Why retailers cluster: An agent model of location choice on supply chains

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Abstract This research investigates the emergence of retail clusters on a supply chain network comprised of suppliers, retailers, and consumers. Agent-based models are employed to study retail location choice in a market of homogeneous goods and complementary goods. On a circle comprised of discrete locales, retailers play a non-cooperative game by choosing locales considering the impact of suppliers and consumer behaviors. Our results disclose the self-organization of retail clusters. Sensitivity tests on the number of retailers, supplier locales, and consumer preferences are also performed.

A market of homogenous goods

Consumers: for consumer p, the attractive index of Retailer Rxi equals:

$$\rho_p = \frac{e^{\lambda_{pi}}}{\sum_{m \in W_x} e^{\lambda_{pm}}}$$

The probability for consumer p to patronize retailer Rxi equals:

$$V^{bt} = K^j \cdot q_{-b}^{bt} + \varepsilon^b \quad \text{(Huff, 1964)}$$

Retailers: in each round, retailers evaluate the expected profits of all locales. Retailers Rxi's expected profit in locale m, is calculated as:

$$\Pi_{xm} = (\sum_{p=1}^{N} \lambda_x \cdot \rho_{pm}) \cdot [\theta_x - \sum_{k=1}^{K} (\delta_x + u \cdot \sigma_{mk}) \cdot d_{mk}]$$

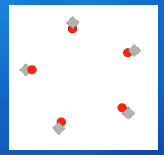
After evaluating profits of all locales on the circle, retailer Rxi moves to the locale providing the highest expected profit given others are geographically fixed at that time. Retailers' initial locations are randomly assigned. Each retailer can only move once per round; the sequence of moving is randomly decided.

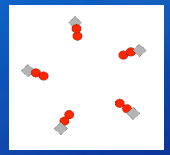
Suppliers: Suppliers are evenly distributed on the circle and are fixed in all rounds.

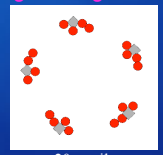
Value of parameters (Model 1: market of homogeneous goods; Model 2: market of complementary goods)

Variables	Descriptions	Model 1	Model 2
β	exponent of distance decay	1.0	1.0
k_1	constant	1	1
C	# of locales on the circle	100	100
N	# of consumers	5000	5000
K	# of suppliers of x	5	10
L	# of suppliers of y		10
u	unit shipping cost per locale distance ($)	0.02	0.02
θ_x	retail unit sales price of x ($)	2.5	2.5
θ_y	retail unit sales price of y ($)		1.5
δ_x	supplier unit sales price ($)	1.5	1.5
δ_y	supplier unit sales price ($)		1.0
λ_x	individual consumer demand on x	20	20
λ_y	individual consumer demand on y		10

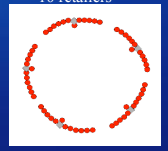
Retail distribution patterns in a market of homogenous goods

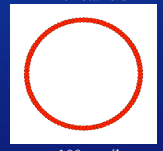

5 retailers

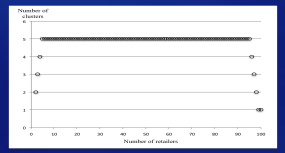

10 retailers


20 retailers

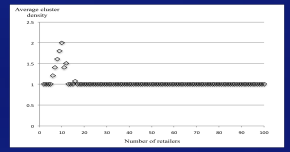

30 retailers


60 retailers

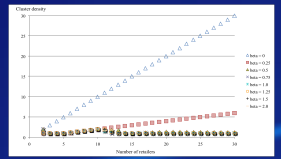

100 retailers



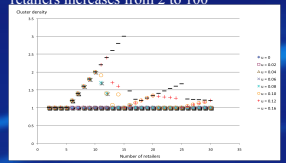
Number of clusters in equilibrium as the number of retailers increases from 2 to 100



Average cluster density as the number of retailers increases from 2 to 100



Average cluster density given different values of β



Average cluster density given different values of u

A market of two complementary goods

Consumers: consumer hope to buy two products (namely, x and y) with minimum cost, indicating minimum travel distance. A trip is defined as a round-trip for a consumer from home to visit Rxi and Ryi. Given Wx number of Rxi and Wyi number of Ryi, there are in total $W_x \cdot W_y$ trip candidates, from which a consumer chooses the shortest trip on the circle. The utility for consumer p to patronize Retailer Rxi equals:

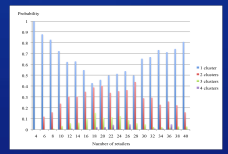
$$A_{pi} = \sum_{i=1}^{W_x W_y} k_1 \cdot d_i^{-\beta} \cdot \pi_{ii} + \varepsilon_p$$

Similar utility functions can be established for retailer Ryj.

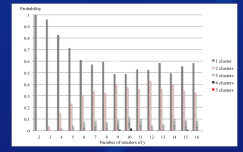
Retailers: The rule of location choice is the same as the first model. For retailer Ryj, the expected profit in locale m equals:

$$\Pi_{ym} = (\sum_{p=1}^{N} \lambda_y \cdot \rho_{pm}) \cdot [\theta_y - \sum_{k=1}^{L} (\delta_y + u \cdot \sigma_{ik}) \cdot d_{ik}]$$

Suppliers: There are two categories of suppliers selling product x and y, which are evenly distributed and co-located. Suppliers of the same goods offer the same unit sales price.



Probability distribution of the numbers of clusters with retailers ranging from 4 to 40 (where the number of retailers of x equals of retailers of y), with total 20 suppliers (10 suppliers of x and 10 suppliers of y). The case of one cluster has the highest probability to appear of all the cases; the greater gap between the number of retailers and the number of suppliers, the more likely that retailers tend to cluster. Retailers of x and y only stay at supplier locales and constitute pairs.



Probability distribution of the numbers of clusters with 10 retailers of product x and the number of retailers of product y ranging from 2 to 16 (shown in the horizontal axis). The case of only one cluster is most likely to emerge. The greater gap between the number of retailers of product x and the number of retailers of product y, the more likely that the case of fewer clusters will emerge.

Conclusions

This paper builds agent models to examine retail location choice on a supply chain network of consumers, retailers, and suppliers, considering the impact of both market demand, transport cost, and travelers' trip chaining behavior. In a market of homogenous goods, we can find symmetric retail distribution patterns and average cluster density change dynamically as different numbers of retailers join the market. Our sensitivity tests also find different patterns when the shipping cost or consumers' willingness to travel changes. It can be learned that based on our simplified supply chain model, the development of a market does not always lead to condensed agglomeration of business locations.

In a market of two complementary goods, we find self-organizing retail clusters with features different from the results of the first model. First, multiple equilibria of retail distributions are common and retailers of complementary goods constitute pairs. Second, co-locating of all retailers of complementary goods appears with a high probability. Moreover, the likelihood of clustering increases with the gap between the number of retailers of complementary goods.