SPATIAL CONFIGURATION AND THEIR IMPACTS ON REAL ESTATE PRICES AND CITY BEHAVIORS

A case study in "Caxias do Sul" - Brazil

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The way streets **connect** to each other in a city can be a **predictor** for the **value of real estate properties**, and other **urban characteristics**.

Everything is connected in the city!

Different spatial configuration data can explain up to:

- 42% of the real estate prices
- 54% of the population density
- 40% of urban complexity
- 44% of income
- 28% of segregation

More information about this project and related ones are available at: **eddeb.com**

INTRODUCTION

"Spatial configurations" are attributes which take account of other relations in a complex. Space syntax is a set of theories and techniques suggesting that spatial configuration exerts a powerful influence on human behaviour: the way that places are connected to each other is directly related to the way that people move, interact and transact. It provides a set of theories and approaches to analyse spatial configurations, including transportation networks. A transportation network can be interpreted as a graph, and analyzed with algorithms from network science, particularly closeness centrality and betweenness centrality.

Cities, similar to living organisms that evolve and adapt, have organized complexity. Social, economic and infrastructure systems are deeply connected. Comprehending the urban dynamics is essential for building prosperous, vibrant and sustainable cities, enhancing public policy and improving business decisions. The main purpose of this study is to explore spatial configuration and its application in a real-world scenario. The case study focuses on "Caxias do Sul", a city of 500,000 people in the south of Brazil. The phenomena studied are related to real estate, population and the dynamics of urban economics.

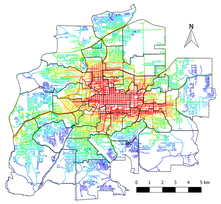
OBJECTIVE

Simulate spatial configuration metrics to investigate road networks and analyze their impact on real estate prices among other urban characteristics, exploring applications in real-world scenarios.

METHODOLOGY

1. **Data acquisition:** Road data gathered from Open Street Maps (open mapping); real estate from Caixa E.F. (bank); city information from IBGE (government census).
2. **Data preparation:** Roads are selected in a 25 km radius. Real estate data is filtered, quantified & adjusted. Census polygons and data table are geolocalized.
3. **Spatial configurations calculus:** "Integration" and "Choice" measures are computed in metric (seven radii, from 1 to 25 km) and angular (seven angular turns, 3 to n) modes, varying six parameters, resulting in 120 vars.
4. **Incorporation of spatial metrics:** Census tracts use their own area to incorporate features, receiving the *max* and *avg* value of each spatial metric. Real estate properties considers eight buffers, resulting in 1,800 variables.
5. **Analysis of features:** Assessment of features is conducted with sensitivity analysis, with Pearson and Spearman correlation, linear and non-linear models.
6. **Real estate predictive models:** Comparison of multiple regression models of housing prices assessment including spatial features.
7. **Analysis of urban characteristics:** Elaboration of city spatial indicators and analysis of features with city behaviors.

SPATIAL CONFIGURATION Space syntax measures for transportation networks



INTEGRATION
Closeness centrality

Ease of going from one segment to others (relative depth)

Fig. 1 - Integration measure at 5,000m metric radius.

CHOICE
Betweenness centrality

Probability of crossing one segment from all origin and destiny points

Figure 2 - Choice measure at 25,000m metric radius.

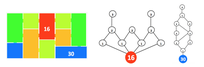
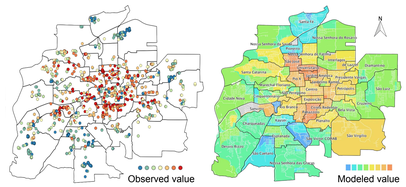


Fig 3 - Space as *Integration* or *Spatial Accessibility* metric

Space syntax metrics can be constructed changing seven parameters: network measure, distance mode, radius of analysis, weight and adjust; selection and buffer to incorporate. Maps in Fig 1. and Fig. 2 are calculated in metric mode, unweighted and normalized. The complete calculation requires road data from 25 km from the center of "Caxias do Sul", analyzing 4.598km in roads length. The maps shows the central portion of 1.347km.

REAL ESTATE PROPERTIES Data from urban-economics markets



- 1690 real estate market values (2016 to 2018)
- Residential apartments
- Around 250 columns of data per property
  Including location, price, and structure (area, building quality, number of rooms, bathrooms and garages…)

Fig. 4 - Spatial distribution of 1500 properties in central area of "Caxias do Sul" (47 districts, 355k hab.) and value estimate for districts, employing a multiple linear regression model.

CITY BEHAVIORS Spatial urban indicators are tools to synthesize and diagnose the city

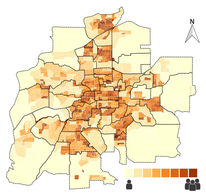


Figure 5

URBAN DENSITY
Measure the distribution and concentration of inhabitants on the land

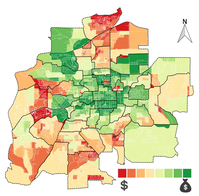


Figure 6

INCOME
The amount of monthly salaries received by the families

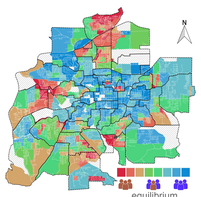


Figure 7

SEGREGATION
Proportion of people with lower resources in relation to the city

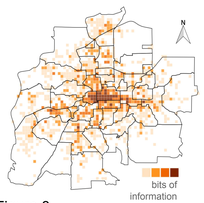


Figure 8

URBAN COMPLEXITY
The diversity and ubiquity of commercial activities on the land

RESULTS

Sensitivity analysis

MEASURE	Spatial configurations "Integration" overall explains analysed phenomena almost twice as accurate than "Choice".
MODE	Metric and angular modes are related on similar radius. Metric is best on longer distances and angular, shorter ones.
RADIUS	Best values are around 5 km or 10 turns

WEIGHT	Unweighted roads are better
ADJUST	Raw value is better than normalized one, except for exponential models
SELECTION	Max. and Avg. values are equivalent
BUFFER	For real estate the best selection buffers are between 300m and 750m

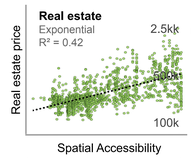
REAL ESTATE PRICES x SPATIAL CONFIGURATION

Spatial configuration explains 42% of the variations of real estate prices.

Integration on metric 5 km radius, raw and unweighted; selected by maximum value at a 500 meters buffer.

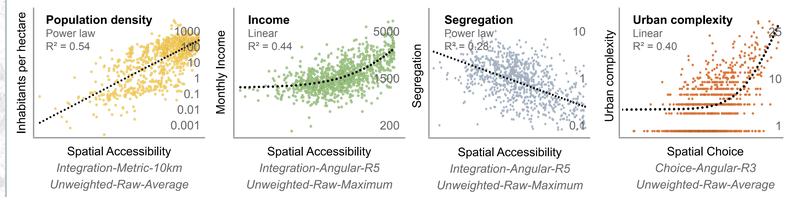
For comparison, the spatial variable "Income" explains 33% of the price.

Structural variables with high predictive power: area (72%); garages (42%); building quality (39%); rooms (34%).



CITY BEHAVIORS x SPATIAL CONFIGURATION

Spatial metrics have significant relationships with urban characteristics:



CONCLUSION

Network science provides enlightening opportunities to explore complexity of cities.

This research analyzed transportation networks by simulating metrics of spatial configurations. Space syntax metrics "Integration" and "Choice" show significant correlations with real-world phenomena, such as real estate price and city behavior. Hillier (1993) suggests that use is posterior to configuration. That is, the spatial network influence dynamics as natural movement patterns, which determine land use among other urban characteristics.

Quantitative urbanism can be used to model, predict and optimize issues in public policy, urban planning and economics. Further research directions may include a deeper data analysis, investigation of complex urban behaviors such as movement and assessing the universality of these properties predictive strength across different metropolitan areas.

Networks are a powerful tool to quantify cities and to investigate old intuitions with new and verifiable insights, e.g. economic interactions, urban scaling, city complexity & infrastructure planning. This whole domain promises exceptional potential and deserves further exploration.

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