

TAGAI GERGELY

**SPATIAL INTERACTION MODELS
IN REGIONAL STUDIES**

Main findings of the PhD thesis

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Introduction and objectives of the research

Spatial interaction models have been integrated in the set of tools for spatial analyses for a long time. They are still preferred methods of a number of economic and econometric analyses, transportation researches and regional studies as well as social geographic investigations. Such applications are favoured mainly due to their positive correlation with empirical findings and to their apparent explanatory force. Although the evaluation of the model building steps and a detailed presentation of its circumstances are regularly realized with reference to the analysed phenomenon, many questions arise about considering the benefits of these models. It is often unclear what is the element, structural schema or mechanism which accounts for the usage of a particular model in a questioned issue. Thus, on the basis the observed empirical fitness one can identify false triviality of the correlations.

The interpretation of the investigated phenomenon is largely defined – directly and indirectly – by the questions about the functional principles and the explanatory framework of the models. It is true that not all adaptations are appropriate for a detailed discussion of these issues. *The main objective of this thesis is to evaluate in what form and in what issues can spatial interaction models (especially potential model, as one of the most representative member of this family) be considered as adequate tools for regional studies.* Questions about the judgement of the use and the role of the model can be approached from several directions. On the one hand, *it is worth analysing the model characteristics and the conceptual issues of the application.* In this spirit, *the thesis attempts to evaluate the role of potential concept and potential model in the domain of social science studies.* Besides, *it also endeavours to explore the framework of adaptations influenced by the different considerations of model building (questions of formalization, main versions, model factors, spatial extension).* On the basis of them, *the explanation of functional principles of the model becomes possible, which allows the interpretation of the meaning of potential model.* This need is supported by the deficiencies found in the interpretation of different potential models. Thus, the research emphasizes the detailed investigation of this problem through the evaluation of its typical applications.

Beside reviewing conceptual-methodological considerations, potential model can also be judged on the basis of the analysis of spatial interaction patterns. Accordingly, *the second aim of the thesis is to present the possible usage of the model in interpreting spatial conditions of social interactions, and through this in presenting relative positions of spatial units within a system.* In order to answering these questions a triple model experiment has been realized. It focuses on different issues in an attempt to explore the possible use of

potential model in the investigation of spatial interaction structures in different regional frameworks and on distinct spatial levels. *The research attempts to interpret the interactions prevailing the European economic space and it evaluates the role of potential model in the analysis of different factors of spatial interactions. Finally the thesis attempts to model and judge how spatial interaction conditions can define the spatial arrangement of different socio-economic phenomena.*

Preliminaries

Spatial interaction models are not recently elaborated methods of regional studies. Their forerunners, the different social physical applications have been in use for about half a century; their evolution was running parallel with that of the various methodologies of social sciences. The potential model applications – as used in the thesis for characterizing spatial interaction patterns and as generally used today – were worked out in 1940s and in the 1950s, mainly by John Quincy Stewart and William Warntz (*Stewart*, 1947, 1948; *Stewart–Warntz*, 1958; *Warntz*, 1964). With the expansion of the tool set of quantitative analysis many analytical studies were published already in this period with the objective of evaluating the model comprehensively and to discuss its special methodological issues – role of its structure and its components (e.g. *Carrothers*, 1956; *Court*, 1966). Studies with the same objectives have been published regularly ever since then (*Taylor*, 1975; *Rich*, 1980; *Pooler*, 1987; *Frost–Spence*, 1995; *Tagai*, 2007a).

The typical adaptations of potential models (population potential, economic potential, market potential and accessibility models) and the framework of their interpretation were already developed on the basis of the earliest models (*Harris*, 1954; *Hansen*, 1956; *Warntz*, 1957). In spite of the fact that the different, but largely interconnected meanings have been introduced by the new dimensions of model applications in the past decades, their basic approach still reflects the logic of the early models (see, for example, *Geurs–van Wee* 2004; *Clemente et al.* 2009). The potential models have become one of the most frequently used tools in analysing spatial interactions – despite the sharp turns regarding the approaches prevailing in regional studies.

Beside the preliminaries dealing with the conceptual, methodological and empirical issues of spatial interaction models (and the potential model) it is worth underlining those writings which represent the modelling approach similar to ours in the thesis. They usually deal with the questions of relative positions in social space. Such works are studies evaluating the role of relative location in forming socio-economic characteristics, its correlations with

these factors and the possibilities of their representation (*Nemes Nagy*, 1998, 2009; *Abreu et al.* 2005). In some cases these studies offer comprehensive analyses, but mostly focus on a specific dimension of relative location (issues of cores and peripheries, accessibility conditions etc.). Several studies merge this approach with the possibilities of modelling spatial interactions and they also evaluate the role of these applications (especially potential model) in the investigation of regional development or other socio-economic processes (*Clark et al.* 1969; *Keeble et al.* 1982; *Spiekermann–Wegener*, 2004, 2006; *Tagai*, 2007b, 2009a, 2009b).

Methodology and data sources

According to the theoretical-methodological character of the thesis, the findings are primarily based on the evaluation of literary sources. Primarily this included reviewing - with a conceptual focus - documents dealing with the fundamental issues of the use of spatial interaction models and the potential model. The solution of model building of many other potential models – dealing with diverse questions of social space – also provided valuable information not only about the evaluation of the phenomena in question (core–periphery relations, regional development or the role of relative spatial positions), but about the refinement of the theoretical-methodological findings. These sources link together the results of many different disciplines like social geography, regional science, transportation research, sociology, econometrics and spatial planning.

All model adaptations discussed in this thesis are built on a very simplified version of potential model. As the objective of these investigations besides the characterization of European and Hungarian spatial interaction patterns is the evaluation of the potential model as a methodological tool in the above mentioned issues, it seemed appropriate to use a simplified model structure. This was completed with a number of additional mathematical-statistical and other analytical tools (calculation of different averages, procedures of making the diverse dimensions comparable, crosstab data evaluation) which relate to the question-formulation of particular research methods. Figures serving the graphic illustration of the research results were made by the simultaneous (complementary) use of several GIS applications and graphical suites.

Due to the simplified nature of representations and the structure of the potential model, the data needs of the presented examples aren't notable. Calculation of distances representing impedance factor of the model was uniformly realized by using the information of geocoded maps. The data source of the economic performance and demographic characteristics of the

European countries was the Eurostat regional statistics on NUTS2 and NUTS3 levels. While Hungarian sub-regional data (personal income and population conditions) originates from the National Regional Development and Spatial Planning Information System, based on the amassed databases of National Tax and Customs Administration and Hungarian Central Statistical Office. Sometimes in the case of international data it was necessary to complete the data series by an estimation procedure. It was realized on the basis of harmonizing national and other regional data series, taking into account the actual value distributions.

Results and conclusions

1) The basic finding of the thesis – and the starting point for further research – is the explanation of functional principles of spatial interaction models (especially potential model) on the basis that through them *the phenomena of social space can be interpreted not only on their own, but as parts of a system whose components mutually affect each other.*

- This can be established by the evaluation of the concept of social physics and by the overview of the theoretical framework of spatial interaction models.
- On the other hand this mechanism can also be confirmed by the detailed methodological analysis of the potential model – through deriving the formalization of the model application (role of model types, physical analogies) or the judgement of the function of particular model components (considerations of model building in relation to mass and impedance factors), or by defining further structural characteristics of the potential model (utility of self-potentials, inner and outer potentials).

2) Explanation issues arising from the conceptual and methodological evaluation of the model can be answered by the *multiple interpretation of the meaning of the potential model.* In the thesis it is worked out by *outlining the evolution of the notion of the term 'potential'* (appearing in empirical adaptations of the model) and by *modelling their network of relations.*

- It turned out that the various semantic fields of potential model (population potentials, economic potentials, market potentials and potential accessibility) largely overlap, yet their substantive elements widely differ. Consequently, their differentiation and independent interpretation are equally justifiable.
- Besides, this synthesis also points at that the potential model places the socio-economic issues in a special framework, in which spatially interpreted social phenomena are completed with the potential interrelationships and interactions among the elements of this spatial system.

3) Through the synthesis of the possible interpretations of the potential model it can be stated that *the model is a suitable tool for representing spatial interaction patterns. And it is also a potential indicator of relative location interpreted in social space.*

- On the basis of interpretation of many different model the thesis emphasizes the possible role of spatial positions (in relation to the whole of a spatial system or to the other parts of it) in the formation of socio-economic characteristics. In this sense the conceptual function of relative location conditions in social space implies a horizontal approach, linking the interpretation of the different meanings of potential model applications to each other.
- The research also highlights the role of the potential model in presenting the different factors of relative location. While the complex notion of relative position in social space can be grabbed through many different dimensions (like geographical localization, accessibility of socio-economic centres, neighbourhood conditions or borderland situation) and the individual factors can be evaluated appropriately in themselves, the phenomenon in its complexity can restrictively be represented by using the tool set of the regional studies. Nevertheless, the potential model may be able to play that role, as it is derived from the comparison of position factors with the described mechanisms of the model.

4) Through the evaluation of the spatial interaction processes, *the research reviewed the transformation of relative location conditions of the European economic space* since the mid-1990s.

- This makes one conclude that the former centre–periphery relations are only slightly modified. Even today the Western-European economic core(area) has the most favourable relative position compared with other parts of the continent. However, it is also detectable that while during the analysed period core areas have lost some of their advantages in the domain of location conditions, positional characteristics of peripheries have moderately improved. The nature of these spatial processes is largely shaded by the different ways of the transformation regarding spatial interaction and development patterns.

5) The thesis also presents *the possibilities for the complex evaluation of different dimensions of relative spatial positions with the help of the potential model.* The analysis focuses on the

role of local facilities and important economic centres and on the function of spatial interaction impacts within a given distance (neighbourhood, local and regional effects).

- One of the results of this review is the independently developed methodology of model building (based on relevant preliminaries). It reflects on the presented factors of relative location and shows an alternative way for accounting potential model components – by dismantling the model and through the (logically different) multiple classifications of its elements.
- The analyses carried out on Europe as a whole indicate that none of the factors taken into account (e.g. influence of economic centres, impact of neighbours) are able to dominate the evolution of spatial interaction processes in themselves. In most cases, only the combined effect of different dimensions can reach dominant position among the actors of shaping spatial interaction structures. Thus, for example, the leadership of the Western-European economic core among the centres of influence on spatial interaction conditions of East-Central Europe is justifiable – it has good accessibility conditions and remarkable economic power too, and these can generate synergic effects.
- At the same time, it was also found that even though under the impact of above mentioned interaction factors the upgrading effect of the relative spatial position of the local metropolitan areas in East-Central Europe is minor, their progress is still a very important spatial process in a local sense.

6) The research *illustrates the evaluation possibilities of the relationship between economic development and relative positions in social space, via the examples of the European economic performance and the Hungarian income conditions.*

- The analyses confirm that there is a strong coherence between the relative location conditions and the spatial structure of the socio-economic phenomena. However, it can also be stated that this relationship isn't linear. The apparent situation suggested by relative location conditions may divert from the actual development position remarkably.
- The thesis also revealed that behind these differences there are both positive and negative local facilities whose impact can overwrite the influence of spatial interaction characteristics in the formation of development positions.

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