Does Land Use Restriction Impede Long-run Urban Development? Evidence from Mexico

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Rapid urbanization

- Cities growing in low-income and middle-income countries
However acquiring new land for urban expansion difficult

Land policies:
- Restrictive floor-area ratio in India (Sridhar 2010)
- Defunct textile mills in Mumbai (Gechter and Tsivanidis 2017)

Insecure property rights:
- Customary land rights in Ghana (Goldstein and Udry 2008)
- Lack of land titles in slums in Peru (Field 2005)
My setting: urbanization in 20th century Mexico
However the historical *ejido* system

- 1917-1992: land redistribution in form of a community land system
- *Ejido* land could not be sold or converted for non-agricultural use
- 1992: half of area surface under *ejido*

![Map of Culiacan showing ejido land](image)
However the historical *ejido* system

- 1917-1992: land redistribution in form of a community land system
- *Ejido* land could not be sold or converted for non-agricultural use
- 1992: half of area surface under *ejido*

Culiacan in 1990: population 415,000
Circled area: estimated footprint given its population; dark blue areas: *ejido* land
My research question

Using the *ejido* system, I study whether land market imperfection constrains long-term city development.
My research strategy and results

- Step 1: spatial RD at *ejido* boundaries and satellite images
  - Result: underdevelopment of *ejido* land in urban areas

- Step 2: OLS with FE comparing localities within the same municipality
  - Result: localities with more *ejido* land has worse housing conditions

- Step 3: matched diff-in-diff of cities from 1900 to 1990
  - Result: More constrained cities grew slower over time
Different constraints of city growth
  ▶ Bertaud and Brueckner 2005; Au and Henderson 2006; Saiz 2010; Libecap and Lueck 2011; Baruah et al. 2017; Gechter and Tsivanidis 2017; Harari 2020;
  ▶ I study one constraint from a historical rural land system

Consequences of imperfect land markets
  ▶ Field 2007; Goldstein and Udry 2008; Galiania and Schargrodsky 2010; de Janvry et al. 2015
  ▶ I study its (unintended) consequence on city growth

Origins and consequences of the ejido system
  ▶ Sanderson 1984; Dell 2012; Larreguy 2013; Albertus et al. 2015; Alix-Garcia and Sellars 2018
  ▶ I study one mechanism: urban land demand
Outline

Introduction and motivation

Historical background on ejido

Research designs and results
  Result 1: underdevelopment in terms of built-up
  Result 2: worse housing quality
  Result 3: slower population growth over time

Conclusion
The Mexican Revolution and subsequent land reform

- Increasing land concentration among the few in 19th century Mexico

- *Ejido* system in 1917 after the Mexican Revolution
  - Farmers who wanted land petitioned for a land plot
  - Not allowed to use the plot for non-agricultural use
  - No individual property rights and reselling prohibited
  - Average size: $29 \text{ km}^2$; median size: $9 \text{ km}^2$

- PROCEDES reform in 1992 with land certification
  - Land transaction allowed after privatization
  - 17.8% of *ejido* holders privatized parts of their land
1930-1940 largest wave of land grants

Number of ejido grants by decade

Source: Registro Agrario Nacional
Extent of ejidos in 1940 and 1990

1940: 14.3% of land

1990: 48.83% of land

Black polygons: state boundaries; blue shaded areas: ejido land
Motivating evidence: *ejidos* overlap with later urban footprints
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Data sources

- *Ejido* shapefile from National Agricultural Registry
- Outcome 1: satellite images 1975-2014
- Outcome 2: 1990 census from INEGI
- Outcome 3: population data of 290 cities 1900-1990
- Geographic control variables constructed using ArcGIS
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Does built-up stop at *ejido* boundaries?

- **Study area:** 500-meter bands along *ejido* boundaries
- **Observations:** 38 meters × 38 meters pixels from satellite images
  - Categorize each pixel has built-up or not
- **2,795 1-km boundaries in my sample:**
  - Have built-up close by in 1975
  - Not coincide with river or elevation change
Raw data: average built-up around boundary in 1990

RD Plot: 1990 built-up

Distance to boundary

Average of built-up dummy

- Sample average within bin
- Polynomial fit of order 5
Three components of one *ejido*

*Ejido:* Santiago Cuautlanlpan

- Human settlement
- Common land
- Parceled land
RD for human settlement: 10.53% of *ejido*
RD for common land: 6.25% of *ejido*
RD for parceled land: 68.34% of ejido

RD Plot: 1990 built-up

Average of built-up dummy vs Distance to boundary
RD for uncategorized land: 14.88% of ejido

RD Plot: 1990 built-up

Distance to boundary

Average of built-up dummy

Sample average within bin  
Polynomial fit of order 5
Spatial RD specification

For each pixel $i$ within 500 meters to boundary $b$:

$$\text{Builtup}_{ib} = \alpha + \gamma \text{Ejido}_{ib} + X'_{ib}\beta + f(\text{location}) + \lambda_{b} + \epsilon_{ib}$$

$X'_{ib}$ : set of geographic controls

$f(\text{location})$ : up to 5th degree polynomial of distance to boundary
Identification checks

RD Plot: residual distance to river

RD Plot: residual distance to town

RD Plot: residual elevation

RD Plot: residual slope

Sample average within bin
Polynomial fit of order 5
1990: discontinuity in built-up with boundary FE

RD Plot: built-up

Average of residual built-up

Distance to boundary

Sample average within bin
Polynomial fit of order 5
Similar findings with spatial RD regression specification

<table>
<thead>
<tr>
<th>Variable: built-up dummy</th>
<th>(1) Year 1975</th>
<th>(2) Year 1990</th>
<th>(3) Year 2000</th>
<th>(4) Year 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ejido dummy</td>
<td>-0.0385***</td>
<td>-0.0433***</td>
<td>-0.0384**</td>
<td>-0.0393**</td>
</tr>
<tr>
<td></td>
<td>(0.0131)</td>
<td>(0.0155)</td>
<td>(0.0156)</td>
<td>(0.0157)</td>
</tr>
<tr>
<td>Observations</td>
<td>74,589</td>
<td>74,589</td>
<td>74,589</td>
<td>74,589</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.288</td>
<td>0.360</td>
<td>0.363</td>
<td>0.356</td>
</tr>
<tr>
<td>Number of clusters</td>
<td>2795</td>
<td>2795</td>
<td>2795</td>
<td>2795</td>
</tr>
<tr>
<td>Mean of dependent variable outside ejido</td>
<td>0.2441</td>
<td>0.4798</td>
<td>0.5359</td>
<td>0.5747</td>
</tr>
</tbody>
</table>

Standard errors clustered at boundary level in parentheses

*** p<0.01, ** p<0.05, * p<0.1
Additional evidence: lack of road access within *ejido*

RD plots for road access using 2014 data
Privatization mitigated the effect

For each pixel $i$ within 500 meters to boundary $b$:

$$\text{Builtup}_{ib} = \alpha + \gamma_1 \text{Ejido}_{ib} + \gamma_2 \text{Ejido}_{ib} \times \text{Privatized1992}_b$$

$$+ X'_{ib}\beta + f(\text{location}) + \lambda_b + \epsilon_{ib}$$

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<th>(2) Year 1990</th>
<th>(3) Year 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ejido</td>
<td>-0.0194</td>
<td>0.00320</td>
<td>-0.0147</td>
</tr>
<tr>
<td></td>
<td>(0.0157)</td>
<td>(0.0195)</td>
<td>(0.0197)</td>
</tr>
<tr>
<td>Ejido \times \text{Privatized1992}</td>
<td>-0.0243**</td>
<td>-0.0592***</td>
<td>-0.0312**</td>
</tr>
<tr>
<td></td>
<td>(0.0114)</td>
<td>(0.0153)</td>
<td>(0.0158)</td>
</tr>
<tr>
<td>Observations</td>
<td>74,589</td>
<td>74,589</td>
<td>74,589</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.289</td>
<td>0.361</td>
<td>0.356</td>
</tr>
<tr>
<td>Number of clusters</td>
<td>2795</td>
<td>2795</td>
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*** p<0.01, ** p<0.05, * p<0.1
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Result 1: underdevelopment in terms of built-up
Result 2: worse housing quality
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Conclusion
Do constrained localities have worse housing?

- Potential mechanism: under-investment on housing and public goods
- Data: 1990 housing census from INEGI
- Sample: 2511 urban localities in 1450 municipalities
- Variable: share of locality land in *ejido*
Small negative effect on housing amenities

For locality $i$ in municipality $m$:

$$HousingQuality_{im} = \alpha + \beta_1 \times ShareEjido_i + \beta_2 \times Control_i + \gamma_m + \epsilon_i$$

Share of built-up in ejido $i$ mean 21.34% and s.d. 30.56

<table>
<thead>
<tr>
<th>Share of land in ejido (%)</th>
<th>(1) Share with electricity (%)</th>
<th>(2) Share with sewage (%)</th>
<th>(3) Share with piped water (%)</th>
<th>(4) Share with good floor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.00929)</td>
<td>(0.0180)</td>
<td>(0.0194)</td>
<td>(0.0125)</td>
</tr>
<tr>
<td>Observations</td>
<td>2,511</td>
<td>2,511</td>
<td>2,511</td>
<td>2,511</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.227</td>
<td>0.328</td>
<td>0.248</td>
<td>0.391</td>
</tr>
<tr>
<td>Mean of dependent variable</td>
<td>89.44</td>
<td>53.29</td>
<td>76.86</td>
<td>74.53</td>
</tr>
<tr>
<td>Sd of dependent variable</td>
<td>10.87</td>
<td>28.27</td>
<td>22.90</td>
<td>19.16</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$
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Did constrained cities grow slower over time?

Observations: 290 cities that have population data from 1900 to 1990

Predicted **ejido** share as RHS variable:

- Predicted city footprint in 1990 assuming all cities growing at the same rate from 1900 to 1990
- Share of footprint that overlays with **ejidos** granted before 1940
- Mean of predicted **ejido** share among 291 cities: 22.27%
Red area: predicted city footprint in 1990; blue area: *ejidos*
Tulancingo: 47.18%
High-constrained cities spread out in Mexico

Blue areas: ejidos established before 1940; triangular red points: cities with lower than median ejido constraint; circular blue points: cities with higher than median ejido constraint

Blue areas: ejidos established before 1940; triangular red points: cities with lower than median ejido constraint; circular blue points: cities with higher than median ejido constraint
# High-constrained cities larger in 1900

<table>
<thead>
<tr>
<th>Variable</th>
<th>Below median</th>
<th>Above median</th>
<th>T-test Difference (1)-(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N/[Clusters]</td>
<td>Mean/SE</td>
<td>N/[Clusters]</td>
</tr>
<tr>
<td>= 1 if coastal town</td>
<td>146 [143]</td>
<td>0.055(0.019)</td>
<td>145 [142]</td>
</tr>
<tr>
<td>= 1 if border town</td>
<td>146 [143]</td>
<td>0.021(0.012)</td>
<td>145 [142]</td>
</tr>
<tr>
<td>= 1 if access to railroad</td>
<td>146 [143]</td>
<td>0.411(0.041)</td>
<td>145 [142]</td>
</tr>
<tr>
<td>Average slope</td>
<td>146 [143]</td>
<td>0.024(0.005)</td>
<td>145 [142]</td>
</tr>
<tr>
<td>Agriculture suitability index (0 - 124)</td>
<td>146 [143]</td>
<td>51.193(1.653)</td>
<td>145 [142]</td>
</tr>
<tr>
<td>Elevation</td>
<td>146 [143]</td>
<td>1008.562(74.285)</td>
<td>145 [142]</td>
</tr>
<tr>
<td>log (Population in 1900 (000))</td>
<td>146 [143]</td>
<td>1.301(0.086)</td>
<td>145 [142]</td>
</tr>
</tbody>
</table>

Notes: The value displayed for t-tests are the differences in the means across the groups. Standard errors are clustered at variable municipality. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.
Time series plot: matched sample

Match each city in the high-constrained group to a city in the low-constrained group with similar 1900 population.
Diff-in-diff regression

For city $i$ in year $t$:

$$
\log(\text{population})_{it} = \alpha + \beta_1 \times \text{Treatment}_i + \beta_2 \times \text{After}_t \\
+ \beta_3 \times \text{Treatment}_i \times \text{After}_t + \epsilon_{it}
$$

where $\text{Treatment}_i$: high predicted share group
Diff-in-diff regression

For city $i$ in year $t$:

$$\log(\text{population})_{it} = \alpha + \beta_1 \times \text{Treatment}_i + \beta_2 \times \text{After}_t$$

$$+ \beta_3 \times \text{Treatment}_i \times \text{After}_t + \epsilon_{it}$$

where $\text{Treatment}_i$: high predicted share group

<table>
<thead>
<tr>
<th>Dep variable: log(population)</th>
<th>(1) No matching</th>
<th>(2) Matching with log 1900 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff-in-diff</td>
<td>-0.184**</td>
<td>-0.107*</td>
</tr>
<tr>
<td></td>
<td>(0.0754)</td>
<td>(0.0642)</td>
</tr>
<tr>
<td>Observations</td>
<td>2,894</td>
<td>2,852</td>
</tr>
<tr>
<td>Difference before</td>
<td>0.243</td>
<td>0.0364</td>
</tr>
<tr>
<td>Difference after</td>
<td>-0.0134</td>
<td>-0.146</td>
</tr>
</tbody>
</table>

$t(0)$ refers to census years 1910, 1921, 1930. $t(1)$ refers to all census years after 1940.

Robust standard errors in parentheses. Standard errors clustered at municipality level.

1900 population in column (2) refers to log (1900 population).*** $p<0.001$, ** $p<0.05$, * $p<0.1$
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Conclusion: land constraint impedes urban growth

- Context: a historical land institution in Mexico
  - Decline in urban development at *ejido* boundaries
  - Worse housing conditions for if living in localities with more *ejidos*
  - Cities predicted to be more constrained grew slower over time

- Future works:
  - A spatial general equilibrium model to estimate aggregate welfare
  - Other types of constraints for urban growth (zoning, railroad tracks)