Urban Water and Housing Infrastructure for Economic Development

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Motivation for Dissertation

- Rapid urbanization in the developing world
  - 30% of urban pop. lives in slums (UN, 2015)
- Informal institutions mean standard policies can have unintended consequences
  - Difficult to detect in standard survey data
- New administrative data can provide a window into these dynamics

Overview of Dissertation

1. Spillover impacts of public housing
2. Child health, overcrowding, and public housing
3. Pricing water when the poor share

Public Housing Spillovers in a Developing Country

joint with Ben Bradlow and Stefano Polloni

Public Housing and Development

- Public Housing $\rightarrow$ primary government response to slums
- Positive effects on direct recipients
  (Cateneo et al. [2009], Franklin et al. [2016], Galiani et al. [2017])
- **Question:** What are the spillover effects of public housing in developing countries?
  - *Positive:* Amenity value
  - *Negative:* Crowd-in slums (share public services)
- **Setting:** 150+ projects in South Africa; GPS price and slum data
- **Findings:** Home prices drop by 16% within 3 yrs and 400m of a project
  - Home quality improves within project footprint but declines nearby (slum crowd-in)

Public Housing in South Africa

- Over 4.3 million houses since 1994 (13% of pop.)
  - 50 to 500 houses per project
  - Fully serviced (roads, water, sanitation, electricity)
  - Greenfield projects on undeveloped land near slums
  - In-Situ upgrading replacing existing slums
- Who gets a house?
  - National/provincial waiting list; no resale within 7 years
  - Must be eligible: Citizens, new homeowners, married or dependents, low income
  - In practice, waiting lists/eligibility weakly enforced

Measuring Public Housing and Spillovers

- Focus on Gauteng Province (includes Johannesburg and Pretoria)

1. **Property Transactions** 500,000 deeds records (bottom 20% of formal housing market)
   - Buyer/seller name, GPS, price, date from 2002-2011
2. **Building Census:** GPS for over 4 mil. buildings in 2001 and 2011
3. **Population Census:** 2001 and 2011
4. **Admin. Project Records:** location, dates, costs
   - Includes planned but unconstructed projects

Identifying Housing Projects

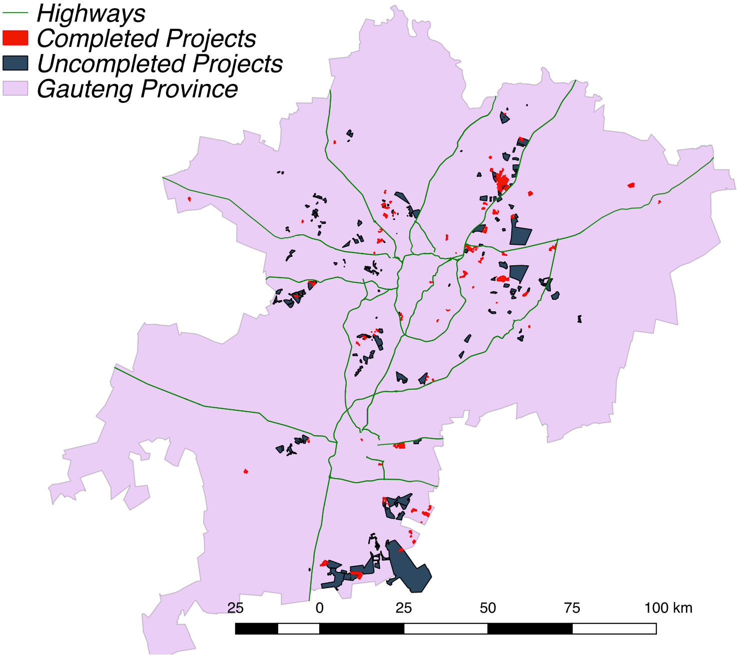
Completed Projects: 56

- Use sales from government sellers on previously empty land plots
- Cluster sales into projects based on geographic proximity
- Include projects where over 50% of sales occurred in the same year
  - Use modal sale year as project date

Uncompleted Projects: 101

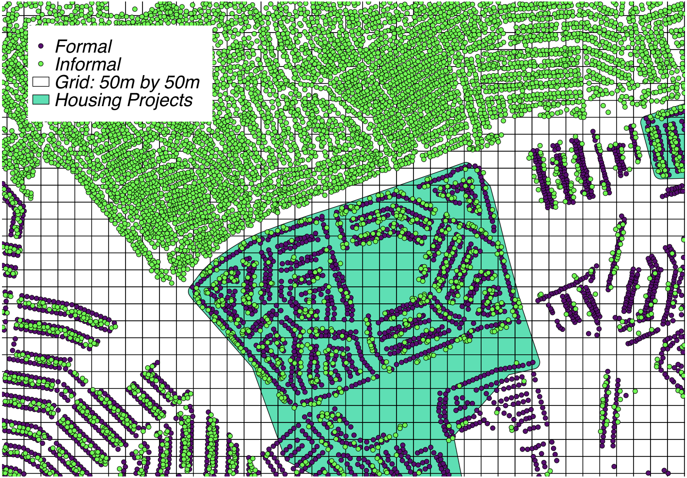
- Admin. projects that do not overlap with completed projects
  - Use estimated completion date as project date
- Why are projects canceled/delayed?
  - Legal disputes, service delivery backlogs, funding complications
  - Delays can exceed 12 years

data appendix


Highways
Completed Projects
Uncompleted Projects
Gauteng Province
25
0
25
50
75
100 km

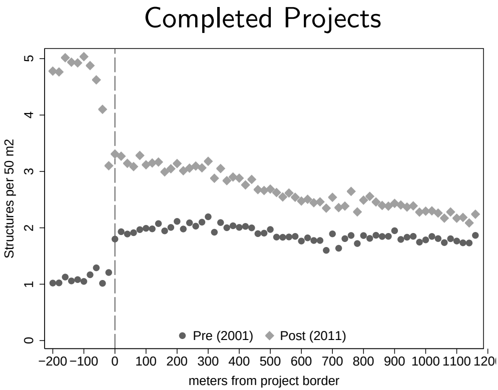
How do projects affect housing growth?

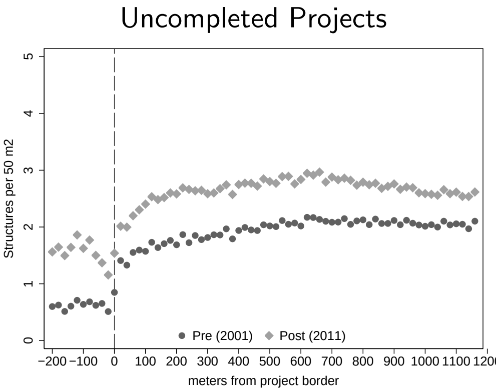
- Count structures within 50 by 50 meter grids



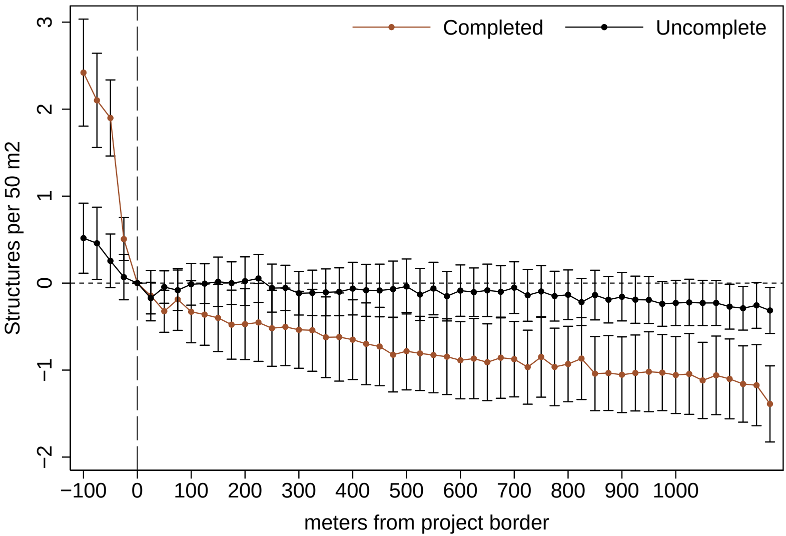
Post construction (2011)

Formal Houses



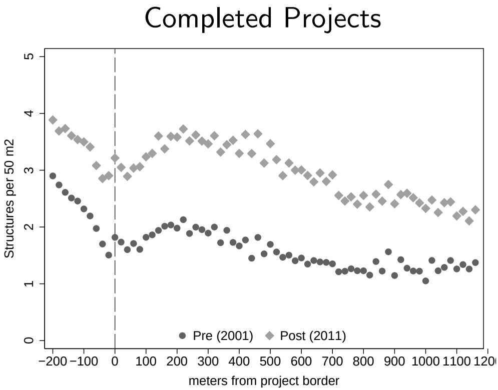


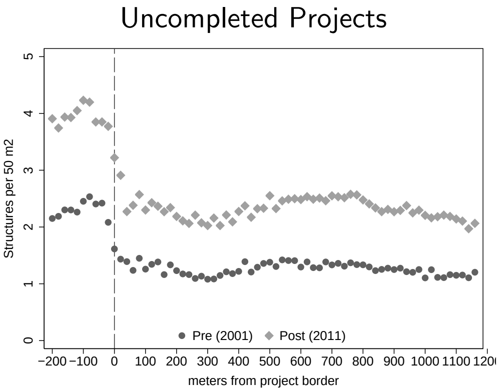
Change in Formal Houses



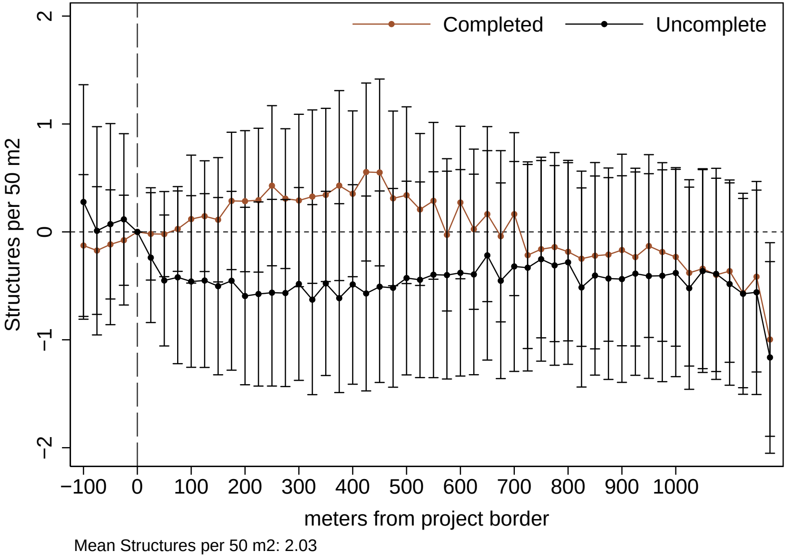
Mean Structures per 50 m2: 2.21

Change in Informal Houses



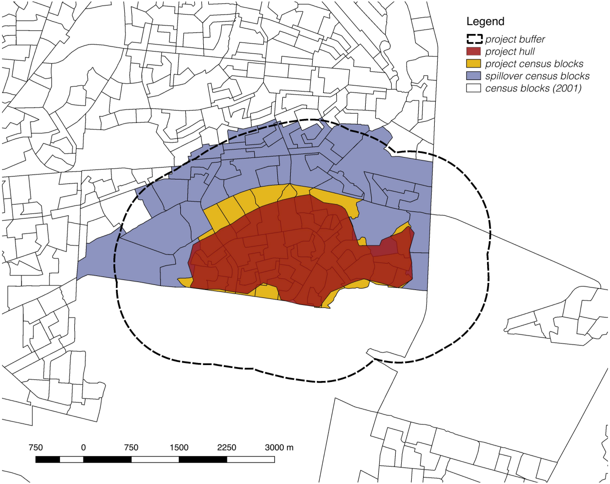


Informal Houses (Slums)



How do projects affect census demographics and house quality?

- Project Blocks: >30% overlap (yellow)
- Spillover Blocks: <30% overlap, centroids within 1.2 km (blue)



Census Descriptives at Baseline (2001)

- Uncompleted project areas have worse outcomes
- Spillover areas are comparable

	Within Project (>30% Overlap)		Spillover (<30% Overlap)	
	Completed	Uncompleted	Completed	Uncompleted
Flush Toilet	0.56	0.26	0.77	0.78
Piped Water	0.21	0.11	0.41	0.37
Owner	0.57	0.43	0.47	0.51
Elec. Cooking	0.58	0.24	0.68	0.63
Elec. Light	0.79	0.36	0.74	0.78
Single House	0.51	0.45	0.52	0.57
Number of Rooms	2.93	3.05	3.11	3.28
Household Size	3.59	3.54	3.27	3.50
Census Blocks	883	967	2,370	2,463
Households	59,460	75,768	213,061	212,005

Census Difference-in-Differences

$$\begin{aligned} Y_{hbtp} = {} & \alpha_1\, Post_{tp}\, C_{bp}\, Project_{bp} + \alpha_2\, Post_{tp}\, C_{bp}\, Spillover_{bp} \\ & + \theta_1\, Post_{tp}\, Project_{bp} + \theta_2\, Post_{tp}\, Spillover_{bp} \\ & + \theta_3\, C_{bp}\, Spillover_{bp} + \theta_4\, Spillover_{bp} + \lambda_p + \varepsilon_{hbtp} \end{aligned}$$

- h: household, b: census block, t: year (2001, 2011), p: project
- $Post_{tp}$: After project
- C_{bp}: Completed
- $Project_{bp}$: $>$%30 overlap
- $Spillover_{bp}$: $\leq$%30 overlap
- λ_p: Project fixed effect

- **Identification**: Counterfactual outcomes for completed projects would have changed in the same way as uncompleted projects.

Census Differences-in-Differences Estimates

VARIABLES	(1) Flush Toilet	(2) Piped Water Inside	(3) Electric Cooking	(4) Electric Lighting
Project X Post X Complete	0.210**	0.202***	0.0679	-0.0482
	(0.0824)	(0.0540)	(0.0849)	(0.0998)
Spillover X Post X Complete	-0.0723*	-0.0464	-0.130***	-0.0461
	(0.0411)	(0.0302)	(0.0449)	(0.0385)
Observations	1,544,285	1,544,285	1,544,285	1,544,285
R-squared	0.360	0.243	0.301	0.306

	(5) Single House	(6) Owns House	(7) No. Rooms	(8) Household Size
Project X Post X Complete	0.183***	-0.0523	0.286*	0.0992
	(0.0451)	(0.0645)	(0.158)	(0.0915)
Spillover X Post X Complete	-0.0957**	0.00820	-0.102	-0.00151
	(0.0374)	(0.0501)	(0.0923)	(0.0462)
Observations	1,479,342	1,496,636	1,459,677	1,532,866
R-squared	0.195	0.147	0.174	0.057
Project FE	YES	YES	YES	YES

Robust standard errors clustered at the project level in parentheses

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

How do projects affect local housing prices?

- Focus on 1,200m buffers around housing projects

Housing Price Descriptives

	In 1.2 km buffer		
	Completed	Uncompleted	Other
Purchase Price (Rand)	248,181.0	230,410.1	243,484.9
Plot Size (m3)	819.2	865.2	1,888.5
Sold At Least Once	0.326	0.350	0.331
Median Purchase Year	2006	2006	2006
Observations	28,943	20,700	167,578

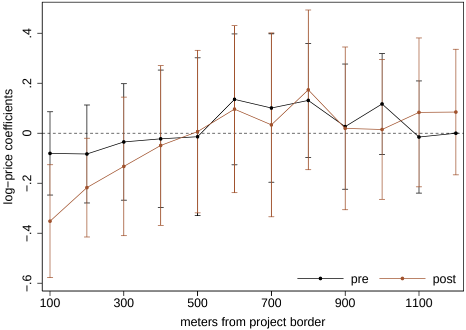
12 Rand = 1 USD

Estimating Differences-in-Differences

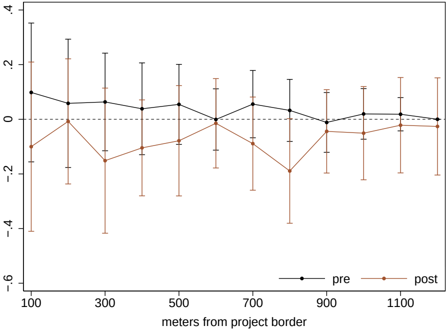
$$
\begin{aligned}
logP_{itp} &= \sum_{d=1}^{D} \alpha_d \mathbb{1}[dist = d] Post_{tp} + \sum_{d=1}^{D} \alpha_d \mathbb{1}[dist = d] Pre_{tp} \\
&+ \gamma_t + \lambda_p + \theta X_i + \varepsilon_{itp} \\
logP_{itp} &= \sum_{e=1}^{E} \alpha_j \mathbb{1}[time = e] Near_{tp} + \sum_{e=1}^{E} \alpha_j \mathbb{1}[time = e] Far_{tp} \\
&+ \gamma_t + \lambda_p + \theta X_i + \varepsilon_{btp}
\end{aligned}
$$

- i: transaction, t: year-month, p: project
- $logP_{gtp}$: log price (formal houses)
- $Near_{tp}$: <400m, Far_{tp}: ≥400m & <1200
- $Post_{tp}$: 36 months after, Pre_{tp} 36 before
- λ_p: project FE, γ_t: calendar month FE

Distance Estimates

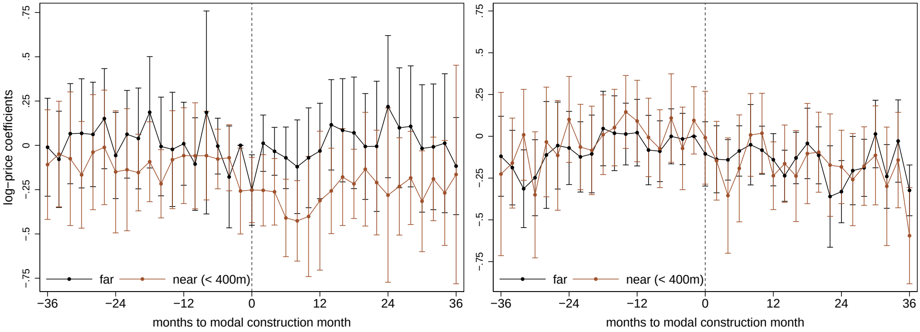


Completed Projects



Uncompleted Projects

Time Estimates



Completed Projects

Uncompleted Projects

Regression Analogue

	Completed		Uncompleted
VARIABLES	Log Price	Log Price	Log Price
3 yrs 0-400m	-0.166*	-0.125	-0.0664
	(0.106)	(0.0892)	(0.0597)
3 yrs 0-400m X In-Situ		0.180	
		(0.289)	
Observations	28,701	28,701	24,562
R-squared	0.488	0.489	0.502
Project FE	YES	YES	YES
Year-Month FE	YES	YES	YES

In-Situ : top 10% of informal home density at baseline

Conclusion and Next Steps

Conclusions

- Home quality improves within project footprint but declines nearby
- Prices in the formal market drop nearby
- **Mechanism:** improved services from housing project lowers cost of new slums which generate externalities

Next Steps

- Estimate total effect on slum growth
- Structurally recover externalities from slum density
- Propose optimal housing policy

Subsidized Housing, Household Size, and Child Health

Public Housing and Child Health

- **Question:** How does public housing impact (recipient) child health?
  - Better materials (Cateneo et al. [2009]; Galiani et al. [2017])
  - More income (Jacob et al. [2014])
  - Better neighborhoods (Franklin et al. [2016]; Kling et al. [2005])
  - **Relieve overcrowded households**
    - More resource investment (more bargaining power for parents)
    - Less spread of disease
- **Approach:** Leverage timing of housing projects in South Africa
  - Analyze heterogeneous impacts by baseline household size
- **Findings:**
  - Public housing does not affect child health on average
  - HHs with 6+ members (1) split between new and old houses and (2) experience gains in child health

Theory of Household Splitting

- With increasing crowding costs, large households split after receiving a new house
- Splitting in response to the program affects child health through
  1. Less consumption (to pay for an extra house)
  2. More housing
  3. Less crowding (divide housing/public goods over fewer people)

Measuring Child Health and Public Housing

Household-Level Panel Data: (2008, 2010, 2012)

- Total: $\sim$5,000 households
- This study: 2,038 households (urban, poor)
- Public housing measure: "Did this household receive a government housing subsidy or any other assistance including RDP housing to obtain this dwelling or any other dwelling?"
- 615 households gain housing over the period

Descriptive Statistics at Baseline

	Control		Treated		
	mean	N	mean	N	T-Test
Height (z-score)	-0.879	1,698	-1.056	309	-2.05
Weight (z-score)	-0.324	1,579	-0.436	267	-1.13
Child Health	1.815	3,093	1.715	643	-2.46
Household Size	5.127	11,080	5.266	2,070	2.32
Children	2.176	11,080	2.389	2,070	5.16
Rooms	3.723	10,657	3.511	2,006	-4.80
Piped Water	0.538	11,080	0.505	2,070	-2.74
Flush Toilet	0.450	11,080	0.472	2,070	1.88
Market Value	19,009	3,714	19,681	735	0.93
Income (month)	3,704	10,569	2,441	1,943	-8.05

Empirical Approach: Estimate with First-Differences

$$\Delta Y_{ijpt} = \beta_0 + \beta_1 \Delta Proj_{ijpt} + \beta_2 \Delta X_{ijpt} + \Delta\gamma_{pt} + \Delta\varepsilon_{ijpt}$$

$$\begin{aligned}\Delta Y_{ijpt} = &\alpha_0 + \alpha_1 Large_{ijpt-1} + \alpha_2 \Delta Proj_{ijpt} + \alpha_3 \Delta Proj_{ijpt} \times Large_{ijpt-1} \\ &+ \alpha_4 \Delta X_{ijpt} + \Delta\gamma_{pt} + \Delta\varepsilon_{ijpt}\end{aligned}$$

- i: individual, j: household, p: province, t: year
- $Proj_{ijpt}$: housing project
- $Large_{ijpt-1}$: 6+ HH members in the previous year
- X_{ijpt}: household/individual controls
- γ_{pt}: province time trends

- **Identification**: Counterfactual outcomes for treated individuals would have changed in the same way as untreated individuals.

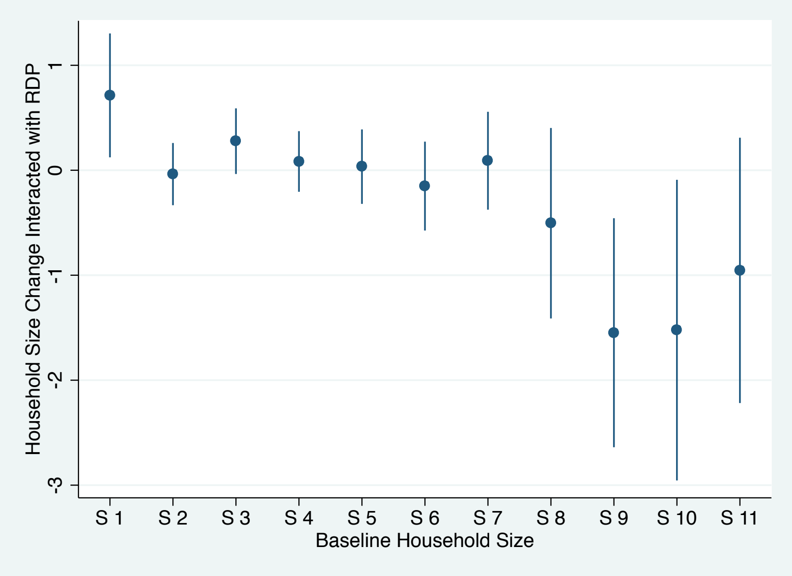
Impacts on Housing Quality

	Piped Water	Flush Toilet	Brick Walls	Refuse Service	Mkt Value	Rooms
Proj	0.160***	0.137***	0.178***	0.0445*	5,577*	0.0172
	(0.0417)	(0.0460)	(0.0393)	(0.0264)	(3,248)	(0.0932)
ProjxLarge	-0.109	0.00559	-0.0823	-0.00740	2,902	0.0396
	(0.0865)	(0.0887)	(0.0801)	(0.0564)	(8,554)	(0.181)
Proj t-1	0.0506	-0.0530	-0.0361	-0.000981	-1,540	0.166
	(0.0578)	(0.0633)	(0.0509)	(0.0382)	(3,176)	(0.179)
Proj t-1xLarge	0.0696	0.0190	0.0211	-0.0224	-526.3	-0.0955
	(0.118)	(0.131)	(0.104)	(0.0914)	(13,938)	(0.349)
Large	0.0330	-0.0338	-0.00299	-0.0214	-120.9	-0.0210
	(0.0355)	(0.0432)	(0.0356)	(0.0264)	(6,368)	(0.116)
Observations	8,421	8,421	8,421	7,621	1,165	7,411
R-squared	0.047	0.079	0.062	0.034	0.115	0.044

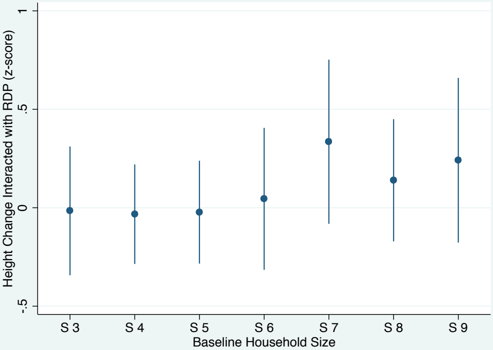
Overall Impacts on Health

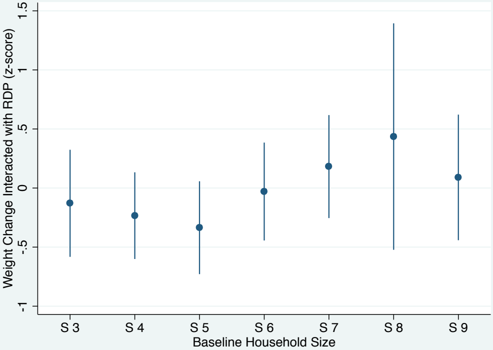
	Height	Weight	Illness	Health
Proj	0.0270	-0.0792	0.0221	0.0661
	(0.0636)	(0.0837)	(0.0179)	(0.0664)
Proj t-1	0.0548	-0.00209	-0.00352	-0.00870
	(0.121)	(0.151)	(0.0303)	(0.130)
Observations	413	445	1,120	1,122
R-squared	0.164	0.183	0.597	0.548
Mean	-0.869	-0.271	0.0618	1.666

Impacts on Household Size



Effects on Child Height and Weight according to Baseline Household Size





Household Size and Health Impacts

	(1) HH Size	(2) Height	(3) Height	(4) Weight	(5) Weight	(6) Health	(7) Ill
Proj	0.0423	0.0102	0.000920	-0.189*	-0.205*	0.0744	0.00461
	(0.0766)	(0.0725)	(0.0717)	(0.105)	(0.106)	(0.0810)	(0.0204)
ProjxLarge	-0.787***	0.130	0.225*	0.371*	0.395**	-0.0439	0.0511
	(0.237)	(0.134)	(0.130)	(0.202)	(0.199)	(0.154)	(0.0481)
Proj t-1	0.0591	0.0719	-0.0113	0.0173	0.0285	-0.0488	0.00972
	(0.101)	(0.133)	(0.140)	(0.153)	(0.161)	(0.137)	(0.0374)
Proj t-1xLarge	-0.479	-0.130	0.0368	-0.619	-0.679	0.120	-0.0725*
	(0.438)	(0.264)	(0.293)	(0.474)	(0.458)	(0.355)	(0.0395)
Large	-0.505***	-0.0608		-0.186**		0.0697	-0.00440
	(0.102)	(0.0654)		(0.0869)		(0.0684)	(0.0195)
Observations	9,898	534	534	576	576	1,122	1,120
R-squared	0.172	0.202	0.237	0.218	0.253	0.547	0.599
Time x Prov FE YES	YES	NO	YES	NO	YES	YES	
Time x Prov x Large FE	NO	YES	YES	NO	NO	NO	
Mean	-0.967	-0.967	-0.262	-0.262	1.731	0.0728	
F-Stat: Proj+ProjxLarge=0		1.429	3.823	1.375	1.537		

All health regressions control for lagged quartiles in outcomes

Conclusion

Additional findings

- No change in HH income
- Fewer people per room
- Improvements in domestic violence and nearby drug use
- Expenditure shifts from non-food towards food
- "Left out" HH members move to slums, work more, and send remittances to family

Conclusions

- Both mechanisms – (1) less disease spread and (2) better bargaining for children – may contribute to child health improvements for crowded households at baseline

Next Steps

- Improve definition of project area using administrative data
- Include most recent wave of panel

Optimal Pricing and Informal Sharing: Evidence from Piped Water in Manila

Pricing public utilities

- Access to public utilities – piped water, electricity, mobile phones
  $\rightarrow$ large economic benefits
  (health, time/cost savings, employment, etc.)
- Govts set prices to increase access while covering costs
  - Low fixed prices per connection
  - High marginal prices per unit (increasing)
  - **Assume** one household per connection
- But people often share connections informally
  - High (increasing) marginal prices tax shared connections
    $\rightarrow$ may lower access and welfare
- **Question:** What is the optimal pricing policy
  when people share connections?

Pricing piped water in Manila, Philippines

- **Question:** What is the optimal pricing policy when people share connections?
- Key inputs: 1) demand, 2) sharing costs, 3) production costs
- **Approach:** source and usage reveal sharing costs and demand
- **New Data:** estimate using transaction panel with sharing survey
  - Sudden price changes identify demand
  - Quasi-experiment identifies sharing costs
- **Policy:** optimum $\rightarrow$ high fixed and low marginal prices
  - Welfare gain: 70% of consumer surplus (0.6% of HH inc)
  - Greater sharing $\rightarrow$ improves access
- Also consider social pricing and pricing without sharing

Contribution to the literature

- Theory: Ramsey (1939); Auerbach and Pellechio (1978); Feldstein (1972)
- Demand estimation: Moffitt (1986); Borenstein (2009); Olmstead (2009)
- Development applications: Szabó (2015); Diakité et al. (2009); McRae (2014); Devoto et al. (2012)

Contributions

- Model not only "intensive" usage, but also "extensive" source
  - Endogenous sharing
- Estimate with micro-data for a large metro-area

Main Findings

Model and Estimation

- Sharing water lets households trade a lower fixed cost for a higher marginal cost
- Households are price sensitive (elasticity of 0.5)
- Households face high "hard-to-measure" fixed costs (repairs, permitting, land tenure, etc.)

Policy Takeaways

- Simple two-part tariff (high fixed price/low marginal price)
  - Large users enjoy low marginal price
  - Small users also enjoy low marginal price through their neighbors
  - Non-linear pricing has negligible impacts on welfare
- Setting marginal price above marginal cost can mitigate free-riding

Next Steps

- Extensive margin of where to get water may respond to price changes over time
- Linearity of demand
- Optimal policy is far out of sample

Thank You!

Identifying Housing Projects

1. **Seller Identity:** match government names and housing authorities in seller-names from transactions

Figure: Top 5 Seller Names

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

return

Identifying Housing Projects

1. **Seller Identity:** match government names and housing authorities in seller-names from transactions
2. **Subsidy Value:** exclude purchase prices R50,000 above subsidy value (<4% of remaining transactions)

Figure: Purchase Price Densities

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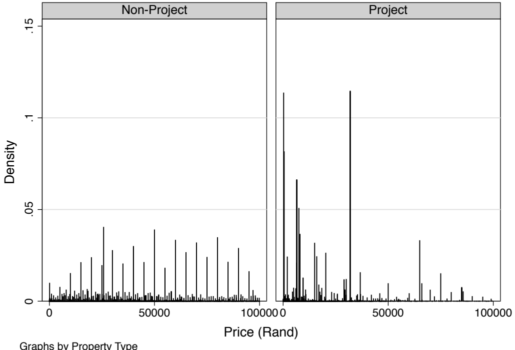

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return

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4. **Spatial Clustering:** collect nearby houses into projects with density-based clustering algorithm

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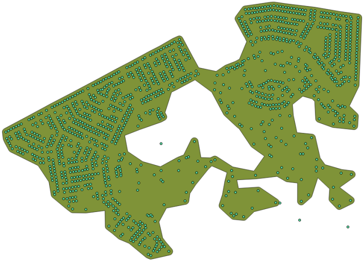

Identifying Housing Projects

1. **Seller Identity:** match government names and housing authorities in seller-names from transactions
2. **Subsidy Value:** exclude purchase prices R50,000 above subsidy value ($<$4% of remaining transactions)
3. **Pre-Existing Formal Dwellings:** exclude land plots with formal structures in 2001 building census (31% of remaining transactions)
4. return **Spatial Clustering:** collect nearby houses into projects with density-based clustering algorithm
5. **Temporal Clustering:** include clusters with $>$50% of transactions during modal year (%50 of clusters)

- Overlaps well with completed projects from admin. data