DISTANCE, SPATIAL INTERACTION AND TRANSPORT MODELS

Geographical distance is the **distance** measured along the surface of the earth. Generally, **distances** between points which are measured by **geographical** coordinates in terms of latitude and longitude.

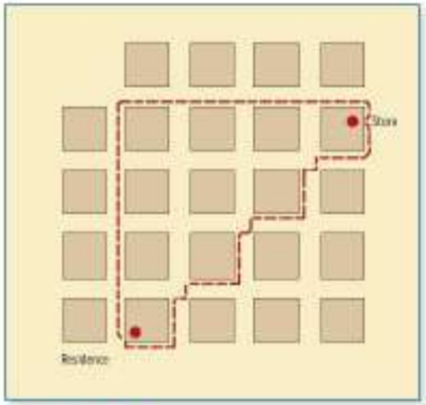
Most of us know what distance is. It's the total space between two things or places, usually measured in feet, yards, miles or even city blocks. In geography, when measured in a standard unit of length, this is referred to as **absolute distance**. What is relative distance, then? **Relative distance** is a measure of the social, cultural and economic relatedness or connectivity between two places - how connected or disconnected they are - despite their absolute distance from each other.

“Geodesics” and the different meanings of distance:

1) **Physical distance or Spatial distance:** objective, spatial, measured

2) Time distance: related to space/physical distance, but not always perfectly correlated. Spatial distance is expressed with respect to time.

- Isochrones (An **isochrone** is defined as "a line drawn on a map connecting points at which something occurs or arrives at the same time".)
- Time distance can vary with time



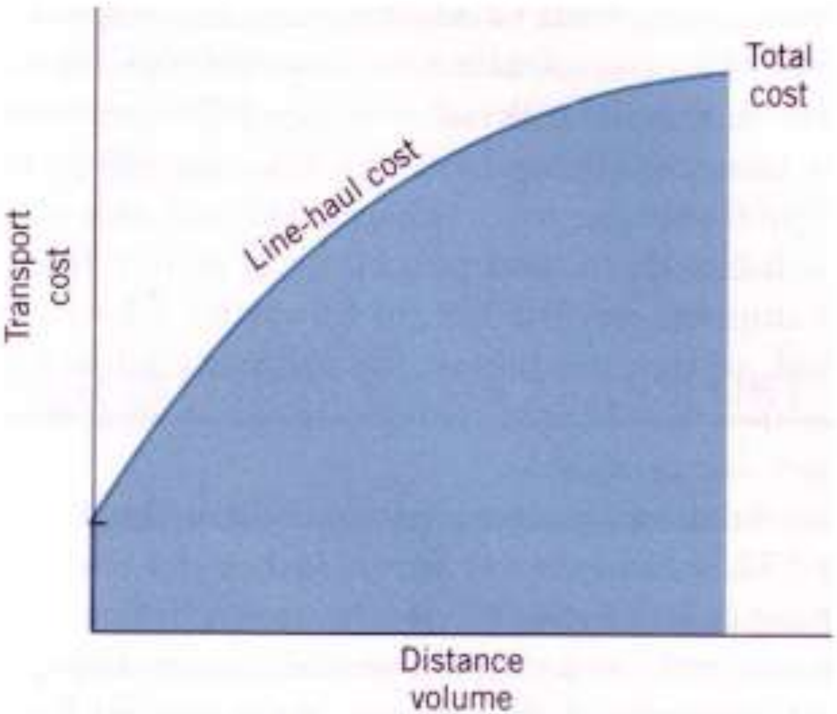
▲ FIGURE 2.6 Shortest distance route

A non-straight line, shortest distance route.

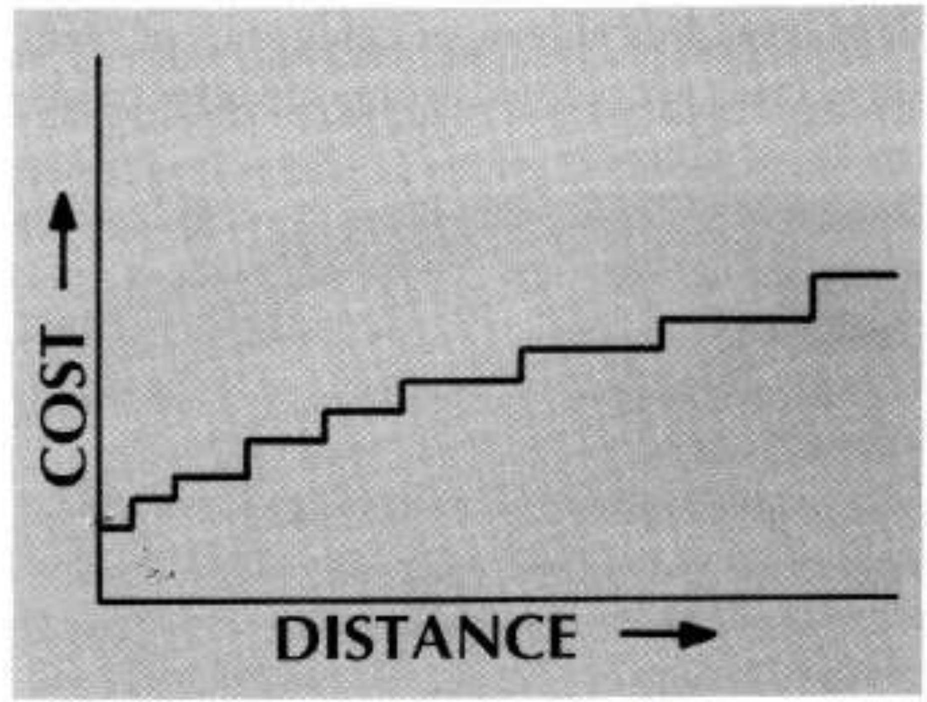
A “switchback” route

3) Economic Distance: converting physical or time distance to cost. Spatial distance is expressed with respect to transport cost.

- Different price structures



"tapering"



"stepped"

4) Cognitive distance: perceptual, cannot be measured, but perhaps more important than 1,2,3?

- Mental maps

5) Social distance: group differences

- ethnicity, race, religion, etc.

Spatial interactions

A **spatial interaction is a realized movement of people, freight or information** between an origin and a destination. It is a transport demand/supply relationship expressed over a geographical space.

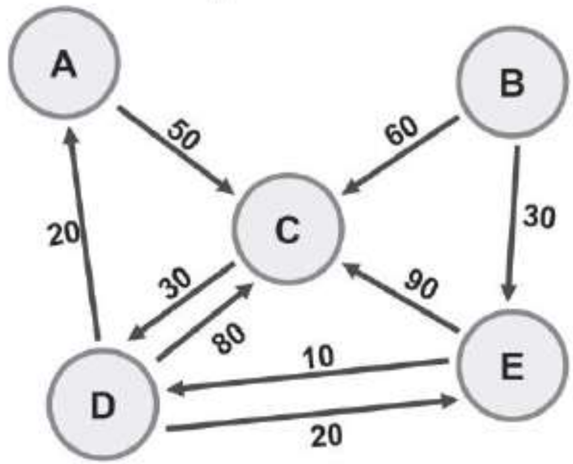
Spatial interactions cover a wide variety of movements such as journeys to work, migrations, tourism, the usage of public facilities, the transmission of information or capital, the market areas of retailing activities, international trade and freight distribution. Economic activities are generating (supply) and attracting (demand) flows. **The simple fact that a movement occurs between an origin and a destination underlines that the costs incurred by a spatial interaction are lower than the benefits derived from such an interaction.**

As such, a commuter is willing to drive one hour because this interaction is linked to an income, while international trade concepts, such as comparative advantages, underline the benefits of specialization and the ensuing generation of trade flows between distant locations.

Origin/destination matrices:

Each spatial interaction, as an analogy for a set of movements, is composed of an origin/ destination (O/D) pair. Each pair can itself be represented as a cell in a matrix where rows are related to the locations (centroids) of origin, while columns are related to locations (centroids) of destination. Such a matrix is commonly known as an origin/ destination matrix, or a spatial interaction matrix.

Spatial Interactions



O/D Matrix

	A	B	C	D	E	Ti
A	0	0	50	0	0	50
B	0	0	60	0	30	90
C	0	0	0	30	0	30
D	20	0	80	0	20	120
E	0	0	90	10	0	100
Tj	20	0	280	40	50	**390**

Above figure represents movements (O/D pairs) between five locations (A, B, C, D and E). From this graph, an O/D matrix can be built where each O/D pair becomes a cell. A value of 0 is assigned for each O/D pair that does not have an observed flow. In the O/D matrix the sum of a row (Ti) represents the total outputs of a location (flows originating from), while the sum of a column (Tj) represents the total inputs of a location (flows bound to). The summation of inputs is always equal to the summation of outputs. Otherwise, there are movements that are coming from or going to outside the considered system. The sum of inputs or outputs gives the total flows taking place within the system (T).

It is also possible to have O/D matrices according to age group, income, gender, etc. Under such circumstances they are labeled sub- matrices since they account for only a share of the total flows.

The basic assumption concerning many spatial interaction models is that flows are a function of the attributes of the locations of origin, the attributes of the locations of destination and the friction of distance between the concerned origins and the destinations. The general formulation of the spatial interaction model is as follows:

$$T_{ij} = f(V_i, W_j, S_{ij})$$

Tij: Interaction between location i (origin) and location j (destination). Its units of measurement are varied and can involve people, tons of freight, traffic volume, etc. It also relates to a time period such as interactions by the hour, day, month, or year.

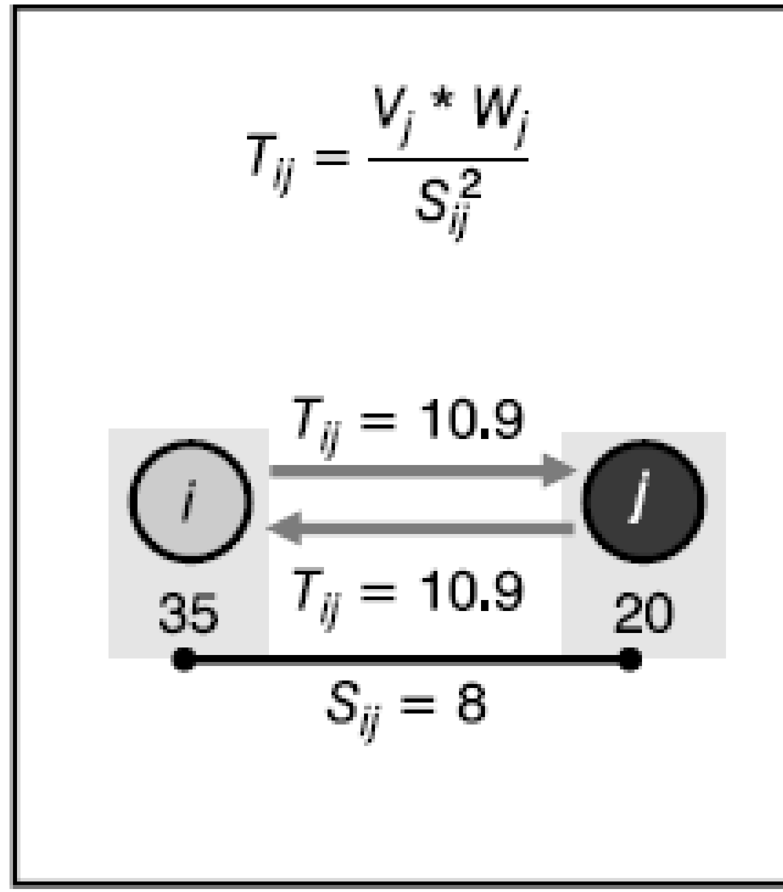
Vi: Attributes of the location of origin i. Variables often used to express these attributes are socioeconomic in nature, such as population, number of jobs available, industrial output or gross domestic product.

W_j: Attributes of the location of destination j. It uses similar socioeconomic variables than the previous attribute to underline the reciprocity of the locations.

S_{ij}: Attributes of separation between the location of origin i and the location of destination j. Also known as transport friction, friction of distance. Variables often used to express these attributes are distance, transport costs, or travel time.

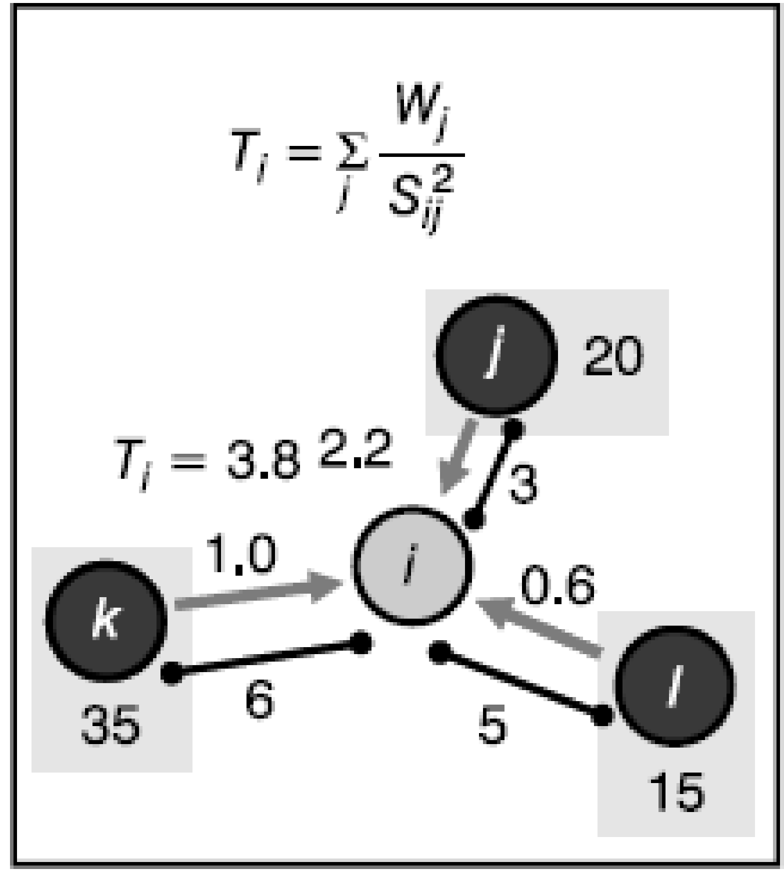
From this general formulation, three basic types of interaction models can be constructed:

Gravity model: Measures interactions between all the possible location pairs by multiplying their attributes, which is then pondered by their level of separation. Separation is often squared to reflect the growing friction of distance. On the given Figure, two locations (*i and j) have a respective "weight" (importance) of 35 and 20 and are* at a distance (degree of separation) of 8. The resulting interaction is 10.9, which is reciprocal.



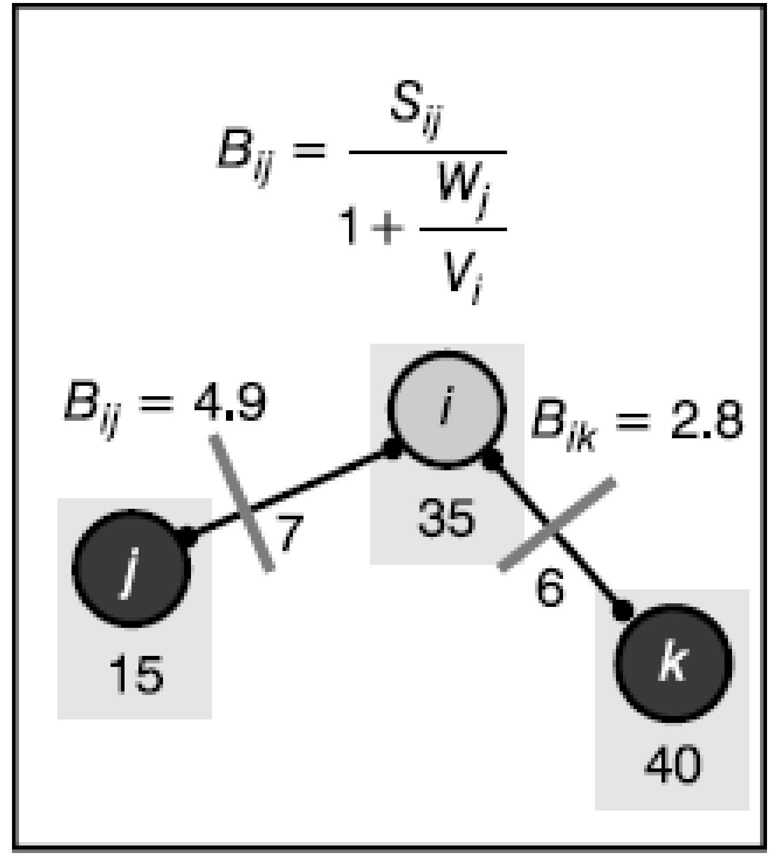
Gravity model

Potential model: Measures interactions between one location and every other location by the summation of the attributes of each other location pondered by their level of separation (again squared to reflect the friction of distance). In the given Figure , the potential interaction of location *i (Ti) is measured by adding the ratio "weight"/* squared distance for each other locations (*j, k and l). The potential interaction is 3.8*.



Potential model

Retail model: Measures the boundary of the market areas between two locations competing over the same market. It assumes that the market boundary between two locations is a function of their separation pondered by the ratio of their respective weights. If two locations have the same importance, their market boundary would be halfway between. In the given Figure, the market boundary between locations *i and j (Bij) is at a distance of 4.9 from i (and consequently at a distance of* 2.1 from *j).*



Retail model

Breaking point Theory

In 1949, Reilly's Law Of Retail Gravitation was modified by P. Converse to predict the distance of the breaking point, i.e., the intermediate point between two cities. He explained that between two towns/cities there is a point of limit up to which one city exercises the dominating retail trade influence and beyond which the other city dominates. If enough breaking points can be established around a city, its theoretical urban field can be delimited in that way. The interaction between the breaking point can be delimited by the help of the following formula–

djk = *dij*

$$djk = \frac{dij}{1+\frac{\sqrt{Pi}}{\sqrt{Pj}}}$$

Where, *i* and *J*	=two cities
k	=Breaking point between two cities
djk	=distance from *j* from the breaking point *k*
dij	=distance between *i* and *j* cities.

$$djk = \frac{15}{1+\sqrt{\frac{16,000}{4000}}}$$

Pi & Pj =Population of *i* and *j* cities.

Suppose two towns with populations of 16,000 and 4,000 respectively are located 15 km apart the breaking point will be at a distance of 5 km from the smaller city according to the formula (Fig. 8.4).