Foresighted Planning, Dynamic Plan – the Role of New Tools in Spatial Transformation

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1 ABSTRACT

Complexity of spatial structures both urban and regional expresses the processes of transformation – an intertwining mechanism of emergence, growth and self-adaptation. The driving forces of these processes are of rooted in social and economic change therefore they are not feasible to foresee. Uncertainty has become one of the most important characteristics of spatial planning. Spatial transformation has to be considered as possible scenarios rather than a final form to be achieved.

Planning of more and more complex spatial structures is becoming interplay between policies, management of change and simulation of the effects of spatial interventions. Traditional 'stable' plan cannot be sufficient anymore. Model of the city should express not only physical order but also flows and relationships between its elements. This model has to allow to test planned spatial interventions and simulate spatial effects of these changes.

In our paper we will demonstrate a few tools which might be useful to foresee the spatial transformation. By using simulation models we are exploring the opportunities of creating imaginary structures and study the possible effects of the spatial intervention. We are examining the way these tools could affect process of creating new kind of dynamic plans. We are discussing advantages and limitations of this new tools as well as form and content of dynamic plan.

2 INTRODUCTION

Cities and regions have been planned for millennia. Planners – whether they were builders, architects, urbanists, surveyors or lawyers – tried to anticipate changes and imagine the future pattern of spatial structure. They arranged the civic activities in the agoras and commerce in the market squares. They gave certain rights to the towns supporting new order of urban settlements in medieval Europe. They imagined monumental axis and social housing neighbourhoods. They conceptualized new models of the cities. Yet since urban growth has exceeded the level of hundreds of thousand inhabitants the future arrangement, the urban layout, the plan is beyond the imagination of a designer. Planners need more specialised tools to foresee the change and conceptualise the effects of their intervention. Complexity is increasing.

3 CONCEPTUAL FRAMEWORK OF URBAN STRUCTURE

The conceptual framework for analysing urban structure is still being discussed. One of the important issues determining this debate might be that there is no clear agreement about the meaning of 'urban structure'. This term could be simply understood as a way in which land use of the city is set out, but that does not reflect the complexity of the problem. This meaning mirrors only a stable, fixed picture and only one aspect of the urban structure.

We define urban structure as a mixture of 3 components: (1) an order of the urban elements, (2) the separate sub-systems joining these parts into entire, complex organism and (3) the fabric of the city, its physical form.

This is an easy way to notice than the 'order' is quite abstract – we do not talk about any specific arrangement, we only indicate that there is a setup of urban elements. If there were no flows and relationships between urban elements – this pattern would not play an important role in urban structure. But the fact is that there are flows and relationships between distinct elements and they influence the composition of the city. Indeed, they shape urban structure.

Conversely, what we defined as the 'joining sub-systems' has a clear physical form which allows these flows and relationships to materialise. These are the networks of different kinds: transportation, infrastructure, communication. They allow to implement contacts between components of turban structure, they represent essential, indispensable relations between activities. Generally flows, relations and connections are considered as the most important component shaping urban structure.

We need a conceptual framework to describe, analyse and understand urban structure able to explain the way in which it performs and produces spatial effects. Many theories have been used as foundations of such a framework. They are usually rooted in social, economic and environmental sciences. For the last 50 years systems theory and physics have been explored as a source of ideas which can help with comprehensive theory.

One more factor has to be considered: planning practice. All the theories claim to explore urban structure not only to satisfy enquiring minds of few researchers but also to respond to the need of creating and managing complex urban structure.

'But, if all communities aim at some good, the state or political community, which is the highest of all, and which embraces all the rest, aims at good in a greater degree than any other and at the highest good' explains Aristotle in the first book of Politics (2008). For him 'the state' meant 'the city' as this was the form of the state he knew and studied. Following Aristotle's vision we can assume that urban management aims at public good. While the goal of enterprises is to increase economic profit the goal of the city has the be to increase social profit.

Management means also that effects of spatial processes or interventions have to be foreseen. This is true about management of any type. Management refers to the future. Steering, governance or even only mundane dealing with urban problems require a vision of possible effects of the decisions. This should be based not only on speculations or intuition but also on well defined criteria. In other words one needs to simulate spatial scenarios for the future. The conceptual procedure reflecting forces which generate urban structure and foresee urban structure itself has to be defined.

4 URBAN NETWORKS. THE RANK-SIZE RULE AS A REPRESENTATION OF FORMULA OF THE URBAN NETWORK AND STRUCTURE

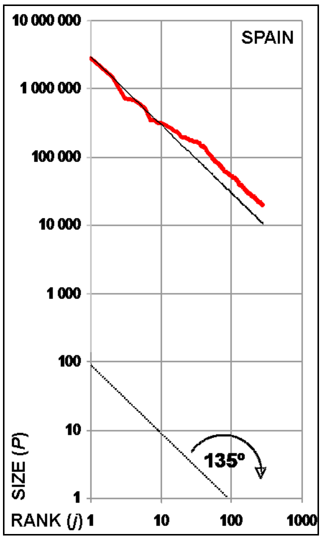
In order to foresee spatial effects of processes of urbanisation one need to define (or discover) the main driving forces or general rules which influence and control the performance of an urban system. These rules are not models – they simply occur and perform within the urban system. They might be considered as kind of *lex naturalis*.

One of the most striking regularities of urban network is widely known as rank-size rule. The idea that the size distribution of the cities within a defined area (country, region) can be approximated was articulated in a precise way in 1913 by Auerbach (Auerbach, 1913) and then redefined, among others, by Zipf in 1949 (Zipf, 1949).

This regularity has been commented and interpreted for the last half-century and it seems that it hasn't revealed its full spectrum of possible explanations yet.

The construction of the rank-size rule is, from the mathematical point of view, surprisingly simple. Auerbach (1913) suggested that the form of the size distribution of cities takes the Pareto distribution.

Zipf (1949) developed this rule claiming that the distribution of cities could not only follow the Pareto distribution but take a precise value of contrast index =1. The final form of Zipf's Law is:



$$P_j = \frac{P_1}{j^{-a}}$$

where:
P_1 is the population of the biggest city within a defined area,
P_j is the population of the city located on the j position within a defined area,
j is the position of the city in the size distribution.

When one calculates the natural logarithm of the rank and of the city population the resulting graph displays remarkably regular log-linear pattern. Following Zipf's assumption that contrast index $\alpha = 1$, the resulting graph creates the angle of 135 degrees with the horizontal axis.

The significant regularity of rank-size distribution applies to the different spatial scales and different times. This is clearly visible on the graph 2a, 2b and 2c presenting rank-size rule relating to region and country: Spain and its provinces, continent: Europe and European countries and the world and continents.

The same regularity can be observed in relation to time – rank-size rule relates to different periods.

Presented data may mean that there are driving forces able to keep urban networks in accordance with rank-size rule. Nobody can 'plan' this order, nobody even can even influence this regularity easily. This phenomenon reflects the self-organisation ability of the urban system.

The next significant conclusion of the study of the rank-size rule is that two driving forces can be clearly extracted.

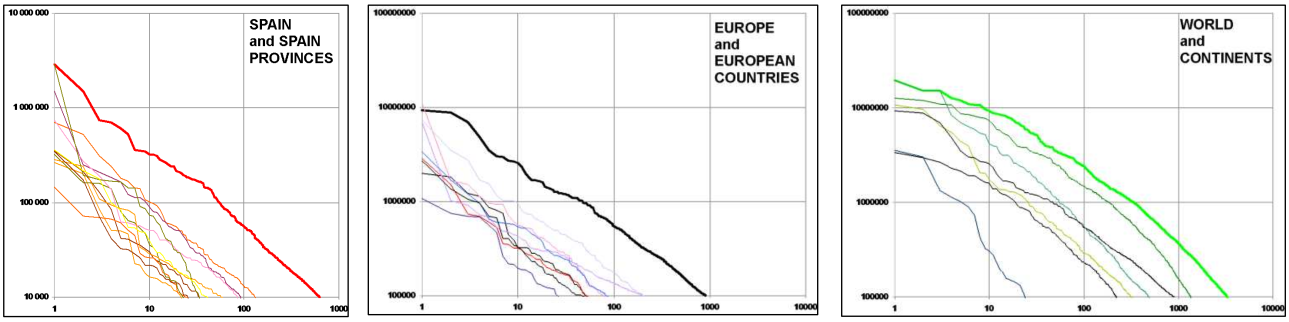


Fig. 2. Rank-size distribution of (a) Spain and its provinces in 1998, (b) Europe and the European countries in 2000 and (c) the world and the continents in 2000.

One of them is **concentration** – as a consequence of the best possible distribution of the activities in the given network of contacts. Concentration is the most 'noticeable' feature of spatial arrangement. Many studies have been conducted concerning concentration – from describing this phenomenon to measuring it (i.e. Clark's and Newling's rule, Gini concetration ratio, Lorenz curve). What is especially fascinating is the mechanism of concentration in real spatial processes. Concentration itself is the result of this mechanism.

The second is **hierarchy** as an expression of the predilection for the self-organisation of an urban system. Actually we can consider hierarchy as a way of managing concentration. Quite evident is that urban systems are not 'flat', quite the reverse, there is strong tendency to structure the network. Hierarchy is one, but probably the most efficient, of the possible patterns of this structure. It is likely that rank-size rule expresses very a important driving force shaping urban structure.

In this paper we consider concentration as a result of contacts shaping urban structure. Using the definition of urban structure defined in section 2 and as a conceptual framework of urban structure and the rank-size rule as an expression of the rules of urban processes we will focus on opportunities of modelling spatial scenarios for the future by using simulation models. Concentration as a result of contacts can be simulated by using mathematical models of this process. In this paper we will use the intervening opportunities model and explore the possible application of this tool in order to foresee spatial effects of urban intervention. We will deliver an interpretation of the results.

5 MODELS IN PLANNING

Models represent the reality, they are not reality itself. If the real world is being considered as a system in terms of system's theory – the model represents a system. Different kinds of models can be defined: physical (or 'analogue'), iconographic, conceptual, abstract. Models have been used in urban studies and planning for millennia. Traditionally they were and still are physical or iconographic models (mock-up development, sketches, plans, designs), sometimes they were/are conceptual if we agree that this kind of models uses ideas to represent other ideas (descriptions, manifestos, charters).

Among widely known conceptual models of urban structure there is the concentric zone model described by Burgess in 1925 or the sectoral model examined by Hoyt in 1939. Lynch (1981) defined his models in a different way – as cosmic, practical and organic. More recently, this kind of conceptual models describes polycentric metropolises, city-regions or eco-cities.

Since the 1960s the focal point has moved towards abstract models describing relations and flows rather than physical form. The typical language of this kind of models is mathematics. The explored relations are often so complex that they require differential and indeterminate equations. Widely discussed models in urban studies were: linear programming, diffusion model, PERT, regression analysis, Lowry-Garin spatial allocation model (Garin, 1966; Lowry, 1964) urban dynamics (Forrester, 1969), cellular automata (Batty, 1997, 2005), gravity model (Voorhees, 1965), intervening opportunities model (Stouffer, 1948).

Models can represent chosen aspects of the urban system. This characteristic is especially important to understand the nature of the real process. Models very often reduce the analysed elements and relationships in order to follow extracted processes. Simulation models are a specific group of models which allow to 'experiment' on them instead of experimenting on the real system. Simulation models are especially useful when experimenting on the real system is extremely difficult or may produce a serious danger to the system.

6 ALLOCATION MODEL BASED ON THE MECHANISM OF INTERVENING OPPORTUNITIES

6.1 Concept of intervening opportunities

There are two groups of models representing the structure of contacts (relationships between components) in urban structure. Assuming for urban research that contacts are mostly responsible for shaping urban structure this kind of models plays a fundamental role in defining rules and mechanisms of relationships producing spatial effects. The first group is based on the gravity model whereas the second group is based on the less used intervening opportunities model.

The basic concept of the intervening opportunities model formulated by Stouffer (1948) is that the trip distribution is not directly related to distance but rather to accessibility of opportunities. Assuming that people travel in order to satisfy their needs, Stouffer analysed the behaviour of an individual choosing possible destinations for a particular trip. Stouffer theorised that the migration between origin and destination places depends not only on number of opportunities given by the latter but also on the amount of intervening opportunities between these two analysed places. Stouffer's assumption was that these intervening opportunities form a set of occasions competing with the final destination which is located farther. In other words they may stop the trips from going to the final destination by offering them opportunities to satisfy their need (trip finishes when the particular need is satisfied). The distance in Stouffer's concept is expressed in the number of opportunities not in typical units of measurement like kilometres or miles. However, the occasions are arranged in the order of increasing distance.

Schneider (1959) proposed a modification of Stouffer's initial concept using probability as descriptive tool. The mathematical tool requires assumptions concerning the spatial decision making process. The structure of this process describing 'average' human behaviour in this regard is as follows.

In order to supply his/her needs an individual tries to involve the lowest possible effort. This is why he/she looks for opportunities starting from the place where he/she is located (this can be the place of accommodation, business, school, etc.). The nearest occasion can be rejected if it does not meet defined criteria. Given the variety of motivations it is likely that the first occasion cannot fulfil the expectations of the travelling individual. In the case of rejection he/she has to continue his/her travel. The trip terminates when the opportunity is accepted. Of course the general model cannot follow each individual motivation and has to construct statistical profiles of the 'travellers'. The trip is represented by the draw which may end with acceptance or rejection of the occasion. Consequently, the decision-making process is represented by a random variable which can have two possible values: success or failure (accepted or rejected occasion).

In other words the process of executing the contact in Schneider's concept is represented by the series of draws (CATS, 1960). Each draw can finish with failure (occasion has not been accepted, trip continues) or success (occasion has been accepted, trip terminates). In mathematical terms this is a Bernoulli distribution. Schneider's hypothesis states that the probability that a trip will terminate in some volume of destination points is equal to the probability that this volume contains an acceptable destination multiplied by the probability that an acceptable destination closer to the origin of the trips has not been found.

We will skip here mathematical description of the model but we have highlight two its important features. First, in mathematical terms we instead of using the discrete distribution we have to shift our consideration to continuous distribution. Considering each separate occasion within a big urban structure could be very difficult or even impossible. This is why it is quite reasonable to aggregate both the starting points of the trip (*origins*) and the opportunities (*destinations*) from the defied areas into nodes representing them. These areas have to be precisely defined to represent the reality. For example each point within an area has to be accessible in 5 minutes which seems to be a proper approximation in the city of 500.000 population. This is the second simplification. Furthermore, the destination nodes can be arranged into zones which are accessible using more or less the same effort (measured i.e. in distance, time, money) from the origin. This simplification is acceptable when one calculates hundreds of thousands or sometimes millions of occasions.

The only parameter of the intervening opportunities model is the selectivity. This parameter expresses a feature of '*being finicky*'. In other words selectivity represents inclination to accept substitute. Of course this inclination relates to need. The more complex or sophisticated need is the less likely it is to be replaced with the substitute. For example, the process of choosing milk or croissants for breakfast is quite simple. If our favourite croissants are not in the nearest bakery we can go to the next shop but it is not likely that we would go to the city centre trying to get the 'best ever' croissants for breakfast on Wednesday. The selectivity will be 'soft'. The selectivity rises when the good is of high rank. When we select univeristy or holiday place location wouldn't play that important role. In this case selectivity will be very 'sharp'. From the examples clearly show that selectivity relates to lifestyle and level of civilization of a given society.

6.2 Allocation Models: Allocation of the Destinations Model

Using Stouffer's and Schneider's concepts as a base Zipser (1972) developed a theoretical and formal simulation model emphasising the process of generating concentration as a main driving force shaping urban structure. Intervening opportunities mechanism reflecting the contacts within this structure seemed to be an ideal tool in this respect.

Allocation models based on mechanisms of intervening opportunities (Zipser, 1972) mirror the process of shaping patterns of concentration by relocating origin and destination activities looking for a balance (or more widely – equilibrium) in urban arrangement. The given, stable element in these models is accessibility – in practice the transportation network – while varying the chances of different urban elements to be explored as destinations. This determinates the entire urban structure.

It is essential to remember that allocation models reflect only one particular aspect which shapes urban structure – contacts are additionally limited to the kind of extracted contact (i.e. home-work, home-leisure, work-services, etc.).

Many kinds of allocation models have been defined. One of them is '*allocation of the destinations*', model which is very useful in studying tendencies of concentration. At the beginning of the simulation process urban structure is defined by the nodes representing origin and destination activities. Origin nodes are 'starting points' of travel aiming at satisfying particular needs in destination nodes. The value of the nodes depends on the kind of contact. For example origin value in contact home-work are residents wishing to work (in practice all adults) and destination value are workplaces. They travel using defined transportation networks (different kinds of networks can be used – roads, rails, public transport, etc.). The basic assumption is that a good measure of attractiveness of the place is how many people look for satisfaction of their need in the particular place. This is why the process of simulation is based on allocation of destinations from the nodes where they haven't been accepted to the nodes where surplus of arrivals has been noticed. This surplus in reality means unsatisfied need.

As the 'allocation of destinations' model ensures freedom of choice in accepting the occasion, the next step in the process of simulating urban structure is to move destination activities from the nodes in which there is shortage of arrivals (acceptance) to those where a surplus of arrivals has been registered. This procedure is repeated until the entire system achieves a balance. This is to say – until the number of arrivals to each particular node equals the number of destination activities in this node.

The big advantage of this model is that one can use 'imagined' data in order to test the reaction of the system. For example simple population volume can be used as origin value to verify trends of concentration, while destination value can be different from reality (i.e. destination value can reflect planned, future state). Different networks (including those not yet existing) can be used as a base of circulation. Thus 'allocation of destinations' model can be used to study spatial effects of development (both planned and unplanned).

Summing up, the representation of the 'real world' in the 'allocation of destinations' model is as follows:

- nodes represent urbanised space,
- the transportation network defines accessibility of the nodes,
- origin and destination values are located in the nodes,
- the selectivity parameter expresses adequate value for contact profile.

The result of the simulation process does not reflect 'the possible future' – it reflects trends and tendencies. Analysing procedure of simulation one has to understand that

- when using simulation models of urbanised space and models reflecting the concentration process – they reflect only chosen aspects of reality, they are not reality itself;
- only one kind of contact is being taken into account at the time.

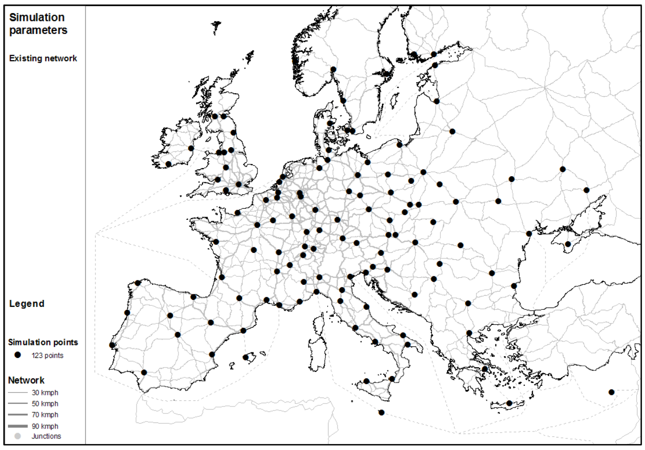
The model does not give 'direct' answers; the results should be studied and interpreted.

6.3 Simulation Data and Process of Modelling

One of the best possible ways of verifying the usefulness of the simulation models is to test whether they are able to reflect reality. This is to say that one can assume that the model represents the real world precisely if the model can produce the existing state of an analysed aspect of reality. This depends also on data used in the process of simulation.

The big advantage of the 'allocation of destination' model is that we can use quite simple statistical data and descriptions of the transportation network.

This procedure will be illustrated with the case of the simulation of the European urban structure. Our aim was to follow trends of concentration in Europe. Source data were 123 nodes representing FUAs – Functional Urban Areas defined in the ESPON Atlas (ESPON, 2006, pp. 29) supplemented with a few chosen cities from Eastern Europe. The Functional Urban Areas consist of wide territories, but in the process of simulation they are represented by nodes located at the junctions of the transportation network. The form of the network and its parameters, especially the average speed value in each particular segment, defines the accessibility of the nodes (Fig. 3).



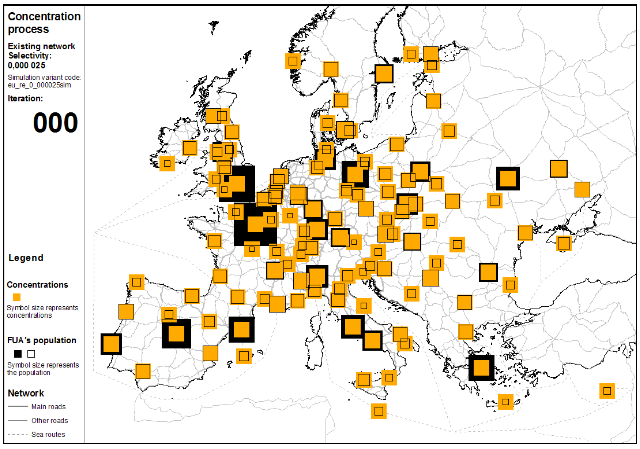


Fig. 3. Simulation of the European urban structure – source data: nodes and transportation network and Fig. 4. Origin and destination values.

Origin values match the population of each node (ESPON 2005, pp. 257-291). The sum of origins equals the volume of destinations. Destinations are equally distributed, which means that each node has the same value (Fig. 4).

According to the formula of the 'allocation of destination model' the first step is to send origins (people travelling in order to satisfy their needs) and observe which nodes have been accepted and which nodes have experienced shortage of acceptance. This result is the starting point of the next iteration. In other words after calculating the complete exchange of contacts in the system during the first iteration we allocate destinations. The value of destination in each node has to be recalculated and is not equally distributed anymore. This kind of simulation might be compared with the real process of locating services. Companies look for the best place to attract clients. They follow client's choices in order to increase the number of customers.

Our simulation has a speculative aim. We didn't assume any particular need but we wanted to test whereas in a given transportation network the European urban structure is driven by a concentration force the way it is described in an intervening opportunities model. The process of simulation is repeated until only a very small number of destinations has to be allocated (i.e. 2%). This means that the system has achieved the state of equilibrium. We performed 100 iterations analysing the process of simulation of European urban structure. The result of a few chosen iterations is displayed on the Fig. 5.

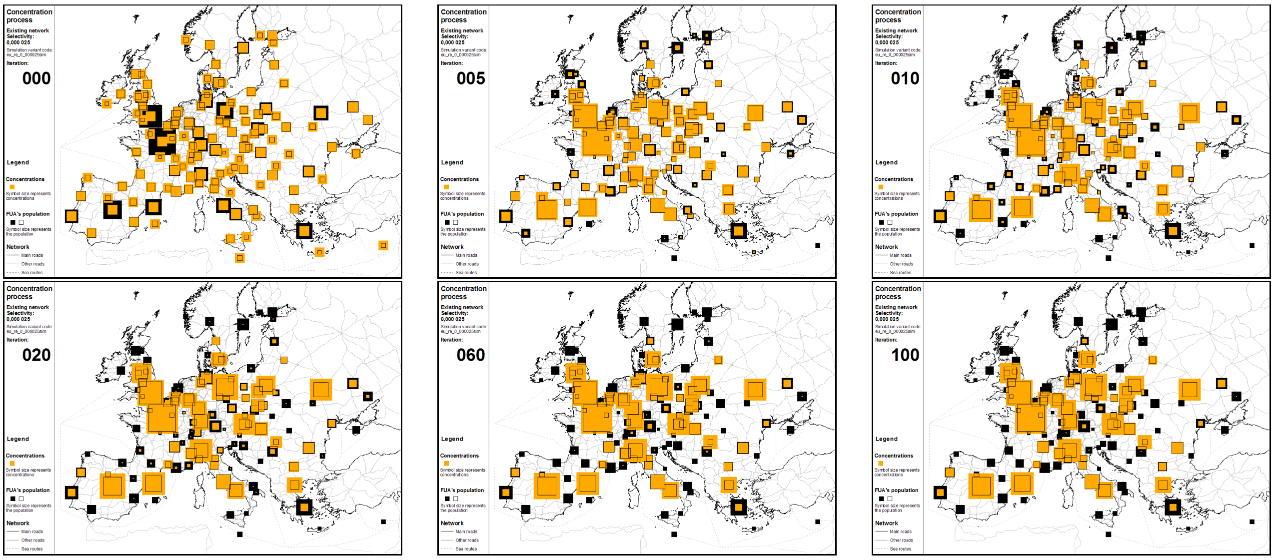


Fig. 5. Simulation of the European urban structure – initial arrangement and results after 5th, 10th, 20th, 60th and 100th iterations

Analysing the results one can observe two significant phenomena. First, that the model reflects the power of concentration very well, and secondly – the essential influence of this driving force in the urban structure. After 5 iterations the accordance with the reality is already quite great. Only peripheral nodes (cities) are underprivileged which is a typical characteristic of the model. This is to say – the accessibility to the peripheral nodes is worse than that of more central locations. If we perform more iterations the nodes with better accessibility will 'pick up' the population like a suction pump. This explains in what way model reflects concentration as a driving force. The final result doesn't reflect 'reality', it mirrors the tendency and describes the driving force.

6.4 Application of the Model

The simulation method is successfully applied for the analysis of settlement systems varying in scale and complexity. The mode and precision of representing such structures depend on the purpose of the simulation. This means that what question is being considered is very important. Fig. 6 presents the application of the model to the continental, regional and metropolitan scales. It can be clearly noticed that concentration as driving force influences every scale of urban structure and produces specific pattern of hierarchy in a given accessibility. Knowing the way the model performs one can judge and study the attractiveness of particular places.

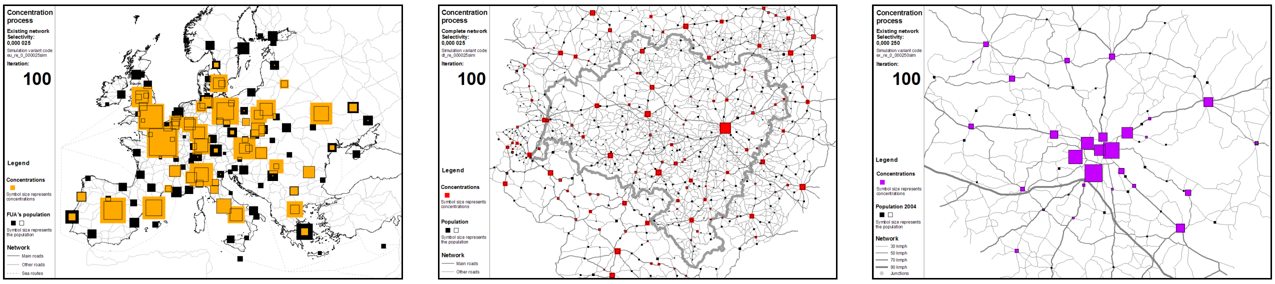


Fig. 6. Application of the 'allocation of the destinations' model to diverse scales of urban structures – results after 100 iterations for Europe, Lower Silesia region (W-S Poland) and the Metropolitan Area of Wrocław, origin value reflects the real population and destinations were initially equally distributed; selectivity for Europe and Lower Silesia equals 0,000025 and for Metropolitan Area of Wrocław – 0,000250.

6.5 The impact of Different Networks

Accessibility is not easy to be imagined. Relaying on intuition in this respect may lead to huge mistakes within complex urban structures. This is why models representing contacts are so useful. The system of accessibility that depends on the shape of the transportation network and the speed of particular segments of this network influence strongly the result of the simulation. It happens that very little change of the network (i.e. adding a new segment or improving parameters of an existing one) changes the results totally because it re-defines accessibility. On the contrary in other cases declared 'improvements' of the transportation network do not influence the simulation results at all.

The Metropolitan Area of Wrocław illustrates this kind of 'reaction of the system'. We observed only a slight influence of planned network on the results of simulation after 100 iterations of modelling, however, all other parameters remain unchanged. We will explore this modelling in the following section.

6.6 The Impact of Different Contact Types – Changes of Selectivity Parameter

Observing the simulation of the Metropolitan Area of Wrocław we can notice that the influence of a selectivity parameter on simulation results is significant, when comparing two extreme values of a selectivity parameter (Fig. 7). Higher selectivity value ('soft') corresponds to the situation when travellers are satisfied with destinations which are quite close to them in the space of opportunities. Lower selectivity value ('sharp') means that many of subsequently encountered destinations are omitted by travellers before they finds the destination of their trip. This expresses also the importance of the need, whereby 'sharp' selectivity is typical of higher rank needs.

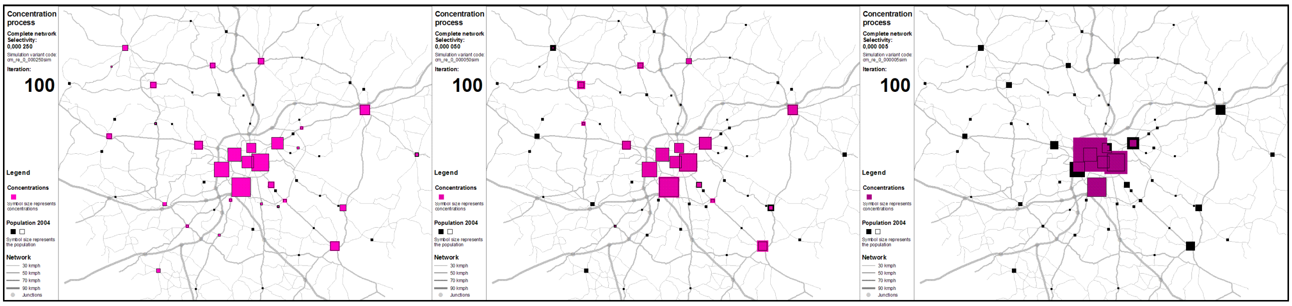


Fig. 7. The impact on simulation results of different contact types represented by changes of selectivity parameter. Case study of the Metropolitan Area of Wrocław – results after 100 iterations of the simulation conducted on the planned transportation network from initial real origins' and even destinations' distribution; the selectivity equals respectively 0,000250 ('soft'), 0,000050 and 0,000005 ('sharp').

Higher selectivity value in the simulation process will result in many small concentrations of destinations. We can interpret them as locally attractive places. Lower selectivity value is favourable to achieving one or a few high concentrations of destinations. Their locations are attractive in a wider (i.e. regional) scale for travellers who are prepared for a longer trip.

7 APPLICATION OF THE SIMULATION MODELS

Models are useful in order to imagine 'answer from reality' and possible consequences. They do not display future reality, they even do not display 'possible future', but they show general trends which may support decision making process. They reflect rules which are not easily readible and not clearly mirrored in stable, fixed plans. By performing on planned and imagined structures they help with creating spatial scenarions for cities, regions and continents. They also reflect how strong are analysed forces.

Below we present a few exaples of application allocation models and explain the way they can support planning process.

7.1 Wrocław Metropolitan Area

The simulation was conducted for the Metropolitan Area of Wrocław (MAW) that covers the city of Wrocław and the towns located within a distance of 35 km from Wrocław. Borders of the MAW are almost the same as the administratively delimitated metropolitan area; the only exception are southern and northern peripheries of the area which were not taken into consideration. We applied the model 'allocation of the destinations'.

The research was aimed at compare various simulation results. We conducted the simulations that used the existing and the planned transportation networks, as well as different selectivity parameter values that represented the variety of contacts. Here we are briefly presenting results of simulation coducted on planned urban structure. We applied as source data all planned road which are expected to increase accesibility to certain places, located especially on the new junctions and in this way attract new, massive investments.

We addressed the issue in what way the new transportation network would influence the structure of the Metropolitan Area of Wrocław. We would like to explore the problem if the system itself would generate new 'magnets' only by increasing accessibility. This question was especially interesting in the context of the planned 'West Pole' which is expected to create the new, specialised 'centre' of the city and rather unplanned 'North Pole' which we expected to appear.

7.1.1 West Pole

In order to simulate development potential growth of the 'West Pole' we performed modelling on planned network. The most remarkable – and in fact rather unexpected! – result of this set of simulation was that almost nothing had changed. Massive investments in infrastructure didn't result in new points of concentration.

Models – as it has been already explained – are especially useful while experimenting on them instead of experimenting on the real system. We were playing this kind of game when trying to figure out what should be done to shift the existing urban structure to a new level of arrangement.

The research aimed to evaluate the ability to reshape the MAW structure due to from changes of the distribution of origin values. This reflected the potential of the places. This is to say that we tried to estimate how big investments had to be made before the system would achieve the ability of 'magnets' generating new urban concentration. Special attention was paid to investigating changes which follow the strengthening of the surroundings of the planned West Pole of Wrocław. In two previously conducted sets of simulations nodes located in this area did not concentrate destination values, in contrast to the nodes located to the East of the city.

The 'Western Zone' was established and located among the motorway bypass of Wrocław, route No. 5 to Poznań, the metropolitan ring road and the A4 motorway running on the southern outskirts of the city. Origin values in the Western Zone were enlarged only for the nodes located inside the zone and those in the city of Wrocław. We tested three different levels of enlargement of origin values. First, the existing values were increased by 10%. Having statistical data analysed we discovered that during the period 2004-2009 the average increase in the Wrocław Poviat (county) had a similar value (11,16%). This value was the biggest growth recorded in all poviats at that time. Even more interestingly, the growth was observed only in the Wrocław subregion and the poviats located close to Wrocław Poviat. We assumed that the 10% increase was a reliable description of natural social processes. For the simulation experiment this growth was concentrated in nodes of the Western Zone. In the second simulation the origin values were doubled and in the third – we performed with 1000% growth (Fig. 8 upper row).

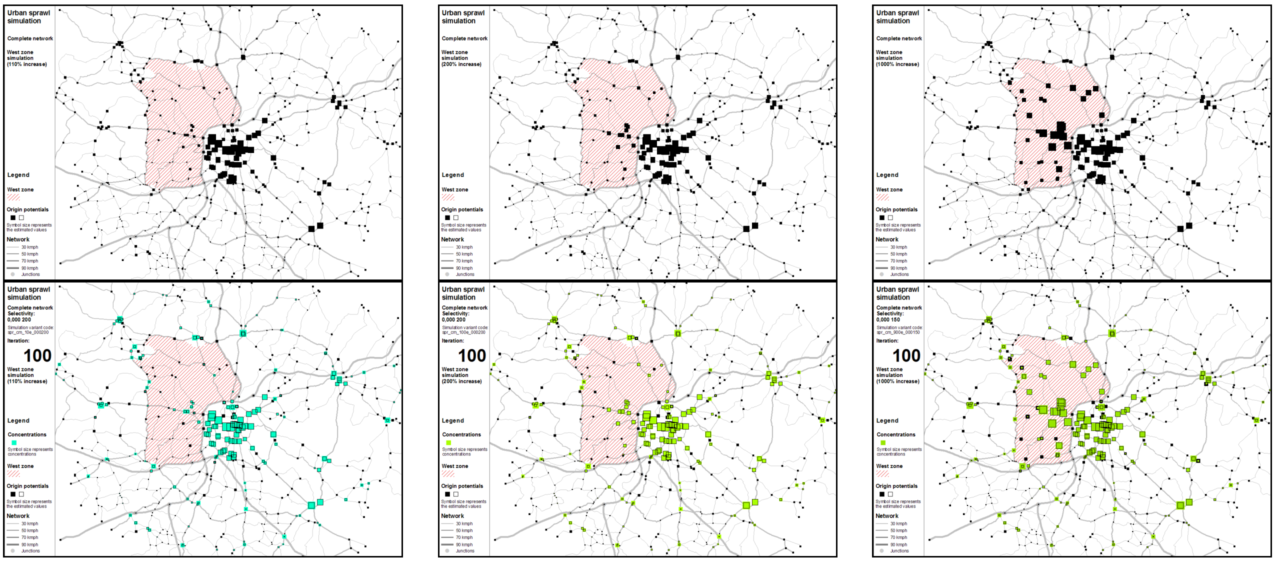


Fig. 8. Distribution of origin values used in modelling of the MAW Western Zone – implementation of 10%, double and tenfold increase in the West Zone node values (uperr row) and results of 100 iterations of the modelling – final distribution of destinations (lower row).

Simulations were undertaken using only one selectivity parameter value. This was the biggest value applied in the two previous sets of simulations (0,000250). The selectivity we used was 'soft' in order to favour the short trips rather than the longer ones. The exact value of selectivity varied slightly because in each simulation the sum of enlarging origin and destination values was different. The results of the simulations are presented on the Fig. 8, lower row.

The Western Zone was our urban laboratory of transformation. What have we learnt from the lesson? First, potential of the place would have to be enlarged enormously to show visible concentrations although they are expected by local planners. Yet, even in the case of enormous increases, the existing concentrations (i.e in and around 'the town within the city' – Leśnica) are stronger and able to attract more destinations than newly created nodes. Secondly, the area located on the northern bank of the Odra river is 'cut off' from the benefits of growth. We notice very few concentrations in this area and in order to 'get started' they require enormous increase of their potentials. Thirdly, the southern part of the Western Zone has quite a low capacity, with the exception of one node (Somlec-Pietrzykowice), to attract destination values.

Analysing the results we must remember that we use a model of reality with all its limitations. This model is enriched with imaginary enlarged values of potentials of the Western Zone. Population enlargement of this kind in the real world would require new investments like roads, infrastructure, commercial, services, etc. These changes would probably affect the position of a few nodes by changing the position of some nodes and bridges. We have to remember that this is only a 'scenario game' displaying trends and tendencies, not 'possible future'.

The research clearly displays very important characteristics of the urban structure:

- the existing arrangement is very stable and it is not easy to shift it to a new level of organisation,
- improvements of accessibility play an important but not ultimately a decisive role in increasing the attractiveness of places,
- in order to 'switch' the urban system onto a new track of self-organisation massive investments are required.

7.1.2 North Pole

On the contrary 'North Pole' seems to be quite natural consequence of increasing accessibility. In this simulation 9 districts of Wrocław, 13 'ring' towns and 40 villages have been taken into account (Mlek, Zipser, 2007).

One of the most significant result is that the existing network is conducive for the South Pole (already clearly generated) and city centre (which is an obvious consequence of the privileged location and accessibility) whereas planned network easily displays advantages of northern zone of Wrocław Metropolitan Area (Fig.

9). This result might be quite surprising for traditional way of thinking about urban development of the city of Wrocław which for decennia was based on 3 poles: Central, South and West. The answer coming from research of existing structure and planned accessibility may give a new insight into development concept of the city.

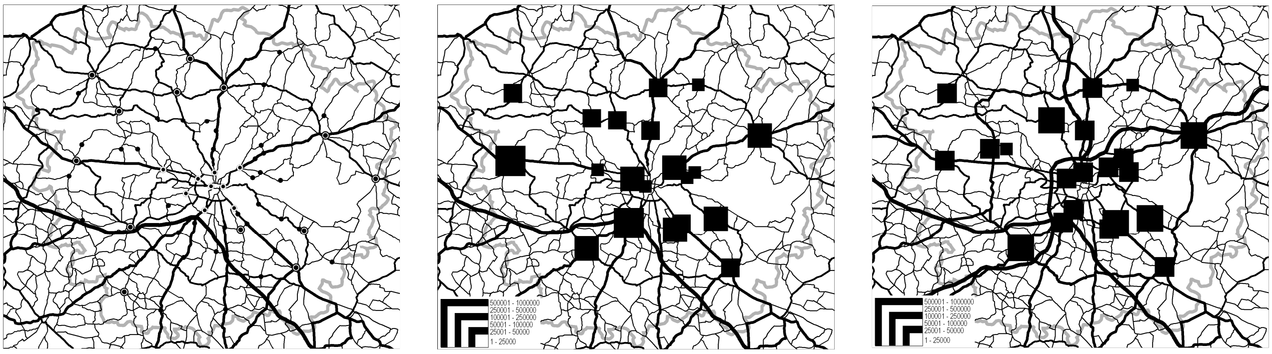


Fig. 9. Distribution of the nodes in modelling of the MAW Northern Zone (left) and results of the modelling – final distribution of destinations on the existing transportation network (middle) and planned transportation network (right). [Mlek, Zipser, 2007)

The research shows that model of the city produced by changed accessibility may lead to the linear-poles structure (South, Centre, North poles located on the axis perpendicular to the Odra river) instead of triangular-poles structures (South, Centre and West poles – all located on the southern bank of the Odra river).

This new structure may strongly affect all the concentrations within the MAW. This new order displays the ‘natural’ or self-organized track of urban development. This structure – on the contrary to the West Pole – is generated only by increased accessibility (already planned) and existing spatial distribution of potentials.

It is important to notice that this answer given by simulation models doesn’t automatically mean that city should give up the concept of creating the West Pole and switch into the North Pole. This only means that considering accesibility and existing structure North Pole might be easier (and cheaper) generated. But spatial policies may take into account other factors like accesibility to infrastructure, need to make urban structure more coherent or requirements coming from environment. Nevertheless results of the simulation might also influence the general picture of the city imagined by planners and supported by local authorities. Models do not display soultions but they can reveal opportunities to be explored.

7.2 Regional Network of Settlements – Case Study of Lower Silesia

Models might be also useful on regional level. Here we present result of simulations of concentrations in Lower Silesia region (South-Western Poland), which aimed at selecting trends affecting growth of town and cities in the region (Zipser et al., 2006).

Regional spatial structure is represented by 224 nodes and surroundings is represented by 184 nodes located in Poland, 94 nodes located in Czech Republic and 64 located in Germany. Simulation was conducted on the ‘flat’ network and on the network with greater performance (speed) on some sections (representing motorway or express roads).

3 different sets of potentials were applied as source data. First was even distribution of both origins and destinations. This kind of simulation reflect ‘pure’ impact of transportation network on concentration patterns. The second set of simulations was based on existing distribution of origins represented by number of residents while destination values were the same for each node. Finally, the third set of simulations increased destination value of chosen nodes.

Simulation process showed that the concentration very quickly revealed its power. Usually after 10 iterations the first nodes already gained far more destination values than others and after 40 iterations usually entire system got a state of balance. This initial phase of simulation is really fascinating because driving force of concentration in this very moment reveals its essential strength.

A few simulation displayed another driving force shaping regional urban structure – hierarchy. Results of modelling regional structure based on geometrical distance between nodes (no transportation network) and even distribution of origins and destinations didn’t reflect position of Wrocław (Fig. 9). This shocking at the first sight result can be easily explained. Hierarchical position of Wrocław is higher than regional, its location is determined by wider connections within state and continental network. By the way simulations conducted on the national and continental level confirmed this thesis.

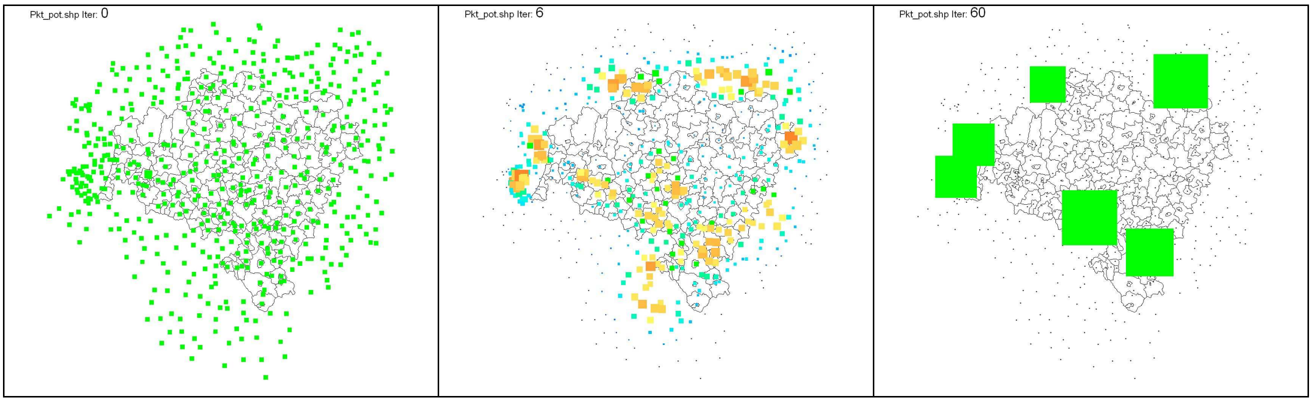


Fig. 10. Distribution of the nodes in modelling Lower Silasia urban structure (left) and results of the modelling – distribution of destinations after 6 iterations (middle) and final distribution of destinations after 60 iterations (Zipser et al, 2006).

Performing on different set of data various conditions of regional development have been analysed. The final result might support decision where different activities in the region have to be located, which connections have to be improved and which places lack of 'natural' attractiveness generated by accessibility.

7.3 Regional Impact of the Express Road Wrocław-Warszawa

Simulation models helps also creating spatial scenarios. The last example presnts possible impact of the road network on the settlement system of Lódź district (Matusiak, 2008). Five variants of the express road crossing the area have been analysed. The results were compared with the planned hierarchy of settlement structure defined in the Lodz regional plan (Central Poland). The research enabled to estimate spatial and functional advantages of different road network variants.

The research revealed that spatial consequences resulted from different location of the road (Fig. 11). It is interestin that no matter which variant has been analysed a few of town were underestimated in regional plan. Simulations indicates which location of the road can generate more positive 'side effects' for regional structure and reveals potential new local centres. In this way simulation may support regional polcy and spatial cohesion.

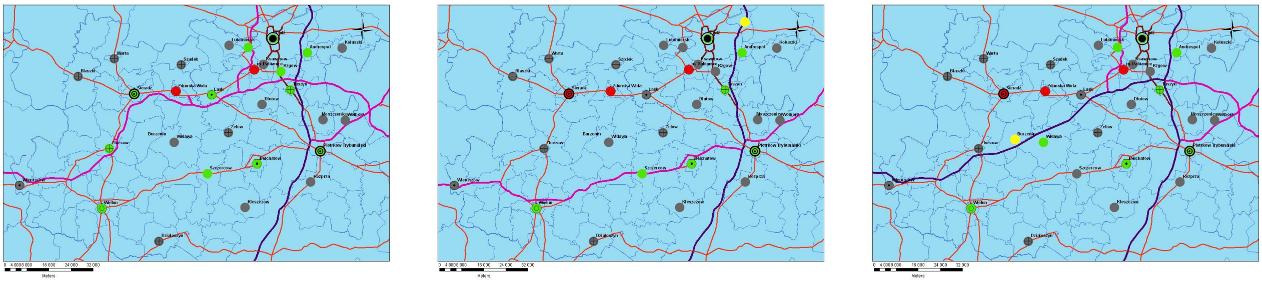


Fig. 11. Hierarchy of regional centres resulted from different location of the express road S8 Wrocław-Warszawa. In red towns with lower hierarchy in regional structure then planned in regional development plan, in green and yellow towns with higher hierarchy in regional structure then planned in regional development plan, in grey town which didn't change the position. Planned S8 express road in northern location (left), southern location (middle) or mixed (right).

8 CONCLUSIONS

The tool we presented to support urban planning should be applied with awareness of all its limitations and simplifications. Although not being perfect, nevertheless it assist in obtaining a deeper insight into processes which are not clearly observed or imagined. We cannot interpret the simulation results as a straight answer because we use a model of urbanised space and a model of the concentration process. By observing simulation results we can estimate general characteristics of an urban system. The model we use is a concentration model and does not encompass other factors of the paradigm of spatial decisions. The simulation results of more complex and sophisticated models (i.e. the ORION model which encompasses all elements of the paradigm) have yet to be interpreted. Simulation conducted on the Metropolitan Area of Wrocław revealed stability of existing node attractiveness resulting from the radial network structure and domination of Wrocław. Although the modelling results have to be interpreted, simulation methods are a useful and effective way to examine urbanised structures.

The problem with understanding and planning the new, complex urban structures might be very much about quantity – of activities, flows and conditions generated by others constituents. This is why computer simulation might help both with diagnosis and new kind of 'scenario' design. We are not talking here about 'drawing tools', but about description of the reality by using mathematical equations and conventional representation of real world.

But there is still decision to be made. Having spatial process analysed and simulated one can decide. Analysis and simulation do not replace the final decision – they only support the decision. This is to say – plan do exist as a final spatial decision shaping urban structure.

Significant is that this new planning should be understood as multiscalar process. Urban structure changes in order to implement even 'small changes' (Prosperi, 2006). This means that new design or planning tools should be totally flexible and be able to follow even these 'small changes'. There is no 'stable plan' any more – what exists is rather sort of 'modelling plan' formulating a diagnosis and 'playing' with scenarios of the future.

Essential question is if this is still 'planning' or this is only 'following natural, uncontrolled process'. We claim that this is new kind of planning because it is still decisive component in it. This means that the essence of design – decision – is still included in this process. We can decide 'against' the simulation, we can test different solutions. The 'core' is not in tools but in object 'to be designed'.

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