Simulation for the Customer’s Decision-making Process of Purchase by the Agent Based Model

(Agent Based Modelによる潜在的購買人口の移動と分布の統計解析)

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Purpose

BIG data (such as POS data) are drawing much more business or scholarly attention.

Those data are, however

1.Expensive, 2.Undeveloped and 3.Restricted for academic research use.

What is required is a NEW approach to grasp market needs

not with BIG data but with existing analysis methods.

Clarify how the store should be located by customer behavior.

Agent Based Model

Agent Based Model

- Autonomy of agent
- Interaction between agents
- Self-organization in agent society

Simulation to clarify behavior of agents how they affected the market as a whole.

Agent Based Model (cont'd)

Application to Demography

- Applied Demography
- Business Demography
- Migration Model
- Matching model for marriage

etc…

Model (cont'd)

Society

- Constituted by 20×20 grid cells
- Closed space

Agents

- Customer (n=160)
- Firm (n=40)

Each agents are arranged so as never overlap in the society.

Model (cont'd)

Customer (n=160)

Each consumer agent make a decision about own purchase different from others on the basis of

1. Distance between his/her residence and the store.
2. Attraction (including the price and others)

The contribution of each factor depends on demographic characteristics of the agent.

The utility is calculated by the Huff model.

Model (cont'd)

Customer (n=160)

$$p_{ij} = c_i a_j^{\alpha} d_{ij}^{\beta} \Big/ \sum\sum c_i a_j^{\alpha} d_{ij}^{\beta} \qquad \alpha > 0, \quad \beta < 0$$

p_{ij} : Probability that a customer located at i selecting store j

d_{ij} : Distance between customer i's residence and the store j

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \qquad i = 1, 2, \cdots, 160. \qquad j = 1, 2, \cdots, 40.$$

$$k_i = (x_i, y_i) = (0,0), (0,1), \cdots, (20,20).$$

$$k_j = (x_j, y_j) = (0,0), (0,1), \cdots, (20,20).$$

a_j : Attraction index of the store j $\qquad 1 \le a_j \le 14$

c_i : Weight of customer i $\qquad 1 \le c_i \le 1.2$

k_i : Cell point of the customer i

k_j : Cell point of the store j

Model (cont'd)

Firm (n=40)

Their attraction on the price, facilities, or the service and others affect the customer's decision-making.

As a result of customer behavior, they should make the prices set and move the location of the store reasonably.

They achieve a desired store traffic volume, or they move to any new location point.

Model (cont'd)

Firm (n=40)

$$k_j^t = k_j^{t+1} \quad \text{if} \quad z_j \geq y_j$$

$$k_j^t \neq k_j^{t+1} \quad \text{if} \quad z_j < y_j$$

$$j = 1, 2, \cdots, 40.$$

y_j : desired store traffic volume per month

z_j : actual store traffic volume per month

k_j^t : cell point of the store at the time t

Model (cont'd)

Attraction index and customer's weight are assigned at random.

Each store and customer are arranged at random.

1. Customers could visit to some store according to their incentives.

2. Stores move to another cell point until the desired store traffic is achieved.

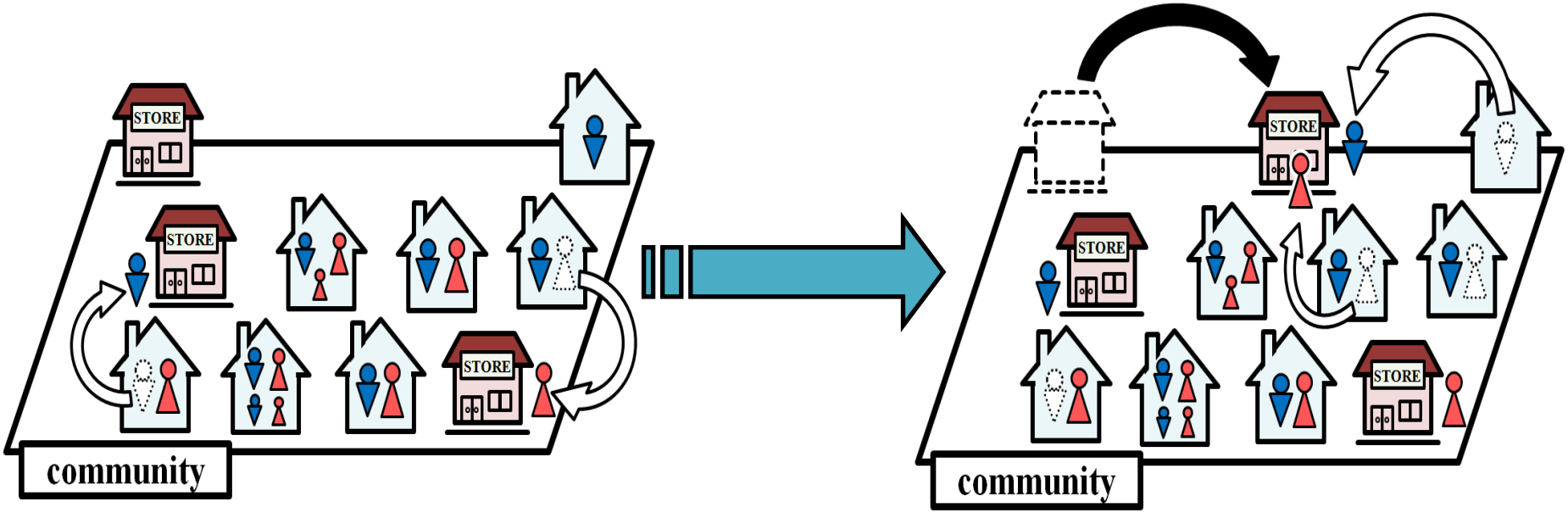
3. Customers could visit to any new store.

Repeat 1. ～ 3.

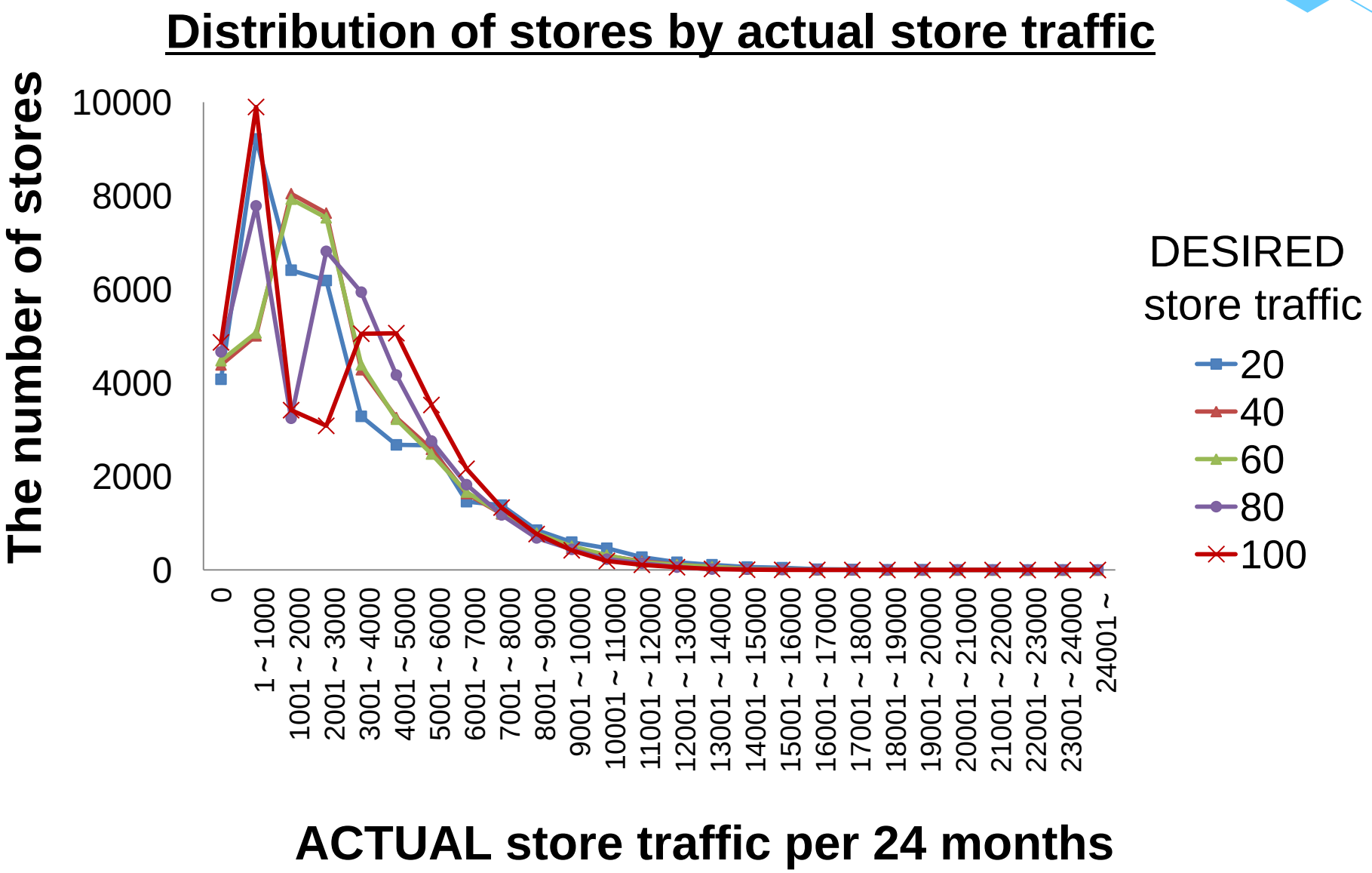
24 months × 1,000 simulations × 4 levels of store traffic= 96,000 repeats

Model (cont'd)

Image of simulation for this research

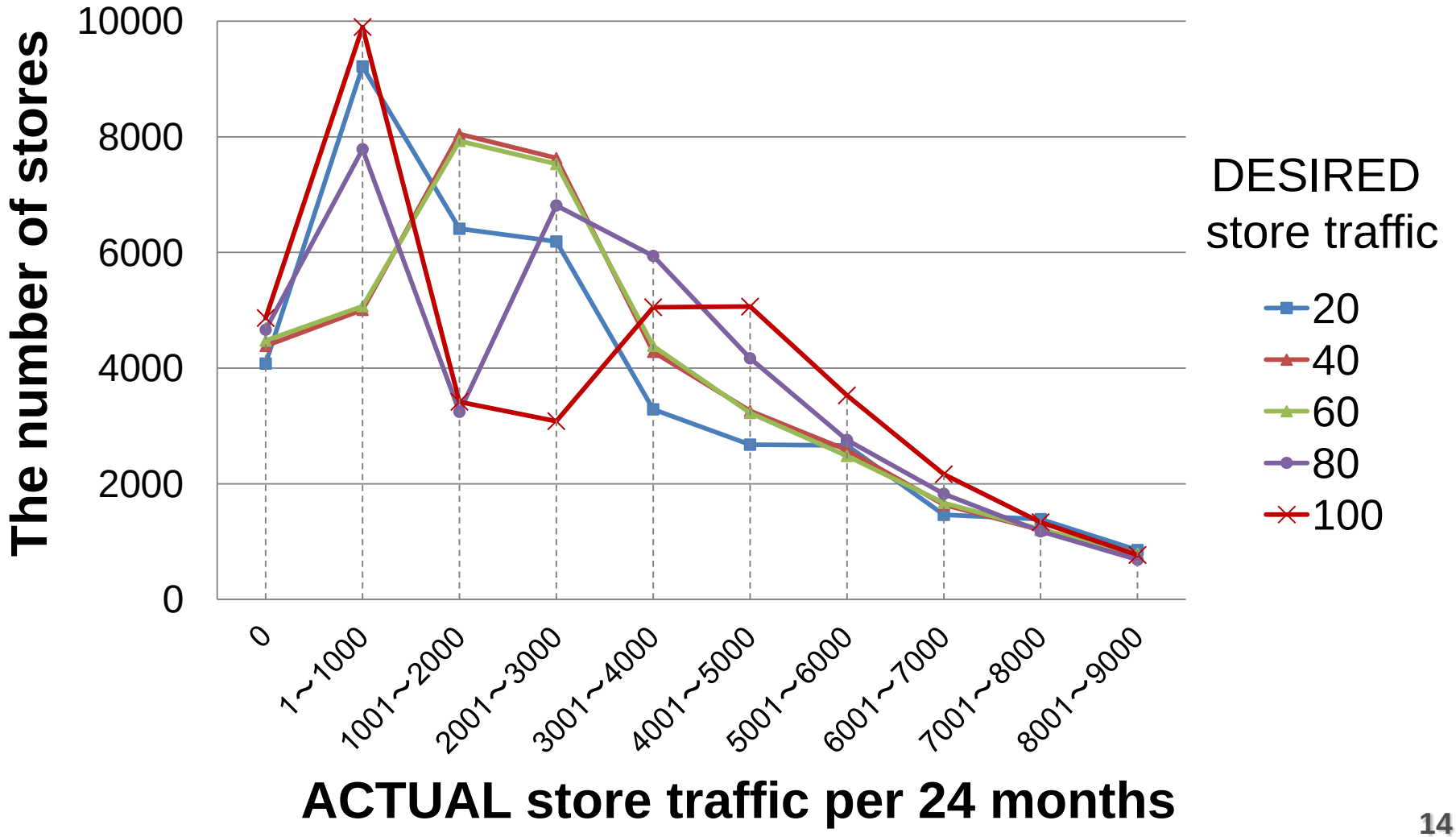


Application and Availability

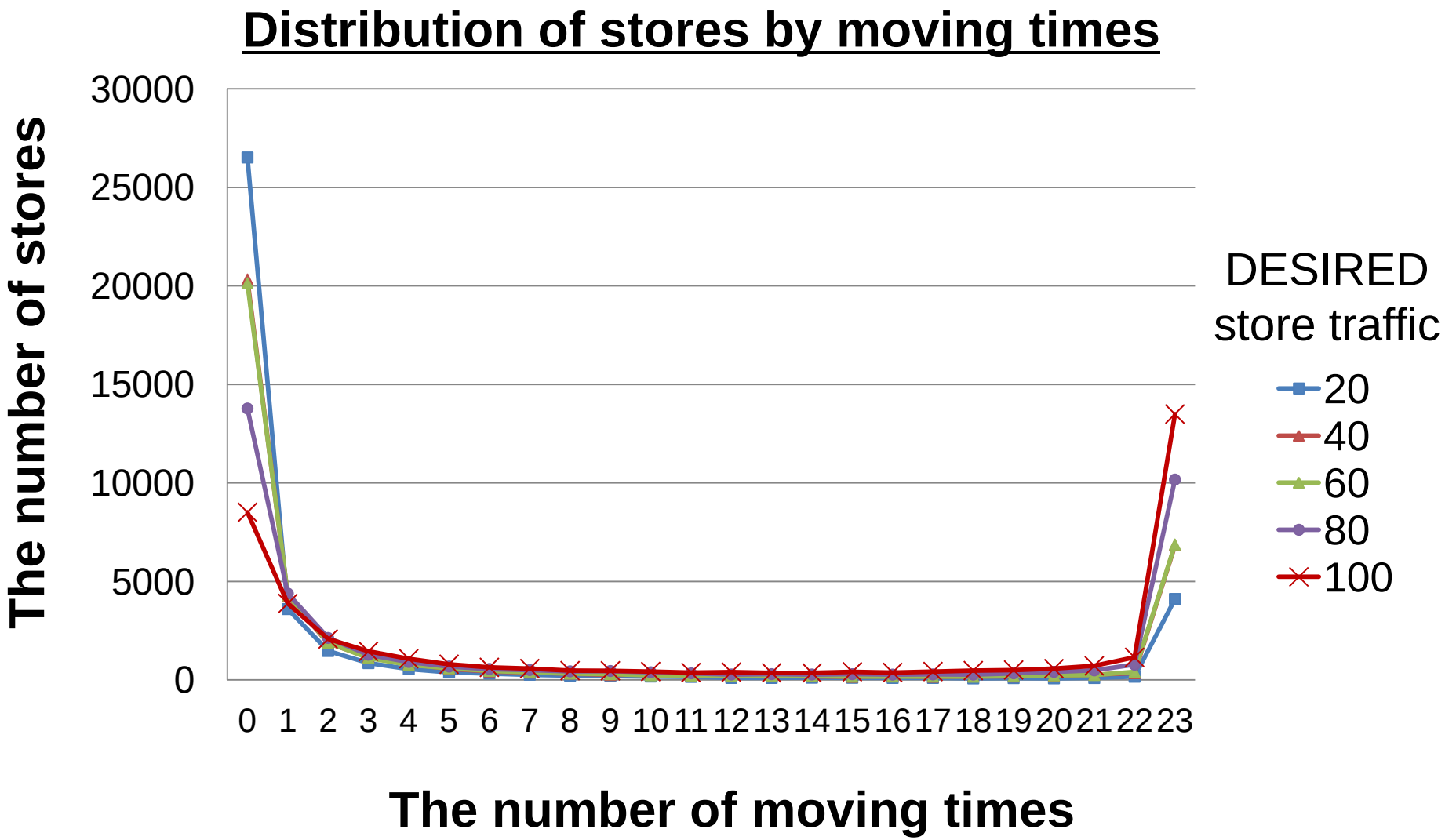


Application and Availability (cont'd)

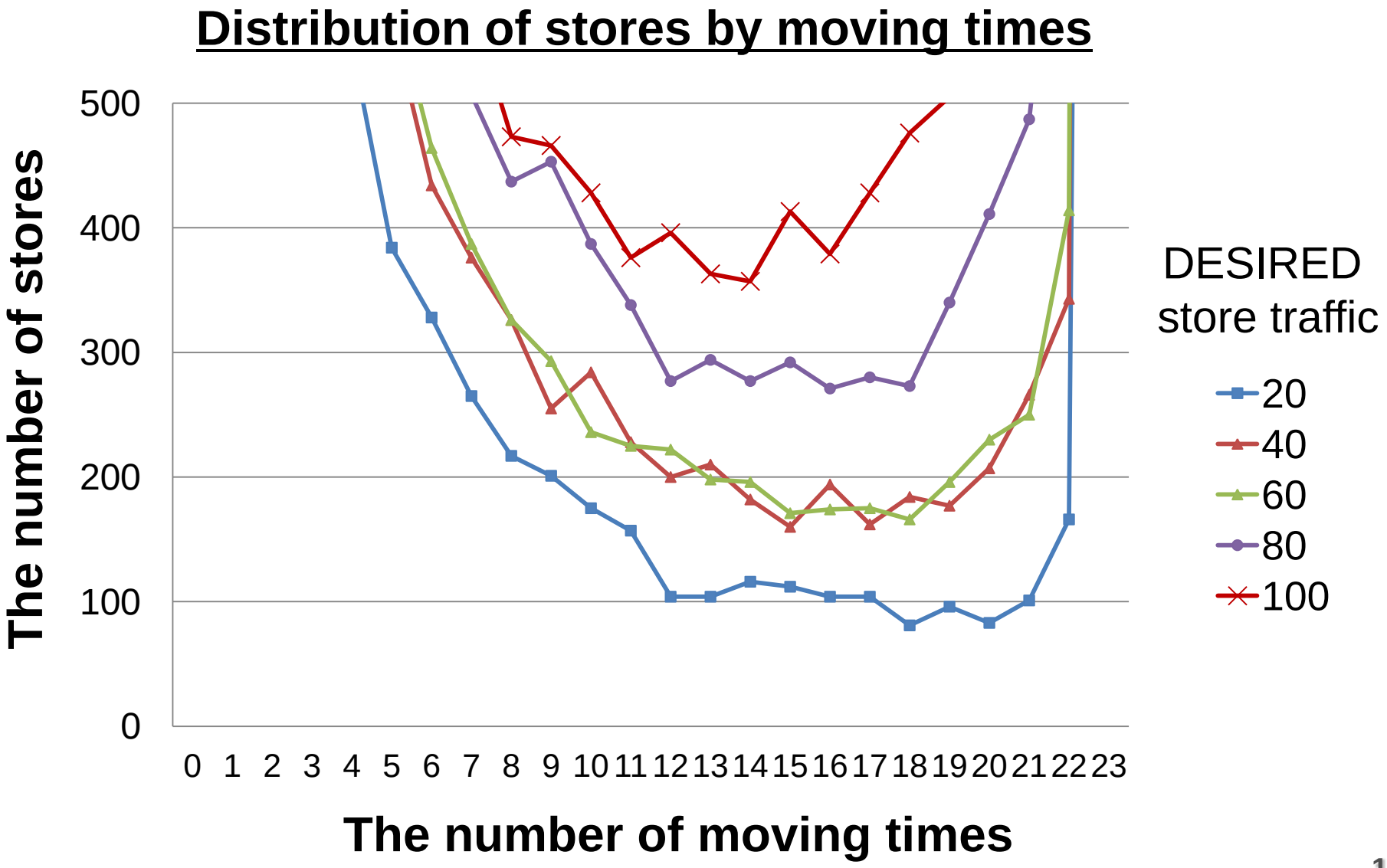
Distribution of stores by actual store traffic



Application and Availability (cont'd)



Application and Availability (cont'd)



Application and Availability (cont'd)

Nearest Neighbor Index

$$NNI = \bar{d}_{jj'} \Big/ \frac{1}{2}\sqrt{\frac{a}{n}}$$

NNI : nearest neighbor index

$$0 \le NNI \le 2.15$$

$\bar{d}_{jj'}$: mean of nearest neighbour distance

$$d_{jj'} = \min d_{jl} \quad (l = 1, 2, \cdots, j', \cdots, 40, l \ne j).$$

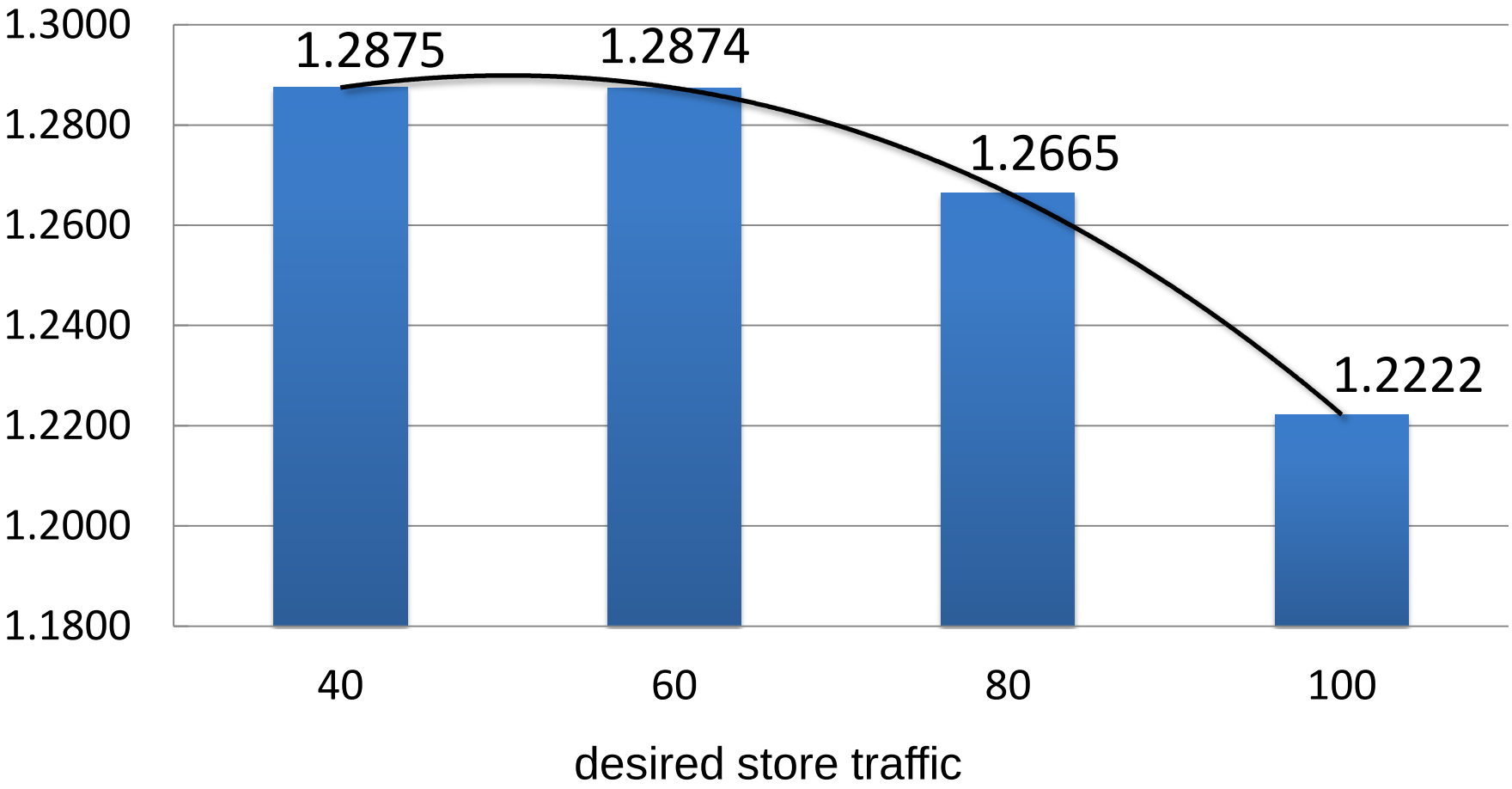
$\bar{d}_{jj'}$: mean of $d_{jj'}$

a : area size

n : number of the stores

Application and Availability (cont'd)

Nearest Neighbor Index



Application and Availability (cont'd)

Ⅰ. As the desired traffic store volume is turned up, times of movement by stores increase. Also, moving costs increases.

Ⅱ. As the desired traffic store volume is turned up, Nearest Neighbor Index decreases. Also, the nearest neighbor stores should approximate.

What would we do next?

1. Discuss the simulation results.
2. Introduce the information space of the customer.
3. Arrange each customer and store randomly or non-randomly and compare the results.
4. Open space where firms can enter and exit.

References

Billari Francesco C. and Prskawetz Alexia, (2003) '*Agent-Based Computational Demography*', Physica-Verlag.

Fukuda Jyunya and Kita Hajime, (2013), "*Agent-based Population Estimation Model considering Demographic Characteristics*" '3rd Symposium of Technical Committee on Social Systems' pp111-114.

Honma Kentaro and Fujii Akira, (2011), "A New Method of Deriving Huff's Model Through Consumer Behavior", '*Papers on city planning'*, 46(3), pp865-870.

Philip J.Clark and Francis C. Evans, (1954), "*Distance to Nearest Neibor as a Measure of Spatial Relationship in Population*" 'Ecology', 35(1), pp445-453.

Thomas C. Schelling, (1978), '*Micromotives and Macrobehavior'*, Norton.