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A modelling project in Poland: the social and intellectual capital aspects

Several dozen simple forecasting models for a range of socio-economic indicators were developed for the NUTS 2 region of Mazowieckie *voivodeship*, the capital province of Poland, with 314 LAU 2 municipalities (*gminas*) being the basic units of modelling. Given that this set of municipalities encompasses the European-level agglomeration of Warszawa, several sub-regional centres, smaller towns and a multiplicity of small rural municipalities, the models reflect quite a selection of social, economic and resource situations, including rural areas of varied characteristics. In view of the broad range of the subject matter, the number of indicators modelled (around 70) and the orientation at the basic administrative units, the undertaking is unprecedented. Social and intellectual capital-related aspects were included among those modelled and the paper focuses on these from the methodological and substantive points of view, presenting some of the results and the conclusions drawn from them. We show that construction of such a varied and versatile model system is feasible, that it can be useful for pragmatic purposes, and that individual models of indicators (phenomena) can effectively represent the processes that are of importance at the local scale and, through aggregation, also regionally. In particular, the diverse courses of processes in the space of municipality types can be checked and verified.[1]

Keywords: forecasting models, empirical modelling, municipality, social capital, intellectual capital, model system

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Introduction

The current socio-economic development brings about intensive changes in both sectoral and spatial aspects. Effective management of these changes should involve forecasting the developments likely to occur in various domains with the aim of designing, on this basis, adequate policies. This was exactly the purpose for which the self-governmental authorities of the NUTS 2 region of Mazowieckie *voivodeship*, the capital province of Poland, commissioned, through the intermediary of the Masovian Bureau of Regional Planning, the project 'Modelling of the social, economic and spatial transformations in Mazowieckie *voivodeship*'. This project constituted a component in a much wider undertaking 'Development Trends of Mazovia'.[2]

The primary objective of this project was to develop an integrated computer tool to support the analysis and decision making with respect to the socio-economic processes of the province in the spatial setting, with the time horizon of 2025. The project involved the development of (a) a set of models of the social, economic and spatial changes; (b) a database of indicator values to be used in the modelling, founded on the data for the years 2002-2009 (updated later on until 2011 whenever possible); (c) forecasts / projections obtained with the use of the models; and (d) computer application, serving to set the parameters of models, as well as to run the models and determine the forecasts and projections, along with the respective data sets for potential further processing.

Following a short discussion of the state of the art in the broad topic of this research, we present the model system in its entirety. We then go on to show in more detail the development and the content of models pertaining to the domains of social and intellectual capital. After a few comments on the computer application, implementing the entire system, we close with some conclusions.

The place in the state of the art

At the level of the entire system of models and the respective computer application, one is dealing with an unprecedented undertaking. This is due, primarily, to (a) the multiplicity of domains and related indicators modelled (altogether close to 100 variables from various domains), and the wide diversity of the character of the indicators included and (b) the fact that the vast majority of models refer to the basic (LAU 2) administrative units as the proper objects of modelling, all this within a single, consistent system. Thus, the issue is not just in the sheer numbers (100 meaningful output variables for 314 municipalities (*gminas*) over 25 years) which, in fact, were much bigger (as some of the indicators were further broken down into more particular variables). The inhomogeneity of these dimensions constituted a challenge in itself. The indicator variables included such quantities as feminisation ratio, own revenues per capita of the municipal budget, investment propensity of the municipal authorities, an information society indicator, social exclusion, quality of the environment, technical infrastructure, transport accessibility, quality of life and degree of urbanisation. Furthermore, the municipalities, for which each model had to be implemented and run, varied between the capital city of Warszawa and peripheral rural communes with very weak commercial activity and population density of around 30 persons per km^2.[3]

This made it difficult to adopt the methodologies that offer relatively comprehensive modelling tools, and that with explicit spatial aspect. Such models do exist (see, for example, Capello, 2007 and Capello and Fratesi, 2012 for MASST; Gardiner and Kancs, 2011 and Brandsma *et al*.,

[1] The project was carried out in the years 2011-2013 by the Systems Research Institute and the Institute of Geography and Spatial Organisation, both of the Polish Academy of Sciences, by a team of 14 persons.

[2] See http://www.trendyrozwojowemazowsza.pl

[3] It must be emphasised that Mazowieckie voivodeship is in the socio-economic sense the most diversified in Poland.

2013 for RHOMOLO; Roeger and in't Veld, 1997 and Ratto *et al*., 2008 for QUEST, and Varga and associates for the GMR family of models) and offer quite important capacities. Even though these models, or approaches, differ significantly, we quote them here because they have become quite justly highly popular in the literature. Some of them make the spatial aspect more explicit and some lean towards specific issues such as innovation or fiscal policies. Yet none of them are capable of representing the processes considered at the level of a small rural community within an approach that treats such a community similarly to a European-level agglomeration. For instance, Varga (2007) goes down only to the NUTS 3 level in Hungary, and that just for quite a narrow set of variables. None of these models can account for a serious proportion of the output variables (indicators) the project here presented was assumed to encompass.[4]

For several decades, attempts have been made to apply the classical form of the input-output (I/O) analysis, originated by Wassili Leontief, to regional and local systems. Since the 1960s, hundreds of studies have been performed and many tools have been elaborated, as witnessed, for instance, by Hastings and Brucker (1993), Maki (1997) – one of the leading figures in the domain – or Bess and Ambargis (2011). This appealing and well-equipped approach is still frequently cited (e.g. Rohman, 2013), but nowadays mainly for rather narrow purposes (such as the broader effects of a single project or event). The I/O approach was not an option for the project at hand because it would require elaboration of the I/O tables at least for 'representative' municipalities which, apart from being beyond the capacity the project, would be, for many of the municipalities or their types, both highly unstable and hard to establish.

Among the more recently developing paradigms which are used to represent spatial dynamics and which allow for modelling of quite complex structures are the cellular automata (CA). It was discovered early (Batty and Xie, 1994) that CA are a nice representation for the changes in space, with special emphasis on urban dynamics. With time, more complex processes started to be modelled (e.g. Ohgai *et al*., 2001) and the methodology has reached maturity in terms of tools and applications (see e.g. González *et al*., 2015). It is plausible to use municipalities as the granules of space in the CA models, but this methodology was not an option for us for two reasons. Firstly, the CA paradigm requires definite theories of spatial interrelations or influences which will have to be formulated and verified for the multiplicity of domains encompassed by the model system developed. Secondly, the number of these domains and indicators is practically prohibitive for the CA approach.

Numerous models and techniques exist that are meant to represent the processes in various separate domains at the local level, but they concern either quite narrow subject areas, with a small set of variables accounted for, or are just the methodological proposals or software tools (see, for example, Marsal-Llacuna and Boada-Oliveras, 2013 for a technical tool, Kloha *et al*., 2005 for fiscal modelling, or Beigl *et al*., 2008 for waste management). The models developed within the project, and forming the coherent system, were all based on the domain-proper expertise while maintaining a definite level of standardisation and user-related simplicity. The use of existing techniques or even ready tools might amount to a formidable effort in standardising among the various domains and indicators modelled.

The set of forecasting models

Even though the primary purpose of the undertaking described here was to provide a tool for the provincial planning authority, there were several questions which were of interest for the developers of the system and of the individual models. The first one was the very possibility of constructing the model system as here presented. This question concerned the design of particular models, their connections, information flow and the feasibility of computer implementation using simple equipment. This turned out to be possible. Regarding individual models, the most frequent and most important issue was the course of respective processes in various types of municipalities and the conclusions therefrom. Of special interest was the distinction between the cores, associated areas, developing areas and peripheries. Verifying certain existing convictions with this respect was one of the essential goals of the models, even though not directly formulated.

The set of domains and the fundamental assumptions

The outline for the system of models, with the list of domains and information-related connections, is shown in Figure 1. The fundamental principle in the development of the models was to base them on the trends and interrelations identified with the use of the available data at least for the years 2002-2009 or, whenever possible, 1999-2011. The majority of the models were empirical models, as simple as possible, but accounting for the respective methodological and theoretical premises, proper for the individual domains or indicators, whenever it was possible and/or necessary. Thus, for each of the domains specified, models were developed separately, using different methodological prerequisites with domain-specific sets of variables and indicators. Yet the causal relationships and the assumptions made for other domains were also accounted for. In practice, this meant quite strong association, in many situations of truly stiff character, between the models of particular phenomena, often leading to feedback loops. Thus, for example, the demographic projections and the expected 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. An essential criterion of acceptance of models within the particular domains was their consistency, which can be understood as the possibility of using the results of some models in the others making up the system, both in substantive and technical terms.

Whereas Figure 1 emphasises the truly substantive influence of some indicators or variables on those from differ-

[4] One should add that these models were often developed and used in order to reflect the effects of European or national policies, as expressed through definite variables, rather than to represent the broadly conceived multiaspect development of individual communities.

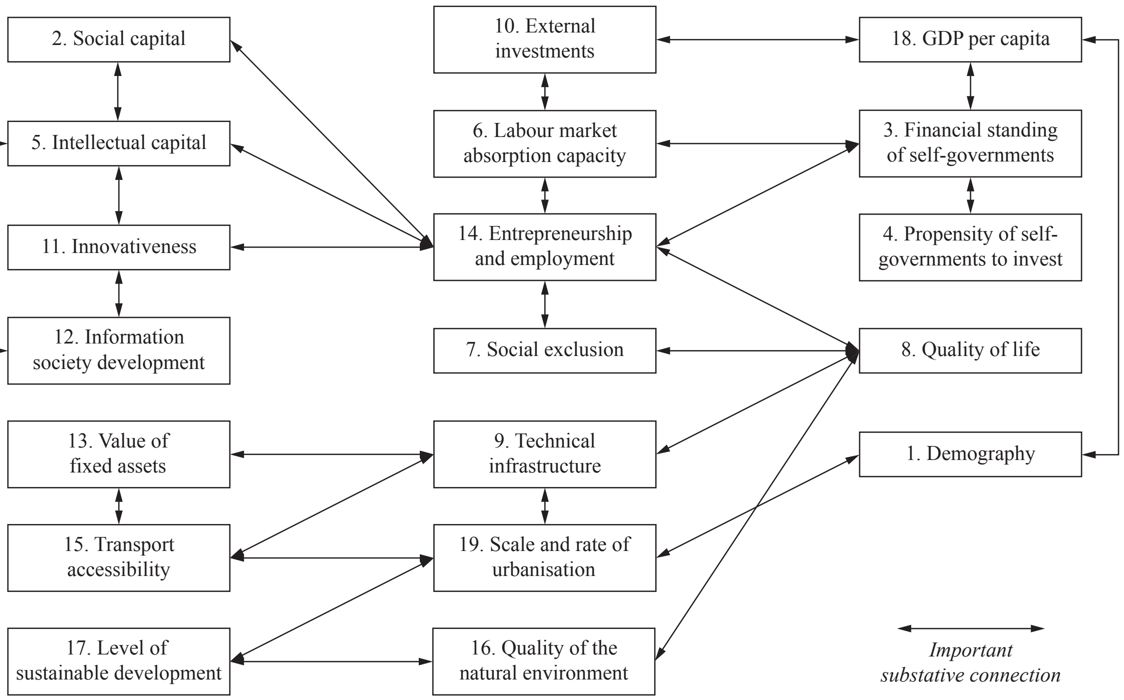

Figure 1: The most important connections among the modelled domains.
Source: own composition

ent domains, Figure 2 shows more connections, but some of them are purely 'mechanical', meaning that, for example, an indicator is a relative quantity, in which the nominator is calculated from a given model, and the denominator comes from a different domain.

The basic spatial units of reference for the models were municipalities or, whenever it was impossible to go down to the municipal level, LAU 1 level counties (*powiats*). For some domains or individual indicators, the models developed also concerned definite classes of spatial units, distinguished with respect to their functional features (model variants differing by definite parameters). Thus, for instance, 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 match better the results obtained to the needs of the conduct of policies and formulation of development strategies in the regional-functional and spatial perspectives.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1		●	●	●	●		●			●	●		●	●		●	●		●
2																			
3				●				●		●	●			●					
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16								●											
17																●			
18						●	●												
19																●	●		

Figure 2: Incidence matrix of the flow of data between the models from individual domains (from rows to columns).
See Figure 1 for the model domains; direction of flow is from the models in the rows to those in the columns
Source: own composition

Scenarios

Among the basic assumptions was recognising various options for the future course of events. For this purpose, individual models were endowed with the capacity for introducing some variants by the user, and the more general development scenarios were formulated. An individual model normally offered a choice of two or three options for future development.

The scenarios exerting the biggest influence on the results for most of the models were those related to demography and to the economic future. These latter scenarios were split into two parts: the economic situation in general ('globally') and the future relationship of the economic development of Poland to that of the European Union, resulting in altogether six scenarios which could be further parameterised. Scenarios were also prepared for the demographic model, related to birth rates, mortality rates and migration. Here, three aggregate scenarios were: continuation of trends, worsening (further decline of the birth rate and slowdown of the life expectancy increase) and improvement (opposite to that for worsening).

Table 1: Typology of municipalities of Mazowieckie *voivodeship* used in the modelling project.

Type		Number	Population number		Area (km^2)	Population density (persons per km^2)
Description	Code		in thousand	% in towns		
Core of the national and provincial capital (Warszawa)	MS	1	1,714.4	100.0	517	3,315
Suburban zone of Warszawa	PSI	27	725.1	72.9	1,297	559
Outer suburban zone of Warszawa	PSE	31	393.0	33.6	2,897	136
Cores of the urban areas of subregional centres	MG	5	526.4	100.0	293	1,797
Suburban zones of subregional centres	PG	20	182.8	4.5	2,236	82
County seats	MP	22	433.9	82.7	1,871	232
Intensive development of non-agricultural functions	O	29	241.1	24.7	3,529	68
Intensive development of farming	R	112	615.1	4.9	13,912	44
Extensive development, mainly farming	E	67	390.3	4.2	9,006	43
Totals		314	5,222.2	64.6	35,558	147
Auxiliary divisions						
MS+PSI+PSE		28	2,439.6	91.9	1,814	1,345
MG+PG		25	709.2	75.4	2,529	280
M+P		75	3,582.7	87.5	6,214	577
O+R+E		208	1,246.5	8.5	26,448	47
Agglomeration of Warszawa in the Spatial Development Plan for Mazowieckie *voivodeship*		40	2,645.5	88.5	2,724	971

Data source: Polish Central Statistical Office

Alongside these general scenarios were several other kinds of scenarios which applied to just one, or only a very limited number of models. The choice of scenarios is left to the user, with 'defaults' being, as a rule, the 'business as usual' or 'least of changes' ones. In just a few cases no options were offered to the user, mainly in view of difficulty in calculations for these different options, and of the difficulty in formulating plausible 'alternative futures'.

Source data, variables and indicators

The model calculations used some 250 kinds of source data. It was assumed in the project that these data shall possibly all originate from official, well-established and publicly available sources, in this case almost exclusively from the Local Data Base of the Polish Central Statistical Office (BDL GUS). This concerns, in particular, the annual data for all the 314 municipalities of Mazowieckie *voivodeship* for population (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 deal with close to half a million source data items.

Most of the 19 domains are represented by more than one indicator. There are altogether close to 70 such indicators being the proper subject of modelling. In addition, there are also a number of auxiliary, intermediate variables, also modelled, which are not formally treated as representing a given domain. Some of these intermediate variables are used in several models.

Thus, from the point of view of data processing we can speak of *input data* (mostly source data), *intermediate variables*, having various characters and resulting from very differentiated transformations, and the proper *indicators*. 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 (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.

The spatial typological distinctions

Owing to the specific 'cross-sectional' character of Mazowieckie *voivodeship*, almost all types of municipalities existing in Poland[5] are represented, especially those that can be treated as rural according to diverse perspectives. The models developed in many instances were calibrated for municipality types. Table 1 shows the classification of municipalities adopted in the work and, at the same time, sheds light on the specific character of the province. The truly rural municipalities (i.e. excluding the urban and suburban ones) take a very important share in the province, and indeed very often parts of suburban municipalities also remain fully 'rural'. Thus, in terms of numbers of units, 66 per cent of municipalities are rural; in terms of area they occupy 74.4 per cent of the province, and in terms of population either 35.6 per cent of the total (formally rural areas) or 23.9 per cent with the full exclusion mentioned. All this for a province with a European-scale agglomeration at its centre. There is a very wide range of municipality types, also among the rural ones, from highly developed and wealthy, down to peripheral, lagging and poor.

The models

Table 2 lists all the domains and summarises their content, with the indicators and the auxiliary variables produced by corresponding models. There were altogether close to 100 separate models designed, developed and verified, not counting their variants for particular classes of municipalities. The models featured quite diverse forms and degrees of difficulty, including from the computational point of view. In some situations, even quite advanced analyses led to very simple models (see Gadomski and Owsiński, 2008 for a similar case).

In terms of numbers, the biggest and the most calculation-wise burdensome model was the demographic model, produc-

[5] The missing ones are, for example, tourist communes of the type encountered at the seaside, on the lakes or in the mountains.

Table 2: The list of domains and indicators used in the modelling project.

No.	Domain name	Indicators	Comments
1	Demography	Population totals and according to age and sex groups, feminisation, share of post-productive population etc.	Models for municipality types; birth rate, mortality and migration scenarios.
2	Social capital	Numbers of NGOs, sports clubs members, cultural and art groups members; also a synthetic indicator.	Three variables, treated as proxies, and an 'artificial' synthetic measure.
3	Financial standing of self-governments	Own and total revenues of local self-governments per capita, expenditures, investment expenditures; auxiliary: jobs per business, expenditures to revenues ratio.	Model types for municipality types, see Owsiński and Andrzejewski (2010).
4	Propensity of self-governments to invest	Investment-related expenditures, budget debt, current budget surplus, propensity to invest.	A model with assumed interaction with the user.
5	Intellectual capital	University graduates, university students, companies with foreign share, a synthetic indicator.	Three basic variables and an 'artificial' synthetic indicator.
6	Labour market absorption capacity	Demand for labour (from GDP and productivity), auxiliary: productivity.	Simple model based on variables from other domains.
7	Social exclusion	Synthetic indicator (share of the elderly, transport-wise accessibility, share of university educated persons, unemployment); Gini-like measure of income inequality.	Two entirely different indicators.
8	Quality of life	Synthetic indicator, based on variables from domains 3, 5, 7, 9, 15, 16 and 17.	Relative indicator based on seven variables, see Owsinski (2009).
9	Technical infrastructure	Shares of inhabitants served by water supply, sewage system, water treatment.	Models for municipality types and levels attained; no synthetic indicator.
10	External investments	Magnitude of external investments – value per capita.	Model based on variables from other domains.
11	Innovativeness	Two indicators, based on intellectual capital, magnitude structure of company population, municipal investments, and company investments.	
12	Information society development	Two indicators, based on innovativeness (domain 11) and Internet in schools.	Two indicators, differing by schools considered.
13	Value of fixed assets	Value of fixed assets owned by public bodies, by companies, total value per capita, auxiliary: investments in self-governmental and in private sectors.	Very rough assessment.
14	Entrepreneurship and employment	Number of businesses, employment per business, unemployment, total employment, employment in manufacturing and service, auxiliary: proxy for employment in farming.	Models for municipality types.
15	Transport accessibility	Expressed in numbers of people within a definite travel time outside and inside.	Based on road network and settlement system, see Komornicki *et al.* (2009).
16	Quality of the natural environment	Synthetic indicator (share of green areas and farmland, population density, car number, and overbuilt area share).	Model partly based on variables from the domains 17 and 19.
17	Level of sustainable development	Anthropogenic pressure (number of cars, population density); sustainable development level (protected areas, forests, grasslands, physical plans); additionally: number of cars, grasslands, physical plans, protected areas, forests.	Partial models (e.g. representing number of cars), contributing to the overall indicators; see Solon (2008a,b).
18	GDP per capita	Global GDP dynamics, and local dynamics, based on salary distribution.	A simple macroeconomic model with six scenarios.
19	Scale and rate of urbanisation	Population density, overbuilt areas, persons employed in manufacturing and services; auxiliary: areas under residential and non-residential structures.	Some variables taken from other domains (see Śleszyński, 2007).

Source: own composition

ing 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 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 five-year age groups, and not year-by-year cohorts (see Owsiński and Kałuszko, 1998, for a similar model). Various kinds of results from this model were used in quite an important proportion of other models (indicators).

Social capital

Since there is no magnitude to be measured directly as 'social capital', and the definitions, which are largely operational, differ widely, also in view of the availability of the data that can be used to represent the notion, some degree of arbitrariness is unavoidable. For the basic opinions, see Coleman (1988), Putnam (1995), Fukuyama (1997, 2000), Cote (2001) and Bjørnskov (2006), and for those related to rural areas, especially in Poland, Heffner and Rosner (2002) and Kołodziejczyk (2003). The models developed by Janc (2009) and Czapiewski (2010) assumed, in the operational sense, that social capital was represented by the following magnitudes: NGO: the number of the non-governmental organisations per 10,000 inhabitants in a municipality; SPO: membership in the sports clubs and associations, also per 10,000 inhabitants of the municipality; and ART: membership of arts ensembles and associations and special interest groups (total number of members per 10,000 inhabitants of a municipality). As with many other models belonging to the system, the choice was guided by both the understanding of the meaning of 'social capital' and the availability of data, fulfilling the assumptions of the project.

In all these cases, models for the future development of the respective variables until 2025 were based on past data with, possibly, allowance for some scenarios. It was also assumed that models would differ for particular types of municipalities. A synthetic indicator was also proposed, in view of the explicit demand from the commissioning agency.

The possibility of applying relatively simple tools to determine the form and the content of respective models is well illustrated by the matrix of the correlation coefficients for all the 314 municipalities for the NGO indicator values in consecutive years. Table 3 shows three essential characteristics that are decisive for the possibility of use of the simple econometric tools: (a) high correlation values; (b) gradual decay of correlation with time; and (c) systematic and uniform nature of this decay.

Non-governmental organisations (NGO)

The model of this variable (indicator) had the following form:

$$NGO_t = (FUND_t / LUDN_t) * 10{,}000$$

where $FUND_t$ represents the number of non-governmental organisations in a given municipality in the year t, and is modelled as:

$$FUND_t = FUND_{t\text{-}1} + (FUND_{baza} * SZT_{FUND}(type\ of\ municipality))$$

and $LUDN_t$ is the population number in the municipality in the same year, this value coming from the demographic model. The number of NGOs in the initial year of the forecast, 2011, appears in the above formula as $FUND_{baza}$. The increment parameter SZT_{FUND} (*type of municipality*) distinguishing between the types of municipalities, was determined on the basis of past annual data for the municipalities in the distinguished types. For future developments, two scenarios were assumed – the one of increase ('ew') and of stagnation ('es'). The fact that a decline scenario was not formulated resulted simply from the fact that at virtually no moment in time nor in any commune has a decline been noted. This may be to some extent due to a statistical artefact, namely the entities which have stopped functioning do not formally disappear, but this phenomenon is very difficult to check.

The historical developments having served to obtain the respective parameters and model form consisted, first of all, in an overall increase in the total number of NGOs from 9,200 in 2000 to 18,300 in 2011. The increase was approximately linear for all municipality types, but with different average rates of increase. After having tried out various forms of the models (including power models)[6], the decision was made to use the simplest linear addition, with distinction of unit types and scenarios. In terms of predicted total changes over the entire period considered, the truly rural municipalities do not fare, in relative dynamics terms, worse than the urban ones (Table 4). Although it can hardly be hoped that they would catch up with the urban areas, they definitely will not lag behind, which is quite a positive statement in view of their handicapped situation. This is, indeed, quite important, given the role assigned the NGOs in shaping the rural social capital (Halamska, 2008; Kamiński, 2008).

Table 3: Linear correlation coefficients for NGO values in consecutive years in all 314 municipalities of Mazowieckie *voivodeship*.

	NGO_{2000}	NGO_{2001}	NGO_{2002}	NGO_{2003}	NGO_{2004}	NGO_{2005}	NGO_{2006}	NGO_{2007}	NGO_{2008}	NGO_{2009}	NGO_{2010}	NGO_{2011}
NGO_{2000}	1.00											
NGO_{2001}	0.88	1.00										
NGO_{2002}	0.81	0.92	1.00									
NGO_{2003}	0.76	0.87	0.96	1.00								
NGO_{2004}	0.76	0.86	0.93	0.97	1.00							
NGO_{2005}	0.75	0.84	0.92	0.96	0.99	1.00						
NGO_{2006}	0.74	0.83	0.90	0.94	0.97	0.98	1.00					
NGO_{2007}	0.74	0.82	0.89	0.93	0.96	0.97	0.99	1.00				
NGO_{2008}	0.72	0.81	0.88	0.91	0.94	0.95	0.96	0.97	1.00			
NGO_{2009}	0.70	0.79	0.85	0.89	0.92	0.93	0.94	0.95	0.97	1.00		
NGO_{2010}	0.69	0.77	0.84	0.87	0.89	0.91	0.92	0.93	0.95	0.99	1.00	
NGO_{2011}	0.68	0.75	0.82	0.84	0.87	0.88	0.90	0.91	0.92	0.97	0.99	1.00

Source: own calculations

Table 4: Predicted changes in the numbers of NGOs in each type of municipality in Mazowieckie *voivodeship* in the period 2012-2025, depending upon the scenario adopted.

Type	Increase		Stagnation	
	Total (initial year = 1)	Average per annum (%)	Total (initial year = 1)	Average per annum (%)
MS	1.6	4.3	1.1	0.9
MG	1.4	3.1	1.1	0.4
MP	1.6	4.6	1.2	1.2
PSI	1.8	5.7	1.3	1.8
PSE	1.8	5.9	1.3	2.2
PG	1.9	6.3	1.4	3.0
O	1.6	4.6	1.2	1.4
R	1.6	4.4	1.2	1.6
E	1.7	4.7	1.2	1.6

For municipality types see Table 1
Source: own calculations

Activity in sports clubs and associations (SPO)

The respective model had a very similar form[7] to the previous one, namely:

$$SPO_t = (CZSP_t / LUDN_t) * 1{,}000$$

with the number of members of the clubs and associations, $CZSP_t$, modelled as:

$$CZSP_t = CZSP_{t\text{-}1} + (CZSP_{baza} * SZT_{CZSP}(type\ of\ municipality))$$

notations generally following the ones from the previous model. In this case three, not two, scenarios were envisaged for the future values of SZT_{CZSP}(*type of municipality*), the ones of increase ('ew'), of stagnation ('es'), and of decrease ('er').

[6] Generally, various forms of models were tried out, even, like here, for very simple relationships. In the case of the GDP model (domain 18), more than ten forms were tested, including quite complex ones. The criteria used in the adoption of a particular form of a model were goodness of fit, but if models were comparable from this point of view, the simpler one was selected.

[7] It was deemed advantageous for the entire system to maintain a certain minimum standardisation in model forms.

Table 5: Predicted changes in the numbers of members of sports clubs and associations in each type of municipality in Mazowieckie *voivodeship* in the period 2012-2025, depending upon the scenario adopted.

Type	Increase		Stagnation		Decrease	
	Total (initial year = 1)	Average per annum (%)	Total (initial year = 1)	Average per annum (%)	Total (initial year = 1)	Average per annum (%)
MS	1.19	1.3	0.99	-0.1	0.79	-1.4
MG	1.12	0.8	0.92	-0.5	0.72	-1.9
MP	1.12	0.8	0.92	-0.5	0.72	-1.9
PSI	1.31	2.1	1.11	0.7	0.91	-0.6
PSE	1.23	1.5	1.03	0.2	0.83	-1.2
PG	1.17	1.1	0.97	-0.2	0.77	-1.5
O	1.10	0.7	0.90	-0.7	0.70	-2.0
R	1.06	0.4	0.86	-1.0	0.66	-2.3
E	1.11	0.7	0.91	-0.6	0.71	-1.9

For municipality types see Table 1
Source: own calculations

Table 6: Model forms tried out for various types of municipality in Mazowieckie *voivodeship* and predicted changes in the numbers of members of arts ensembles and associations and special interest groups in the period 2012-2025.

Type	Functional form	Value of *b*	Value of *a*	R^2	F	Predicted changes	
						Total (initial year = 1)	Average per annum (%)
MS	$y=x^a+b$	12,112.91	0.29	0.795	27.161	1.5	3.6
MG	$y=a^x+b$	10,667.87	-0.09	0.915	74.978	0.3	-4.9
MP	$y=\log_a x+b$	4,111.59	1,440.36	0.982	383.131	1.2	1.2
PSI	$y=\log_a x+b$	6,598.64	1,743.83	0.866	45.084	1.1	0.9
PSE	$y=ax+b$	2,065.67	381.40	0.989	646.044	1.9	6.8
PG	$y=ax+b$	285.65	139.13	0.987	529.341	2.2	8.8
O	$y=ax+b$	1,360.01	198.48	0.959	161.855	1.9	6.4
R	$y=ax+b$	3,212.38	92.83	0.825	32.980	1.3	1.8
E	$y=ax+b$	4,614.04	58.83	0.411	4.891	1.1	0.8

For municipality types see Table 1
Source: own calculations

Despite the importance of this variable (Seippel, 2006), the data needed for model development were the scarcest of the three components: data were available for the municipalities only for the years 2008 and 2010. The more aggregate data, those for NUTS 3 subregions (Mazowieckie *voivodeship* is composed of six subregions or *podregions*) show an increase at the beginning of the period 2002-2010, due to an increase in the number and intensity of different sports- and recreation-oriented events and initiatives, but also, on the other hand, to the demographic change (decrease in the number of children and teenagers, in the second part of the period). Altogether, these data suggest, firstly, rather variable dynamics, although quite consistent among the subregions and, in view of the similar consistency with the data for municipalities, a possibility of advancing rather reliable hypotheses concerning the further course of events. Yet, given the high degree of volatility, three scenarios were envisaged. The ultimately obtained coefficients used in the model were obtained from a study, performed in the framework of design of the model, relating the respective changes to the macroeconomic and demographic ones.

In this area the situation of rural municipalities is certainly worse than in the case of NGOs (Table 5). The envisaged dynamics are in almost all cases lower than for the more urbanised municipalities. This is largely due to the demographic shifts and means that the rural areas, which have been for decades the source of sportsmen and sportswomen, shall soon cease to play such a role, irrespective of the significance for the social capital.

Membership of arts ensembles and associations (ART)

A similar model was proposed for this variable, whose introduction can be advocated by referring to, for instance, Daly (2005):

$$ART_t = (CZAZ_t / LUDN_t) * 10{,}000$$

with the number of members given as:

$$CZAZ_t = CZAZ_{t-1} + (CZAZ_{baza} * SZT_{CZAZ}(\textit{type of municipality})).$$

In this case, for the future values of SZT_{CZAZ}(*type of municipality*) only the distinction between the municipality types was envisaged. The data have been collected in the two-year cycle and so were available for the years 2003, 2005, 2007, 2009 and 2011. For the majority of municipality types (including all of the rural ones) a quite monotonic, though rather slow, upward trend has been observed, but there were three quite important exceptions: Warszawa (MS), showing a distinct drop at the end of the historical period after a significant increase, and the suburban zone of Warszawa (PSI), which mimicked the same changes, though with much less pronounced dynamics. On the other hand, the cores of the urban zones of subregional centres (MG) have shown a distinct downward trend over the entire period 2003-2011.

This differentiation led to the necessity of trying out several model forms (altogether four model forms were tested for various municipality types) (Table 6). It can be expected that the forces behind the dynamics shown were somewhat similar to those for SPO. Altogether, in view of the statistical results obtained, it was decided to propose only one future course of events for each of the municipality types.

Intellectual capital

Although it might be expected that intellectual capital can be measured with more objectivity than social capital (level of education, presence of – possibly local – high-tech companies, attraction for the intellectually intensive external companies etc.), it is clear that in this case, as well, all the potential contributing variables have to be treated as 'better proxies' or at most, rough, even if reasoned, approximations. Three variables were again proposed, with the distinction that the respective data do not always exist at the municipality level, and rightly so, since many phenomena related to intellectual capital cannot be perceived as proper for such small spatial and social units. These three variables are: SWM – a proxy for the educational level of the population of a municipality (percentage share of university graduates in the population of the municipality aged 13 and more); STU – number of students per 10,000 inhabitants of a subregion (*podregion*); and PKZ – number of companies with foreign capital share per 10,000 inhabitants of the municipality[8].

Share of university graduates (SWM)

This model takes a very simple shape of:

$$SWM_t = SWM_0 + t * dSWM$$

with *t* being the number of years since the start of the projection, and *dSWM* being the increment parameter, determined on the basis of the past data. It should be noted that most of the models here sketched are only weakly connected with the rest of the system, namely mainly through the population variables. The specification of this particular model required the analysis of both the 'internal' dynamics of the share of persons having graduated and the 'external' one of the respective population numbers. On the basis of such analyses, the differentiation of the municipality types with respect to the levels and changes in shares of university graduates in respective populations is shown (Table 7).

Thus, the overall trend towards the flattening of this distribution, to the advantage of the rural areas, not only has occurred in the past but is expected also to continue in the next ten years. This flattening, still far away from the evening out and shown here in purely relative terms (Table 8), has to be seen against the background of the very intensive process of increase in the numbers of university graduates in Poland and in Mazowieckie *voivodeship*. This aspect constitutes the subject of the next variable considered.

Table 7: Ratios of the shares of university graduates in the populations of each type of municipality in Mazowieckie *voivodeship* to the average for the entire province – historical and forecasted data.

Type	True ratios based on National Census data				Model-based ratios	
	1970	1978	1988	2002	2011	2025
MS	2.38	2.14	2.02	1.80	1.60	1.55
MG	0.61	0.78	0.89	1.01	1.05	1.05
MP	0.35	0.45	0.53	0.69	0.80	0.80
PSI	0.63	0.64	0.69	1.02	1.15	1.25
PSE	0.23	0.29	0.36	0.58	0.75	0.80
PG	0.06	0.11	0.15	0.33	0.45	0.55
O	0.12	0.17	0.22	0.31	0.35	0.40
R	0.06	0.10	0.14	0.24	0.35	0.40
E	0.18	0.18	0.20	0.25	0.30	0.30
Mazowieckie	1.00	1.00	1.00	1.00	1.00	1.00

For municipality types see Table 1
Source: own calculations

Table 8: Shares of the university educated population in the total population exceeding 13 years of age of each type of municipality and in Mazowieckie *voivodeship*, and the absolute average annual changes thereof.

Type	Share of university graduates among those aged at least 13 (%)			Absolute average annual change (%)	
	2002	2011	2025	2002-2011	2011-2025
MS	25.3	39.0	51.8	1.5	0.9
MG	14.3	25.6	35.1	1.3	0.7
MP	9.7	19.5	26.8	1.1	0.5
PSI	14.4	28.0	41.8	1.5	1.0
PSE	8.2	18.3	26.8	1.1	0.6
PG	4.7	11.0	18.4	0.7	0.5
O	4.3	8.5	13.4	0.5	0.3
R	3.4	8.5	13.4	0.6	0.3
E	3.5	7.3	10.0	0.4	0.2
Mazowieckie	14.2	24.4	33.4	1.1	0.6

For municipality types see Table 1
Source: own calculations

Share of university students in subregions (STU)

This simple model has a form similar to models related to social capital, that is:

$$STU_t = (LSTU_t / LUDN_t) * 10{,}000$$

with the number of students in a subregion, $LSTU_t$, determined through:

$$LSTU_t = LSTU_{t\text{-}1} + (LSTU_{baza} * SZT_{LSTU})$$

where $LSTU_{baza}$ is the value for the initial year of the forecast and SZT_{LSTU} is the coefficient, estimated from the past data. As mentioned already, this set of variables is heavily dependent upon the demographic characteristics and these are expected to change substantially in the period considered, meaning an important future decline in the numbers of young people in the 20-24 years age bracket. The change is actually faced by the tertiary education sector in Poland, especially the non-public tertiary education. Based on this premise and on the general trends in university enrolment (after a dramatic upward surge in the 1990s and a stabilisa-

[8] Anon. (2008) was an important source for this model development. In Polish conditions it was established that there exists a clear correlation between the characterisation of presence of companies with foreign capital share and various observable elements of intellectual capital on the local basis.

tion in the 2000s, a slight decline followed), the respective data, essential for the determination of values of the model coefficients, were obtained after tests with two kinds of models for the particular subregions of Mazowieckie *voivodeship* (Table 9).

The number of companies with foreign capital (PKZ)

This model has an analogous form:

$$PKZ_t = (ZAGR_t / LUDN_t) * 10{,}000$$

with the number of companies in question given as:

$$ZAGR_t = ZAGR_{t-1} + (ZAGR_{baza} * SZT_{ZAGR})$$

$ZAGR_{baza}$ being the value for the base year of the forecast and SZT_{ZAGR} being the coefficient estimated from the past data. The dynamics of the number of companies with foreign capital share in the reference period, i.e. until 2011, in the particular types of municipalities, had been quite uniformly upward, with Warszawa again in the lead by almost an order of magnitude.

Based on these data, and on the test with two kinds of model forms (linear and power), the basis for the model coefficients was established as given in Table 10. No alternative scenarios were envisaged for this variable, both in view of the quite consistent and smooth course of events in the past, and in view of lack of prerequisites for such alternative futures. The potential increase for the 'truly rural' areas is somewhat lower than otherwise, although the rate of increase is distinctly higher for the municipalities with intensive agricultural activities, this phenomenon being not only quite understandable, but also already clearly visible.

Table 9: Predicted changes in the numbers of students in the subregions (*podregions*) of Mazowieckie *voivodeship* and the entire province in the years 2012-2025.

Subregion	Total (initial year = 1)	Average per annum (%)
Ciechanowsko-płocki	0.3	-5.4
Ostrołęcko-siedlecki	0.4	-4.3
Miasto Warszawa	0.9	-0.4
Radomski	0.3	-5.3
Warszawski-wschodni	1.1	0.9
Warszawski-zachodni	1.0	0.1
Mazowieckie	0.9	-1.0

Source: own calculations

Table 10: Predicted changes in the numbers of companies with a share of foreign capital in each type of municipality in Mazowieckie *voivodeship* in the period 2012-2025.

Type	Total (initial year = 1)	Average per annum (%)
MS	1.6	3.9
MG	1.3	2.1
MP	1.4	3.0
PSI	1.7	5.2
PSE	1.7	4.7
PG	1.5	3.7
O	1.2	1.2
R	1.4	3.2
E	1.2	1.6

For municipality types see Table 1
Source: own calculations

Computer application

The project produced a computer application intended to provide the users with a hands-on tool for obtaining forecasts and projections of the particular indicators for the selected units or aggregates, and for the selected scenarios. The application is easily installed and functions in the Java environment, with special emphasis on the use with the Microsoft™ operational systems, but with a possibility of deploying 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 supposed 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 was carried out in cooperation with the representatives of the commissioning body. A working relationship was established for this purpose, which added an important value to the final product.

Conclusions

This paper provides an insight into aspects of a much bigger modelling project in Mazowieckie *voivodeship* which pertain to the issues of social and intellectual capital. The respective analyses and the models, as well as projections, were performed at the municipality level, and the municipalities were grouped according to their characteristics, including those of rural character, with definite distinctions. Owing to this, it was possible to show how the rural areas of varying features fare against the urbanising and urban ones. The general conclusion is that both the social capital and the intellectual capital, as defined in the operational sense for the purpose of this project, but on a much broader substantive basis, are expected to increase significantly in rural areas of Mazowieckie *voivodeship*. This increase is, in relative terms, often more pronounced than in the urban space, but in most cases the existing gap shall persist and, in absolute terms, may even, for some of the variables considered, grow. Thus, while, generally, the respective distributions would become flatter, further efforts must be made to overcome the still persisting, and sometimes sharpening, gradients in space. Another issue is that of the increasing divide between the more 'advanced' and more 'backward' rural areas. Although it appears only in some dimensions, attention has also to be turned towards this phenomenon. These exemplary conclusions not only illustrate the usefulness of the model system, but in themselves constitute a response to quite important cognitive and applied questions.

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