



CITY GROWTH AND ZIPF'S LAW

Hélène van Heijningen & Matthijs Brouns

CPB: Bureau for Economic Policy Analysis

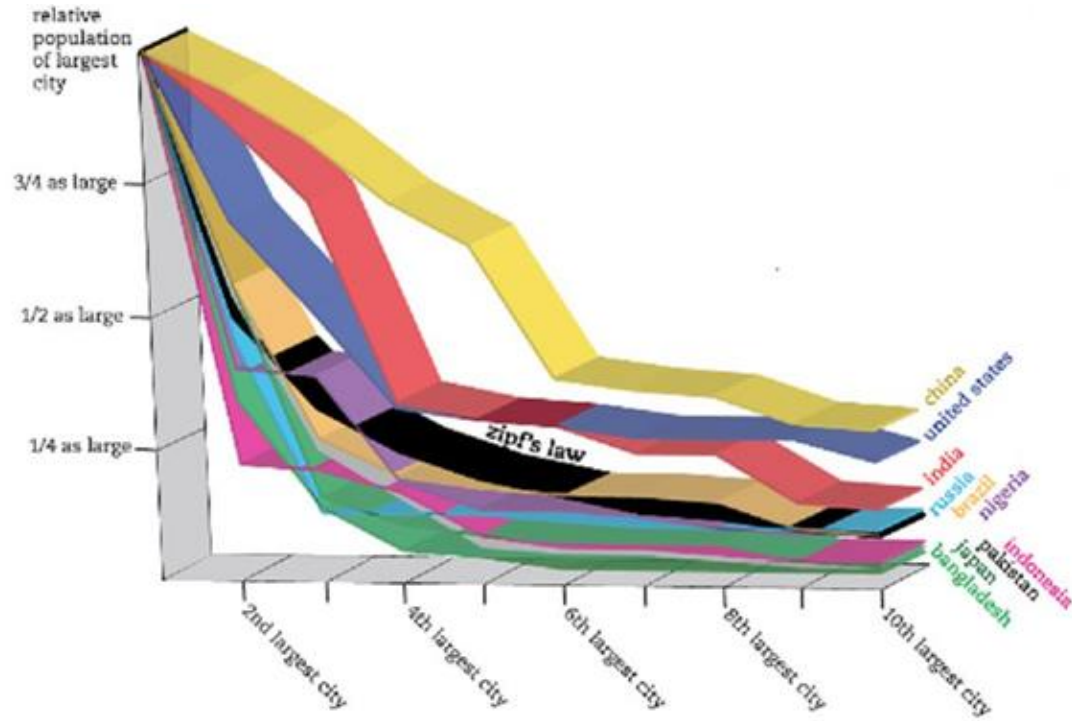
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CPB AND ZIPF'S LAW

- The largest cities in a country show a Zipfian distribution



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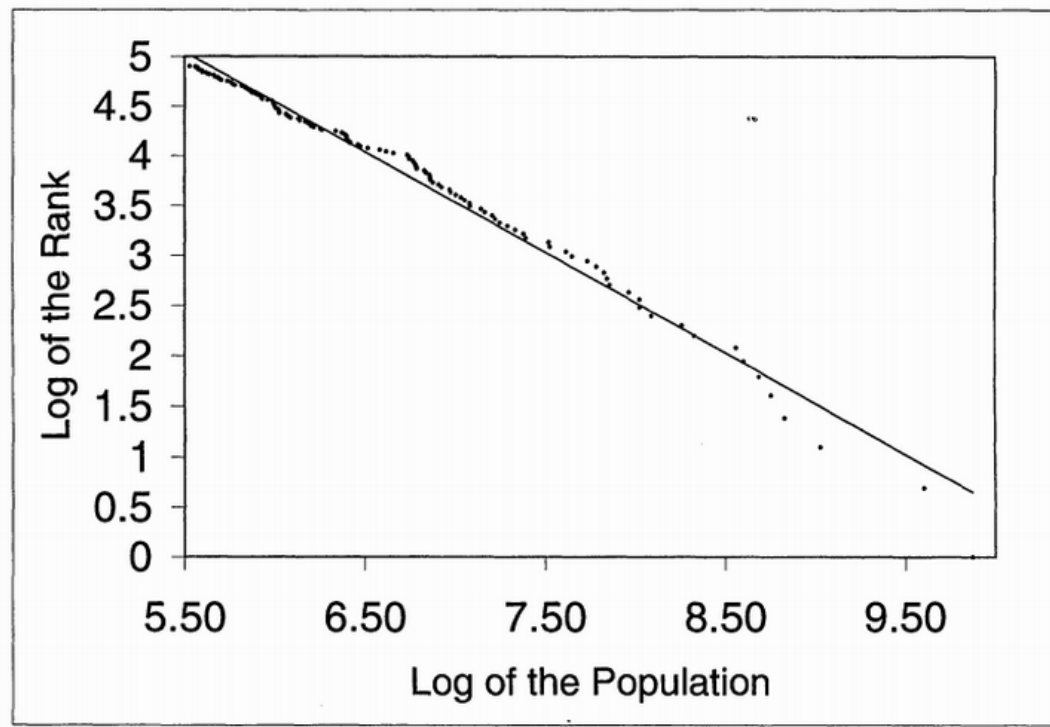


FIGURE I

Log Size versus Log Rank of the 135 largest U. S. Metropolitan Areas in 1991
Source: Statistical Abstract of the United States [1993].

CPB AND ZIPF'S LAW

○ CPB:

- Can we influence this type of city growth?
- Can we design policies knowing this type of behaviour occurs?
- What causes the Zipf's law to emerge?



RESEARCH QUESTION & APPROACH

- Focus: Decisions made on household level

Research question:

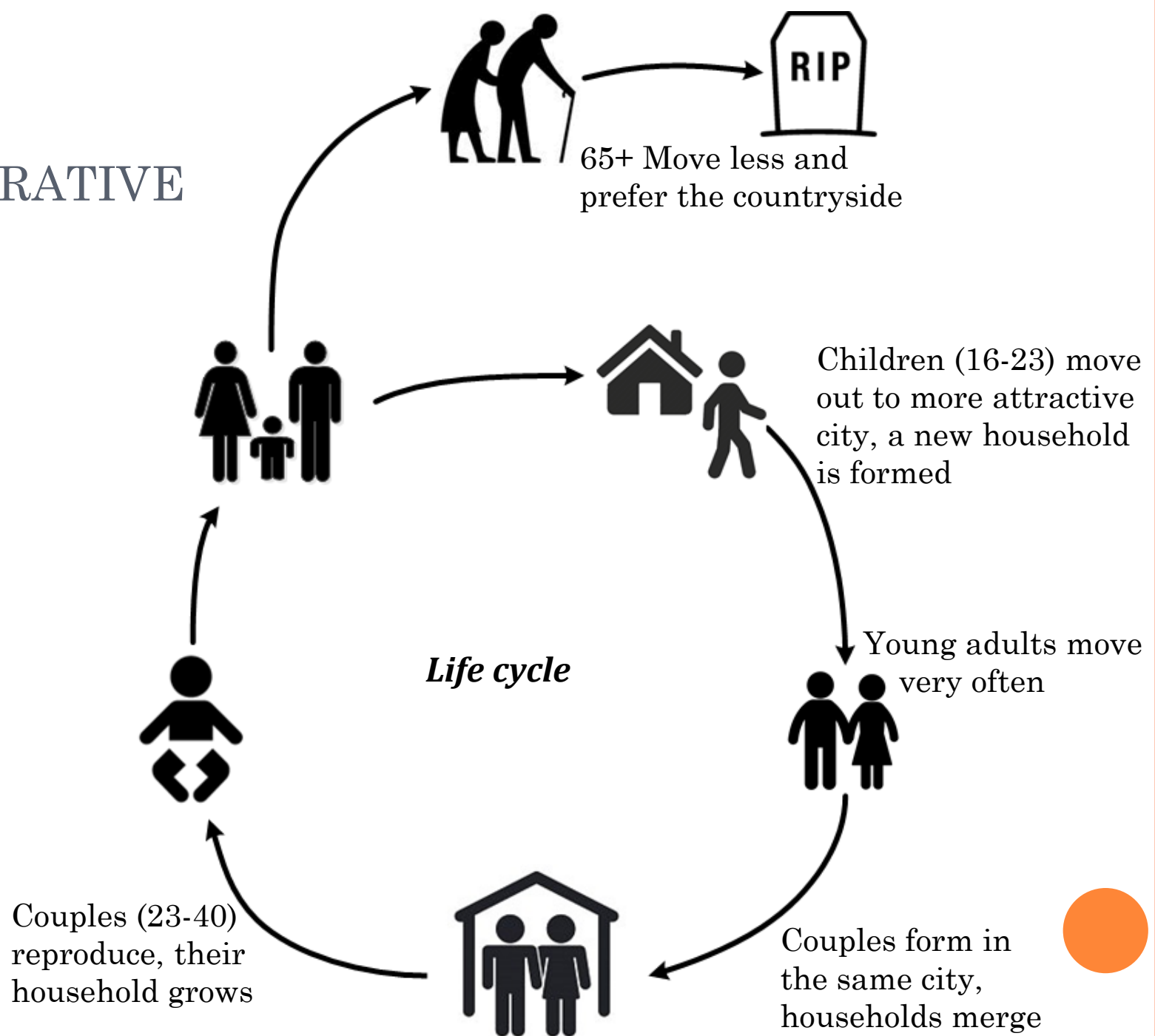
How do decisions made at household level influence moving behaviour between cities to cause the emergence of the Zipf's law?

○ Approach:

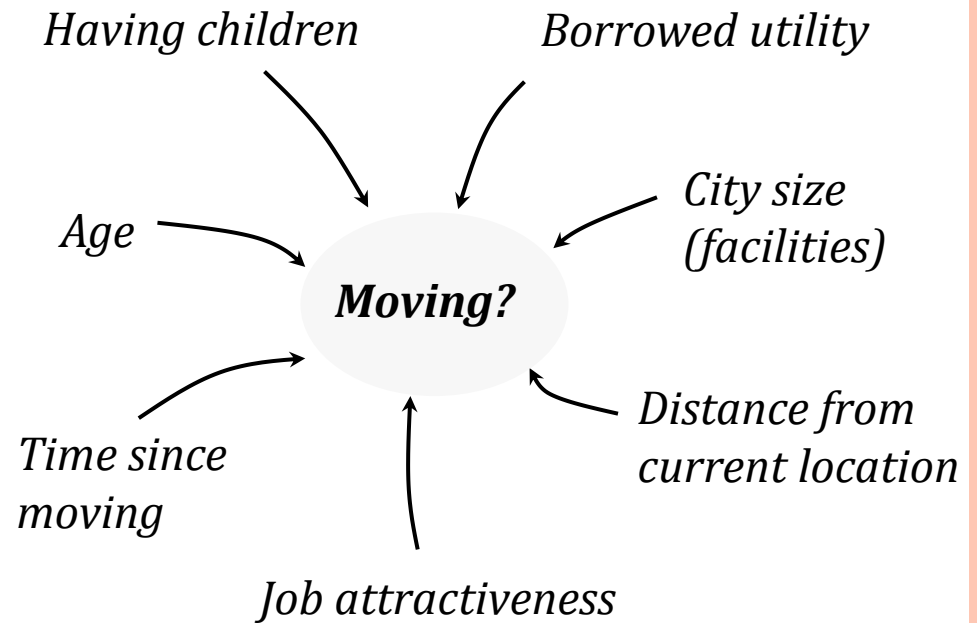
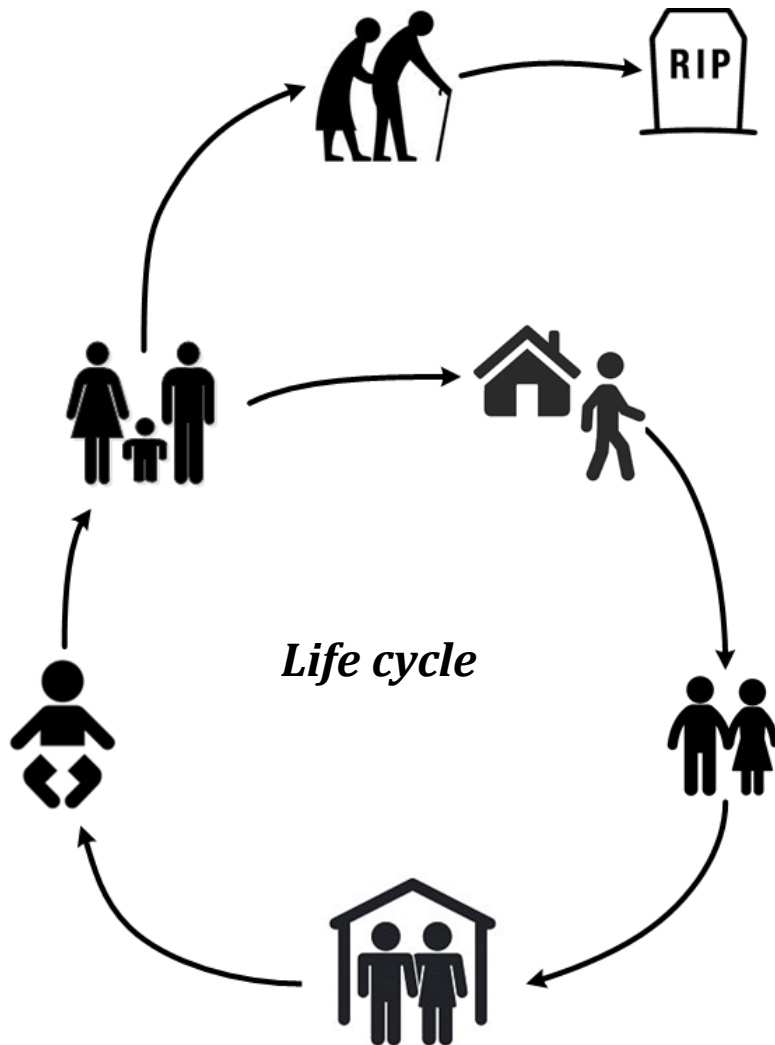
- Literature research: for what reasons do people move?
 - Stage of Life
 - Job opportunities



NARRATIVE

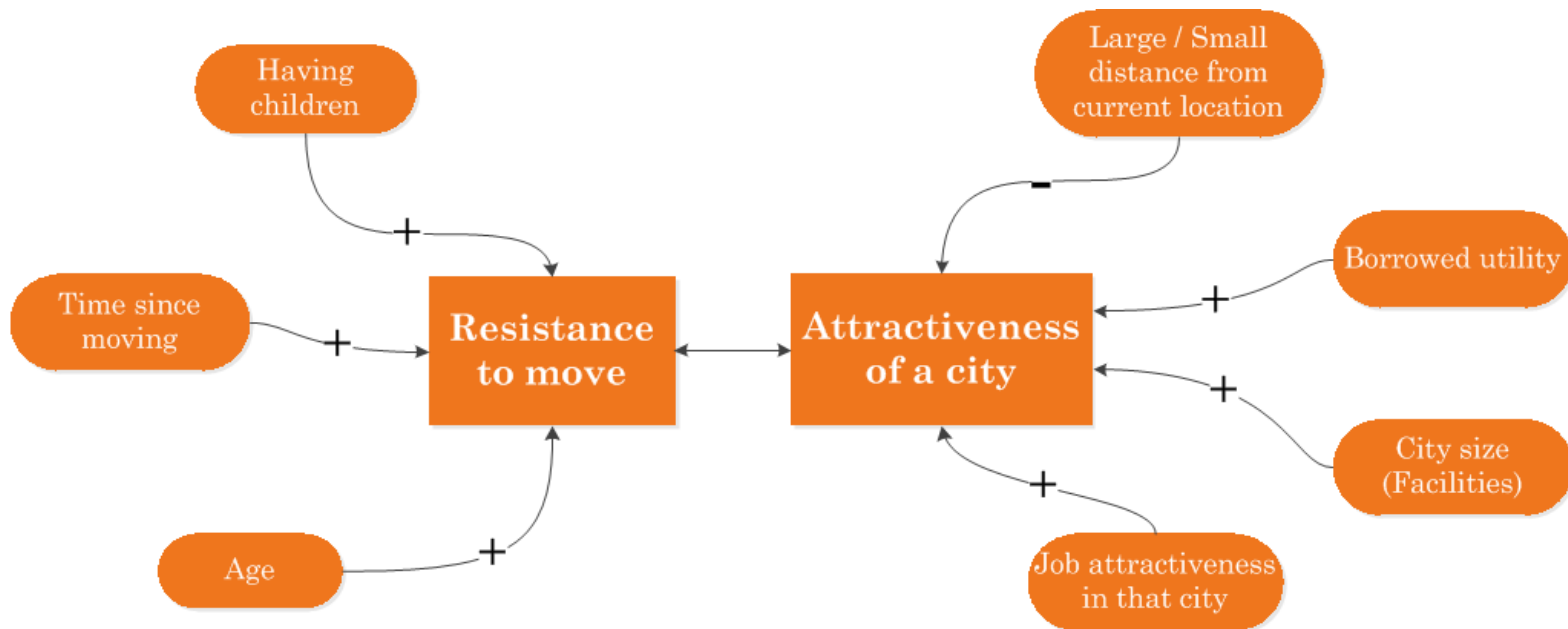


NARRATIVE

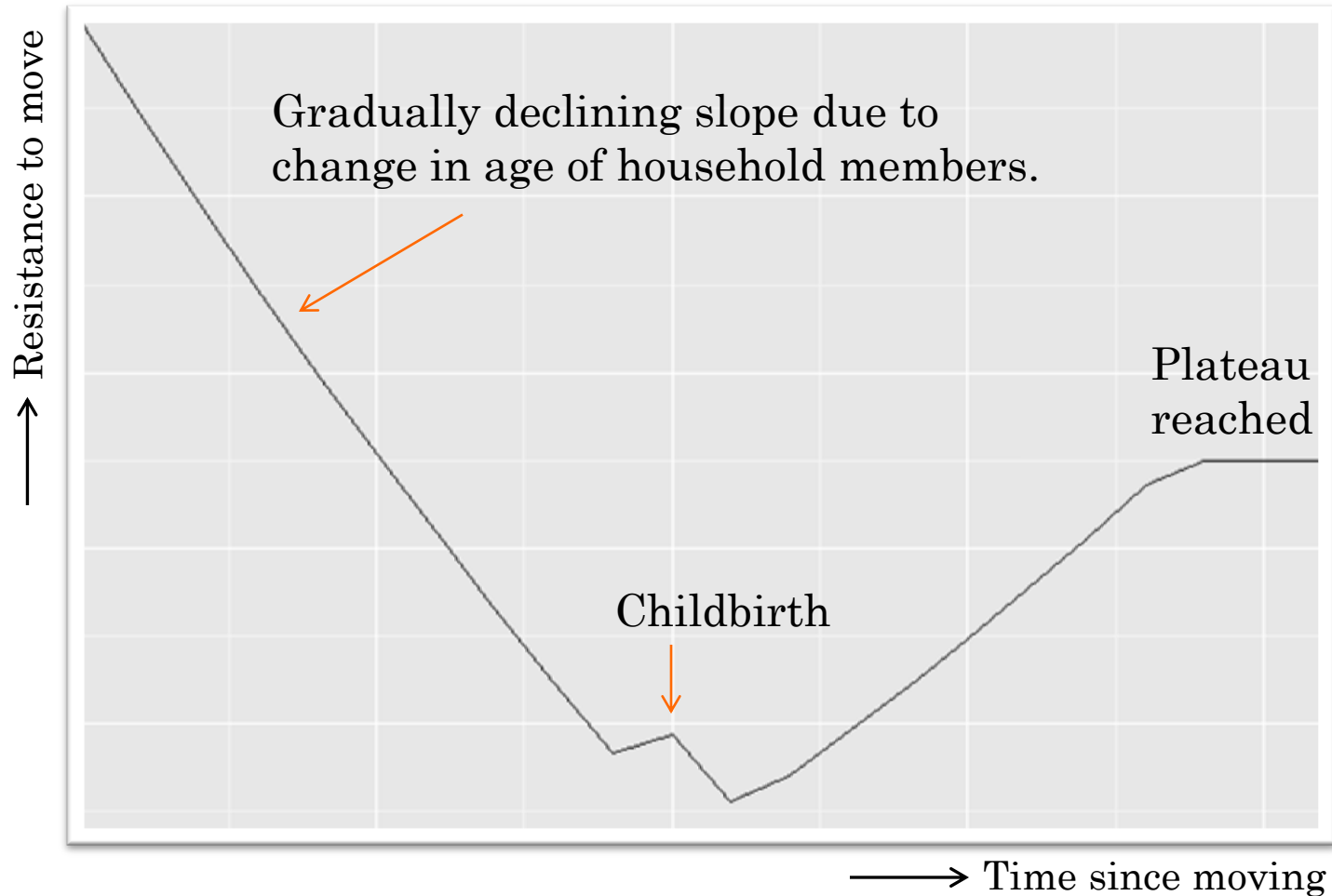


MODEL LOGIC

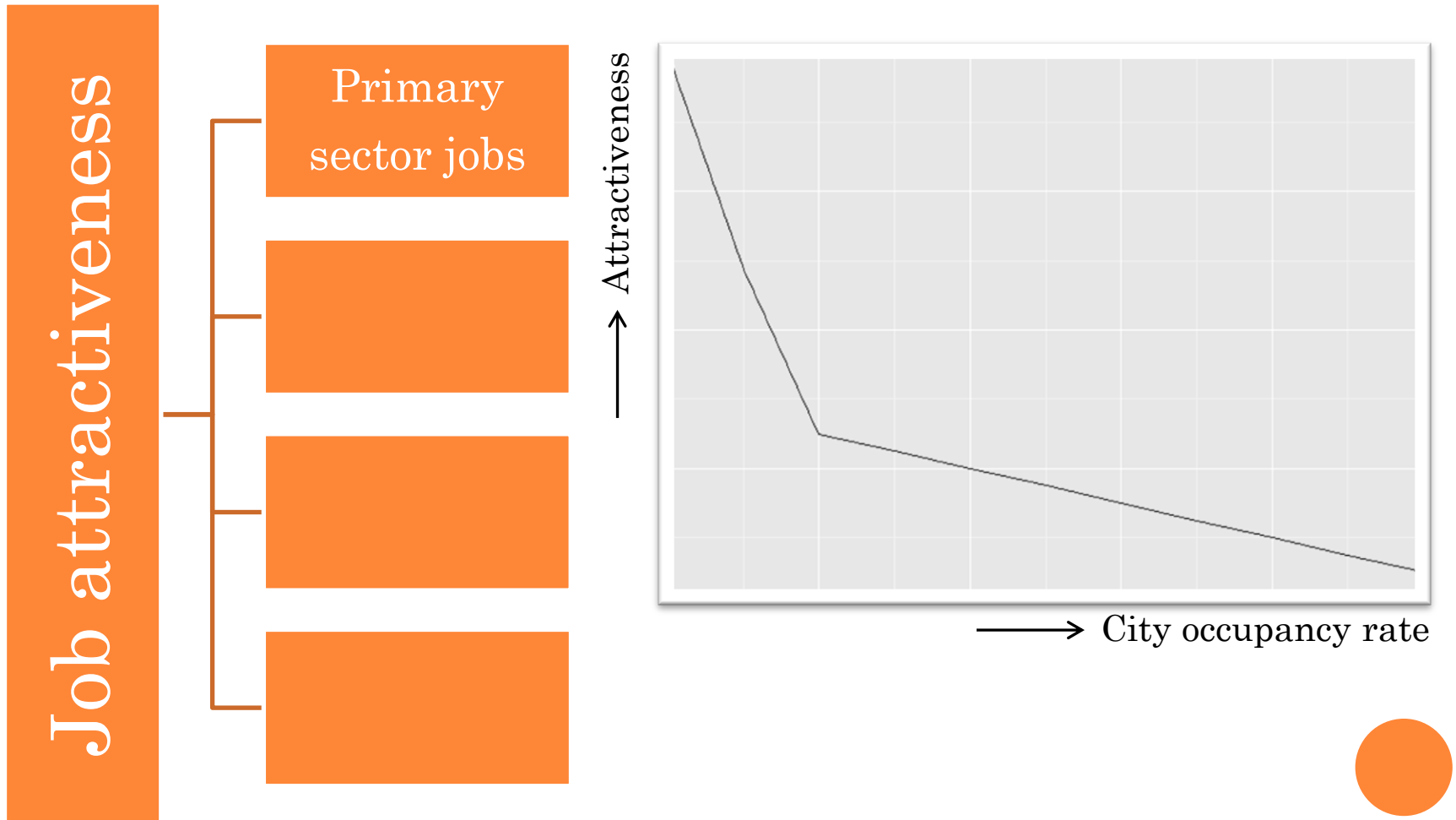
- Rule: A household moves to a random city for which its 'Attractiveness' > 'Resistance to move'



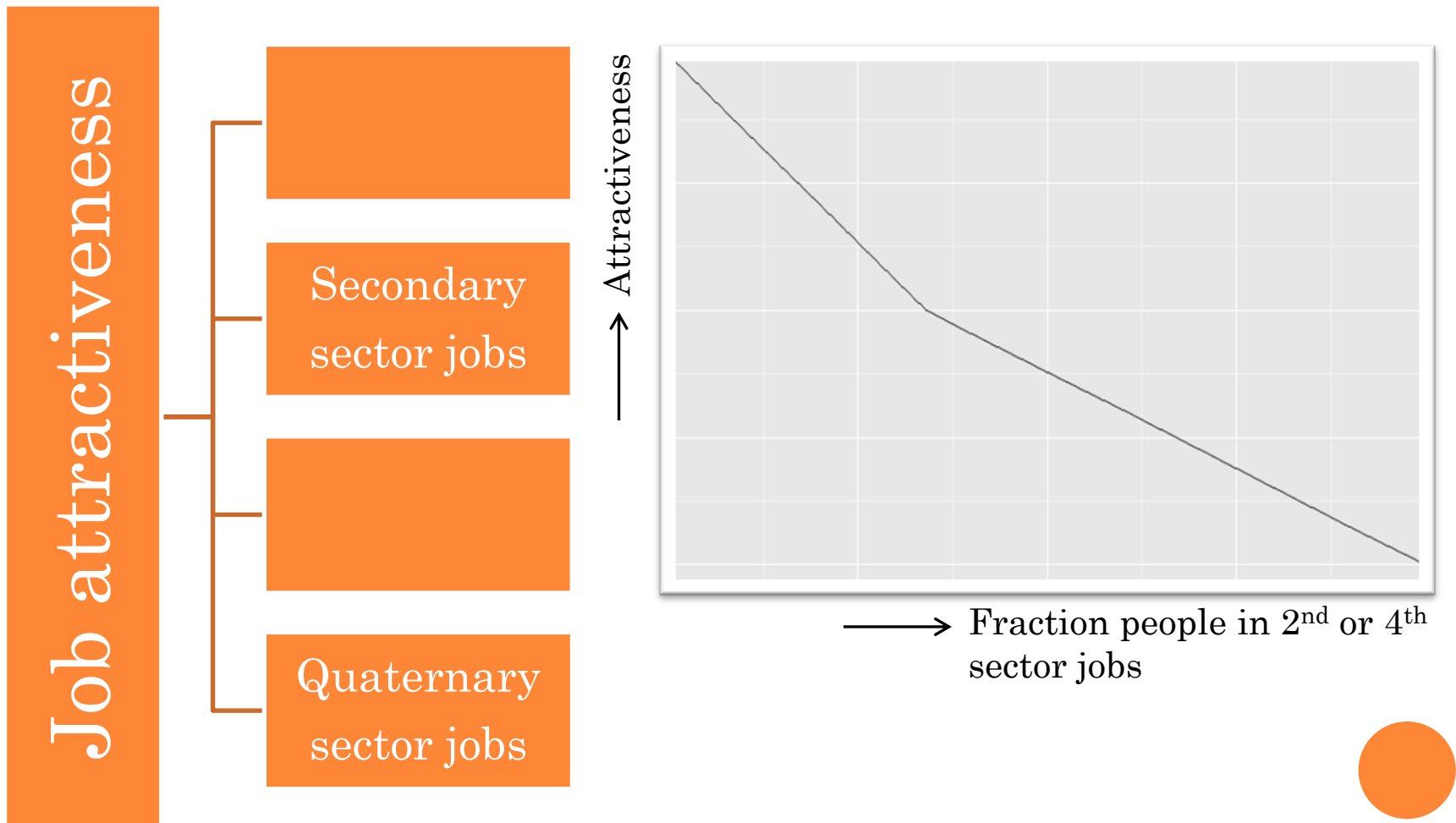
MODEL LOGIC: RESISTANCE TO MOVE



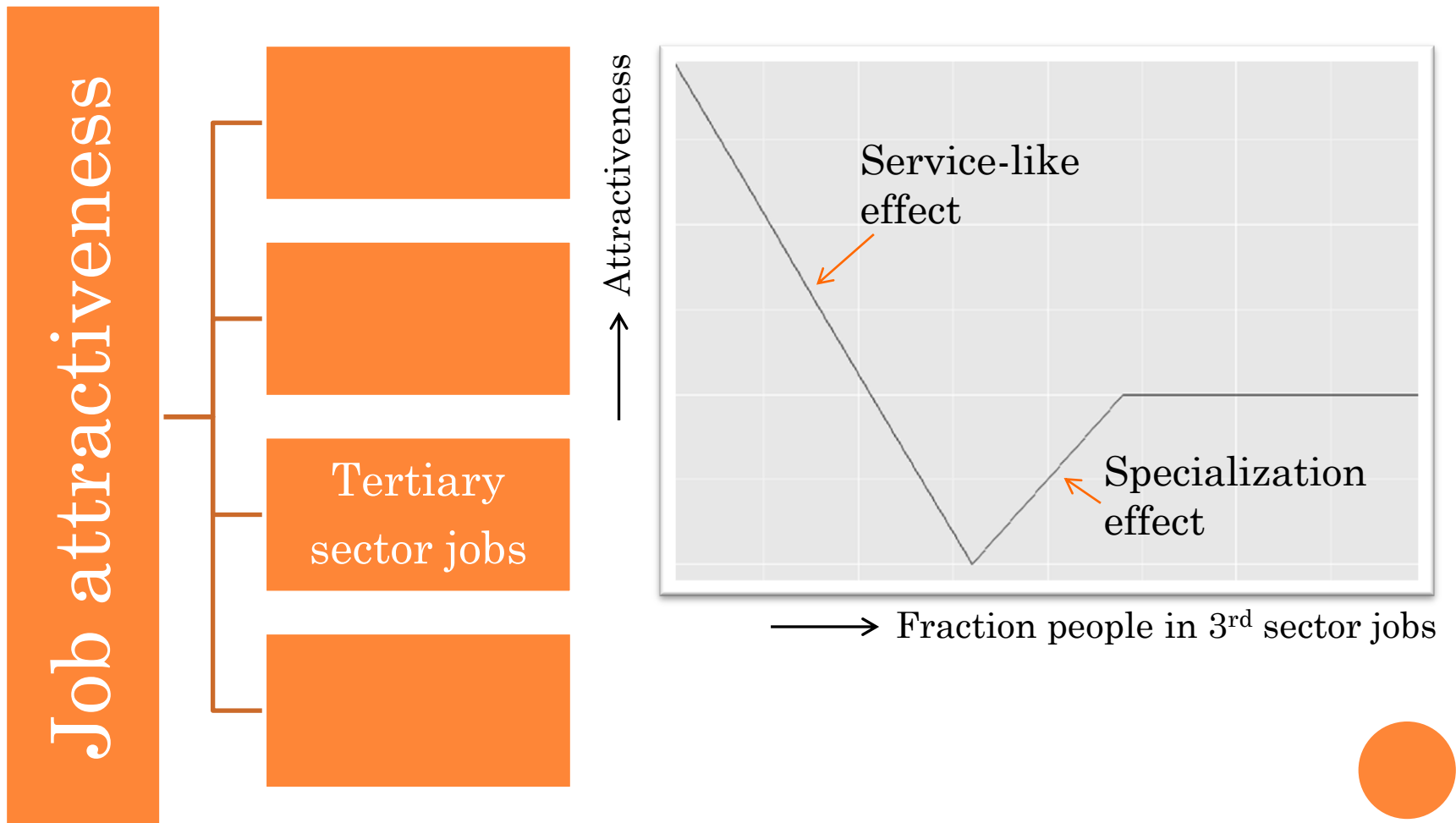
MODEL LOGIC: JOB ATTRACTIVENESS



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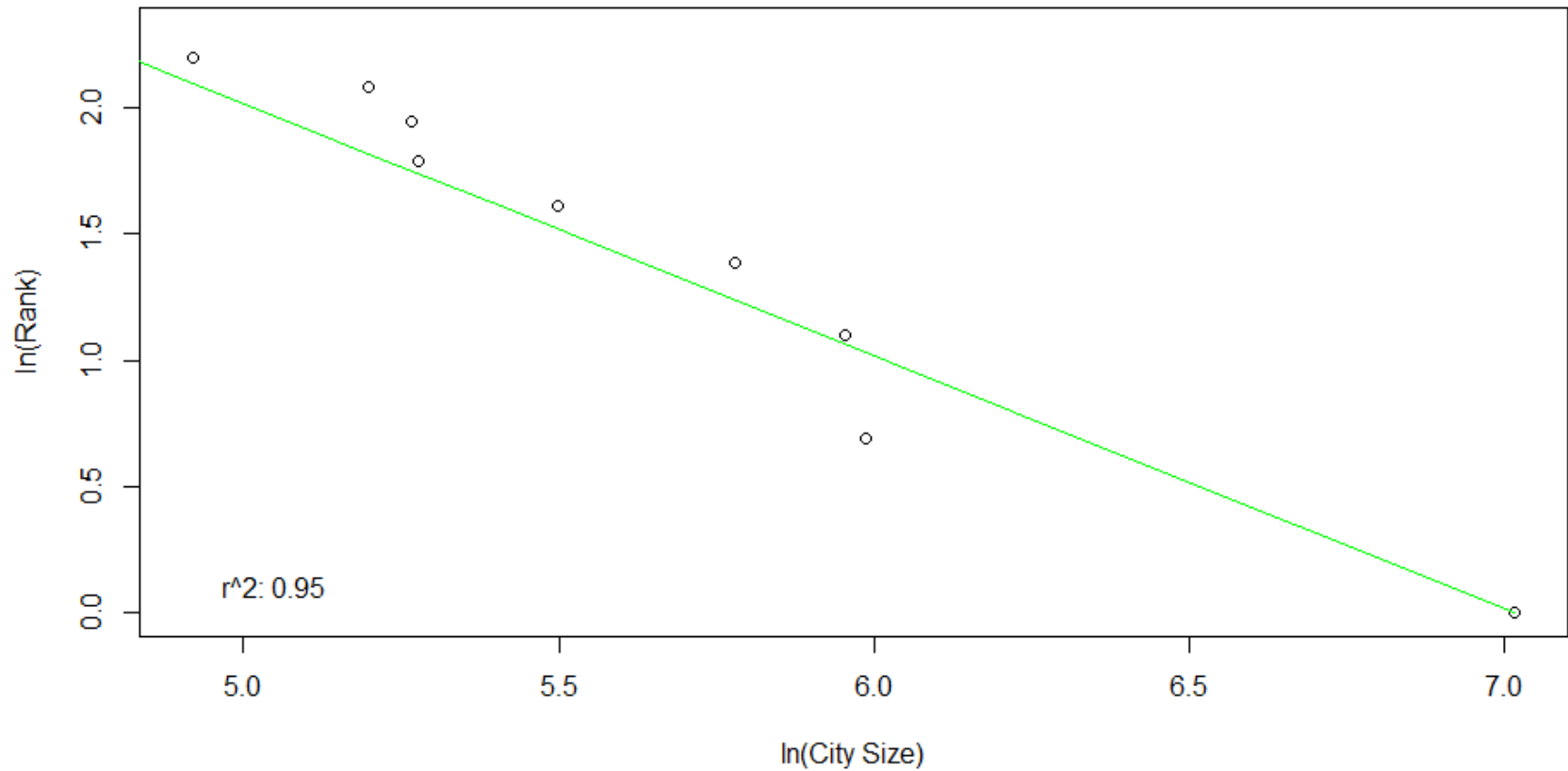
MODEL OUTPUT

- Map with randomly distributed cities
- Households distributed over cities & countryside
- For every tick (1 year)
 - Total number of households
 - Number of households in and out of cities
 - Number of households for the 10 different cities



MODEL OUTPUT

Zipf Regression



VERIFICATION & VALIDATION

○ Verification

- 6 Tests on a single-agent, minimal interaction and multi-agent level
- The model is implemented as intended

○ Literature validation

- Parameters and relations are based on literature

○ Face validation through expert consultation

- Assumptions
- Relations
- Concepts

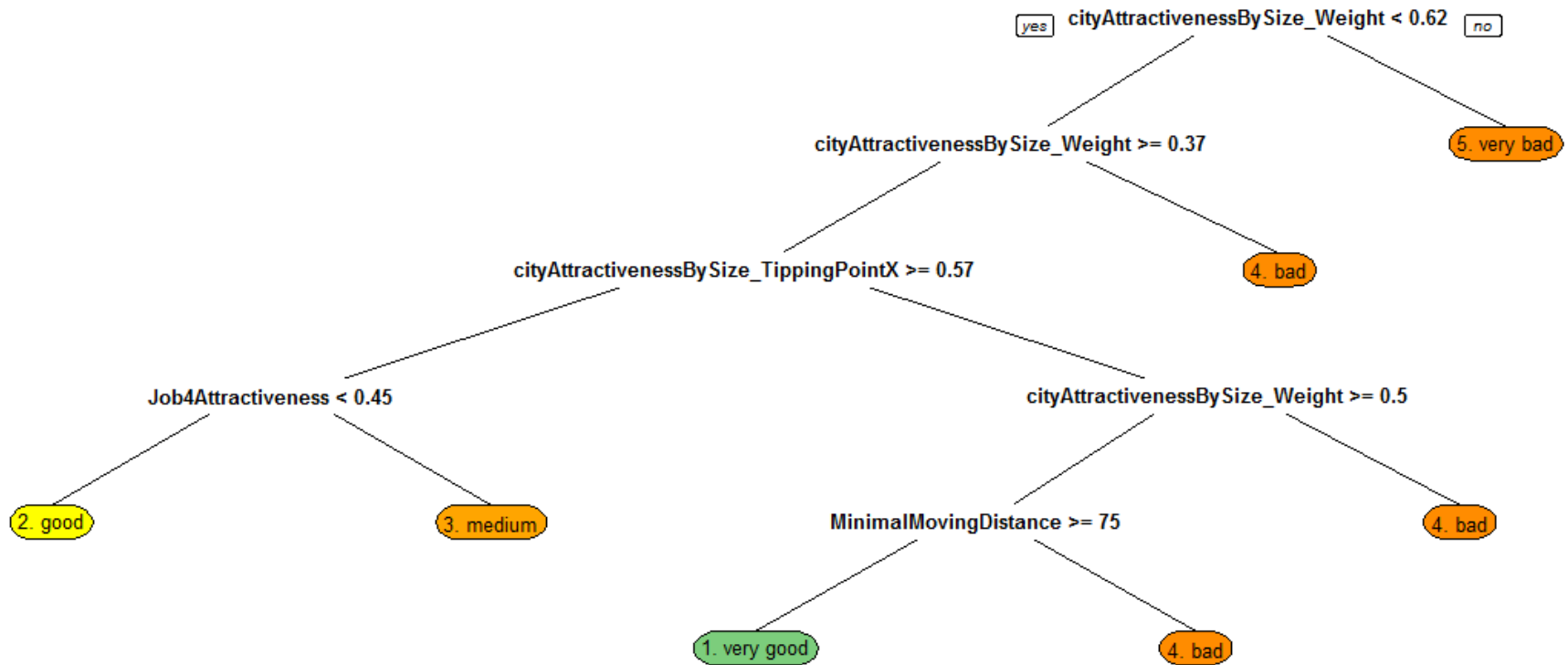


EXPERIMENTAL DESIGN

- Which variables have the most influence on creating the desired model output?
- Multi-variate analysis
- Latin hypercube
- Because of long run time, limited number of runs (300)
- Compare R-squared to a pure Zipfian distribution
- R-squared $> 0,80$ found in literature



MODEL EXPERIMENTATION



MODEL EXPERIMENTATION

- 1/3 of the runs R-squared $> 0,8$
- Verified by running the model again, with the outputs of the decision tree as an input space
- These runs showed quite a lot of runs concurrent with the Zipf's law compared to the base runs



CONCLUSIONS

- Our model is able to produce cities according to a Zipfian distribution
- However, very specific parameter values are needed to obtain a Zipfian distribution
- The Zipf's law has been around for centuries
- Two variables seem to have the most effect:
 - The city size effect
 - Distance between cities
- Do we now understand why a Zipf's law emerges?



FUTURE RESEARCH

- Why doesn't the Zipf's law fit as well in the Netherlands as it does abroad and how does this affect decision making?
- What happens when European borders disappear entirely?
 - Will Paris or London become the most important city?
 - What will happen to our cities?



NETLOGO IN PRACTICE

- Netlogo is all about turtles, and it moves about as fast as one
- Too much time spent on making model run at reasonable speeds
 - Table implementation 100x slower than regular list
 - Subtracting sets undoable
- No support for unit testing or assertions
- Memory leaks in RNetlogo
- Overall unsuitable due to speed limitations



MODEL FILES & REFERENES

- If you're interested in the model files and documentation, please visit:

<https://github.com/MBrouns/Zipfs-Law-and-city-development>

- References
- Newitz, A. 2013. *A mysterious law that predicts the size of the world's biggest cities*. Retrieved from: <http://io9.com/the-mysterious-law-that-governs-the-size-of-your-city-1479244159> at the 6th of January, 2015.
- Infrastructurist. 2011. *A Capital On The Move*. Retrieved from <http://keith-travelsinindonesia.blogspot.nl/2011/06/capital-on-move.html> at the 20th of January, 2015.

