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MODELLING OF THE SOCIAL, ECONOMIC AND SPATIAL TRANSFORMATIONS IN THE PROVINCE OF MASOVIA

Jan W. Owsiński[1] • Przemysław Śleszyński[2]

[1] Systems Research Institute
Polish Academy of Sciences
Newelska 6, 01-447 Warsaw, Poland
e-mail: Jan.Owsinski@ibspan.waw.pl

[2] Institute of Geography and Spatial Organization
Polish Academy of Sciences
Twarda 51/55, 00-818 Warsaw: Poland
e-mail: psleszyn@twarda.pan.pl

The general prerequisites and the objectives of the project

Contemporary socio-economic development gives rise to intensive changes concerning spatial development and land use, which, in turn, requires effective territorial management. One way to ensure such effective management is to forecast changes that will take place in various domains of socio-economic life, with the aim of adopting, on this basis, adequate policies: social, spatial, environmental, etc. This was exactly the purpose for which the self-governmental authorities of the province of Masovia commissioned, through the intermediary of the Masovian Bureau of regional Planning, the project entitled "Modelling of the social, economic and spatial transformations in the province of Masovia". This project constituted a component in a much wider systemic undertaking, "Development Trends of Masovia".[1]

The project here considered was carried out in 2011-2013 by the Systems Research Institute of the Polish Academy of Sciences (SRI PAS, project leader) and the Institute of Geography and Spatial Organization, also

[1] For more on this broader project see http://www.trendyrozwojowemazowsza.pl. The results of this project were published, in their major part, in 19 volumes of the series entitled "Trendy Rozwojowe Mazowsza" ("Development Trends of Masovia") and in "Atlas. Społeczno-demograficzny rozwój Mazowsza" ("Atlas. The socio-demographic development of Masovia") http://www.mbpr.pl/seriatrm.html.

of the Polish Academy of Sciences (IGSO PAS, subcontractor), by a team of 14, namely:

- SRI PAS: Jan W. Owsiński (head of the project), Marcin Andrzejewski, Jan Gadomski, Anna Olwert, Przemysław Prygiel, Rafał Ponichtera;
- IGSO PAS: Przemysław Śleszyński (coordinator from the side of IGSO PAS), Konrad Czapiewski, Aleksandra Deręgowska, Krzysztof Janc (University of Wrocław), Tomasz Komornicki, Piotr Rosik, Jerzy Solon, Marcin Stępniak.

The primary objective of this project was to develop an integrated computer tool, supporting the processes of analysis and decision-making with respect to the socio-economic system of the Masovian province in a spatial setting. In particular, this concerned the development of:

1. A set of models of the social, economic and spatial changes in the province of Masovia;

2. A database of indicator values to be used in the modelling of the social, economic and spatial transformations in the province of Masovia, founded on the data for 2002-2009 (subsequently updated until 2011 whenever possible);

3. Forecasts, elaborated with the use of the models developed, until 2015, and the projections, in most cases, up until 2025 or even 2030;

4. Computer application, serving to set the parameters of models, as well as to run the models and determine the forecasts and projections.

Construction of the forecasting models

The outline for the conceptual and logical structure of the approach adopted is provided in Figure 1. The fundamental principle in the development of models was to base them on the trends and interrelations, identified with the use of the available data for 2002-2009, or, in cases when this was possible, 1999-2010. This meant that the models developed were in their majority quantitative empirical models. Models were to span 19 subject-wise defined domains, specified by the commissioning body (Fig. 2).

For each of the domains specified models were developed separately, using different detailed methodological prerequisites, with a domain-specific set of variables and indicators (one can get a feeling of this diversity by comparing the exemplary references for different domains, say Czapiewski, 2010; and Solon, 2008a,b). Yet, the causal relationships and the assumptions made for other domains were also accounted for. In practice, this meant quite strong associations, in many situations of a truly strict nature, between the models of particular phenomena, often leading to essential feedback loops. Thus, for instance, the demographic projections, and the expected

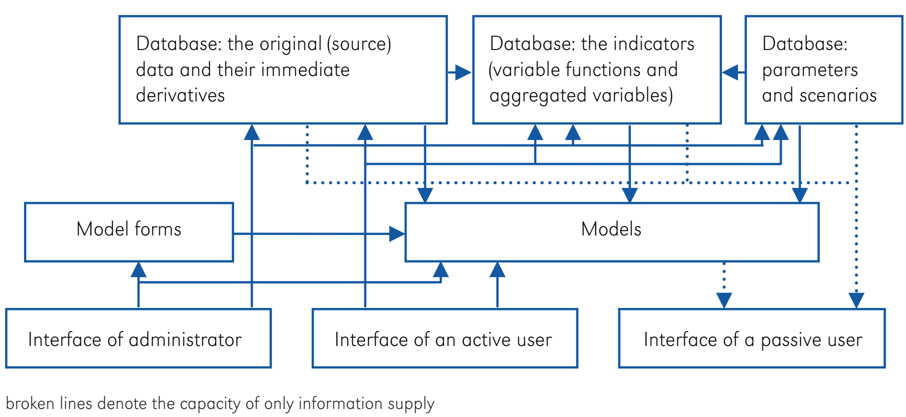

Figure 1. Scheme of the structure of ultimate computer application and its basic use and servicing forms

migratory inflows exerted an influence on the indicators, related to the labour market absorption capacity and to the financial standing of the self-governmental authorities (for a pertinent analysis, see Owsiński 2009; Owsiński & Andrzejewski 2010).

An essential criterion of acceptance of models within the particular domains was their mutual and systemic consistency, that is, the possibility of interpreting the respective results in the framework of the holistic perspective. Two fundamental aspects of modelling were in sight in this context: (1) the possibility of interpreting the results of models from the point of view of the entire system considered (holistic interpretation), and (2) technical consistency, meaning, in particular, the possibility of using the results of some models in the framework of the other ones from among all those making up the system.

The basic spatial units of reference for the models developed were municipalities and counties. For some domains or individual indicators, the models developed also concerned definite classes of spatial units, distinguished with respect to their functional features. Thus, for instance, a distinction was made between the bigger towns, suburban zones, and farming municipalities. This was meant to improve the fit of the projections, since there is a higher probability of adequate prevision of the processes considered within the so-defined relatively homogeneous classes, more so than for the individual municipalities. Hence, it was also possible to better match the results obtained to the needs of the

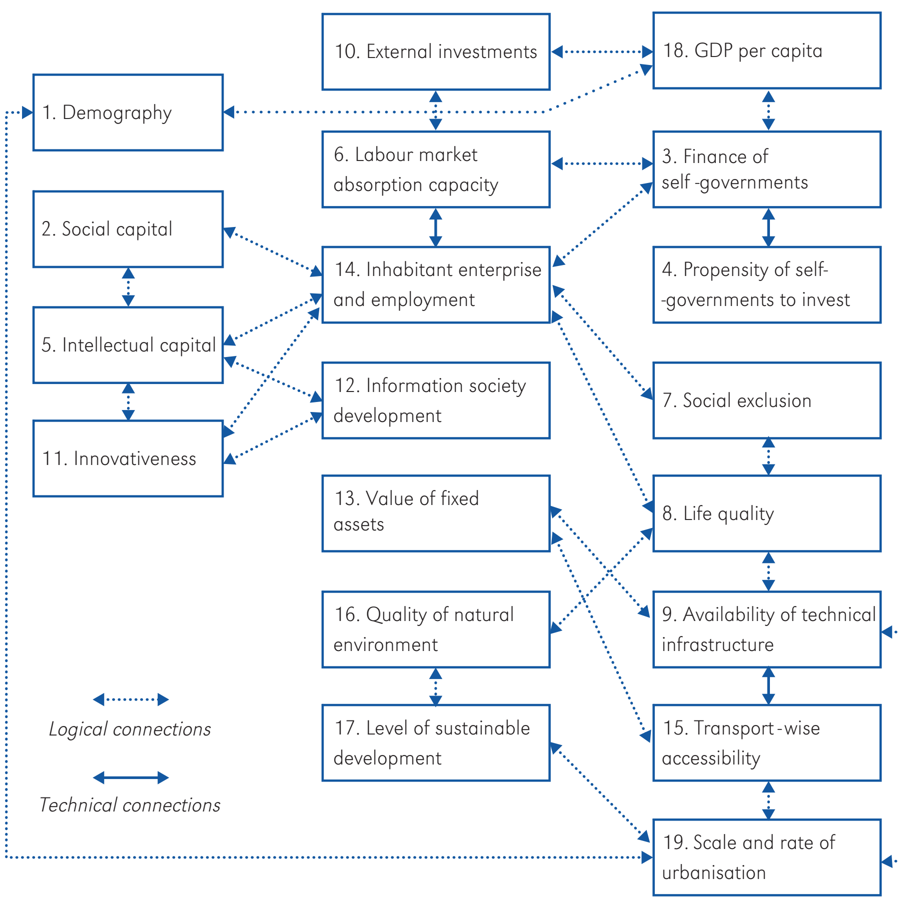

Figure 2. The most important logical and technical connections between the 19 domains of modelling

conduct of policies and formulation of development strategies in the regional-functional and spatial perspectives.

Development variants and scenarios

One of the fundamental assumptions in the modelling work was to admit various options of the future course of events. For this purpose, both individual models were endowed with the capacity of introducing some variants by the user, and the more general development scenarios were formulated. It was most frequent that an individual model offered a choice of two or three variants of the course of future development. In particular, in the domain of urbanization (domain 19) these options were:

1. The variant of moderate urbanization: persistence of the present-day trends as to the spatial changes – the concentric pattern of economic activity in the setting of cores-suburban zones-peripheries; preservation of the strong position of the cores as the primary destination of job commuting, along with slow economic growth in the peripheries, but also with the assumption of stagnation or slow growth on the labour market and slow expansion of the transport systems, which shall not be conducive to the processes of extension of the daily reaches of influence;

2. The variant of heavy urbanization, or, in extreme cases – hyper-urbanisation – the intensification of the polarization tendencies and of the current trends regarding the economic-spatial changes, i.e. especially the concentration of jobs in the best developed centres, especially in Warsaw, at the expense of other areas, extension of the transport system components, which serve mostly to improve in job commuting and not so much the diffusion of development stimuli and the creation of new jobs;

3. The dis-urbanisation, or even counter-urbanisation, variant – strong expansion of the transport systems, conducive to commuting and farther migrations of a permanent character, slight increases or even decreases of the numbers of jobs, especially in the bigger urban centres, to the advantage of the smaller centres and rural areas, stronger tendencies of de-concentration of populations, associated with a deeper re-evaluation as to the location factors, decisive for the undertaking of migration, including, as an important aspect, the environmental one, but also an increase in the nuisances of urban life, as the basic factor, pushing-out from the cities towards the more traditional rural areas.

It was assumed that of these three variants the most probable one is the first – the variant that admits the future developments most similar to the current ones (for a related study, see Śleszyński, 2007).

A different example concerns the demographic model, where three basic variants were also assumed (with the classic setting of 'continuation', 'worsening', and 'improvement'), but the active user was also allowed 'manual manipulation' of some of the fundamental parameters (related to trends in fertility and mortality).

In just a few cases no options were offered to the user, mainly in view of difficulty in performing calculations for these different options, and of the difficulty in formulating plausible 'alternative futures'.

The mainline general scenarios concerned the megatrends associated with changes in the GDP, lifestyles and consumption, the share of the province of Masovia in national economic growth, spatial and environmental policies, etc. There are, however, altogether only 6 variables governing the general scenarios, with two or three values assigned to these variables. Altogether, a user has the possibility to choose among several dozen composite general scenarios.

Source data, variables and indicators

There are five types of source data, distinguished for both technical and substantive purposes in the development of models. First, *constants* (assumed not to change over the entire period envisaged, i.e. 2010-2025, usually well-established known values); then: *arbitrary* values (assumed by the author of the model on the basis of own knowledge, experience and intuition), *estimates* (assumed on the basis of trends formed by the recent available data, with the trend having either linear or some nonlinear character), *model-based* values (transmitted from other models, where such data are calculated). Such data within a given model were referred to as *algorithmic* data, resulting from the concrete form of a model.

There were altogether some 250 kinds of source data used in the calculation of the intermediary and output values of the respective models. It was assumed in the project that the source data would possibly all originate from official, well established and publicly available sources – in this case primarily (in fact almost exclusively) from the Local Data Base of the Central Statistical Office (BDL GUS). This concerns, in particular, the annual data for all the 315 municipalities of the province of Masovia for population numbers (17 age groups for both genders, i.e. 34 numbers, deaths and births, as well as migration data). Given that the basis for the demographic models was constituted by the data for 12 consecutive years, we dealt with close to half a million source-data items.

It should be emphasized that while we dealt with 19 domains, almost each of these domains mentioned in Figure 2 is represented by more than one indicator, treated as representing the given domain. There are altogether close to 70 such indicators, which are the proper subject of modelling. In addition, there is also a number of auxiliary, intermediate variables, which are also usually modeled (sometimes, actually, they are quite simple transformations of the source data), but by themselves are not formally treated as representing a given domain. Some of these intermediate variables are, in fact, used in several models.

Thus, from the point of view of data processing we can speak of *input data* (mostly source data, or arbitrary data), *intermediate variables*, having various characters, and resulting from very differentiated transformations, and the proper *indicators*. This, however, is not really the final stage, because in many cases indicators from one domain are used to calculate the indicators in other domains, and so are treated as intermediate variables. These latter indicators might have a synthetic character (an indicator, being an aggregate of several other indicators and/or intermediate variables), or might be a further transformation, based on the input indicator and other quantities.

Models

Models developed for the particular domains and their indicators were based on the original methodological developments proposed by the respective authors. These models featured quite diverse forms and degrees of difficulty, and from the computational point of view as well. As mentioned before, their forms also differed substantially. In some situations, even quite advanced analyses led to very simple models (see a similar case reported in Gadomski & Owsiński 2008).

Thus, for instance, in the case of transport-wise accessibility, the notion of potential accessibility was made use of, based on the modelling of car traffic velocity, following the methodology elaborated within the IGSO PAS (Komornicki et al. 2010). In this concrete case the indicator of the potential accessibility for a municipality, accounting for the so-called own potential of the municipality and the exponential function, representing the friction of space (of distance), took the following form:

$$DTR_i = LUDN_i \exp(-\beta t_{ii}) + \\ + \sum_i LUDN_j \exp(-\beta t_{ij}) + \\ + \sum_k LUDN_k \exp(-\beta t_{ik})$$

where:

DTR_i – denotes the transport-wise accessibility of the municipality *i* from the province of Masovia,

$LUDN_i$, $LUDN_j$ – are the population numbers in the municipalities *I* and *j* in the province of Masovia,

$LUDN_k$ – is the population number in municipality k outside of the province of Masovia,

t_{ii} – denotes the internal travel time in municipality i,

t_{ij} – denotes the travel time between municipalities i and j,

t_{ik} – denotes the travel time between municipalities i and k, and

β – is the coefficient, having the sense of weight of travel times.

In terms of the sheer numbers, the biggest and the most burdensome model, calculation-wise, was, of course, the demographic model, producing at each run several hundred thousand numbers, summing up to several basic indicators for each of the municipalities, with, of course, the possibility of aggregation to counties and to the province as a whole. The essential methodological difficulty in the development of this model consisted in the possibly precise identification of model parameters, given that the source data concerned 5-year age groups, and not year-by-year cohorts (see Owsiński & Kałuszko 1998 for a similar model). In this case the indicators were population number, the feminization index, the shares of people of pre- and post-productive age, etc. At the same time, the results from this model were used in quite a significant proportion of other models (indicators), as shown, for instance, above.

Computer application

The project produced a computer application, as mentioned above, meant to provide the users with a hands-on tool for obtaining forecasts and projections for the selected units or aggregates, and for the selected scenarios. The interface developed for the application is possibly intuitive, and is based on a number of standard elements and mechanisms, so as to allow for an easy use and interpretation of the results obtained. This concerned both the visual and functional layer (buttons, icons, sequencing of actions, etc.), and a certain similarity to the typical spreadsheet applications (see an instance in Fig. 3).

The application is easily installed and functions in the Java environment, with special emphasis on use with Microsoft operational systems, but with the possibility of deployment with Linux, as well. Although the models can be run for all the municipalities and/or for all the counties of the province, the application is not endowed with a mapping function, since an already existing mapping application was to make use of the output from the respective models. The output from the model runs takes the form of graphics, as well as exportable tables of values. Some definite comparison functions are also available (comparison between selected units, or with the corresponding averages for the province).

The development of the application in terms of details of its presentation layer and functionality was carried out in close cooperation with the representatives of the commissioning body. A working relationship was established for this purpose, which added quite significant value to the final product.

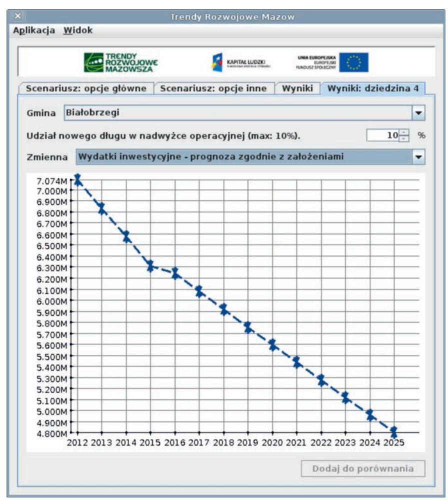

Figure 3. A screenshot showing a glimpse of the graphical aspect of the application

Editors' note:
Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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