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Interdependence of Population Concentrations and Their Activities as a Dynamic Factor of Continental Cohesion

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***A*bstract:** This work attempts to achieve the image of cohesion by simulating the emergence of concentrations of population and its activities.

This task is accomplished in coherence with earlier simulations operating with relatively simple procedure. It is consisted in sequential shifting of population primarily uniformly distributed and proportional activity loads. A modified intervening opportunities model is used and some parameter values observed and predicted are involved. The results encourage to some farther extensions of the procedure. The new approach involved few stimulating factors and self-supporting mechanism in order to ensure realistic diversification of initial territorial and functional predispositions.

The next step is the introducing of a kind of self-training procedure which intends to achieve the compability of current and simulated sizes in a process of modification of parameter. That run of changes became a significant characteristic of particular zones. Subsequent operation brings forth a reverse process converting the current diversity into a uniform distribution. Those simulations both allow us, in a quantitative way, to estimate the “labour” of the system needed to achieve the equilibrium as a “steady state”.

Some aggregations of primarily independent zones are involved together with the introducing of group selectivity affecting the big scale conditions of integrity.

JEL Classifications: C21; J61; O52; R23

Keywords: Simulation; Urban concentrations; Intervening opportunities; Reverse process; Selectivity fluctuations; Self-training procedure

1. The Idea

Due to its nature, origin and the very concept, the European Union requires cohesion and continuity throughout its entire area.

The issues that arise are as follows:

1. What is the objective measurement of cohesion and continuity? What is the mechanism of creation of cohesive spatial systems?
2. What is the present and future situation of the European Union in the light of possible answers to the questions above?
3. What can be done to eliminate possible shortcomings of this situation?

The cohesion of functional systems based on spatial relations is related to potential mutual accessibility. These relations concern the flow of matter, energy and information.

The present civilization level offers a diverse set of capabilities to fulfil these tasks through transport systems and any limitations are mostly of technical nature. It would appear that any restrictions in the flow of information are practically negligible. Yet, it is solely an appearance. Today, as in the past, the indispensable flow of information is linked to the movement of people: those with knowledge, skills and experience.

The purpose of this article is to present a trial to check whether the relatively simple modelling mechanism is able to generate the image of a complex urban system in continental scale. It has to be achieved by the diversification and iterative modification process of only one parameter which is considered the common synergetic factor consisting of various impacts and determinants. The recognition of these constituents will be a farther task.

The basis of such approach is the role of competition effects among the cities brought up by Fotheringham (1983) and also Batty (2004). The latter draws attention to that fact that already Beckmann (1958) more than 50 years ago pointed the cities are organised with respect to their functional and spatial dependence, surrounding hinterland and sphere of influence.

The interest of the literature in city system (and the role of particular cities in it), mostly focused on the rank-size distribution and understanding of the way the Zipfs rule regularity emerges (Zipf, 1949). The hierarchy in city system is considered in terms of theoretical patterns. Berry (1964) as one of the first proposed an approach in derivation of population distribution using entropy maximizing techniques. That is important for both main interaction models in their actual versions. The model of A. G. Wilson (1967) and intervening opportunities model introduced by M. Schneider for CATS (1960) are based on the principle of maximum entropy. It is essential for the choice of model to check the credibility and accuracy in reflection of observed actual contact distribution. The comparisons between both models are relatively frequent subject. The works of Sumi and Kuwahara (1983), Zhao (2001), Guldmann (1998) show that intervening opportunity model, though represented even by the crude formulation of Stouffer (1940) is of similar power as the gravity and sometimes better in reproducing the work and business oriented contacts. Just such category of relations seems to be most effective in stimulating the growth and promotion of a city.

The splitting of the set of cities during the simulation in our experiment may suggest the interpretation based on the separate domains of prevailing cooperation or dominating competition. In this matter the proposal of a new gravity-opportunity model (Conçalves, Ullyséa-Neto, 1993) on the other hand the role of scale-free networks (Batty, 2004) especially in broad context described by Castells (1996) may be helpful to farther research.

All the authors did not find literature similar to the simulation procedure presented here.

It is no coincidence that the home-work movements are still one of the most important measurements of the integration of urban areas, as the most frequently decisive explanatory variable in structure models.

It should be added that people's trips pose particularly strict requirements as far as time; hence speed, but also safety, as well as staying within certain admissible trip durations are concerned.

In order for contacts to be effective in a system, they must reach their destination.

It is generally known that due to the nature of our civilization the probability of an appearing contact does not depend only on the distance that needs to be covered, but more so on the mutual suitability of the origin and the destination. In the light of the huge diversity of system elements and much observed tendency for maximization of its entropy, we can only use the probability of the most important relations.

Therefore, for the analytical and simulation approach employed herein, the model of "intervening opportunities" is proposed, assuming that its key parameter reflects this probability (CATS, 1960).

Hence, this parameter can be referred to as contact selectivity.

The distance resistance can be overcome by migrations, generation of concentrations and properly determined locations.

What is linked to it and results from it is the shifting of destinations or shifting of destinations and origins. These locations are appropriate not only for individual contacts, but also fulfil the fundamental condition for the stability of a system, which is a balance between the number of destinations and the number of acceptances by the origins in contact with them. Only an accepted destination may survive and exist as a structural element and only an origin which is able to satisfy its indispensable needs may preserve its spatial location (Zipser, 1973).

The acceptance of this approach involves the necessity of an adequate "modelling oriented" formulation of the definition of urbanization processes:

Urbanization is the state of arranged space characterized by the achievement of a suitable degree of the probability of contacts resulting from the leading pattern of needs accepted by given civilization.

2. The Method

We must keep in mind that the process of appeasing needs represents a constant confrontation between objective necessities and demands on the one hand, and possibilities offered by the environment on the other.

So far several applied settlement simulation models have tried to consider these three factors (needs, environment and mode of confrontation). However, they are often content with rigid characteristics accepted from the "outside". It will be mentioned here the arbitrary localizations of base employment, the rigid treatment of capacities of land portions, and others like the Lowry (1963) types of models do.

The contacts are not constraint inside of separate towns, cities or even regions. They have to link them in some kinds of networks creating the field of interactions of diversified activities, where the mutually conditioned positioning of destinations together with origins of stabilized contacts occurs.

This model was to carry out a series of simulations which were to reproduce a probable course of urbanization processes based on the here accepted definition factors: selectivity and balance. Particular simulation was aimed at finding the best location of elements, in fact their concentrations, just in order to satisfy the conditions of balance.

The key parameter of "intervening opportunities", namely the selectivity of needs generating contacts, is to be recognized as containing some social characteristics such as professional specialization, variety of lifestyles, diversification of activity patterns, economic conditions and others. Hence, selectivity may be regarded as a good determinant factor – something like civilization indicator and simultaneously the propulsion of urbanization process measure. But professional component may reflect also the role of given city in the continental or global game (Zipser, 1990).

Any cooperation between cities results in interdependence. Another after-effect may be a kind of permanent competition. There are better and worse locations in terms of geographic determinants, as well as settlement network nodes. Thus interactions of both, actual and virtual nature, can entail some shifts in equilibrium in the system. A "steady state" in that system is very often likely to be subject to change, the evidence of which seems to be the swapping of positions in the hierarchical order. A good example is the historic rivalry between harbour cities for the status of a main maritime gateway of Europe.

The method presented below was initiated and developed within research activity of Department of Spatial Planning at Wrocław University of Technology. One of the most engaging goals was to take advantage of some features of intervening opportunities model like the positive nature (human needs) of its key parameter. Unlike that the gravity approach is based on the negative factor (the restraining distance). The target was to transform the trip prediction procedure into the tool for simulation of self-organization of the spatial structure and first experiment of this kind was completed during 1969/1970 (Zipser, 1973).

The simulation model is based on the presupposition that the selectivity of needs and a definite system of accessibility of the area make it necessary to distribute origins and destinations of movement in such a way that the balance could be maintained to a possibly high degree. By the balance of the system we mean here such a situation in which the number of needs to be satisfied in a particular zone resulting from a definite selectivity is in agreement with the number of available there possibilities. The surplus of trips (contacts) to certain regions end their deficiency in others are levelled out according to the principle of successive redistributions satisfying the surplus tendencies. The "driving" force of the model, that is the tendency to create surpluses, may be written in the form of a function which will be analyzed to achieve information on the dependences between the function and several characteristics of the model elements.

Thus, the effect of simulation, i.e., the new distribution of origins and destinations of movement (or only the destinations or only the origin sources) fulfilling the balance conditions already referred to, may be described by the formula (Zipser, 1973, 1990):

$$\sum_i V_i [e^{-pa_i} - e^{-p(a_i + a_{ij})}] \frac{A'_d}{a_{ij}} = A_d \pm \propto \qquad (1)$$

for all *d*'s, where a_{ij} is the number of occasions in the ring *j* constructed for the zone *i* and including the zone *d*; a_i is the number of all occasions situated closer to the zone *i* than the ring *j* including *d*, and $\propto$ is the accepted tolerance. (The expression in square brackets defines thus the probability of stopping the travels, which are sent from *i* in the ring *j*, in accordance with the already quoted formula).

A'_d is the actual number of occasions valid in the last iteration in the zone *d*. Hence $\frac{A'_d}{a_{ij}}$ determines the share of the zone *d* in the occasional reserves of the ring *j* conditioning, at the same time, the proportion of travels terminating in the ring.

Moreover, we can give a formula for a "centre-creating force" causing the necessity of shifting the destinations from certain zones to others. This concerns the ratio of travels terminating in the zone d to the number of occasions in this zone (Eq. 2). Thus we get:

$$o_d = \sum_i V_i [e^{-pa_i} - e^{-p(a_i + a_{ij})}] \cdot \frac{1}{a_{ij}} \qquad (2)$$

The *p* value or selectivity is determined at the beginning of calculations and may be constant during all course of calculation or changed in its successive iterations. This value is, of course, adapted to the kind of considered contact and usually known from measurements and observations of real occurrences. Starting with the definite spatial distribution of destinations determined suitably to a given nature of the structure to be modelled (e.g., work, education, services, etc.) and the definite table of mutual accessibility of zones, calculations of penetration and selective acceptation of potential occasions are made by means of the intervening opportunities model.

The independent penetrations of several origin locations usually make any numerical coherence of occasions and acceptations impossible. After the each calculation of contact scattering all surpluses of acceptation of destinations ascribed to zones and all insufficiencies of acceptation in other places are obtained and then used to arrange a modified distribution of destinations accordingly to the achieved repartition. In this way moving to the next approximation, the "shifting“ is carried out, i.e., surplus zones are now ascribed such a number of destinations anticipating acceptance as the number of acceptances recorded in the preceding calculations. At the same time the destination potential in zones in which deficits were observed is decreased to the level of acceptances. Next, the calculation of movement exchange is made as the following approximation, and balance conditions are checked again after that shifting is repeated and the successive calculation is made. This procedure leads to the moment when no zone shows a surplus exceeding the assumed tolerance (admissible surplus). Since this process is convergent, the sum of surpluses decreases with the increasing number of approximations, which do not exclude different fluctuations in the zones which may change from growing to decreasing and vice-versa (Eq. 3). It may generally be written as**:**

$$a_i^{m+1} = I_i^m \qquad (3)$$

where: a_i^{m+1} the number of destinations in the zone is determined for the m+1 approximation, and

I_i^m is the sum of acceptances made in the zone during calculations of the m-1 h approximation.

The “general shift model” is a farther extension of that idea.

The operation of this model is similar to that of the "shifting of destinations" model. Simultaneously with the change in destination potential there is a change in the origin potential. It should be assumed that there exists in each region a certain proportion of origins and destination goals and, in particular cases, an "apparent equilibrium” based on quantitative equality (e.g., the equal number of professionally active inhabitants and work places in a settlement unit). Then we can write:

$$V_i^{m+1} = A_i^{m+1} = I_i^m \qquad (4)$$

where:

V_i^{m+1} is the number of origins assigned for the zone *i* in the (m+1)-st iteration;

A_1^{m+1} is the number of destinations in the zone *i* in the same approximation; and

I_i^m is the number of acceptances recorded in the zone *i* in the m-th iteration.

The rule of equality of origins and destinations is not indispensable in the model. The proportion may be differentiated either with the region potential or with the region dynamics. This differentiation is necessary to ensure the maintenance of a definite number of origins in the entire system (Zipser, 1990).

In order to verify this assumption several ex post simulations were executed. Their task was to bring out the present image of settlement subsystems of different scale, the initial state being an absolutely uniform distribution of origins and destinations (population and work). The actual transportation network, however, was often introduced as determining mutual accessibility. Many results of such simulations, which could be interpreted as an affirmation of the hypothesis concerning the explanatory power of modelling mechanism, encouraged us to use it in scale of the whole country system as well as a set of countries.

The finally achieved balance showed interesting pictures of emerged concentrations. The selectivity value of $50 \cdot 10^{-6}$ estimated on the basis of measurements of real phenomena in Poland has evoked the polycentric network of polish urban concentrations resembling the existing one.

The results were especially improved when a small bonification was involved in the time distance table concerning these zones which included the most developed transportation nodes (more than 11 links or more than 6 main roads and simultaneously more than 3 railway links). That bonification consisted in considering these zones as being shifted into a closer ring of distance. In this case nearly all Polish conurbations were evoked by the model in their actual position.

Further modification, namely the differentiation of the initial "size" of zones preserving their uniformity but differentiating them according to the mean density in a given part of the country, enabled the model to reach good accordance in the proportion of distributed magnitudes.

For the comparison of the size of 70 largest towns (where the towns of Upper Silesia Industrial Region were aggregated), very high correlation coefficients were obtained:

- Comparing the year 1970 with B1 (simple simulation): 0.701;
- Comparing the year 1970 with E1 (simulation with bonifications and modified density): 0.929 (Zipser 1987).

The experience gained in the practical application of the "intervening opportunities" and "shifts of sources and destinations" simulations models seems to suggest certain points for further work on the simulation model of settlements development. Whereas "small-scale" simulation referring to individual towns, urban clusters and, occasionally, even to regions yields fairly realistic pictures or at least discloses the actual trends, the simulation techniques applied to big regions, not to mention whole countries, prove to involve a number of specific imperfections.

The analyses made so far neglect the stratification of selectivity within one category of movements. Our own investigations made both within a big city (Wrocław) and in a considerable part of the Opole region have confirmed the necessity for such stratification, resulting in specific fluctuation of generalised values.

These values correlate presumably, with education and with individual occupational groups. But some specific "depressions" of the selectivity parameter in the small towns of the Opole region also seem to indicate the need of identifying the resident's knowledge of the proffered opportunities and their "competitive efficiency" as compared to people penetrating the given area from considerable distance.

So the spatial system of information spread affects the process of choosing and accepting the destinations.

3. The Operation

How can this rule be used towards the examination of the cohesion of the EU's urban system?

To reiterate, as in any such system, the current state, or at least the so-called steady state of a system is the balancing out of the number of destinations by the number of their acceptances by the contacts.

The contacts can be treated separately, as individual connections or it can be assumed that the origins are grouped within some local collectivity.

We assume then that this territorial collectivity of origins is primal and results from biological (family), cultural and, in particular, economic and infrastructural reasons.

Whereas the territorial collectivity of destinations is secondary, resulting from the overlaying of contact penetrations.

Consequently, it is more flexible and spontaneous and hence more difficult to predict and control. In any case, this results in practice in concentrations of activities and people.

If we make this assumption regarding the nature of concentrations and the mechanism that generates them, we can recognize as one of the key measurements of cohesion, a set of values of the selectiveness parameter, which brought about the current state. This is a notion related to simulation analysis, which entails a possible, but well defined process that changes a uniform distribution of origins and destinations. It is a virtual, theoretical process, which may not necessarily have taken place in the past, but it may have something in common with the actual process. It also needs to be noted that it is a dynamic process, during which the values of the parameters may also change while reaching the state of balance.

However now we intend to achieve the compatibility of current and simulated sizes as good as possible. The aim is different than in previous experiments. As we already know precisely actual situation and all particular magnitudes we need the information about the process of modification of parameter in course of emerging final size. Such modification should be an individual characteristic of each zone.

It allows us to obtain precisely the actual size of every unit in the selected system of cooperating cities, without any diversification present initially. A necessary course of changes concerning the process parameters is recognized because the procedure is something like a self-teaching action. Further classification and interpretation of consecutive fluctuations and trend variations help to explain probable factors affecting reality.

The parameter of selectivity applied in presented simulations was understood as group selectivity to reflect a unity of about 100 persons assuming that in such proportion one person among nearly hundred may be engaged in exogenic activities of interregional importance.

In order to manage such self-steering process a simple formula was used:

$$p_i = \frac{-\ln R}{B_i} \quad (5)$$

after each iteration resulting in a too small size of the zone, when it must limit the range of contacts for keep them inside.

$$p_i = \frac{-\ln R}{A_i} \quad (6)$$

when the zone is exceeding its expected size and has to get rid of that surplus.

The formula puts the selectivity parameter for the next iteration; R is allowed fraction of contacts generated in the zone, which is sent outwards, and usually is equal 0.001; B_i is the number of acceptations received in given iteration, and A_i is the expected number of destinations.

The method described herein works on different scales. It has been applied to all of Europe (the entire continent) and to the entire country (Poland), as well as to three Polish regions of Lower Silesia, Malopolska and Opole (Zipser, Mlek, Zipser 2011). In all cases, it provided similar conclusions and identified some problematic spots in the system.

Recently we have performed a series of simulations concerning the European system of big cities together with their regional supporting environment in two variants – for European Union (94 zones) and for the whole continent (129 zones being in fact big urban regions).

This modelling brings to achieving exact size of almost all existing European concentrations. The correlation coefficient reached the value 0.9461 in 250. iteration of EU simulation but already after 4. iteration this coefficient was 0.7700. The correlation obtained in whole continent modelling was a little worse with coefficient equal 0.8947 in 250. iteration – mainly because of too big zones in Russian part which are not able to attract sufficient amount of destinations (all zones in that continental set had the same initial average volumes).

In the subsequent simulation analysis of the European Union presented below as the final sizes of 123 biggest cities the numbers of inhabitants of FUAs (functional urban areas) were fed according to the ESPON data (2005).

The following actions were undertaken, which differentiate the factors listed below:

1. A homogenous communication (road) network and one diversified according to speed were used.
2. The present territory of the European Union, as well as the EU plus the territory of Ukraine were referred to, shown in Figure 1.
3. A transformation of a system with identical concentrations of origins and destinations into systems of diverse concentrations was simulated, as well as a purely theoretical process of reversal from the actual situation to a regular distribution.

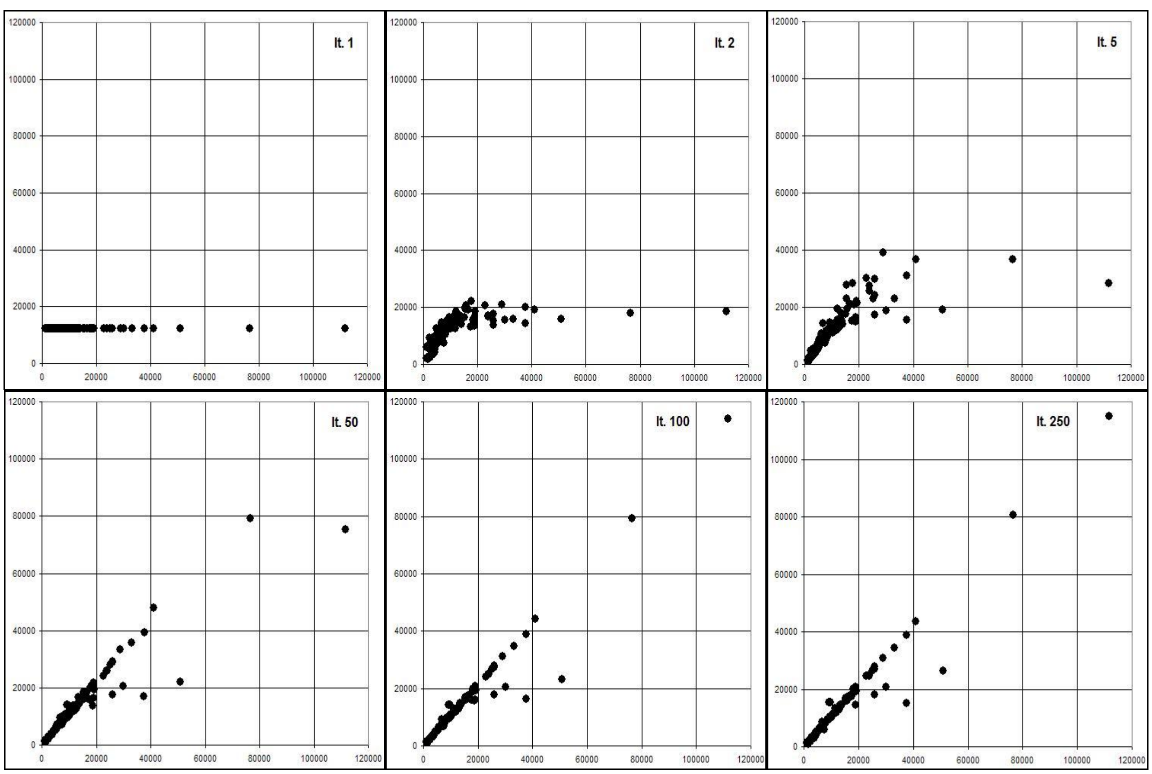

Figure 1. Self-training simulation. EU+UKR – diversified network. Correlations between expected sizes (X axis) and obtained in selected iteration (Y axis)

On the graph showing nearly perfect correlation in EU simulation one can see a group of few zones beyond the main 45˚ ribbon. They build during 250 iterations their own parallel axis. This group consists then of only 5 zones: - all dramatically losing their population (between 4 and 50 iterations), shown in Figure 2.

The simulation results reveal an interesting division in the set of zones. A very great majority of them achieve their expected sizes very quickly – even during the second iteration, when the biggest cities need sometimes nearly hundred iterations.

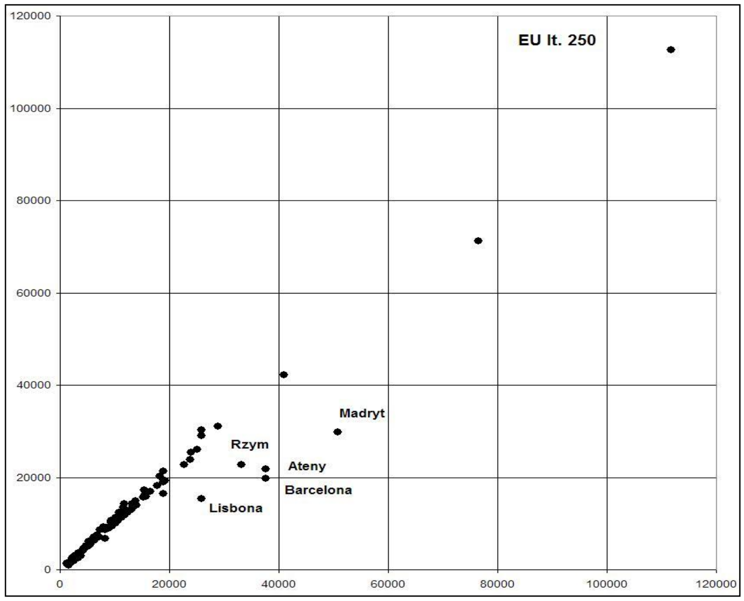

Figure 2. Self-training simulation. EU – homogenous network. Correlations between expected sizes (X axis) and obtained (Y axis) in 250 iteration

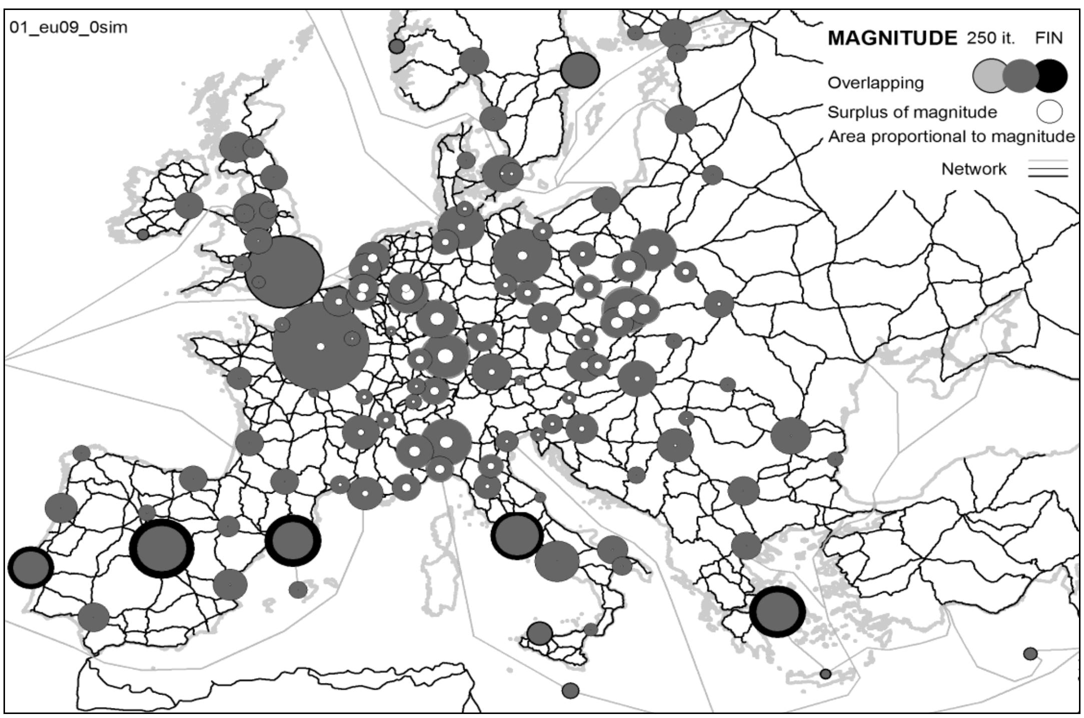

Figure 3. Self-training simulation. Final results (250. iteration) EU – homogenous network

So some zones (Lisbon, Madrid, Barcelona, Rome and Athens) cannot collect the needed number of destinations even during the entire modelling process of 250 iterations, as shown in Figure 3. The reason is probably their peripheral location together with ignored (by model) influence of external relations (perhaps of African or Asiatic origins) and ancient roots in Roman Empire as well some global impacts.

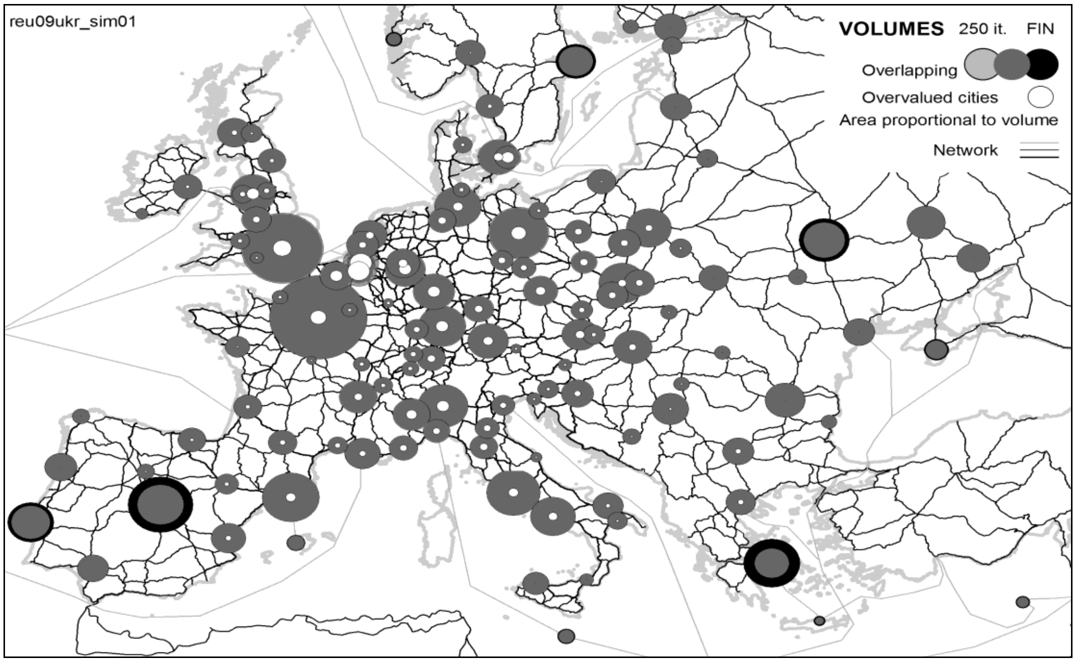

Figure 4. Self-training simulation. Final results (250. iteration) EU+UKR – diversified network

The second variant including Ukraine and in addition using diversified network shows such deficiencies only for Lisbon, Madrid, Athens and Kiev. Rome and Barcelona but also Paris and London increased achieving some surpluses as compared with their actual sizes (Fig. 4 & 5).

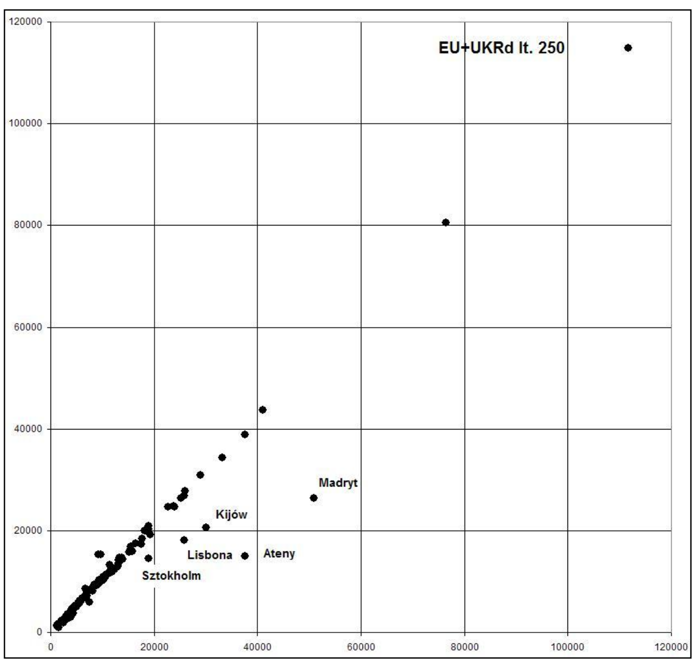

Figure 5. Self-training simulation. EU+UKR – diversified network. Correlations between expected sizes (X axis) and obtained (Y axis) in 250 iteration

At any rate the final diversification of parameter values has to be viewed as an important product. The selectivities which were uniform (equal) in the beginning, became subject of wide spread of values. It was from 164 times or 197 times. But in fact the majority of them differ only about 35 times and again a limited number only of smallest zones get through to the extreme values (Fig. 6 on the next page).

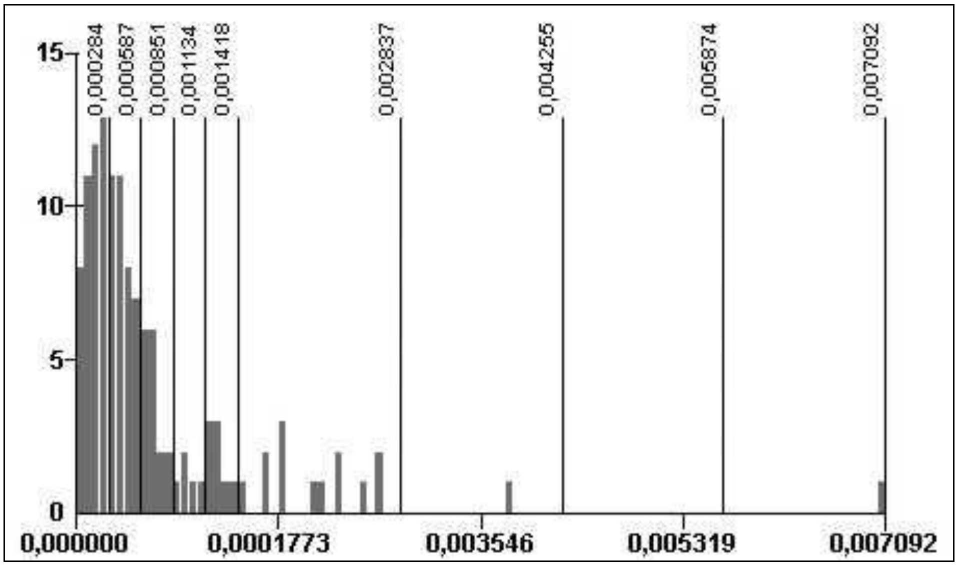

Figure 6. Histogram of 250. iteration selectivity values. Self-training simulation of EU+UKR – diversified network

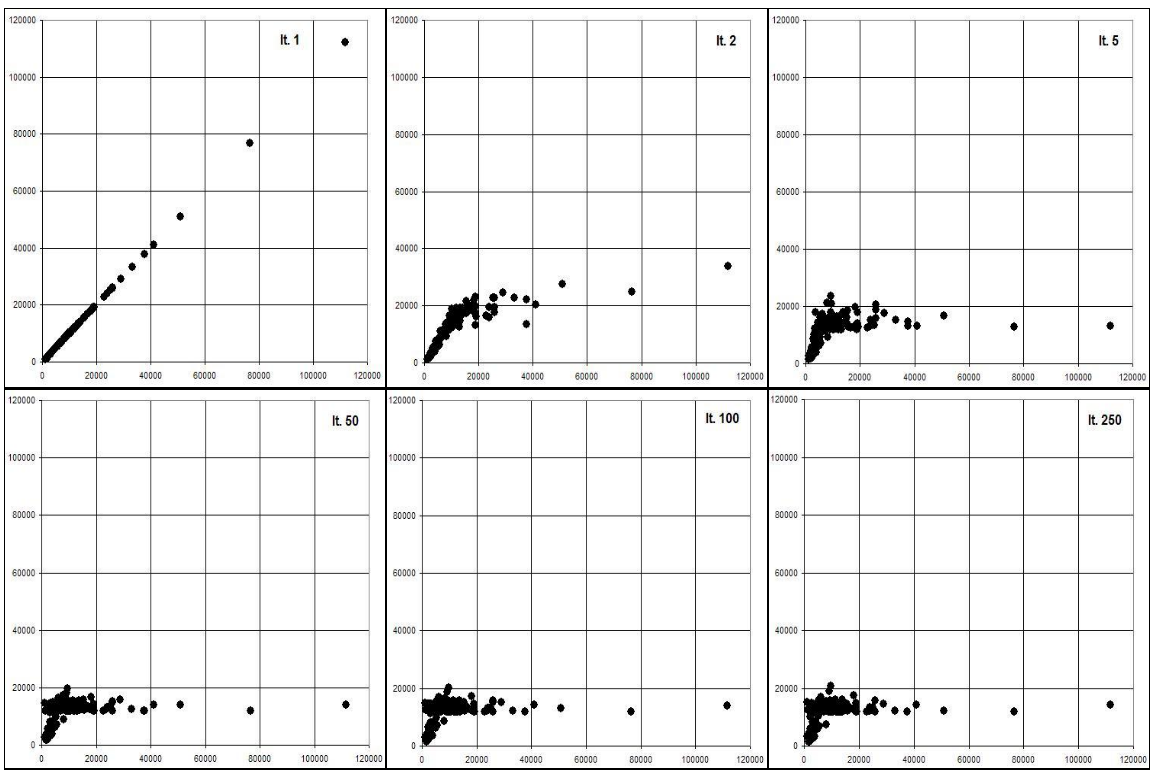

Figure 7. Self-training simulation. Reverse process. EU – homogenous network. Correlations between initial sizes (X axis) and obtained in selected iteration (Y axis)

Now we use nearly the same algorithm but including a reverse process of abolishing any concentration getting a uniform repartition. On this way it could generate an intended pattern of increased polycentricity too. However the most interesting fact is the same difference between biggest cities and those not exceeding the level of about 1.500.000 inhabitants. Now they are reluctant to change, they preserve their actual sizes when the biggest cities take already uniform positions on a nearly horizontal line. At the end of simulation (250 iterations), several units of those groups shape still a skew steep ribbon intersecting the horizontal set of the rest of cities, shown in Figure 7. That very distinct contrast may be resultant from the spatial situation and has to be subject to explanation.

The fact that the zones reach the expected volumes by a number of consecutive relocations of origins and destinations doesn't mean that in balanced stage there are no flows between zones. On contrary the stabilized populations and selectivity generate the contacts but they present now the current "normal" relations which are not transformed into migrations.

So it is especially interesting how these contacts fill the network and how they indicate stronger and weaker cohesion inside of the system.

Here we have a very important observation. It is strongly linked to the intention of this analysis and concerns the flows between zones. Those flows are present after achieving the expected balance and they connect together several zones into separate clusters. As the system is already practically balanced they don't influence farther changes of volumes being rather signs of reciprocal interdependence and cooperation of zones. They are visible in all variants of simulations forming the strips of very intensive contacts and characteristic gaps between them so that they remind the former course of "iron curtain" (Fig. 8 & 9).

Taking it into consideration it seems to be justified to check how the system would react to some arbitrary changes of parameter values in selected places involved in order to enforce other stronger flows across the mentioned gaps.

Such experiment was done in 3 variants. They differed in the considered area including Ukraine as the extension of Union or not doing so. Another difference consisted in 7 or 9 cities which have obtained very sharp selectivity (small value) and were chosen on both sides – western and eastern edge of the gap. At the same time 5 other cities inside of this gap were equipped with bigger value to enable them to keep received destinations "forever", as shown in Figure 10.

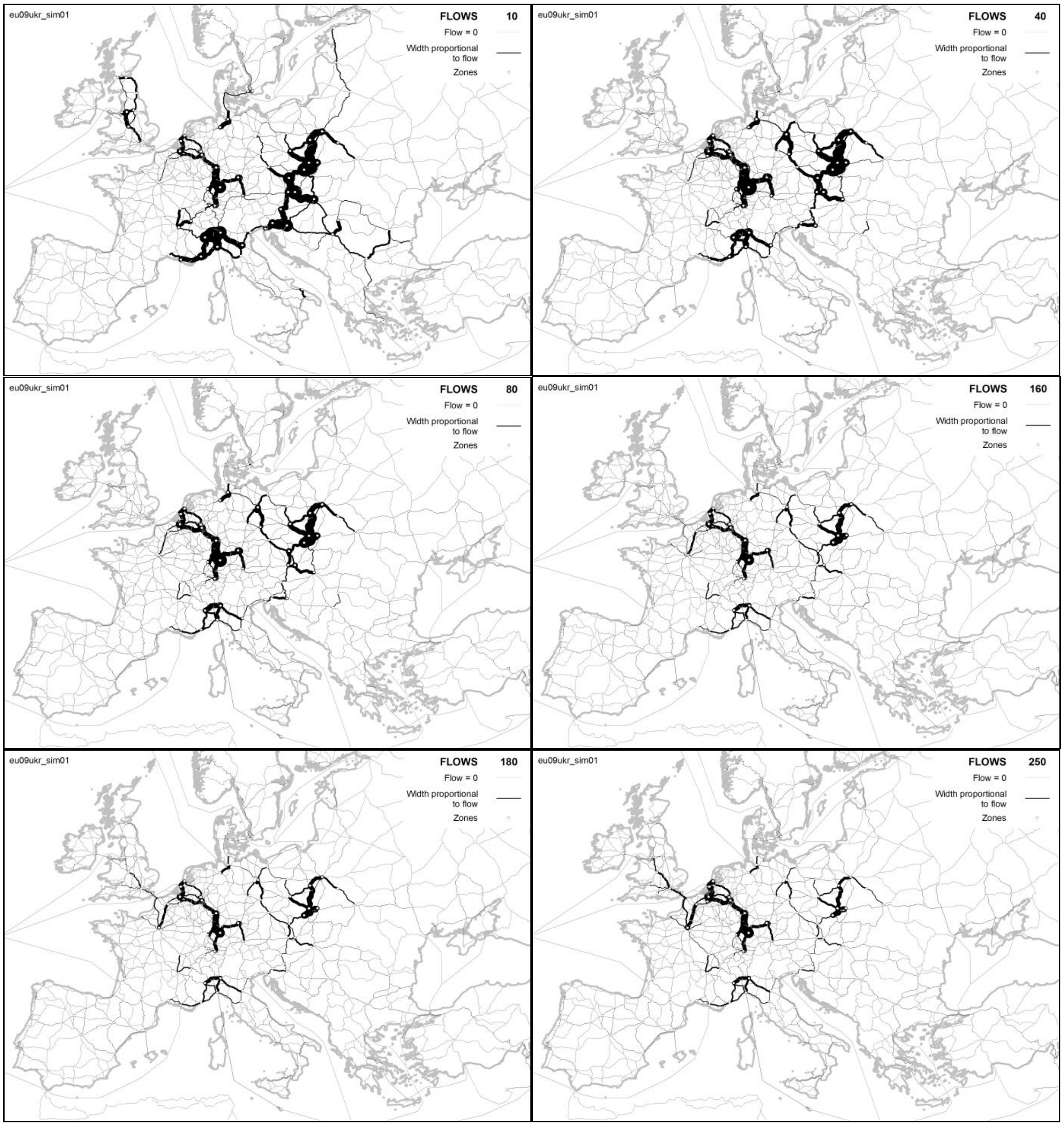

Figure 8. Main flows during the simulation iterations.
Self-training simulation of UE+UKR – homogenous network.
Iteration 10, 40, 80, 140, 180, 250

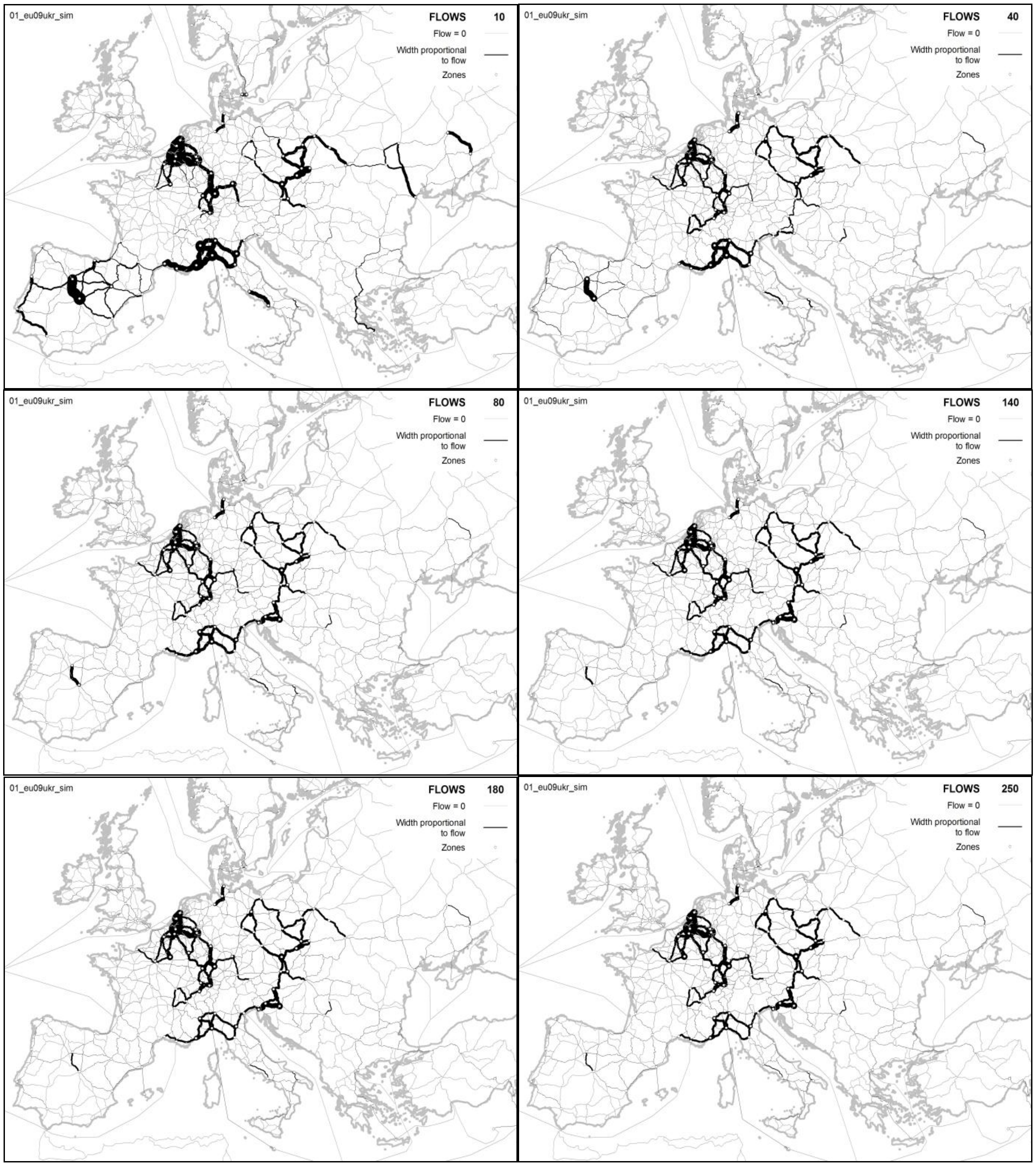

Figure 9. Main flows during the simulation iterations.

Self-training (reverse process) simulation of UE+UKR – homogenous network.

Iteration 10, 40, 80, 140, 180, 250

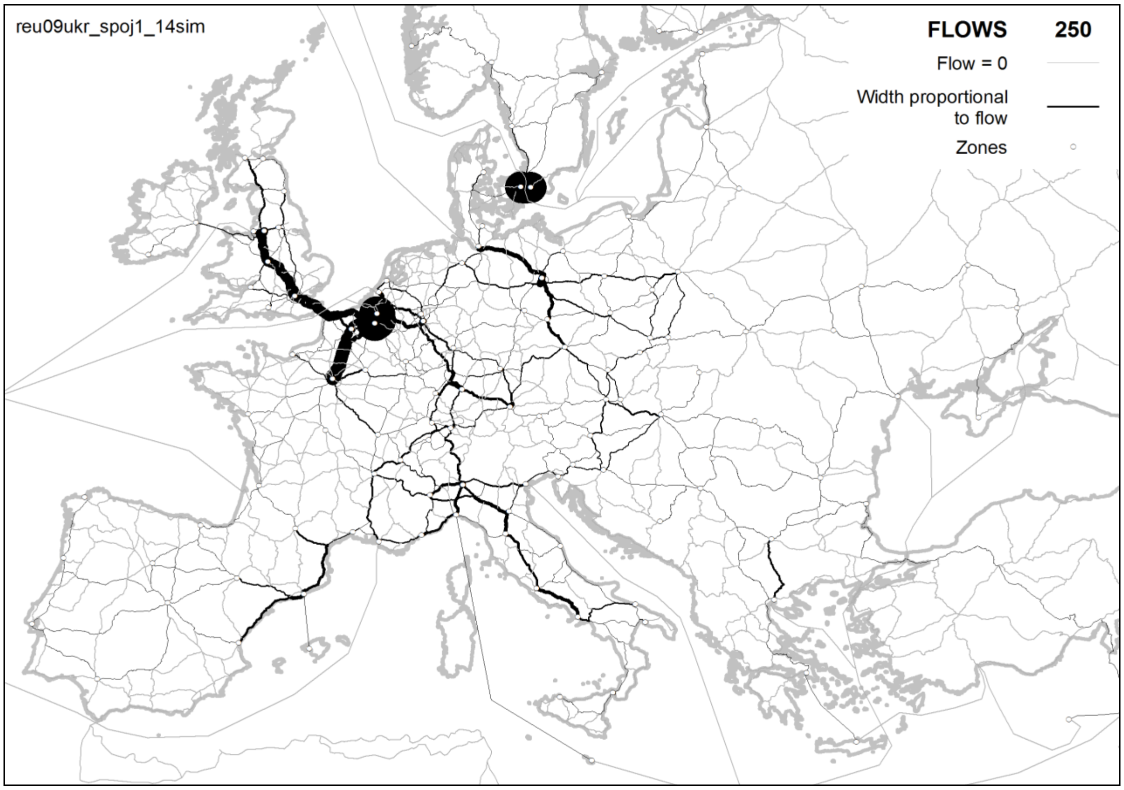

Figure 10. Main flows in 250. Iteration; Self-training simulation of UE+UKR – diversified network, arbitrary correction of selectivity, “7 cities”

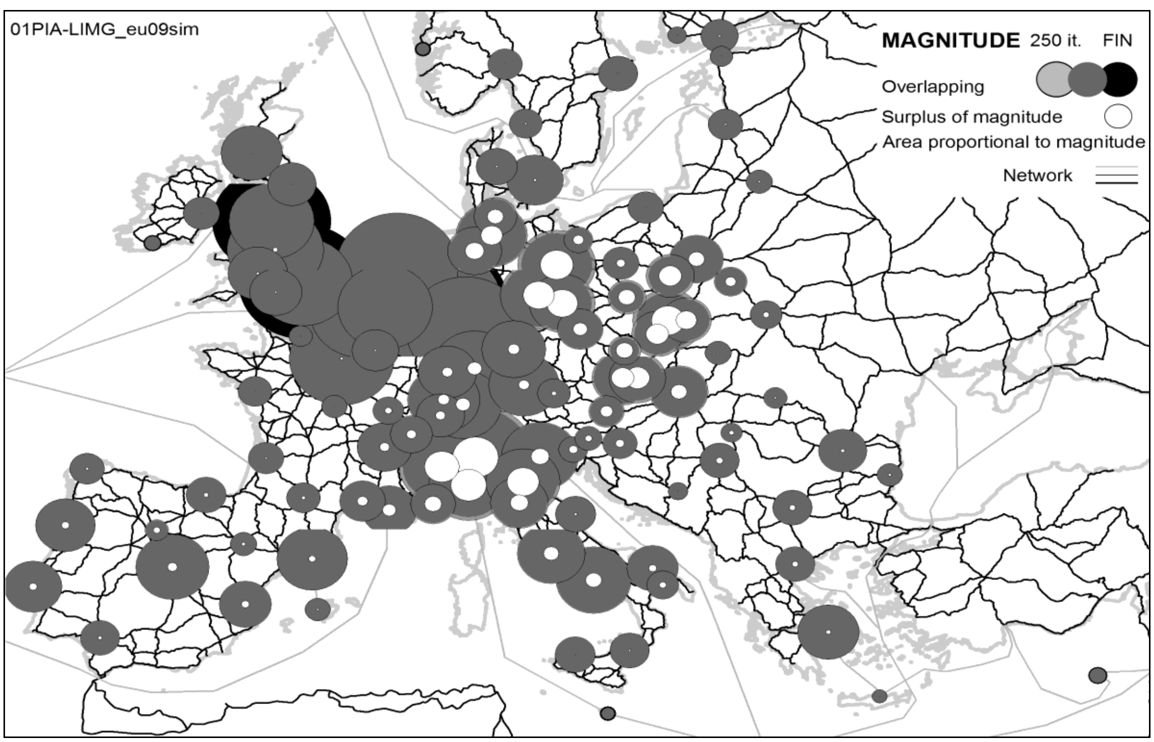

Figure 11. Self-training simulation. Final results (250. iteration) EU – homogenous network, PIA magnitude, an upper limit of five zones.

Indeed that operation resulted in a reinforced and more dispersed image of interactions but also produced several new strong connections behind of the gap area in question especially in Great Britain, between Paris and Brussel, in vicinity of Copenhague. Also it generated a more dispersed moderate contact streams between the units of eastern bundle.

Generally the variant including Ukraine and diversified network speed improved the connection flows over the whole system.

It seemed to be interesting to test how the main characteristics of the simulated process may change due to another defining of elements of the system.

Hence for the next simulation the particular cities (FUAs) were replaced with large accumulations of presumably cooperating strongly and interdependent settlement units. They are considered by ESPON as PIAs (potential integration areas) and are of significantly bigger dimensions.

The results achieved were rather of the same nature as the preceding outputs. A very big cluster of concentrations emerged across the European north-south axis (Fig. 11).

An upper limit of the size was needed to avoid excessive surpluses. It allowed to reduce an unexpected deficiency of concentration in two English zones: Manchester and London. On the contrary the southern end of the cluster contains the zones with big surplus tendency.

While those enormous volumes of urbanized population form a massive belt between Glasgow and Milano, the most intensive balancing flows are concentrated along them on the eastern side between Hamburg and Budapest. Very long ribbon of large flows runs additionally to Venice, Milano, Barcelona, Madrid and even Bordeaux (Fig. 12).

The balanced situation shows several isolated groups of connected zones. Besides two Italian groups they are remainders of that eastern system.

4. Results

The results obtained by modelling operations can be put in two categories. First, it was recurrently proven that the self-training procedure used here is able to reach a very good accordance of its outcomes with the current data referring to the population of biggest functional urban areas of the European Union. It means that even within a very complex system containing uneven mass distribution, very wide spread of magnitudes and confined by complicated contours the simulation algorithm manages to achieve the solution of multistage task.

We have to comment on the emerged final spread of parameter values. It is mainly evoked by the biggest units in European urban system. However the prevailing majority of zones act with the selectivities which vary but only inside of more limited interval. It means that rather moderate amplitude of fluctuations is enough to generate an actual basic structure of set of European cities.

The sum of all these fluctuations may be considered as the measure of work the system has accomplished for reaching the ability to proper and effective operating. In such terms it is something like a potential energy of urban system.

The experiment is aiming for the insight into the fine subtle structure of reciprocal competing forces and conditionings so that the sequence of forced changes of selectivity parameters would be like the rings in an old tree stump. We have to learn how explain these tendencies, hesitating and turns, though it is a virtual history not a real one.

The second kind of results regards some concrete facts emerging during the modelling. Perhaps the most important findings concern the surprisingly distinct spontaneous splitting of the set of zones into three classes. The first class contains majority of zones which achieve their expected sizes during few initial iterations (even during the second one). Hence they are supposed to be strongly dependent upon the simple interactions with neighbourhoods and so exposed to the game of geographical distance and territorial barriers.

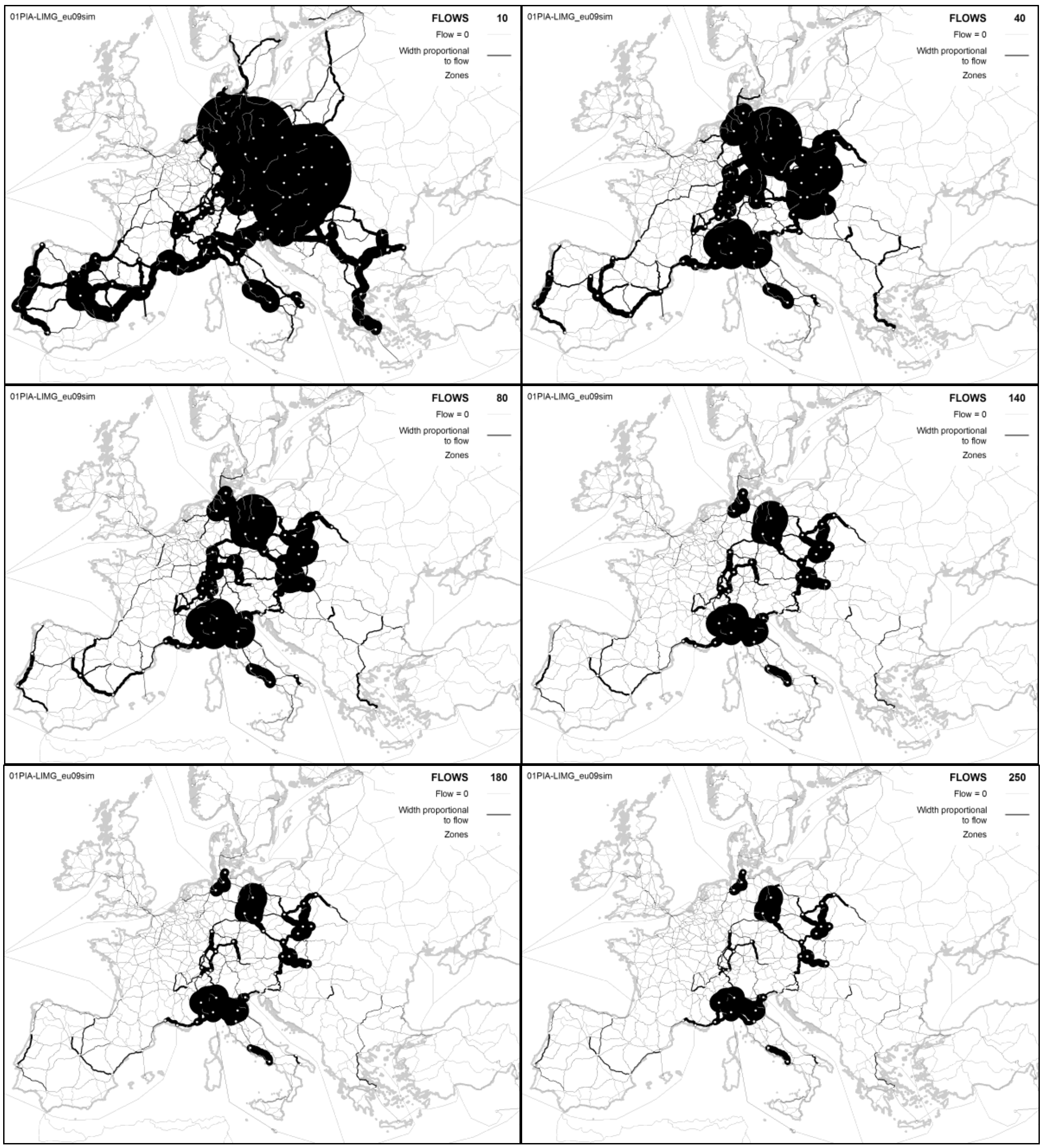

Figure 12. Main flows during the simulation iterations.
Self-training simulation of EU – homogenous network, PIA magnitude,
an upper limit of five zones. Iteration 10, 40, 80, 140, 180 and 250

That group embraces practically all cities with population less than 1,500,000 inhabitants.

Above that threshold the biggest urban concentrations approach their actual volumes very slowly and stepwise gradually. We can interpret this phenomenon that the smaller concentrations emerge in a kind of "natural" balancing process based on vicinity and proximity rule. Those bigger ones are determined by more complex, long distance or even "free scale" links.

The comparison of this separating level with the point of sudden change of the bias in rank-size graph prepared for set of all functional urban areas (FUAs) in European Union shows the level of both discontinuities are similar.

The third class includes very limited number (5-6) of zones which are not able to attract the needed population during long sequence of 250 iterations. In that case we suppose the reason may be an ancient (Roman Empire) or cut of basis of their growth (the southern coast of Mediterranean Sea not involved).

Here we have emphasized that including of only six distant Ukrainian zones changed visibly the situation in different parts of system. It confirms the role of long distance relations in procedure.

Nevertheless the size and the shape of the flows supporting the resulting structure seem to remind of the trace of "iron curtain".

The reverse process was to strengthen the reasoning concerning the ways the units of spatial European urban network are mutually tied. Unlike the gravity model the intervening opportunities model does not operate in symmetrical manner as for relation origin–destination. This proceeding helps to realize what means could be engaged to promote more polycentric spatial pattern and improve the intercontinental cohesion. The reverse process which eliminates quickly the biggest concentrations, very slowly restores the equal size distribution among the smallest units and so repeats mentioned above division.

Both, the file of changing parameter and the image of flows constituting and maintaining the structure have to become subjects of investigations in order to recognize their generators, components and limits.

5. Conclusions

The method presented here enables us to evoke the existing image of settlement system with very high accuracy. This goal is not achieved by any direct intervention but only by involving the system in a kind of complex game of penetration, acceptation and adapting to the possible balance. That seems to demonstrate the power and the capacity of intervening opportunities idea as we operate with the modifications of the only one parameter.

The decisive key parameter of that game – the selectivity of contacts is a subject to observation and current measurement. It is an average value in an area so that all these fluctuations have been caused by different pattern of participating in the activities of local, regional, macro-regional and continental level. They reflect the wide set of economic, cultural and social roles of particular urban units as the elements of civilization system.

The analysis of ways of changing the selectivity parameter seems to be a good tool for a specific classification of the situation of the cities with respect to interdependence and possible competition among them. The survey of very different sequences of increasing and decreasing selectivity, the turning points of tendency or hesitating stabilization offers probably a new base for evaluation of chances and risks.

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