# Gravity model

The gravity model is aimed at formalising, studying and predicting geography of flows or interactions. The distribution of interactions in a set of places depends on their configuration, i.e. the force of attraction of each one and the difficulty of communication between them. The model has first been formulated in analogy with Newton's law of universal gravitation: two objects attract each other in direct proportion of their masses and in inverse proportion of the distance separating them. In the same way, in a relatively homogeneous circulation space, exchanges between two regions or two cities will be all the more important that the weight of these cities or regions is consequent and all the lower that they are distant from each other.

Thus the flow *Fij* between two areas *i* and *j* is directly proportional to the product of the masses *Pi* and *Pj* of each area and inversely proportional to the distance *dij* which separates them:

*Fij = k Pi Pj / dija*

*k* is a constant determined when adjusting the model and *a* is a constant, either a priori assumed as equal to 2 or estimated by adjustment, it represents then the intensity of <u>friction</u> opposed by <u>distance</u> to interaction.

Analogy with the Newtonian model is not an explanation for geography, and only partial interpretations of the gravity model have been established up to now. A real explanation should rely on the knowledge of behaviours in geographical space. Reasons for general relevance of the model may be intuitively understood if it is observed that:

the product of masses *Pi Pj* represents a conditional probability for an element of *i* to interact (or to exchange its location) with an element of *j*; the very quick decrease of interactions with distance is explained on the one hand by the cost implied by its covering, but also because it represents a considerable increase of the number of potential interactions around a given place: in a space that would be homogeneous from the standpoint of possible locations, to migrate to twice a distance means prospecting four times as many potential destinations, nine times as many if the distance is triple, twenty-five times as many it the distance if five times longer. It can be conceived that the probability to possess information about all these places, with such quality as to make a settlement decision, is decreasing rapidly and more like the square of distance than proportionally to it.

This simple formulation has been improved in order to make the model operational, in particular thanks to the works of A. Wilson. The model with constraint on the origins allows to fix the total flows generated by the origin areas, the one with constraint on destinations fixes the total flows on destination, while the one with double constraint ensures that the total flows estimated by the model will actually equate the total flows observed for each area. The gravity model is frequently used in order to analyse migration flows and to delimit trading areas in marketing (see law of Reilly). More refined expressions of the model are used in order to predict needs in transport infrastructure. Finally, under various forms, the gravity formulation of spatial interaction is integrated in numerous more complex models.

The gravity model generally summarises well the largest part of movements occurring in an environment where mobility and accessibility are relatively homogeneous. For example it predicts pretty well the importance of flows of home - work travels in an urban employment basin, based on the distribution of residential areas and of work areas, or else the pattern of interregional or interurban migrations of population at middle term in a given country. Although quite useful from a practical standpoint, the gravity model is a poor model from a theoretical standpoint; besides, it is a static model, which does not take into account evolution of configuration, in particular the one generated by the flows.

**Bibliographie**