QUANTITATIVE GEOGRAPHY & RESEARCH TECHNIQUES

GRAVITY POTENTIAL MODEL

DR. SUPRIYA

GUEST ASSISTANT PROFESSOR
DEPARTMENT OF GEOGRAPHY
PATNA UNIVERSITY, PATNA

CONTENTS

- Introduction
- Conceptual background
- The Gravity Model
- Other Models
- Criticism
- Model questions
- Suggested Readings

INTRODUCTION : GRAVITY MODEL

➤ The gravity model is a popular mathematical model used to predict the interaction between two or more places.

➤ In geography it has been used to simulate a variety of flow patterns, such as traffic and mail flows, telephone calls, and migration.

➤ Essentially, the gravity model can be used to account for any interaction or flow that is expected to move from one place to another.

➤ This idea has generated many mathematical manipulations of the model.

CONCEPTUAL BACKGROUND

➢ **The original gravity model is based on Newton's law of gravitation, expressed as :**

$$Gij = MiMj / (dij)^2$$

  ➢ where Gij is the gravitational bond between objects i and j,

  ➢ G is the gravitational constant,

  ➢ Mi and Mj are measures of the attractiveness of masses i and j,

  ➢ and d2 ij the square of the distance between objects i and j.

➢ The theoretical principle of the gravity model is two fold:

  (1) The degree of interaction is directly proportional to the size of the Ma

  (2) The degree of interaction is indirectly proportional to the distance that separates them.
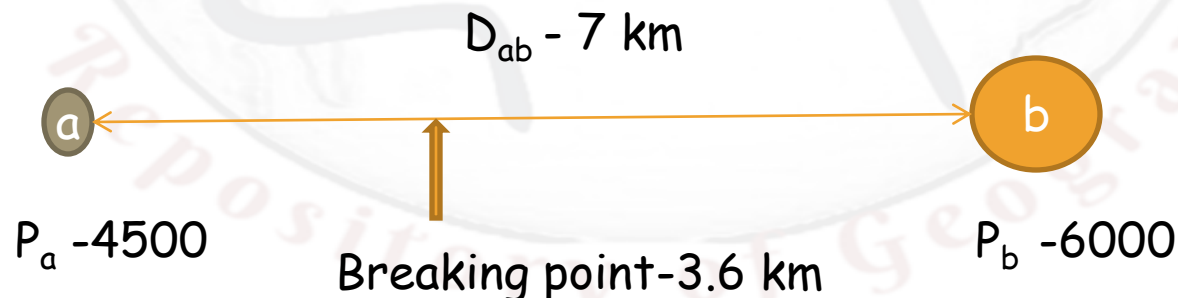
GRAVITY MODEL

- Social scientists have been using a modified version of Isaac Newton's law of gravitation to predict the movement of people, information, and commodities between cities and even continents.

- The Carey-Stewart-Warntz conceptualized "gravity model", of the so-called "social physics school" of geographical research, one of the four schools of quantitative geography, according to human geography historian Ron Johnston, in which population potential maps, or distributions of populations divided by distances between cities, are central.

- It takes into account the population size of two places and their distance. Since larger places attract people, ideas, and commodities more than smaller places and places closer together have a greater attraction, the gravity model incorporates these two features.

- The relative strength of a bond between two places is determined by multiplying the population of city a by the population of city b and then dividing the product by the distance between the two cities squared.

©Dr.Supriya

THE GRAVITY MODEL

✖ The gravity model was expanded by William J. Reilly in 1931 into Reilly's **"law of retail gravitation"** to calculate the breaking point between two places where customers will be drawn to one or another of two competing commercial centers.

✖ Equation :
$$Mab = \frac{P_a P_b}{(D_{ab})^2}$$

+ Where a & b is two centres, P_a & P_b is its Population;
+ D_{ab} is distance between the centres a and b;
+ M_{ab} is Interaction between two centres

D_{ab} - 7 km

a ⟵⟶ b

P_a -4500

Breaking point-3.6 km

P_b -6000

GRAVITY MODEL ....

➢ The basic gravity model formulation is the foundation of origin- and destination-specific models. It takes the following form: where I_{ij} is the interaction between places i and j, k is a constant, P_i and P_j are measures of the size of places i and j (e.g., populations), d_{ij} is the distance between places i and j, and b is the friction of distance.

➢ Larger values of b indicate that the interaction between i and j declines more rapidly with increased distance. Commonly, origin-specific models are used to predict flows from one place of origin to several destinations.

➢ With destination-specific models, flows are predicted from several origins to one destination.

➢ The gravity model was later reformulated to account for a network of interactions between places.

GRAVITY MODEL .....

➢ E. G. Ravenstein applied these principles and the gravity model concept to the social sciences with a study of migration patterns during the 19th century.

➢ Generally, three types of gravity model have evolved since Ravenstein's formulation:

✖ (1) Origin specific,

✖ (2) Destination-specific, and

✖ (3) Network or Potential models.

✖ Potential model is important in geographical research. Results of the potential model show the position of each place relative to all other places. Often, the results are illustrated spatially with a potential surface map.

OTHER MODELS

Some other models based on Gravity Model

- **Gravity Model is Further Developed in different calculation of Potentials like as:**

- Working Population Model: Mab= $\underline{WP_a\ WP_b/(d_{ab})^2}$

- Goods Shop Model: Mab= $\underline{S_aS_b/(d_{ab})^2}$ Where S = Shops

- Population Density Model: Mab= $P\underline{D_aPD_b/(d_{ab})^2}$

- Per Capita Income Model: Mab= $\underline{PCI_aPCI_b/(d_{ab})^2}$

- Travels Mean Model: Mab= $\underline{MT_aMT_b/(d_{ab})^2}$

- Communication line Model: Mab= $\underline{MC_aSMC/(d_{ab})^2}$

CRITICISM

- Opponents of the gravity model explain that it can not be confirmed scientifically, that it's only based on observation.

- Most criticism of the gravity model has concerned its use as a predictive tool.

- They also state that the gravity model is an unfair method of predicting movement because it's biased toward historic ties and toward the largest population centers. Thus, it can be used to perpetuate the status quo.

- Others believe that the model is biased toward existing spatial patterns and that this will perpetuate the status quo.

MODEL QUESTIONS

Q1. Describe the conceptual background of 'Gravity Potential Model' ?

Q2. The Population and distance are the two most significant factors in determining the extent of the relationship and interaction between two cities. Explain this statement with reference to Gravity Model.

Q3. Critically Examine the Gravity Potential model.

Q3. Write short Notes on:

I.   R**eilly's** The law of Retail Gravitation Model

II.   Ravenstein's Gravity Potential Model

Contact me:
Mob/ WA: 9006640841
Emai:supriyavatsa52256@gmail.com
Webpage: http://bhuvankosh.com

SUGGESTED READINGS

➢Barnes, Trevor J. and Wilson, Matthew W. (2014). "Big Data, Social Physics, and Spatial Analysis: the Early Years" (in: *Big Data & Society*, Jun.

➢Carey, Henry C. (1858-59). *The Principles of Social Science* (Vol I , Vol II, Vol III). J.B. Lippincott & Co.

➢Haynes, K. & Fotheringham, A. (1984). Gravity and spatial interaction models. Beverly Hills, CA: Sage.

➢Hartshorne, R., Perspectives on Nature of Geography, Rand MacNally, 1959.

➢Johnston, Ron J. and Sidaway J. (1997). *Geography and Geographers: Anglo-American Human Geography Since 1945* (pgs. 62-73). London: Arnold

➢*Kaushik (2009) Bhaugolik Chintan avam Bidhitantra (Hindi) , Pp.384-386, Rastogi Pub.Meruth.*

➢Ravenstein, E. The laws of migration. Journal of the Statistical Society of London vol. 48 pp. 167–235. (1885).

➢Stark, Werner. (1962). *The Fundamental Forms of Social Thought* (pg. 143). Routledge & Kegan Paul.

➢Stewart, John Q. (1940). "The Gravity of the Princeton Family," Princeton Alumni Weekly (pgs. Feb 9; in: Box 3, folder 9, John Q. Stewart Papers, Rare Books and Special Collections, Princeton University.

➢Stewart, John Q. (1947). "Empirical Mathematical Rules Concerning Distribution and Equilibrium of Population" *Geographical Review*, 37(3):461-85