# Is the monocentric urban economic model still empirically relevant? Assessing urban econometric predictions in 192 cities on all five continents.

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  - **Real estate pricing model**.
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- Based on two main mechanisms and one hypothesis:
  - **Real estate pricing model**.
  - **Housing production model**.
  - In its most standard version, **monocentricity hypothesis**.
- Main conclusions:
  - **Negative density gradient** from the city center to the periphery.
  - **Urbanized areas' sizes** depend positively on income and population and negatively on transportation costs and agricultural land prices.

## Research question

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## Main objectives

- Assessing the potential of data availability increase to work on urban structures.
- Investigating the empirical relevance of the key stylized facts predicted by the SUM on a large number of cities and with a wide geographical coverage.
- Understanding discrepancies between the SUM and actual urban forms.

# Literature (1)

- Many studies investigate whether cities exhibit the **negative density gradient** expected from the theory:
  - Clark (1951): 19 cities in 9 countries.
  - Bertaud and Malpezzi (2014): 57 cities of different regions / levels of development.
  - Lemoy and Caruso (2017): 300 European cities.

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  - Lemoy and Caruso (2017): 300 European cities.
- Several papers also checked the aggregated predictions of the SUM on the **size of urbanized areas**:
  - Paulsen (2012): 329 cities in the United States.
  - Oueslati et al. (2015): 282 European cities.
  - Schmidt et al. (2020): 92 cities in Germany.
  - Jedwab et al. (2021): 1010 cities in developing countries.

# Literature (2)

- Few studies assess the **underlying mechanisms of the model**:
  - Housing production model: McMillen (2006) on Chicago.
  - Real estate pricing model: Yinger (1979), McDonal and Bowman (1979), Ahlfeldt (2011),...
  - **None of the two mechanisms have been assessed on a large number of cities**.

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    - Africa has the fastest growing cities (UN, 2018).
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  - Cities with most future relevance in terms of total urban population and growth dynamics are systematically underrepresented:
    - Africa has the fastest growing cities (UN, 2018).
    - Asian cities have the largest share of the global urban population (UN, 2018).
- **Knowledge gap on the underlying mechanisms of the model**, whereas they remain widely used to understand the impact of transport and land-use policies (OECD, 2020).

# Key results

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# Key results

- The monocentric SUM is a simple and old model, but remains a useful analytical tool, consistent with many city structures across the world.
- It however much better describes aggregated variables on cities (e.g. urban area) than the precise internal structure of the cities.
- High income inequalities in cities, informal housing, and strong locational amenities are important factors explaining why the model fails in practice to capture some city structures.

# Data

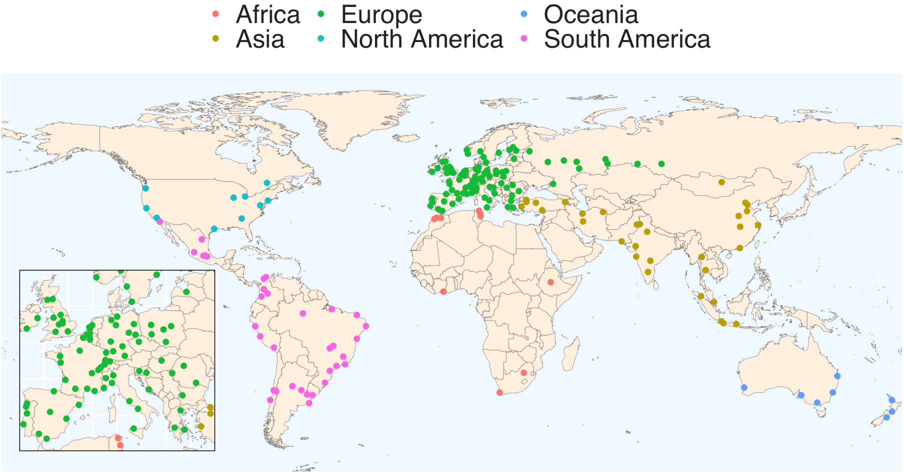


Figure: Sample of cities. *Total number of cities: 192.*

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- Aggregated over a 1km resolution grid encompassing the urban area.

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- **Fuel cost:** World Bank data on gasoline prices multiplied by IEA data on fuel efficiency.

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- **Informal housing data** and **Gini indices** from the World Bank.
- **Planned cities:** dummy based on Bertaud and Malpezzi (2014) for the cities in their dataset and on our judgement for the remaining cities.

# Urbanized areas

| | Urbanized area | ln(urbanized area) |
|---|---|---|
| population | 0.000*** | |
| | (0.000) | |
| ln(population) | | 0.856*** |
| | | (0.039) |
| income | 0.014*** | |
| | (0.004) | |
| ln(income) | | 0.409*** |
| | | (0.037) |
| land price | -169.932*** | |
| | (34.984) | |
| ln(land prices) | | -0.218*** |
| | | (0.037) |
| fuel cost | -13199.329*** | |
| | (3740.833) | |
| ln(fuel cost) | | -0.160 |
| | | (0.109) |
| commuting speed | 39.789*** | |
| | (7.215) | |
| ln(commuting speed) | | 0.448*** |
| | | (0.103) |
| monocentricity | 201.458* | 0.141* |
| | (107.085) | (0.082) |
| constant | -700.851** | -13.349*** |
| | (350.325) | (0.644) |
| Observations | 192 | 192 |
| $R^2$ | 0.736 | 0.859 |
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# Density gradients

$$\boldsymbol{ln(n_i){=}\alpha_1 + \beta_1 ln(Y - T_i) + \beta_2 ln(L_i) - \beta_3 ln(q_i) + \epsilon_i}$$

- We regress density $n_i$ on income net of transportation costs $Y - T_i$. Our main parameter of interest is $\beta_1$.
- Based on Qiang et al. (2020), we use commuting times and distances from Google Maps' data.
- Two additional contributions:
  - two transportation modes.
  - we account from both opportunity and monetary transportation costs.
- We control by land cover constraints $L_i$ and dwelling sizes $q_i$, as predicted by the SUM.

# Density gradients

Predictions of the SUM in terms of density gradient also hold on our sample of cities.

| | |
|---|---|
| min. | 0.029 |
| 10th | 0.191 |
| 25th | 0.252 |
| 50th | 0.362 |
| 75th | 0.477 |
| 90th | 0.585 |
| max. | 0.734 |

Table: R2 distribution

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Table: R2 distribution

| | |
|---|---|
| Positive and significant (5%) | 179 cities |
| Negative and significant (5%) | 2 cities |
| Non significant (5%) | 10 cities |

Table: Parameter $\beta_1$

# Real estate pricing model

Do transportation costs impact rents?

$$ln(R_i) = \alpha_2 + \beta_4 ln(Y - T_i) + \epsilon_i$$

- We want to know how rents $R_i$ depend on transportation costs.
- Our parameter of interest is $\beta_4$ ; it is expected to be positive and significant (households are willing to pay lower rents if transportation costs are high).

# Real estate pricing model

Predictions of the SUM hold in a majority of cities.

| | |
|---|---|
| Positive and significant (5%) | 159 cities |
| Negative and significant (5%) | 2 cities |
| Non significant (5%) | 30 cities |

Table: Parameter $\beta_4$

# Real estate pricing model

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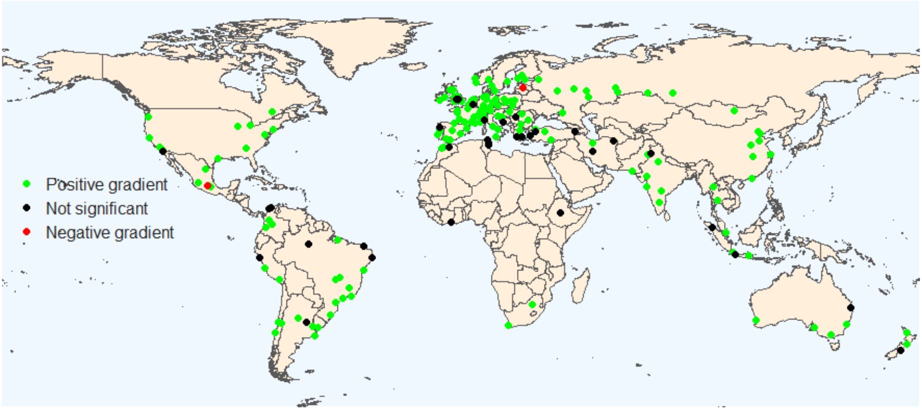


Figure: Estimates of the impact of income net of transportation costs on rents.

# Real estate pricing model

| | $\beta_4$ not significant |
|---|---|
| gini index | 0.002 |
| | (0.004) |
| informal housing | 0.006** |
| | (0.003) |
| planned city | 0.011 |
| | (0.055) |
| monocentricity | 0.022 |
| | (0.068) |
| coastal city | 0.129** |
| | (0.056) |
| population | -0.000*** |
| | (0.000) |
| income | -0.000 |
| | (0.000) |
| market data cover | 0.000 |
| | (0.000) |
| spatial data cover | -0.618* |
| | (0.316) |
| constant | 0.103 |
| | (0.213) |
| Observations | 190 |
| $R^2$ | 0.186 |
| Adjusted $R^2$ | 0.145 |

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2. Data
3. Do global conclusions of the model hold?
   - Urbanized areas
   - Density gradients
4. Do internal mechanisms of the model hold?
   - Real estate pricing model
   - Housing production model
   - Robustness checks
5. Conclusion

# Housing production model

Do rents impact population densities?

$$ln(n_i) = \alpha_3 + \beta_5 ln(R_i) + \beta_6 ln(L_i) - \beta_7 ln(q_i) + \epsilon_i$$

- We want to know how housing production, and thus population density $n_i$ depend on rents $R_i$.
- Our parameter of interest is $\beta_5$ ; it is expected to be positive and significant (developpers are willing to build more dwellings if rents are high).

# Housing production model

Predictions of the SUM hold in slightly more than half of the cities.

| | |
|---|---|
| Positive and significant (5%) | 106 cities |
| Negative and significant (5%) | 15 cities |
| Non significant (5%) | 70 cities |

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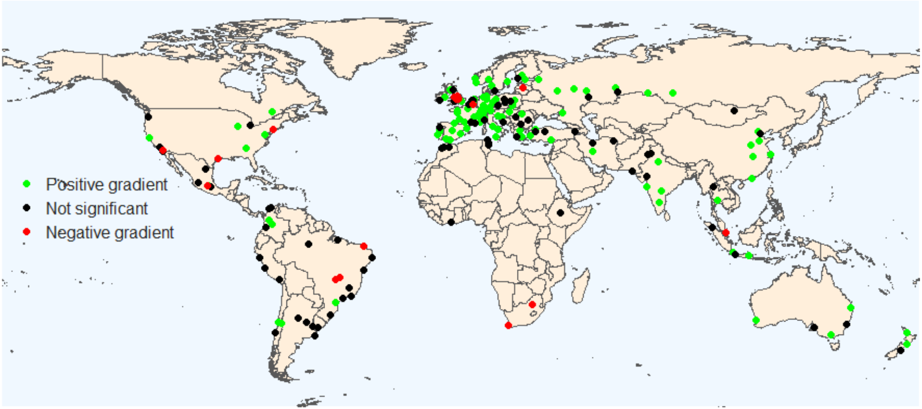


Figure: Estimates of the impact of rents on housing.

# Housing production model

| | ($\beta_5$ negative) | ($\beta_5$ not significant) |
|---|---|---|
| gini index | 0.1759** | 0.0340 |
| | 0.078 | 0.030 |
| monocentricity | 0.6093 | 0.1292 |
| | 0.939 | 0.459 |
| informal housing | -0.0473 | 0.0488** |
| | 0.067 | 0.023 |
| spatial data cover | 7.2976* | -8.2646** |
| | 4.151 | 3.509 |
| market data cover | -0.0001 | -1.15e-06 |
| | 0.000 | 1.83e-06 |
| planned city | 0.1476 | -0.1583 |
| | 0.675 | 0.352 |
| coastal city | -0.3465 | 1.5579*** |
| | 0.647 | 0.413 |
| population | -5.901e-08 | -1.183e-07*** |
| | 8.03e-08 | 4.39e-08 |
| income | 1.142e-06 | -2.354e-05* |
| | 1.83e-05 | 1.36e-05 |
| constant | -10.7329*** | -1.0499 |
| | 3.533 | 1.630 |
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# Robustness check

In this study, our main robustness concerns are about the quality of real estate data. We run 8 robustness checks:

- Aggregating rents data:
  - By taking the median instead of the mean in each grid cell.
  - By regressing rents on dwelling sizes in each grid cell.
- Excluding outliers using:
  - The boxplot method.
  - The percentile method.
  - The hampel method.
- Excluding the grid cells:
  - Where we have less than 4 data points.
  - Where we have less than 10 data points.
  - Where less than 50% of the area is urbanized.

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- We could only study the most simple version of the SUM (monocentric / one income class), because of data availability on income distribution and employment sub-centers.
- It was not possible to run panel analysis because of real estate and transportation data, gathered at one point in time.

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- Its conclusions on the internal structure of cities are less empirically relevant, especially for the housing production model.
- One reason is the inertia of cities evolutions: densities and built environment are evolving slowly, whereas rents and land prices can change quickly.
- High income inequalities in cities, informal housing, and strong locational amenities are important factors explaining why the model fails in practice to capture some city structures.

# Thank you for you attention!

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