Urban Scaling Laws: Foundations, Implications, Gaps

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Cities as complex systems

Physically, socially, economically, cities manifest as regularities, in spite of different historical trajectories and forces of growth. They also show heterogeneities!
Cities as complex systems

So, throughout, the science of cities to focus on what cities are (positive aspects) and on what they should be (normative aspects).
Cities as complex systems

Rising urbanisation
Rising inequalities

Are urbanisation and inequality connected?
Are urbanisation and inequality connected?

85% of Australia's 21.5 million people lived in urban areas in 2011.

Are urbanisation and inequality connected?

60% of Australia's 21.5 million people lived in the 5 capital cities in 2011.

Are urbanisation and inequality connected?

Distribution of household net worth

- **Proportion**: 61% for the poorest 20% and 1% for the wealthiest 20%.
- **Wealth**: $2.2 million per household for the wealthiest 20% and $31,065 per household for the poorest 20%.
Are urbanisation and inequality connected?

A highly **urbanised** population

With significant & growing **inequality**

Living in a **very small number of urban centres**
Are urbanisation and inequality connected?

Larger city = higher inequality?

Is this a proportional pattern?
Then, no worries!

Does this grow disproportionately?
(Income and housing costs)
Enter urban scaling laws

Enter urban scaling laws

Urban indicator vs City Size (Population)

Sub-linear

Economic inputs:
- Lengths of roads
- Lengths of infrastructure networks
- Any measure of per capita expenditure on maintaining a city

Enter urban scaling laws

City Size (Population)

Urban indicator

Super-linear

Economic outputs:

- Income / GDP
- Patents
- Any measure of economic output or benefit
- But also diseconomies like crime, pollution, congestion

Larger cities are more efficient, innovative, productive, diverse...

Fundamental ideas:
- Urban economics
- Increasing returns to scale
- Marshallian agglomeration principles

City Size (Population) vs. Urban indicator

Larger cities are more efficient, innovative, productive, diverse...

City Size (Population)

Urban indicator

Super-linear

Y = aX^b,

Where

Y = urban indicator,

X = population,

a = constant,

b = scaling exponent.

If b < 1, sub-linear

If b = 1, linear

If b > 1, super-linear

Larger cities are more efficient, innovative, productive, diverse...
But, the validity of these findings is open to debate...

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Why are these findings interesting to us?

Back to the “bigger is better” claim/idea,

we wanted to explore specifically the dimension of INEQUALITY.

Hypothesis:

Larger cities are richer, but they are also more unequal.
### The scaling of income and housing cost distributions

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<td>Study scaling of income and number of people in income categories with city size</td>
<td>Australia, Source: Australian Bureau of Statistics (ABS), Australian Taxation Office (ATO)</td>
<td>X: Population of Significant Urban Areas, Y: No. of people in each income, rent or mortgage category</td>
<td>Linear regression of log(popn) against log(variable) &amp; Maximum likelihood based model testing</td>
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Complexity, Criticality, Computation, 2017
The scaling of income and housing cost distributions

$\beta = 0.96, R^2 = 0.92$

$\beta = 1.11, R^2 = 0.84$

Larger the city, more pronounced the super-linear behaviour of high income categories.

Higher the cut-off for population size or densities, more pronounced the super-linear behaviour of high income categories.
The scaling of income and housing cost distributions

- Larger the city, more pronounced the super-linear behaviour of high income categories.
The scaling of income and housing cost distributions

Rent categories scale in the same way:

Lower rents sub-linear and higher rents superlinear with city size
The scaling of income and housing cost distributions

Mortgage categories scale in the same way:

Lower mortgage numbers sub-linear and higher mortgage numbers superlinear with city size

Complexity, Criticality, Computation, 2017

Sarkar, S., in review.
The scaling of income and housing cost distributions

USA housing cost categories scale in the same way:

Lower costs numbers sublinear and higher costs numbers superlinear with city size

Complexity, Criticality, Computation, 2017

Sarkar, S., in review.
Note that these are not proportional but disproportional rises by city size.

This is empirical evidence for agglomerations of higher earners, higher living costs in larger cities, pushing lower income earners out, driving inequality.

Is there a role for policy and planning?
Australia has unbalanced city size distributions: 2 very large cities, 3 large cities, no middle sized cities, lots of small cities. There is a “missing middle” of cities.

If larger cities drive disproportional agglomeration of high housing costs, planning must address this missing middle to take pressure off the largest cities.

Response: the balanced growth of smaller and medium sized cities that can provide similar opportunities as largest cities.

Australia’s largest cities show polarisation and segregation in local housing and employment markets.

The larger a system gets, the higher the possibility for more spatial heterogeneities to arise.

If larger cities drive disproportional amounts of segregation, planning must address local segregation and local spatial inequalities in the largest cities.

Response: Having X number of affordable dwellings and Y number of people to be transported each day as targets is insufficient, their spatial distributions are critical.

Conclusions

- More research needed into how scaling and agglomeration works: focus on not just the economies of scale and increasing returns, but diseconomies of scale too!
- The role of regions and smaller and medium sized cities as important as the largest cities.
- As system size gets larger, heterogeneities arise naturally, leading to segregation. Planned response needed on spatial distributions of housing and employment.
Thank you!

Questions?