SPATIAL INTERACTION CONCEPT OF ULLMAN

A systematic approach to the study of transportation in the context of spatial interaction was developed by Ullman (1954, 1956, 1957, 1967, 1970, and 1973).

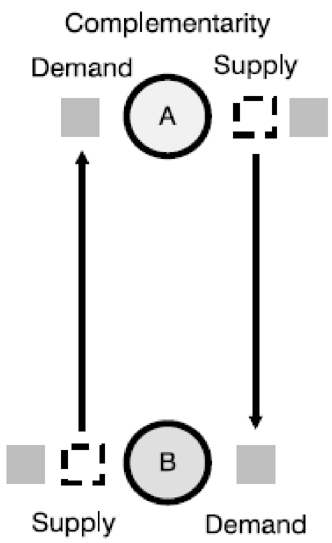
The fundamental concept developed by him is known as 'Ullman's Principles' or 'Ullman's Traid'. Ullman (1954, 1957, and 1973) put forward three main reasons of the interactions involving transportation:

(i) Complementarity

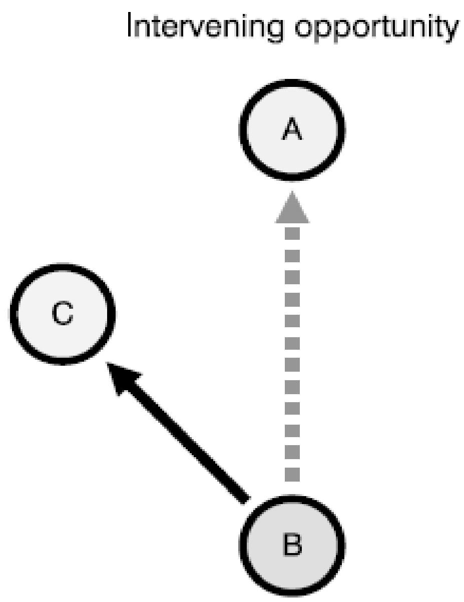
(ii) Intervening opportunity, and

(iii) Transferability.

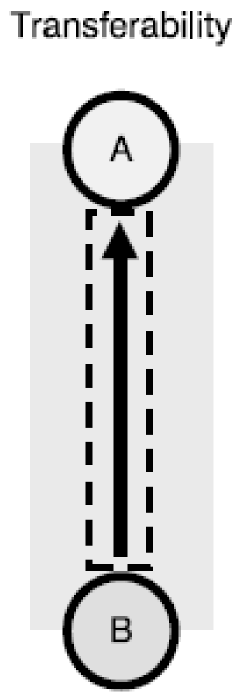
Complementarity: There must be a supply and a demand between the interacting locations. A residential zone is complementary to an industrial zone because the first is supplying workers while the second is supplying jobs. The same can be said concerning the Complementarity between a store and its customers and between an industry and its suppliers (movements of freight). If location B produces/generates something that location A requires, then an interaction is possible because a supply/demand relationship has been established between those two locations; they have become complementary to one another. The same applies in the other direction (A to B), which creates a situation of reciprocity common in commuting or international trade.



Intervening opportunity: There must not be another location that may offer a better alternative as a point of origin or as a point of destination. For instance, in order to have an interaction of a customer to a store, there must not be a closer store that offers a similar array of goods. If location C offers the same characteristics (namely complementarity) as location A and is also closer to location B, an interaction between B and A will not occur and will be replaced by an interaction between B and C.



Transferability: Freight, persons or information being transferred must be supported by transport infrastructures, implying that the origin and the destination must be linked. Costs to overcome distance must not be higher than the benefits of related interaction, even if there is complementarity and no alternative opportunity. Transport infrastructures (modes and terminals) must be present to support an interaction between B and A. Also, these infrastructures must have a capacity and availability which are compatible with the requirements of such an interaction.



Transferability is a combination of 3 considerations-

1. The characteristics and value of the commodity.
2. The distance over which the interactions need to take place (as measured in both time and money penalties).
3. The ability of the commodity to bear the costs of movements. If it costs too much money to transport or it takes too long time to arrive then interaction will not take place.

THE GRAVITY MODEL

The gravity model is the most common formulation of the spatial interaction method. It is named as such because it uses a similar formulation than Newton's law of gravity. Gravity like representations have been applied in a wide variety of contexts, such as migration, commodity flows, traffic flows, commuting, and evaluating boundaries between market areas.

Accordingly, the attraction between two objects is proportional to their mass and inversely proportional to their respective distance. Consequently, the general formulation of spatial interactions can be adapted to reflect this basic assumption to form the elementary formulation of the gravity model:

$$T_{ij} = k \frac{P_i P_j}{d_{ij}}$$

Pi and Pj: Importance of the location of origin and the location of destination.

dij: Distance between the location of origin and then location of destination.

k is a proportionality constant related to the rate of the event. For instance, if the same system of spatial interactions is considered, the value of k will be higher if interactions were considered for a year comparatively to the value of k for one week.

Thus, spatial interactions between locations i and j are proportional to their respective importance divided by their distance. The gravity model can be extended to include several calibration parameters:

$$T_{ij} = k \frac{P_i^{\lambda} P_j^{\alpha}}{d_{ij}^{\beta}}$$

P, d and k refers to the variables previously discussed.

β (beta): A parameter of transport friction related to the efficiency of the transport system between two locations. This friction is rarely linear as the further the movement the greater the friction of distance. For instance, two locations services by a highway will have a lower beta index than if they were serviced by a regular road.

λ (lambda): Potential to generate movements (emissivity). For movements of people, lambda is often related to an overall level of welfare. For instance, it is logical to infer that for retailing flows, a location having higher income levels will generate more movements (customers).

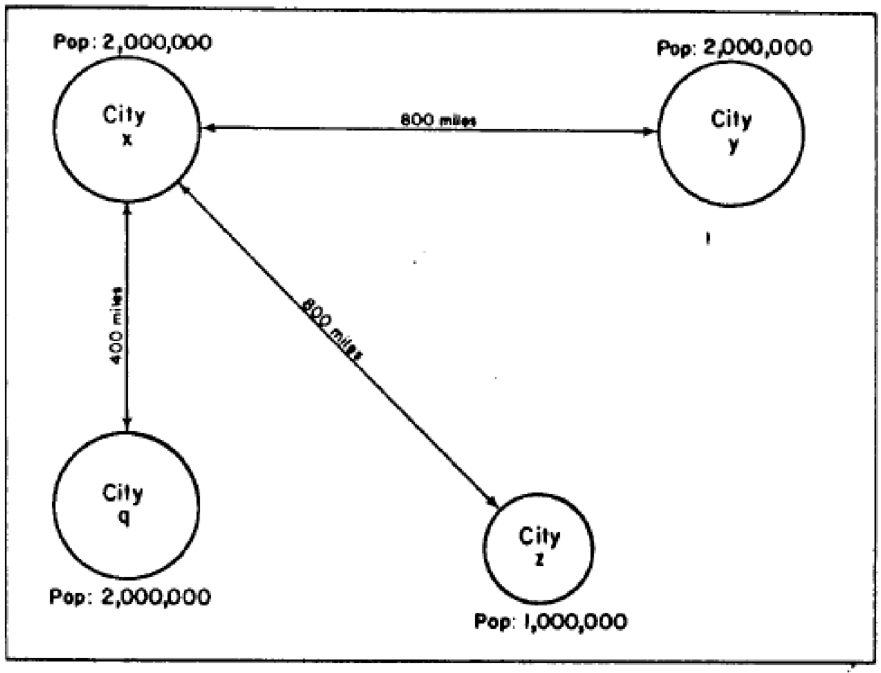
α (alpha): Potential to attract movements (attractiveness). Related to the nature of economic activities at the destination. For instance, a center having important commercial activities will attract more movements.

A significant challenge related to the usage of spatial interaction models, notably the gravity model, is related to their calibration. Calibration consists in finding the value of each parameters of the model (constants and exponents) to insure that the estimated results are similar to the observed flows and that those results can be replicated. If it is not the case, the model is of limited use as it predicts or explains little. It is impossible to know if the process of calibration is accurate without comparing estimated results with empirical evidence.

In the two formulations of the gravity model that have been introduced, the simple formulation offers a good flexibility for calibration since four parameters can be modified. Altering the value of **beta**, **alpha** and **lambda** will influence the estimated spatial interactions. Furthermore, the value of the parameters can change in time due to factors such as technological innovations, new transport infrastructure and economic development.

For instance, improvements in transport efficiency generally have the consequence of reducing the value of the beta exponent (friction of distance). Economic development is likely to influence the values of alpha and lambda, reflecting a growth in mobility.

The value of Beta can vary according to the socio-economic conditions in a region. Low levels of development and unsophisticated transport development implies higher power than 2. When the exponent value is high it implies a rapid decrease in the movement with distance and vice versa. When it is 0 there is no frictional effect of distance.



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