within over 30 categories including formal and informal residential dwellings. Out of 3,817,840 structures, this building census includes 1,628,073 formal structures and 1,560,345 informal structures. These data serve as both outcome measures of informal housing development as well as additional measures of public housing construction.

For demographic and economic outcomes, we have access to the full census of population and housing for 2001 and 2011, which provides information on housing characteristics, population density, as well as income and employemnt measures. To spatially link these households in both samples to their corresponding housing projects, we conduct the analysis at the census block level, which is the smallest geography available with 28,437 total blocks in Gauteng Province and 20,457 within 4 kilometers of a housing project.

3.1. Constructed Housing Projects

We define projects as successfully constructed when we observe at least some recipients receiving deeds to their new government houses. Deed transfers are assumed to belong to a housing project if the seller name includes a government, municipality, or large developer. As recommended by the data provider, we exclude deeds flagged as large buildings used for commercial purposes (<2% of transactions) as well as purchase prices that are more than R50,000 above the yearly subsidy value (<4% of remaining transactions). Using this criteria, we are able to identify over 68 constructed housing projects out of 192 planned projects.

This approach may introduces measurement error insofar as we are mis-attributing deeds to housing projects. We use a limited definition of verified seller names to minimize the chances that unconstructed projects are misclassified as constructed projects. However, this approach increases the possibility that this definition mistakenly excludes constructed projects.

Descriptive evidence supports our project definition. First, Figure 1 shows that the top five most frequently occurring seller names clearly correspond to government housing programs in the region. Second, transaction prices for project houses are strongly clustered around subsidy values. Figure 2 provides a histogram of deed prices under R100,000 for transfers that meet our project

Figure 1: Top-Five Sellers

Seller Name	Observations
City Of Johannesburg Metropolitan Municipality	29,087
City Of Johannesburg	27,672
City Of Tshwane Metropolitan Municipality	24,780
Ekurhuleni Metropolitan Municipality	21,758
Gauteng Provincial Housing Advisory Board	13,058
Total Observations	549,704

definition as well as those that do not. Government agencies often record either zero price or the value of the subsidy in the deeds, producing substantial bunching at these values compared to non-project transactions.

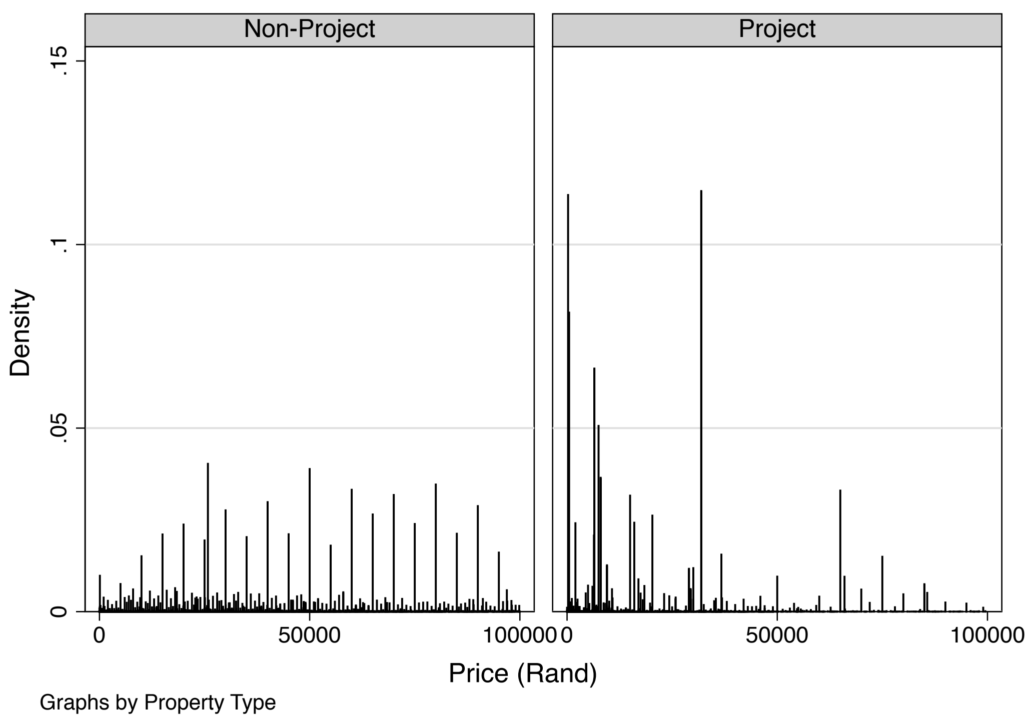
We assign a completion date for each project according to the modal year of these deeds transactions. Figure 3 indicates the distribution of transaction dates for properties within a 4 km buffer around housing projects (above panel) and within the selected project areas (below panel). Project areas exhibit substantial bunching during a single month when projects were completed. There are also more transactions after the modal year than before the modal year, consistent with either a gradual roll-out for some project areas or immediate resale of projects houses after construction, which would be counter to housing regulations.

Evidence of similar bunching around the modal year for transactions coded as non-project transactions (above panel) would suggest that we may be miscoding project transactions as non-project transactions; instead, we find a smooth pattern relative to the modal year for these non-project transactions. The slight increase in density around and just following the modal year may also be consistent with housing projects having an immediate impact on local housing markets, which we will explore further below.

3.2. Planned but Unconstructed Housing Projects

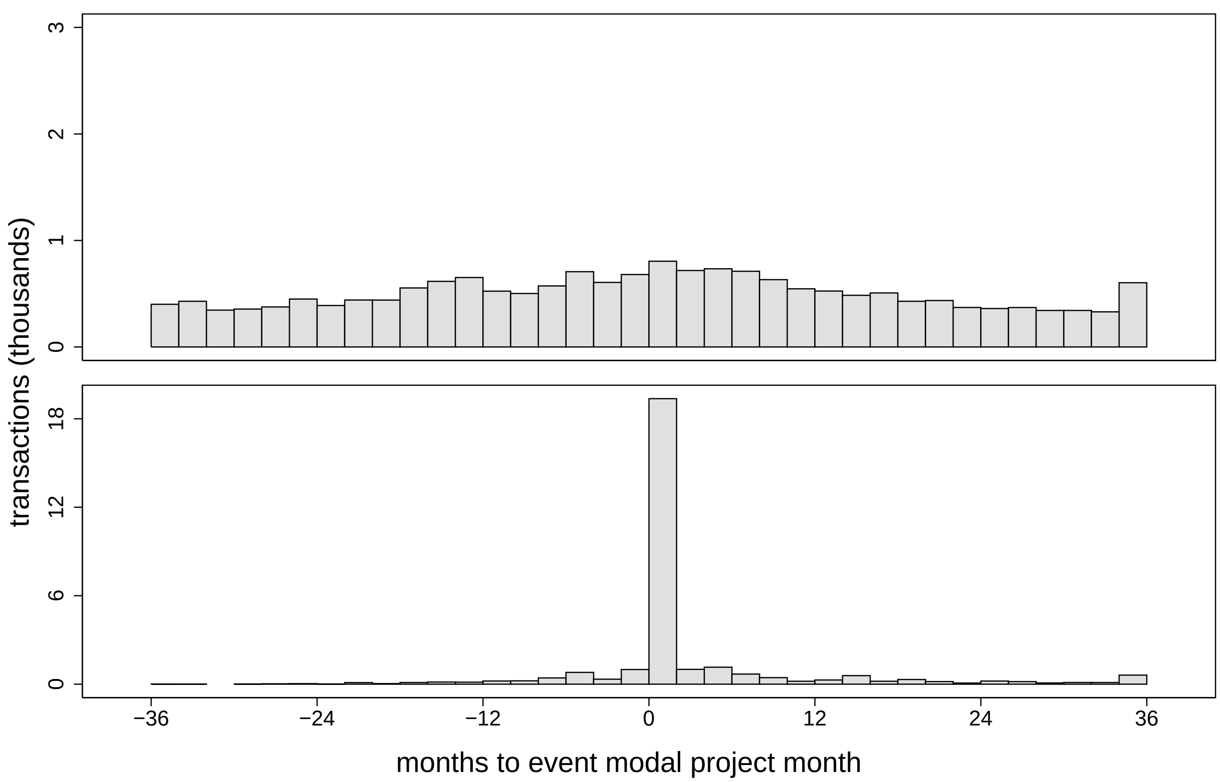
Identifying 68 constructed housing projects leaves 99 planned but possibly unconstructed housing projects from the administrative map. We propose using these projects as counterfactuals in our

Figure 2: Transaction Price Histogram



Note: Transactions are censored at R100,000.

Figure 3: Transaction Densities Relative to Modal Project Month



The above panel includes transactions within a 1.2 kilometer buffer around a project cluster relative to the modal year of that cluster. The below panel includes all transactions within the final sample of clusters.

analysis, capturing the level of the development that would have occurred in the absence of housing projects.

In order to determine which of the unconstructed projects were planned to be completed between 2001 and 2011, we construct an estimated completion date using National Treasury budget reports. We were able to digitize data for 132 projects from budget reports spanning 2004 to 2009, which detail the name, start date, expected completion date, and cost of each housing project. We then use a fuzzy-string matching algorithm with bigrams to link project names from the budget reports to the administrative maps. We keep all matches with over 60% similarity with 44 projects matching exactly. Appendix 8 compares unmatched and matched projects finding that matched projects have much higher densities of informal housing and project housing density, but similar densities of formal housing and project dates. One reason may be that the budget reports only include larger, more expensive projects.

We find that the project start date (from the budget reports) is three years before the project completion date (from the deeds data) on average. In other words, beneficiaries receive title to their new houses about three years after the housing program is announced in the budget. We assign a expected completion date for unconstructed projects that is three years after the announced start-date in the project. This procedure results in a final sample of 65 unconstructed projects.

Table 1 tabulates project descriptions from the administrative data according to our definitions of completed and uncompleted. We find that constructed projects are much more likely to be classified as “completed,” “planning,” or in “implementation” while unconstructed projects are more likely to fall into “Uncertain” or “Investigating” categories. These correlations provide an external validation of our classification of constructed and unconstructed projects with deeds records.

4. Descriptive Evidence

Table 2 provides descriptive statistics for the final sample of 68 constructed and 68 constructed projects. At baseline in the 2001 building census, we find that completed and uncompleted project areas have similar formal building density although uncompleted projects have much higher densi-

Table 1: Project Descriptions

	Unconstructed	Constructed
Implementation, Completed	5	18
Planning	12	8
Future, Investigating, Proposed	18	5
Uncertain	2	0
No Description	28	37

Descriptions from administrative project map.

Table 2: Housing Project Descriptives at Baseline

	Unconstructed	Constructed	T-Stat
Number of Projects	65	68	
Area (km2)	2.21	3.62	-1.48
Project Houses (per km2)		516	
Informal Buildings (per km2)	1,194	997	0.90
Formal Buildings (per km2)	355	428	-0.63
House Price (Rand)	113,956	88,781	1.13
Distance to CBD (km)	33	30	1.27

Central Business Districts (CBD) are measured
with respect to Johannesburg and Tshwane.

ties of informal structures. Consistent with this finding, slum areas may face greater challenges in organizing funding as well as infrastructure provision necessary to complete large housing projects. After project follow-through, completed areas experience dramatic increases in formal building density between 2001 and 2011 compared to uncompleted projects. Both areas also experience substantial and similar growth in their levels of informal settlement growth. The median year of completion as well as distance to Central Business District match well between completed and uncompleted projects

To assess the extent to which these project areas are representative, Table **??** shows average characteristics for transactions in buffer areas for completed projects, buffer areas for uncompleted projects, and all other transactions outside of all buffer areas. Average prices for completed projects closely resemble prices outside of buffer areas while uncompleted projects have much lower prices, supporting earlier evidence that these uncompleted projects are located in places with greater slum density. Plot sizes for properties in completed and uncompleted project buffers are similar and

Table 3: Housing Project Descriptives at Baseline

	Unconstructed	Constructed	T-Stat
Flush Toilet	0.532	0.765	-3.55
Piped Water in Home	0.324	0.469	-2.38
Household Size	3.10	3.28	-2.12
Owns House	0.375	0.503	-2.90
Single House	0.440	0.622	-3.11
Number of Rooms	3.13	3.26	-0.79
Pop. Density (per km2)	6,454	8,428	-1.99

Central Business Districts (CBD) are measured with respect to Johannesburg and Tshwane.

much smaller than plots outside of these areas. This finding is consistent with housing projects being located nearby dense residential or slum areas instead of in rural locations throughout the province. Close to a third of all properties are sold multiple times and all share the same median purchase year.

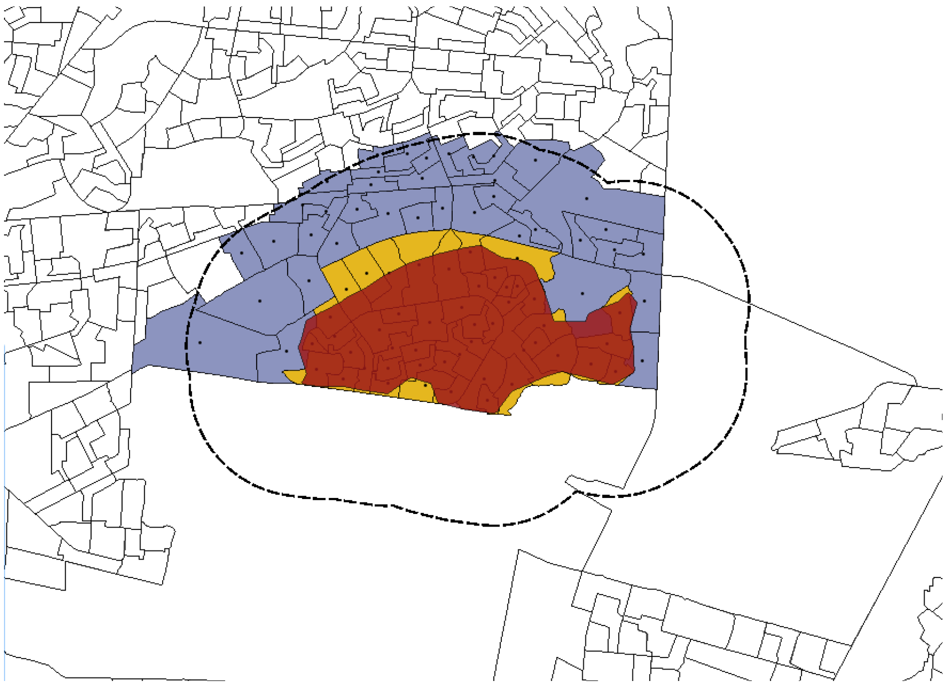
We use a similar buffer approach to examine census characteristics by including census blocks whose centroids fall within 1.2 km buffers of nearby projects. Figure 4 provides an example project that distinguishes between census blocks (in yellow) with greater than 30% overlapping area with project areas and census blocks (in blue) with less than 30% area overlap but whose centroids fall within the 1.2 km buffer. This criteria allows for separating the direct effects of the housing projects within their footprint from the spillover effects of housing projects on the surrounding areas. We focus on the 30% area overlap threshold to account for cases where housing project areas are small relative to the nearest census blocks.

4.1. Building Growth around Housing Projects

Using the building structures survey, we provide a first look at housing development around completed and uncompleted projects. Figure 5 plots the average number of new structures between 2001 and 2011 in distance rings from the boundary of both completed and uncompleted project areas. Negative distances measure new structures within the project areas themselves.

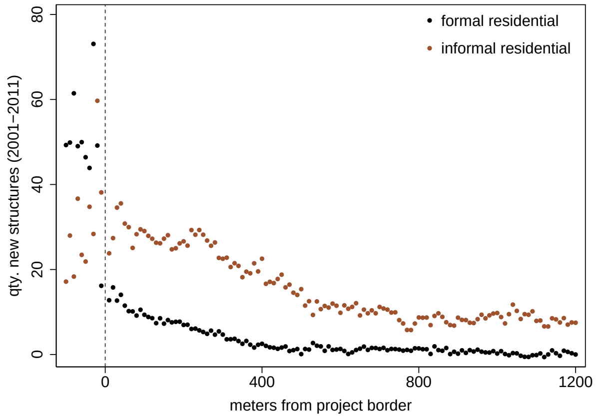
Focusing on completed projects in the left panel, strong growth in formal residential structures

Figure 4: Buffer Design Census Block Example

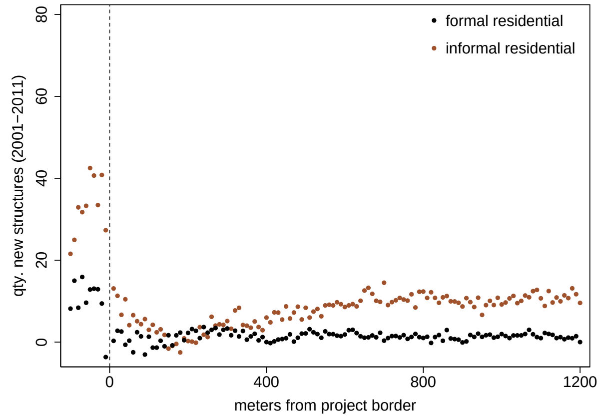


- Census Blocks with ≥30% project area overlap : yellow polygons
- Census Blocks with <30% project area overlap : blue polygons
- Buffer Area (1.2 km from clusters) : dotted line
- Project Area : red polygon

Figure 5: Growth in Structures between 2001 and 2011



Completed Projects



Uncompleted Projects

at negative distances provides another measure of the direct impact of the housing projects. We also observe strong growth in informal residential structures within project areas. This finding is consistent with anecdotal evidence from fieldwork in South Africa pointing to the prevalence of backyard shacks where owners of project houses use their land plots to construct informal housing. At positive distances, the growth in formal structures immediately dissipates while the growth in informal structures remains substantial up to at least 400 meters from the project border. This sustained growth in nearby informal dwellings matches a common complaint of local housing authorities and NGOs who notice crowding-in of slum areas around project areas in order to utilize the public services offered within the projects.

Results for uncompleted projects in the right panel indicate a similar pattern of informal structure growth in project areas. However compared to completed projects, lower levels of formal structure growth occur within uncompleted project footprints before quickly dissipating outside of the projects. Informal structure growth also decreases suddenly outside of the projects. This result suggests that completed housing projects may play an important role in generating nearby growth in informal settlements in the right panel. The flat, smooth trends in structure growth past 500 meters for both completed and uncompleted projects support interpreting these regions as capturing the types of local development that we might expect in the absence of the housing projects.

5. Results: Price Spillovers

To identify the spillover effects of public housing on residential home prices in the formal market, we use a difference-in-differences approach comparing prices for areas close and far from project areas before and after project implementation. Our main empirical strategy takes the following specification:

$$P_{itp} = \alpha D_{tp}T_{ip} + \theta_1 D_{tp} + \theta_2 T_{ip} + X_i^{'}\beta + \lambda_p + \eta_t + \varepsilon_{itp}$$

The outcome, P_{itp}, is measured in terms of the log-purchase price of property i sold at time t in the vicinity of project p. To capture changes in prices over time within project areas, D_{tp} is equal to one if date t is after the month of project implementation and zero otherwise. T_{ip} takes a value of one if property i is within 400m of the project boundary (zero otherwise). The coefficient of interest, α captures the differential change in prices between near and far properties before and after project construction. X_i controls for a quadratic in lot size, which can affect prices over time. Additionally, λ_p includes a project fixed affect controlling for any fixed, unobserved drivers of house prices that vary between projects. Likewise, η_t controls for calendar month (year $\times$ month) fixed-effects to account for any factors such as shifts in aggregate housing demand that may be correlated with prices and the timing of housing projects.

Interpreting the coefficient, α, as the causal effect of housing projects on nearby home prices requires the following assumption:

$$E[\varepsilon_{itp}|X_i, T_{ip}, D_{tp}, \lambda_p, \eta_t] = 0$$

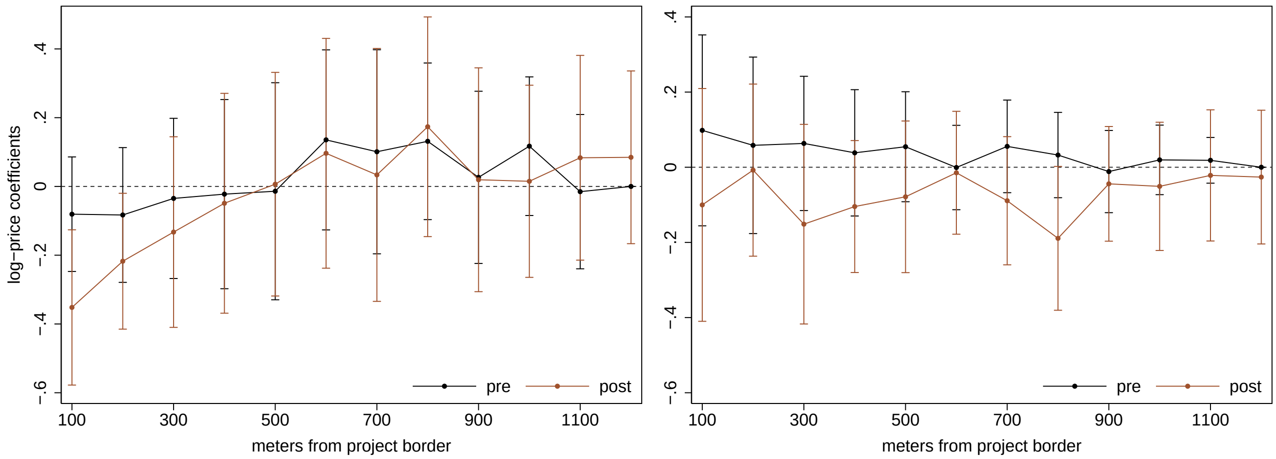
This assumption implies that there are no other factors occurring in the same time and place as the housing projects which may otherwise impact home prices. One possibility is that housing markets anticipate the construction of these projects so that transactions in the pre-period may be partially treated by the advent of a housing project. Anecdotal evidence suggests that completion dates for these projects are very uncertain due to the large coordination of stakeholders needed for each project, making it difficult to accurately anticipate implementation. Another concern would be that housing projects are accompanied by other social programs that would stimulate investments in neighborhoods near project areas. In order to isolate market anticipation or accompanying social programs from the actual impacts of housing projects, we estimate an identical model for planned but uncompleted projects to test the robustness of the results.

Similarly, in targeting housing projects to particular areas, governments may be responding to local trends in housing markets or economic conditions. To separate project impacts from secular market trends, we leverage the sudden roll-out of housing projects under the assumption that market trends are relatively smooth over space and time relative to the construction of housing projects. In order to non-parametrically assess identification in this way, we also estimate a more flexible model both in terms of distance to project, D_{tp} and time relative to project construction, T_{ip}. Specifically, we estimate separate treatment effects for each 100 meters of distance, $\sum_{d=100}^{1200} \alpha_d D_{tpd} T_{ip}$. We also allow effects to vary according to two-month intervals relative to construction, $\sum_{l=-36}^{36} \alpha_l D_{tp} T_{ipl}$. All regressions cluster standard errors at the project level in order to account for potentially correlation in prices due to unobserved factors within very localized housing markets.

Figure 6 separately plots coefficients for average home prices before construction, $\alpha_{d,pre}$ and after construction, $\alpha_{d,post}$ for each 100m distance ring from housing project boundaries. The left panel presents price gradients for completed projects. The pre-project gradient slopes slightly upwards consistent with housing projects being located in undeveloped land or preexisting informal settlements. After implementation, the price gradient slopes downwards sharply within 400 meters of the project area while remaining unchanged past this 400 meters threshold. This result is consistent both with the growth of informal settlements concentrated in the same spatial interval as observed in Figure 5.

Uncompleted projects in the right panel exhibit a flat price gradient before project implementation. One explanation may be that since uncompleted projects are more often located in large slum neighborhoods, spillover areas may closely resemble these project areas. After the estimated date

Figure 6: Price Estimates over Distance



Completed Projects

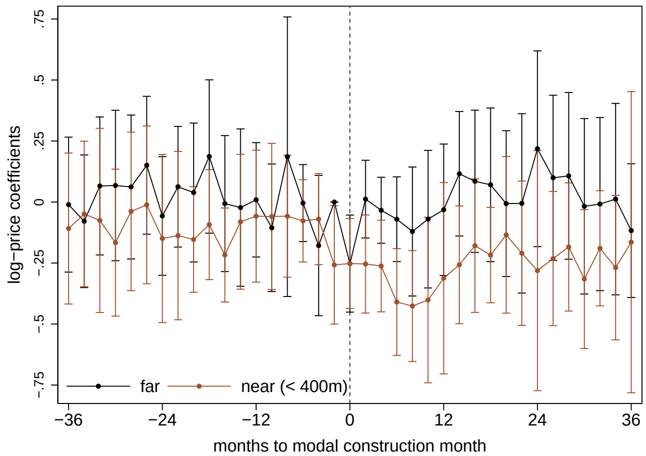
Uncompleted Projects

of project completion, the price gradient remains flat shifting slightly, but noisily downward at all distances from the project boundary. These findings suggest little local spillovers from the uncompleted projects alongside a deterioration in the local housing market affecting all properties evenly. Additionally, these results provide suggestive evidence that exact location of housing projects does not appear to be strongly correlated with housing market trends at a very local level.

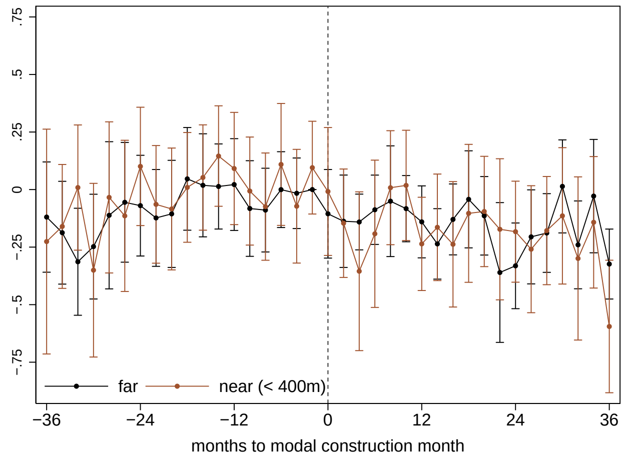
Complementing these distance gradients, Figure 7 plots coefficients for average price changes over time relative to the modal construction month for properties within and beyond 400 meters of a project boundary. Focusing on completed projects in the left panel, both areas far and near project boundaries follow a smooth, parallel evolution in prices over time. This parallel trend provides evidence against large shifts in policy or economic conditions that may be correlated with the onset of these housing programs. The price trajectories begin to deviate in the few months preceding the modal transaction date of the housing project. While further away properties maintain a steady price level following the housing project, nearby properties experience a sustained dip in prices that persists up to three years after the project is implemented. The sustained reduction in housing prices provides evidence for a lasting structural change in local housing market instead of a temporary resorting of households from nearby residences to project houses.

The dip in prices begins in the couple months before the modal transaction year, which is con-

Figure 7: Price Estimates over Time



Completed Projects



Uncompleted Projects

sistent with nearby housing markets anticipating projects during their construction periods. One hypothesis is that given the large observed decline in house prices, it would rational for housing markets to anticipate construction, producing a declining pretrend in prices before completion date. The absence of an extended pretrend may speak to the unpredictability of the timing for these projects, especially given high coordination costs and frequent unplanned delays.

For uncompleted projects in the right panel, areas far and near project boundaries follow similar parallel trends to completed projects leading up to the expected completion date, but then remain indistinguishable for the entire duration after this date. This null result helps to exclude competing explanations that rely on the timing of housing projects such as targeting housing programs according to hyper-local housing market trends or pairing housing projects with other place-based policies.

Table 4 and Table 5 provide the difference-in-differences regression analogues to Figure 6 and Figure 7. In the first column of Table 4, we estimate a simple difference-in-differences specification and report the coefficient for properties within 400 meters of the project and 3 years of the start date. Since the outcome is measured in log-prices, the coefficient indicates that housing prices in this range decline by 23.8% as a result of the housing program. Including project fixed-effects in the second column attenuates this effect to 16.6% and reduces its statistical significance from 5% to

Table 4: Price Estimates for Completed Projects

VARIABLES	(1) Log Price	(2) Log Price	(3) Log Price	(4) Log Price
3 yrs 0-400m	-0.238**	-0.166*		
	(0.106)	(0.0835)		
1st yr 0-400m			-0.147*	
			(0.0754)	
2nd yr 0-400m			-0.180	
			(0.115)	
3rd yr 0-400m			-0.118	
			(0.0971)	
3 yrs 0-200m				-0.224**
				(0.0961)
3 yrs 200-400m				-0.0701
				(0.0664)
Observations	28,701	28,701	28,701	28,701
R-squared	0.229	0.488	0.489	0.489
Project FE	NO	YES	YES	YES
Year-Month FE	YES	YES	YES	YES

Robust standard errors in parentheses

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

All control for cubic in plot size. Standard errors are clustered at the project level.

10% by accounting for fixed differences in the housing markets between clusters. The third column disaggregates the coefficients by years following project completion. Comparing coefficients, we only find a statistically significant coefficient for the first year of the project although effect sizes remain similar for all time intervals. With just over 150 projects, significant noise in the housing price data, and a rich set of fixed effects, these specifications have difficulty precisely recovering price estimates. In the spirit of Figure 6, the fourth column examines price effects at a finer spatial scale, finding an especially large and statistically significant price decline in the immediate 200 meters of a housing project which sharply attenuates past 200 meters.

Table 5 repeats the same differences-in-differences exercise in Table 4 but for uncompleted projects. Across all four columns, estimates are statistically insignificant and very small in magnitude compared to results in Table 4. In column three, we find one statistically significant coeffi-

Table 5: Price Estimates for Uncompleted Projects

VARIABLES	(1) Log Price	(2) Log Price	(3) Log Price	(4) Log Price
3 yrs 0-400m	-0.0435	-0.0664		
	(0.0784)	(0.0597)		
1st yr 0-400m			-0.0687	
			(0.0662)	
2nd yr 0-400m			0.00256	
			(0.0729)	
3rd yr 0-400m			-0.159*	
			(0.0841)	
3 yrs 0-200m				-0.0365
				(0.0739)
3 yrs 200-400m				-0.0896
				(0.0624)
Observations	24,562	24,562	24,562	24,562
R-squared	0.307	0.502	0.502	0.502
Project FE	NO	YES	YES	YES
Year-Month FE	YES	YES	YES	YES

Robust standard errors in parentheses

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

All control for cubic in plot size. Standard errors are clustered at the project level.

cient at the 10% level for price effects in third year, which appears to be driven by an outlier in the 36th month (according to the right panel in Figure 7). Taken together, these results provide additional evidence that price effects are primarily driven by the completion of housing projects rather than local trends in housing markets or economic conditions which would also affect uncompleted projects in theory.

6. Results: Infrastructure and Demographic Changes

To provide additional evidence on how the demographics and infrastructure may be changing as a result of these projects, we use slightly modified differences-in-differences design where uncompleted project areas are directly treated as counterfactuals. The specification for analyzing the census data takes the following form:

$$Y_{hbtp} = \alpha_O D_{tp} T_{bp} O_{bp} + \alpha_S D_{tp} T_{bp} S_{bp} + \theta_1 D_{tp} O_{bp} + \theta_2 D_{tp} S_{bp} + \theta_3 T_{bp} S_{bp} + \theta_4 S_{bp} + \lambda_p + \varepsilon_{hbtp}$$

The outcome, Y_{btph}, includes demographic characteristics for household (or person) h living in census block b and project area p in year t. O_{bp} takes a value of one for census blocks with greater than 30% area overlap with housing projects (zero otherwise) while S_{bp} is the converse identifying "spillover" census bocks that have less than 30% overlap but whose centroids are still within a 1.2 km buffer of the housing project boundaries. To account for secular changes in outcomes between 2001 and 2011 affecting all census blocks, D_{tp} is equal to one if year t is equal to 2011 and zero otherwise. T_{ip} takes a value of one for census blocks near completed projects and a value of zero for census blocks near uncompleted projects. Controlling for differential time trends for overlap and spillover projects, $D_{tp}O_{bp}$ and $D_{tp}S_{bp}$ as well as separate means for both completed, $T_{bp}S_{bp}$, and uncompleted, S_{bp}, spillover areas leaves census blocks that overlap with uncompleted projects in the pre-period as the reference group. λ_p includes a project-level fixed effect to control for fixed differences in census characteristics between different projects. The coefficients of interest, α_O and α_S, capture differential changes in outcomes between completed and uncompleted projects separately for overlapping and spillover census blocks.

To interpret the coefficients, α_O and α_S, as the causal effects of housing projects on both overlapping and spillover outcomes, we make the following assumption:

$$E[\varepsilon_{hitp} | T_{ip}, D_{bp}, S_{bp}, O_{bp}, \lambda_p] = 0$$

Intuitively, this assumption requires that there are no other factors occurring at the same time both within and around the completed housing projects that may drive changes in local demographics. By limiting the control group to only include uncompleted projects, we make the following parallel trends assumption: outcomes near completed projects would have evolved in the same ways as outcomes near uncompleted projects in the absence of the housing projects. This design leverages similarities in areas around completed and uncompleted projects rather than comparing project areas to the entire region of Gauteng. To the extent that locations of housing project may be targeted to local economic conditions, other areas in the province may be less likely to satisfy parallel trends assumptions.

At the same time, local economic and political conditions may determine which projects are completed and which are either canceled or delayed. To the extent that these conditions may be correlated with changes in local demographics, the assumption of parallel trends would not hold in the analysis. Table **??** and Table 2 provide evidence that uncompleted project areas have more informal settlements and fewer services at baseline, consistent with policymakers placing less priority on finishing projects in these areas. At the same time, spillover areas appear very similar in Table **??** suggesting that differences in trends in these areas may be more plausibly associated with completion of housing projects.

Table 6 provides difference-in-differences estimates for a range of household level outcomes. The first two rows include the coefficients of interest, which measure the differential change in outcomes for completed and uncompleted projects. The first row reports effects for census blocks with greater than 30% overlap (Project) and the second row includes census blocks with less than 30% overlap (Spillover). Broadly, infrastructure and home quality measures (flush toilet, piped water, single house, and number of rooms) increase in overlapping areas while these same measures decrease in spillover areas. Many effects ares statistically significant at the 5 to 1% level and are large in magnitude. For example, the first column predicts a 21% increase in piped water for project areas with a corresponding decrease of 7% in spillover areas. While we observe large changes in infrastructure provision, estimates are small and insignificant for household size and home ownership.

The third and fourth rows capture secular changes in outcomes over time for uncompleted project areas. These measures indicate large overall increases in infrastructure and home quality measures in roughly similar magnitudes for spillover and project areas.

Table 7 repeats the same exercise focusing on changes in demographic composition for house-

Table 6: Census Household-level Estimates

VARIABLES	(1) Flush Toilet	(2) Piped Water Inside	(3) Electric Cooking	(4) Electric Lighting	(5) Single House	(6) Owns House	(7) No. Rooms	(8) Household Size
Project X Post X Complete	0.210**	0.202***	0.0679	-0.0482	0.183***	-0.0523	0.286*	0.0992
	(0.0824)	(0.0540)	(0.0849)	(0.0998)	(0.0451)	(0.0645)	(0.158)	(0.0915)
Spillover X Post X Complete	-0.0723*	-0.0464	-0.130***	-0.0461	-0.0957**	0.00820	-0.102	-0.00151
	(0.0411)	(0.0302)	(0.0449)	(0.0385)	(0.0374)	(0.0501)	(0.0923)	(0.0462)
Project X Post	0.115**	0.148***	0.353***	0.270***	0.0535**	0.223***	0.353***	-0.242***
	(0.0448)	(0.0298)	(0.0760)	(0.0822)	(0.0238)	(0.0498)	(0.106)	(0.0771)
Spillover X Post	0.136***	0.182***	0.268***	0.138***	0.129***	0.289***	0.390***	-0.236***
	(0.0313)	(0.0205)	(0.0347)	(0.0285)	(0.0312)	(0.0245)	(0.0670)	(0.0351)
Spillover X Complete	-0.205*	-0.0732	-0.262***	-0.450***	-0.0540	-0.217***	-0.148	-0.202*
	(0.122)	(0.106)	(0.0885)	(0.0935)	(0.0731)	(0.0724)	(0.222)	(0.122)
Spillover	0.328***	0.185**	0.373***	0.429***	0.147***	0.128**	0.474***	0.150
	(0.0873)	(0.0719)	(0.0788)	(0.0831)	(0.0560)	(0.0624)	(0.180)	(0.103)
Constant	0.498***	0.217***	0.389***	0.537***	0.439***	0.468***	2.746***	3.334***
	(0.0514)	(0.0425)	(0.0379)	(0.0415)	(0.0301)	(0.0292)	(0.0927)	(0.0515)
Observations	1,544,285	1,544,285	1,544,285	1,544,285	1,479,342	1,496,636	1,459,677	1,532,866
R-squared	0.360	0.243	0.301	0.306	0.195	0.147	0.174	0.057
Project FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

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

Standard errors are clustered at the project level.

Table 7: Census Person-level Demographic Estimates

VARIABLES	(1) Over HS Educ.	(2) HH Income	(3) Unemployed
Project X Post X Complete	-0.0360***	-96.45	0.00604
	(0.0117)	(395.0)	(0.0222)
Spillover X Post X Complete	-0.00455	22.31	0.0200
	(0.0125)	(476.6)	(0.0159)
Project X Post	0.0786***	705.2***	-0.142***
	(0.00946)	(252.2)	(0.0110)
Spillover X Post	0.0298***	2,231***	-0.134***
	(0.00684)	(288.1)	(0.00801)
Spillover X Complete	-0.0194	-1,425***	0.0299
	(0.0156)	(532.9)	(0.0220)
Spillover	0.0236*	860.2*	-0.0591***
	(0.0138)	(455.4)	(0.0159)
Constant	0.825***	2,460***	0.505***
	(0.00600)	(244.7)	(0.00837)
Observations	2,191,516	972,949	1,145,850
R-squared	0.028	0.062	0.057
Project FE	YES	YES	YES

Robust standard errors in parentheses

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

Standard errors are clustered at the project level.

holds living in these areas. In the first row of column one, we find a statistically significant decrease in the share of high school (or greater) educated adults by around 3.6%. One explanation is that the housing policies are able to target recipients based on means and many of the original beneficiaries continue to reside in project areas. For spillover areas and measures of household income and employment, we find no detectable effects of the housing program.

7. Discussion

Within the framework of US housing policy analysis in Diamond and McQuade [2016], South African housing projects would likely be considered as positive amenities at least within their footprints. Housing projects successfully deliver large numbers of new structures (Figure 5) and much better access to bulk services (Table 6). Results in Table 6 and Table 7 also indicate that these new project houses are at least as good as neighboring houses at baseline while program beneficiaries share similar demographics to their neighbors. Therefore, consistent with the model in Diamond and McQuade [2016], we would expect to find that these programs increase nearby home prices; however, models from developed contexts often do not take into account the presence of informal markets and associated congestion externalities.

In the context of South Africa, we find evidence of complementarities between public housing programs and informal housing markets, which have large implications for prices in nearby formal housing markets. Just outside of their footprints, housing projects lead to large increases in slums demonstrated both in terms of more informal structures in Figure 5 as well as greater shares of un-serviced and informal housing from census data in Table 6. We hypothesize that informal housing markets benefit both from greater access to public services as well as newly zoned and cleared land around housing projects.

Using both time and geographic variation in housing projects in Table 4, we find that formal home prices decline substantially and overlap geographically with observed growth in slums. The persistence of these declines in formal home prices supports the interpretation of these projects as representing structural shifts rather than temporary readjustments in local housing markets. Given the high quality of the project houses themselves, we interpret this decline as more associated with the sudden increase in nearby informal settlements than due to any disamenities created by the project houses. Taken together, these results suggest that complementarities between housing projects and slum growth may outweigh any amenity gains from the housing projects themselves and work to impede formal development in neighborhoods surrounding these projects.

8. Conclusion

This paper serves as a cautionary tale for low-density public housing in developing countries. While these projects may be designed to improve local housing markets and reduce local slum growth, they may instead support local slum growth through a mix of available land and improved infrastructure. It is important to emphasize that our analysis does not currently speak to the overall welfare implications of these policies. For example, public housing may lead to an overall net reduction in slums in the city, which may generate total welfare gains through fewer congestion externalities or other mechanisms. According to our model, the optimal housing policy depends crucially on the shape of these congestion externalities. We look forward to using variation in the South African housing program to estimate these externalities in future work. In light of South Africa's emphasis on using housing policy to stimulate neighborhood development, we hope that this paper will be useful for policymakers in considering the range of informal housing market responses as they design new housing policy.

References

M. Busso, J. Gregory, and P. Kline. Assessing the incidence and efficiency of a prominent place based policy. *American Economic Review*, 103(2):897–947, 2013.

M. D. Cattaneo, S. Galiani, P. J. Gertler, S. Martinez, and R. Titiunik. Housing, health, and happiness. *American Economic Journal: Economic Policy*, 1(1):75–105, 2009.

Department of Human Settlements. Breaking new ground: A comprehensive plan for the development of sustainable human settlements. Technical report, 2004. URL http://abahlali.org/files/Breaking%20new%20ground%20New_Housing_Plan_Cabinet_approved_version.pdf.

Department of Human Settlements. Annual reports. Technical report, 2012,2015. URL http://www.dhs.gov.za/content/annual-reports.

F. Devoto, E. Duflo, P. Dupas, W. Parienté, and V. Pons. Happiness on tap: piped water adoption in urban morocco. *American Economic Journal: Economic Policy*, 4(4):68–99, 2012.

R. Diamond and T. McQuade. Who wants affordable housing in their backyard? an equilibrium analysis of low income property development. Technical report, National Bureau of Economic Research, 2016.

P. Dlmini. R95m down the tubes as housing project picked apart brick by brick. 2017. URL https://www.timeslive.co.za/news/south-africa/2017-09-12-r95m-down-the-tubes-as-housing-project-picked-apart-brick-by-brick/.

E. Durojaye, G. Mirugi-Mukundi, N. Munshi, and K. Tissington. Jumping the queue, waiting lists and other myths: Perceptions and practice around housing demand and allocation in south africa. Technical report, Socio-Economic Rights Institute of South Africa, Community Law Centre University of the Western Cape, 2013. URL http://www.seri-sa.org/images/Jumping_the_Queue_MainReport_Jul13.pdf.

S. Franklin. Enabled to work: the impact of government housing on slum dwellers in south africa. 2016.

S. Galiani, P. J. Gertler, R. Undurraga, R. Cooper, S. Martínez, and A. Ross. Shelter from the

Table 8: Assessing Name Matching between
Budget and Spatial Administrative Data

	Unconstructed		Constructed	
	Matched	Unmatched	Matched	Unmatched
Formal Density: 2001	188.4	142.5	481.7	546.1
Formal Density: 2011	505.0	284.0	1,527.2	1,575.4
Informal Density: 2001	998.6	457.2	1,611.1	985.2
Informal Density: 2011	1,619.1	701.3	2,379.3	1,064.2
Project House Density	0.0	0.0	558.6	348.4
Project Mode Year	.	.	2004	2005
Area (km2)	2.2	2.9	5.4	1.4
Observations	67	32	75	18

Density is measured in structures per km^2.

storm: Upgrading housing infrastructure in latin american slums. *Journal of Urban Economics*, 98:187–213, 2017.

B. Marx, T. Stoker, and T. Suri. The economics of slums in the developing world. *Journal of Economic Perspectives*, 27(4):187–210, November 2013. doi: 10.1257/jep.27.4.187. URL http://www.aeaweb.org/articles?id=10.1257/jep.27.4.187.

M. Mathoho. A case study of participation in the thinasonke ext 4 fedup pledge project. 2010. URL http://www.planact.org.za/participation-and-development-from-the-perspective-of-the-poor-2008-2009/.

D. Matsena. Premier launches rdp housing project in north. 2018. URL https://rekordnorth.co.za/121824/premier-launches-rdp-housing-project-in-north/.

A. Takeuchi, M. Cropper, and A. Bento. Measuring the welfare effects of slum improvement programs: The case of mumbai. *Journal of Urban Economics*, 64(1):65–84, 2008.

K. Tissington. A resource guide to housing in south africa 1994-2010: Legislation, policy, programmes and practice. Technical report, Socio-Economic Rights Institute of South Africa, 2011. URL https://www.seri-sa.org/images/stories/SERI_Housing_Resource_Guide_Feb11.pdf.

United Nations. Annex millennium development goals, targets and indicators, 2015: statistical tables. 2015. URL http://mdgs.un.org/unsd/mdg/Resources/Static/Products/Progress2015/StatAnnex.pdf.

Appendix