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MECHANISMS OF ECONOMIC SPACE DEVELOPMENT. AN ATTEMPT AT A THEORETICAL RECONSTRUCTION

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Abstract: This paper presents a set of concepts aiming at the reconstruction of mechanisms of economic space development. These concepts are ordered in the way that consecutive concepts add new pieces of knowledge increasing the degree of cognition of the mechanisms of the economic space. This set includes among others: a shift from one steady-state to the next steady-states, self-organization and the development far from equilibrium, multiple equilibrium, punctuated equilibrium, innovation in the phase transition, a pulsative course of the development process, an emergence of complex spatial systems, a development code of the system of regions.

Keywords: Theoretical reconstruction of processes, steady-states, self-organization, punctuated equilibrium, emergence of complex spatial systems.

JEL codes: B52, E32, E70

1. Introduction

The literature on economic space development is extensive and develops fast together with the paradigm of spatial economics as a separate field of knowledge, research and a spatial policy. Most numerous are publications dedicated to the factors of spatial development, especially the population, physical capital, a land-use pattern. These works were accompanied also by publications on technical progress, human, social and territorial capital, on institutions, and urban and regional governance.

The second group of works involves the studies concerning relations and dependencies between factors. In the economic-oriented literature the most frequent

are studies inspired by economic growth theory, e.g. the studies of relations and dependencies between the production and capital, work, infrastructure, investments in production and services. Gradually, there were also more and more positions of the literature dealing with more complicated issues, that is with feedback, agglomerations, adaptation processes, networks of cities and regions, fluctuations of economic activity in space, core-peripheries relations, spatial diffusion of innovation and economic growth, knowledge spillovers, the learning cities and regions that learn, the self-organization of the economic space. A significant event was the formation of new economic geography and rewarding its founder, Paul Krugman, with the Nobel Prize in science. Creative teams and scientific centres continued to investigate geo-economic and spatio-economic issues. The subjects were not always new. The issue here was to explore already known problems and their modification, and to give research methods an operational form which would enable empirical studies and practical application. However, there were also novelties. This can be ascribed to the issues of evolution in the economic space and its complexity. There appeared many interesting research subjects related to it, the study of which paves the way for a new, evolutionary trend in spatial economics.

The main idea of this trend is an attempt to inquire into the mechanisms of economic space development. Previous research on the factors of the development of cities, regions, countries and the global economy and relations between them led to the expression of numerous conceptions emphasizing various aspects of this complicated concept structure. Apparently, there is no coherent theory explaining the structure and functioning of the mechanisms of economic space development. This study does not seek to present the history of spatio-economic and geographic thought related to its subject. This would require a separate, considerable work. Naturally, we cannot do without the use of the valuable output produced by subsequent schools of thought in economics, especially the neoclassical one, and also without an attempt to create theoretical bases for economic geography started by Christaller (1933). We will focus, however, on the latest conceptions.

2. Towards a theoretical reconstruction of mechanisms

The mechanism of economic space development in a theoretical sense (non-substantial) is understood here as the pattern of interrelated elements, relations and processes which stimulate and develop spatio-economic movements and transform space. The basis is the present state of spatial development. Practically, we will study this state in the form developed after the World War II at the scale of cities, regions, countries and at the entire globe. Dendrinos (Dendrinos & Mullally 1985; Dendrinos 1992) specified this general definition introducing the following hypotheses: 1) the evolution of each large metropolitan area is determined by a code which can be empirically assigned to it; 2) the code of a particular metropolitan area is the result of the potentials of all the remaining metropolitan areas and reasonable individual and collective dynamic actions of particular areas; 3) the basic principle determining the code is a relative parity of attractiveness prevailing

in the national and international patterns; 4) continuous desire of particular agglomerations to achieve a favourable parity of attractiveness lead to quick changes in their socio-economic structures in a short time horizon. In a long time horizon, the level of a relative parity is only subject to slow dynamics.

Interdepences combining elements of the economic space stimulate multiple interactions (economic, social, political, cultural, ecological etc.), which manifest themselves as national, international and inter-period flows. The main types of such interactions are the population migrations, the exchange of goods, capital and information flows. Movements in time and space co-occur with them leading to the dissemination of such phenomena as new technologies, ethical standards, social ideas. They are indispensable for economic growth and progress. These interactions also result in negative developments, such as a spread of unemployment, poverty and environmental pollution, the exhaustion of natural resources, the emergence of political dominations, and destructive cultural paradigms and demographic tendencies.

If we, in a theoretical (non-substantial) sense, imagined the economic space as a virtual map divided into different fields, we could notice that many fields are gradually filled out while others remain empty. The distribution of the occupied and empty fields is irregular; they take up various parts of space. The process of gaining knowledge about the economic space consists in the filling of subsequent empty fields by formulating new conceptions. This reduces our ignorance. New elements can change the structure in various directions. Occupied and unoccupied fields form a new structure. Of great significance is a creative intuition suggesting the choice of direction. It is based on the knowledge already accumulated and the acquired experience. Thus, the knowledge is broadened and its new structure is formed. This work seeks to make a step towards it.

3. Project of a theoretical reconstruction of spatial processes

In this part of the work we make an attempt at a tentative outline of the mechanisms of economic space development referring to the line of thinking presented in the previous chapter. This project will be an organized set of traditional and new conceptions of dynamics and the economic space evolution. It will involve adding conceptions which occupy subsequent fields on a virtual map. Thus, an increasingly complex configuration of occupied fields is created, which is indicative of gradual expansion of knowledge about the mechanisms of economic space development. According to a dominant trend in theoretical studies in spatial economics, this knowledge will have a form of models and hypotheses. Its cognitive value will depend on whether its explanatory power concerning spatial development is greater than that of competitive conceptions. An assessment of whether, and to what degree, such an increase takes place is the task of scientific criticism. A brief discussion of the mechanisms reconstructuring economic space development is presented below where only the main courses of action of these mechanisms will be described. The next chapter will expand on its details.

Neoclassical models presenting the functioning and development of cities, regions, countries and the global economy are developed relatively the best. In the past years and decades, the author devoted several works to this subject so it will be not repeated in this article. These works stem mainly from the idea of the economic growth of the areas of different sizes. The issues listed in the further part of this article are mentioned by the authors with innovative approaches. There are no comprehensive studies and the present author does not aim to change it. In this part of the article they are reviewed and in subsequent parts they will be discussed further. He intends to organize the issues which make up the conception of the mechanisms of economic space development. It is not an usual classification, however. What is outlined is a certain arrangement aiming at a theoretical reconstruction of the development process of the economic space.

The neoclassical model of growth leads to a steady-state in the long run. This is the state when the production, capital, employment and investment growth rates are the same. In the graphic form, this state takes the form of a parabola and in the next stages of development, a pulse curve.

The dispersed action of different entities filling the geographical space are ordered by a self-organization system. Self-organization occurs when spatial systems meet three conditions: they are open to an exchange with the surrounding area, their development is non-linear, and new cities and regions as well as the existing ones develop far from the equilibrium.

Generally, there are several places – candidates for the new dynamics of economic growth. The new dynamics is accelerated, but only in short periods of time. In the graphic form its development line is steep. Between periods of accelerated dynamics (rising development lines) there are longer periods of slighter changes. This type of variability is called a punctuated equilibrium (a term comes from geology).

A punctuated equilibrium suggests that the conception of a multiple equilibrium may be inspiring in the research on the development process of spatial systems. In a market economy a multiple equilibrium appears when the degree of the use of production factors varies in different places. In such conditions an economy with a given resource of production factors may display many equally plausible equilibrium states. They can be classified according to the Pareto optimality. Which of these multiple equilibria is going to be reached or selected will depend on the initial state and the chain of creative transitions.

Evolutionary genetics makes it possible to explore this type of variability more thoroughly and give it a precise form. This is possible thanks to a model known in the literature as Price's model (1970). It is the equation which is a formal, thorough and precise description of biological evolution and enables the reconstruction of the evolutionary process by distinguishing selection factors and transmutation factors. Slow and quick changes occurring under the influence of radical innovations are the equivalents of these factors in the economic space.

Trends in the development of cities, regions and countries show steady tendencies. They are mapped by a code which is a record of individual and systemic features and which determines the transmission of hereditary features.

Innovations in the transition phase. A shift from a less organized state to sustainable development requires innovation at a larger scale than those implemented on the gradual development path. In order to achieve the objective, these innovations should create a coherent system involving changes in technology, infrastructure, economic and social behaviour patterns, cultural values and politics.

The main conceptions mentioned in this part of the article will be highlighted in the next chapter, the excerpts of which have been taken from the author's larger work devoted to a theoretical issues of spatial economics (Domański 2018).

4. Reconstruction elements of the mechanisms of economic space development

A shift from a steady-state to the next steady-state

The movement in metropolitan areas is a combination of two movements (Dendrinos & Mullally 1985, pp. 62–64): one toward a steady-state, usually spiralling downwards and a movement made by a shift to a new steady-state. The first type is called a proper movement, whereas the second one, produced by a shift in the equilibrium, an apparent movement. A proper movement is endogenous within a city and is an adjustment mechanism to static surroundings, while an apparent movement is made under the influence of changes in the surroundings. The apparent movement is related to a slow equilibrium; the proper one with a fast equilibrium.

Dendrinos and Mullally showed that in the USA the development paths of metropolitan areas were not random; on the contrary, they manifested qualitative features consistent with dynamic models of a Lotka-Volterra type. In rare cases in which disturbances occurred, computer simulation allowed are production of changes in the model parameters and the demonstration of a certain consistency in these changes.

Two conclusions can be drawn from the conducted statistic observations. The first one suggests that random events in a system of metropolitan areas are not frequent: they were not recorded during the 90 years of observations. This conclusion can be accepted only with a certain reservation. This is so because in this period severe nationwide shocks appeared. Urban areas experienced also radical changes in technology and in people's behaviour: the use and possession of cars became more common, the conditions of production and life styles changed, large shopping malls were built. Moreover, government functions changed, suburbs appeared, single-family housing developed, and urban renewal processes intensified. In the light of these facts, the second conclusion must be accepted. Technological, economic, social and spatial shocks affect only selectively the steady-state of cities which in the vast majority demonstrate resilience to radical changes. This statement shows that a relative position of particular cities in the national economy

expressed in terms of comparative advantages did not change so often (approximately in 100 years).

The following conclusions can be drawn from the historical analysis of city dynamics and the relations between cities: in the development of metropolitan areas what took the longest was the movement towards a steady-state expressed in a relative number of the population and in per-capita income. On this dominant path, cities lose the production and income potential they created thanks to comparative advantages. As they were reaching the borders of their production capacity cities succumbed to disturbances. These disturbances shift older metropolitan areas toward a new steady-state. This new long-term equilibrium can be related to a lower or higher relative number of the population and variable per-capita income.

The recent history proves that in older and larger metropolitan areas attempts are made to partially renew exhausted income potential. By transforming old and depreciated physical capital and new investments in small towns linked to the transformation of labour resources, previous industrial base of metropolitan areas changes from the dominant processing industry to service activity, especially to specialized services (banking, insurance, R&D centres, meeting new consumer needs).

Before the change in the policy of enterprises and public institutions toward technical progress stimulation, production per worker increases at fixed rate in such a way that the logarithm of the production value per worker rises linearly (Jones 2002, pp. 36–45). After the change in the policy, production per worker starts growing faster. This accelerated growth lasts as long as the production-technology ratio reaches its new steady-state. In this point an increase returns to a new long-term level (a fixed rate of technical progress).

Technical progress can offset a tendency to a decrease in marginal income from capital and in the long run countries exhibit per capita GDP at such a growth rate as the rate of technical progress. The process in which capital, consumption and the population grow at a fixed rate is called a steady state growth path.

Self-organization and transformations far from an equilibrium

Darwin's theory of evolution replicates a gradual formation of increasingly advanced and more complex species. Boltzmann, in turn, formulated the basis of the process in which the world will gradually lose its structure and that will lead to the state of the so-called heat death.

The question arises how to accommodate these two completely contradictory points of view. Attempts to reconcile these views made by Prigogine (1967), Haken (1997) and Weidlich (1991) turned out to be fruitful. As a result, a bridge between physics and animated nature and its evolution was created. Haken and Weidlich formulated the theory of synergetics defined as a multi-discipline field of knowledge searching for universal regularities in the functioning and development of macrostructures forming in multi-component systems as a result of the mutual interaction of components. Prigogine's contribution is the theory of self-organization related to the term of dissipative structures.

The dissipation of energy is understood as the scattering of organized forms of macroscopic movement in an irreversible process of transformation into chaotically distributed energy, usually into the thermal energy of the movement of particles. Matter is also subject to dissipation. The reverse processes, that is the self-organization of scattered particles from which new structures called dissipative structures emerge, are parallel to the processes of dissipation of energy and matter. Self-organization processes may involve ever wider spheres as a result of which more and more complex dissipative structures emerge which display new properties and are able to perform new functions.

Self-organization of a system takes place when three conditions are met. First, the system must be open, i.e. it has to be able to exchange matter and energy with the surrounding area. Second, it must be non-linear (described by non-linear systems of equations). A linear system in the development process replicates only its structure, although it may also enlarge its size. However, for the system to develop, its structure has to change. Third, the system can transform far from the previous equilibrium. If the system exists close to the equilibrium, minor deviations from this state can be contained, as a result of which it returns to the equilibrium. These states are called a dynamic equilibrium due to the movements occurring around the equilibrium point or line, but without a change of the main trajectory, and the ability to return to the equilibrium state is called the system stability. The movements occurring close to the equilibrium state are too weak to change the system structure. They can slightly change the direction of the system, and then deviate to the opposite one. They cause the fluctuations around the equilibrium state, but in a narrow band in which the return to the equilibrium is possible. The change of the system structure can only take place far from the equilibrium.

Multiple equilibrium

A plain lecture on a multiple equilibrium was presented by Bludnik (2012, p. 126). Its starting point is „the potential appearance of many equilibria in the market economy, different in terms of the degree of the use of production factors. A direct reason for the multiple equilibrium is no possibility to harmonize all the decisions made individually by rational entities at the central level. As a result, the economy with a given resource of productive factors displays a series of potential, equally probable states of equilibrium which can be classified according to the Pareto optimality criterion".

In the literature on spatial management the issue of a multiple equilibrium is considered in terms of path dependence. In contrast to a steady state economic process, in each path-dependent economy specific details and the sequence of historical events govern the course of development. Historically it is called a random (uncertain) evolution. In this system the current state of the economy depends on its origins and the way it has reached this state. In such a historical process there is nothing that would require the demonstration or achievement of the state of a stable equilibrium. The conception of path dependence can be argued to be basically antagonistic in relation to the equilibrium methodology. According to the

second conception, the state of a long-term equilibrium can be defined and reached regardless of the path that led to it, while in the path-dependent conception each long-term configuration achieved by the economy will depend on the path that led to it. Thus, there is no economic result and the result independent of history or context settled in advance. The argumentation that the economy, its landscape is a path-dependent historical process would seem incongruent with the argumentation that this is a balance process.

However, emphasizing the need to go beyond the equilibrium methodology of the main stream economy, path-dependent theoreticians restrain from questioning the idea of equilibrium thinking in general. A new approach to a historical economy was made in the form of the path-dependent balance analysis. This strategy of the reconciliation of the contradiction seen in this sentence aims to define path dependence in terms of the dynamics related to certain kind of non-ergodic processes and the systems with the multitude of marginal distributions, i.e. multitude of equilibrium.

Theoretical works on dynamics and path dependence enable economists to keep the possibility that instead of searching for the dynamics of one unique equilibrium, they should consider the process which seeks an evolving and historically probable equilibrium. The events of low importance, random in character, especially those which occur at the beginning of the path may be significant for the selection of one set of stable equilibrium or attractors. Which of these multiple equilibria is going to be reached or selected will depend on the initial state of the system, on the initial random events and the chain of transitions created by the repeated interactions of the system in time. In this sense there is no *ex ante* unique pattern of an economic system as in general equilibrium theory. Real marginal distributions depend on history and especially on where an economic system was formed (e.g. what was the technology and industrial structure). Next, when the path-dependent process blocked a system (technological, industrial) in one of the alternative stable equilibria (or attractors), the unblocking of any particular path or attractor requires an external shock to create new possibilities.

Punctuated equilibrium

Graphs depicting economic growth in cities, regions and countries are in the shape of more or less wavy curves. Their analysis shows a certain similarity with a hypothetical development image called a punctuated equilibrium. In this hypothesis, the variability of development curves forms in such a way that the rises are short-lived, whereas the sections preceding and following them are smoother and relatively longer. The rises expressing the acceleration of dynamics interrupt a foregoing tendency of smooth fluctuations, and an activated system shifts to a new trajectory which can be an upward or downward curve with smooth fluctuations.

This chapter does not aim to verify the hypothesis of a punctuated equilibrium. What is intriguing, however, is the pattern of development curves in the economic space, which displays certain properties of such tendencies. We want to emphasize one of these properties, namely the occurrence of relatively short-lived rises

against the background of the tendencies taking place in a longer period of time. We will call such rises phase transitions. Their adoption for the subject of the research is justified by their significance in the evolutionary process of the economic space. In their course, mechanisms of growth are modified, structures of systems transform and qualitative changes in the economic space occur. Under the term 'economic space' we will understand a set of economic activities the position of which is indicated, through the analogy to the definitions of physical spaces, by temporal coordinates and three spatial coordinates. We consider a temporal coordinate as the dependence of development on the initial state and the variability of the development path. Two spatial coordinates determine the size and shape as well as the position of cities, regions and countries in relation to other areas, especially those well-developed. In the place of the third spatial coordinate we put socio-economic factors. The most often used is the value of the GDP or its value calculated per inhabitant (as in this chapter). However, there are many socio-economic factors functioning in space so the third spatial coordinate must be presented in the form of a vector with many elements (physical, human, and social capital, work, research and development, technical and social infrastructure, etc.). Deciphering of phase transitions and mechanisms of growth makes it possible to explain the dynamics of spatio-economic changes; it is the core of the theory of space-time evolution. In the future research in this field, it would be advisable to seek the formulation of the law of motion in the economic space evolution.

The curves depicting the economic growth of cities, regions and countries are similar. Their generalization would require a separate analysis. Focusing on the character of rises, we only offer comments about the graphs of the economic growth of European countries and their capitals. Taking capitals into account, we want to have an access to the course of development of probably the most dynamic spatial units that characterize urban systems. Figures 1–4, drawn based on the statistical data available to the author, can be a basis for the comments.

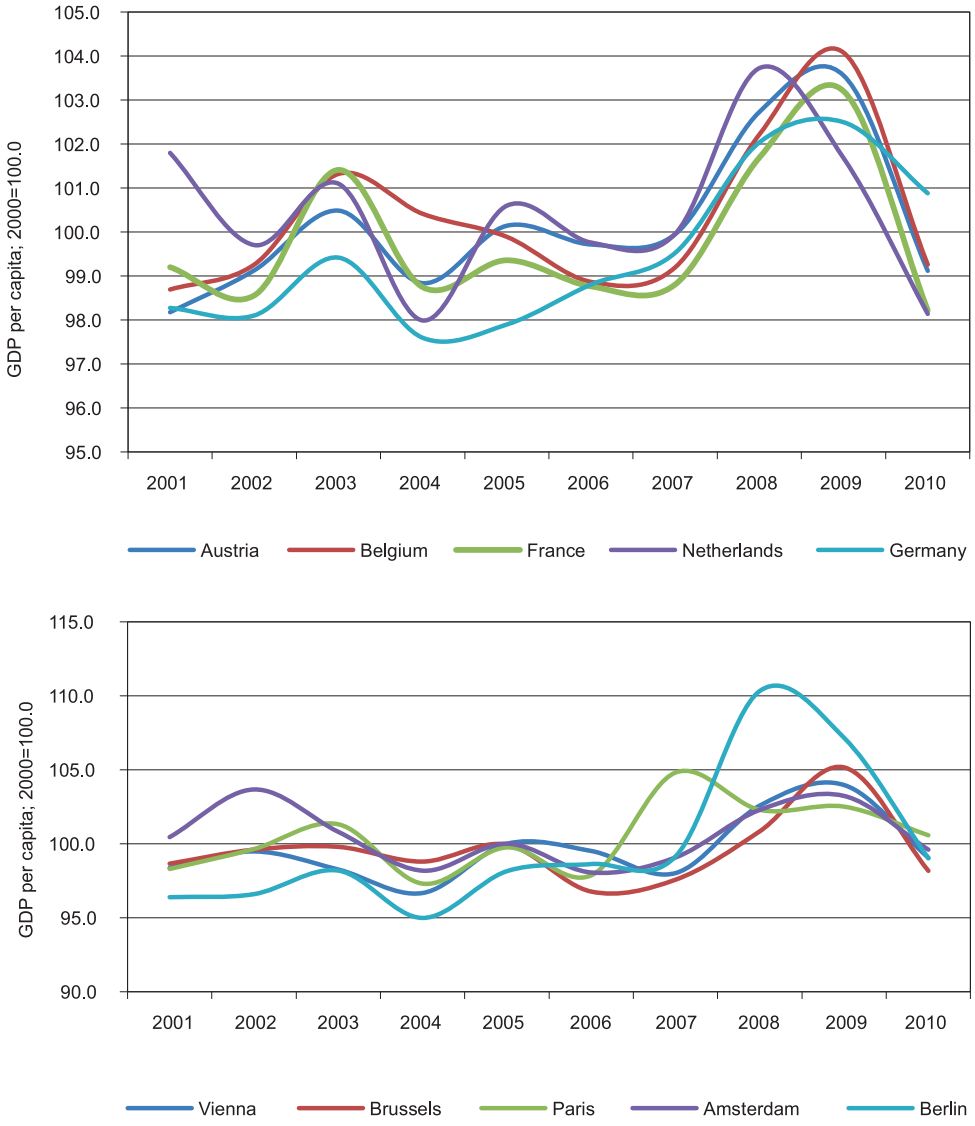
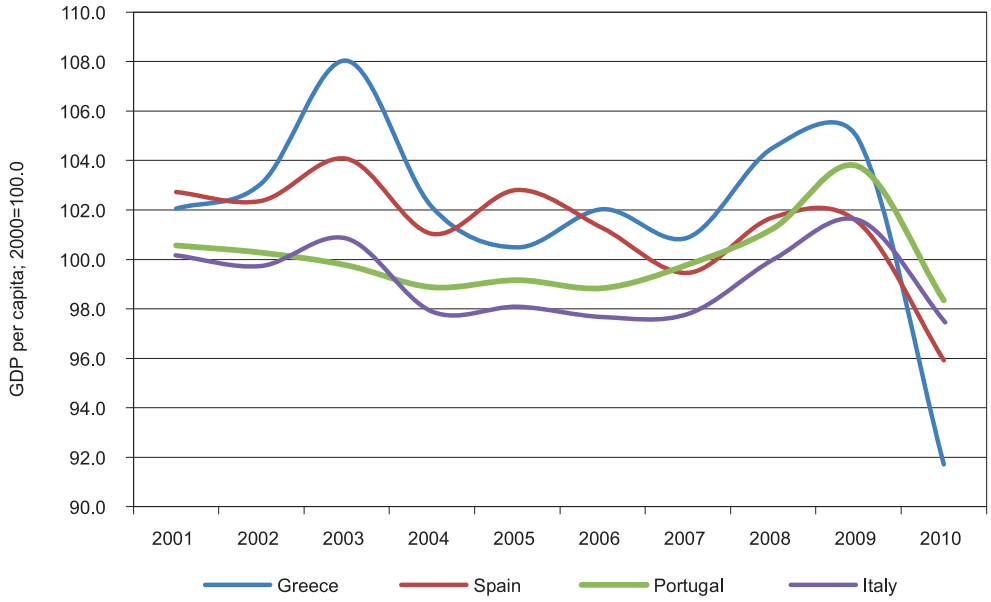


Fig. 1. Fluctuations of economic growth in West European countries and their capitals.
Source: own study.



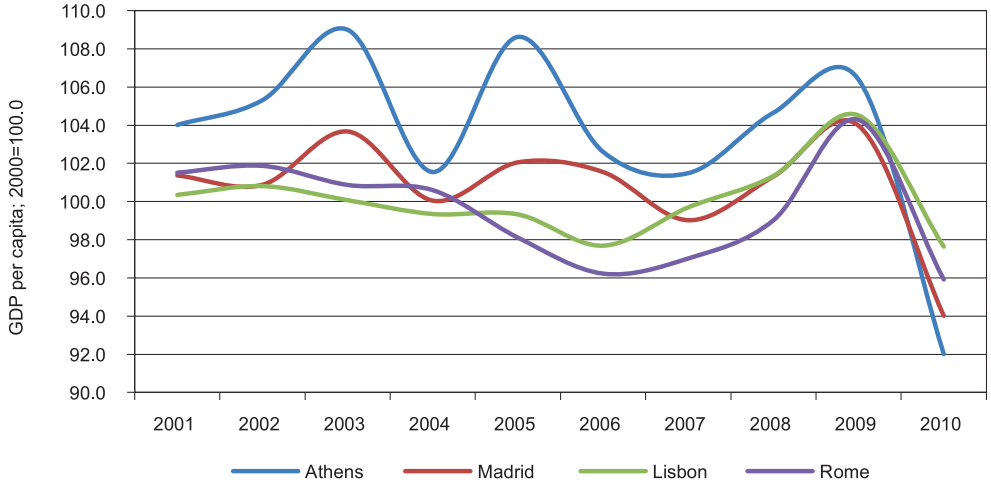


Fig. 2. Fluctuations of economic growth in Mediterranean countries and their capitals.
Source: own study.

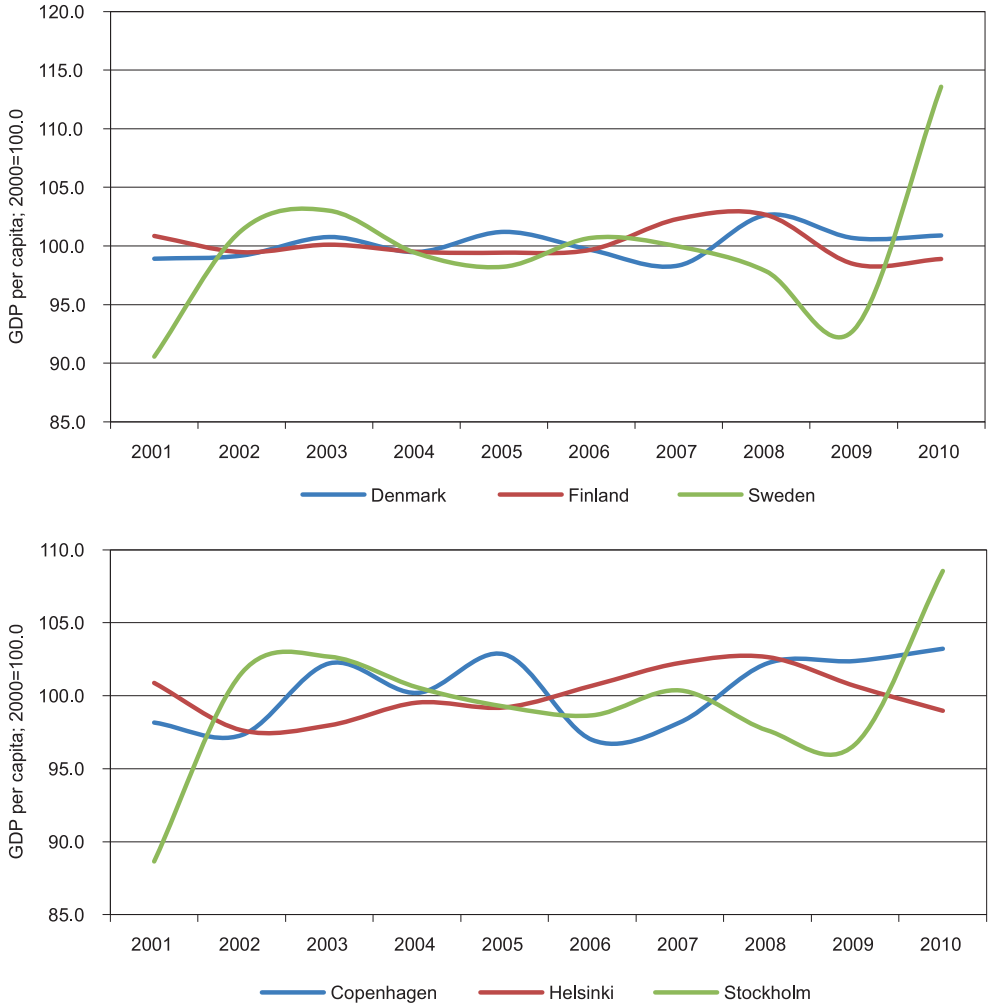


Fig. 3. Fluctuations of economic growth in Scandinavian countries and their capitals.
Source: own study.

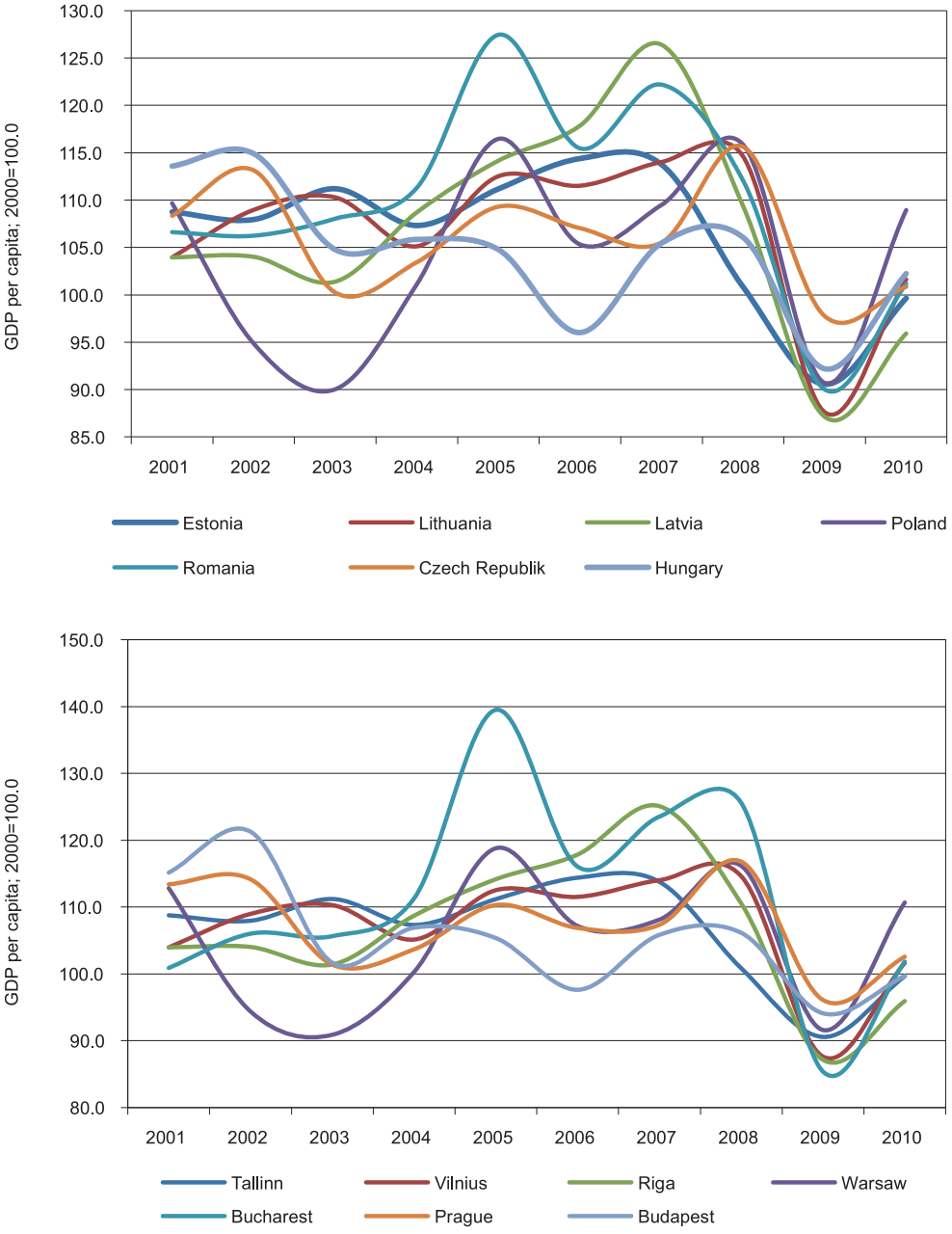


Fig. 4. Fluctuations of economic growth of new EU members and their capitals.
Source: own study.

Pulsative course of development

The reflection on the way the processes in the spatial system of the economy take place, shown in this work, led to the drawing of the pulse curve, the curve of a smooth course and a rising trend. Both these properties concern the entire family of curves. Fig. 5 shows two of them. Curve A show periodical drops below the former levels. Curve B does not display falls, it rises constantly although with different intensity.

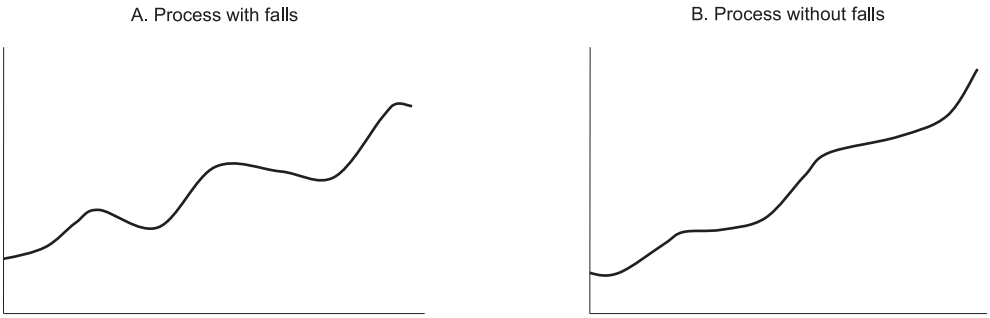


Fig. 5. Pulse curves. Synthesis of the development process.
Source: own study.

The course of the process in time shown in Fig. 3 may be also expressed in an analytical form. A good approximation of a smooth and rising pulse curve is the function:

$$y = A + bx + c\sin dx.$$

Function y developed as a consequence of combining the periodic function expressed by the equation:

$$z = c\sin dx,$$

and the linear function expressed by the straight line equation:

$$q = a + bx;\ \ a = 0, \text{ if } \ y = 0 \ \ \text{for } x = 0.$$

Thus, it combines the features of both these functions. Parameter b decides about its inclination in relation to the axis of the coordinates, and parameter a – about the position in relation to the origin of the coordinates. Parameter d decides about the distance between the points of inflection. Parameter c influences the distance between parallel straight lines tangent to their course.

What mechanisms lead to organizing the course of the process in the form of a pulse curve? These are:

1) stimulating innovation by the application of the factors for system development,
2) overlapping of the waves of diffusions of subsequent innovations (Fig. 6),
3) filling in the depressions in the curve by delayed adaptation processes and by autonomous and continued processes,

4) increased concentration of pulsation caused by late innovations (larger scale and more effective progress),
5) controlling the course of the process, which can influence the choice of more effective types of innovation, the reduction of distances between next innovations, and the targeted application of other instruments shaping the course of the process in a desired direction.

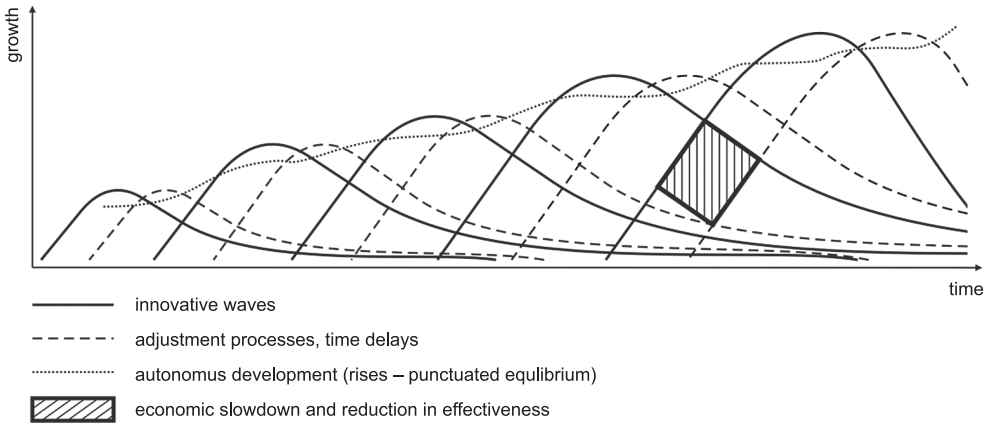


Fig. 6. Structure of the development process.
Source: own study.

Pulsation as a way in which spatial processes take place, has not attracted much interest of researchers fascinated by the idea of even development in time. Yet, the accumulating observations indicate that real development, even methodically managed, does not occur without fluctuations. In this development periods of the concentrated application of development impulses can be distinguished as well as cycles in the investment activity and as a result in other kinds of socio-economic activity, a jump in the development of infrastructure, and a decrease in agricultural production caused by crop failures.

Development in particular innovative waves could take place further (downward the curve) than the intersection point with the next wave. However, a dynamic economy is strong enough not to cross this point. Crossing would mean slower pace and less effective growth. It is prevented by new innovative waves. Taking no advantage of a slower pace at less effective growth and reaching a relatively lower income can be called an additional cost of innovation (the term close to creative destruction). It is illustrated in Fig. 6 by the marked rectangular. Due to the limited space, it is only marked on the one (last) innovative wave.

Innovations in the transition phase

The innovation system in the transition phase should consist of the following features: a multitude of entities (actors), a multitude of factors (technical, regulatory,

social changes as well as those of behaviour patterns), a multitude of levels (micro, meso, macro), consistent implementation of programmes in the long period (Elzen et al. 2004).

A multi-level perspective presents the entire process in various scales and in the long period. However, it is too aggregated; therefore it should be supplemented with more diversified solutions. The distinction of transition types is a step towards it. There are four types distinguished by two criteria: 1) the degree of the coordination of changes between actors, networks and institutions, 2) the location of resources required to react to pressures appearing in the transition phase. These four types are named: targeted transitions, endogenous renewal, trajectory reorientation and sudden (leap) transformation.

The transition to sustainable development cannot be managed in the strict sense. There is a widespread opinion that it is a good solution to find out ways to influence the present dynamics so that it can be directed towards desirable objectives. Even a small change in the direction at the initial period of transition can be incomparably much more effective in the long term. Such an approach is metaphorically called: *to escape poverty*. This movement can be successful provided the entities taking decisions understand the development dynamics, which enables them to identify opportunities for intervention and to determine how productive this intervention can be. Such a policy suggested for the transition period is nothing less than learning by doing.

It is not possible to direct dispersed actions of entities towards defined objectives; what is real is taking initial steps based on limited knowledge and limited diagnosis of the situation, and then, after some time assessing the results of these steps, adjusting the strategy if needed and continuing the influence of the change in a cyclical process of action and evaluation.

Moreover, effective influence in this phase requires answering the following questions: 1) how to evaluate the objectives of many different entities making decisions? 2) how can the knowledge gained be used in selecting specific political tools? In the transition phase a significant role can be played by a government which should interact with the sector of enterprises and social institutions, not giving up the traditional policy of governing and controlling. The occurrence of tensions is unavoidable in these interactions. On the one hand, a government should act at the same level with other entities and, on the other hand, it should stand above and apply monitoring instruments.

How to deal with these tensions is an open question and the choice of a solution depends on a specific case. A government strategy should be based on the evaluation of the dynamics of the cases which are subject to the influence of strategies and objectives of various entities. It is not clear how to achieve that and there is an ongoing debate about it. The solution often suggested is building a vision (Korcelli et al. 2010; Markowski 2008). It means that various entities should discuss long-term objectives and, in the negotiation process, reach some level of agreement. Next, the vision ought to be applied in the identification of subsequent steps on the way to implement objectives.

Emergence of the complexity of spatial systems

Emergence can be defined as the development of new, coherent structures and properties during the process of self-organization in complex systems (Corning 2002, pp. 18–30). Common features of emergence are: 1) radical novelty, 2) cohesion or correlation in integrated wholes which last over a certain time, 3) a global or macro level displaying the features of a whole, 4) is an effect of a dynamic process which develops, 5) can be perceived and understood.

Emergence can be weak or strong (Saviotti 2011, pp. 141–142). It is weak when the system creates properties as a result of interactions at the elementary level. It is strong when the system has properties not related directly to its elements. In other words, emergent properties are not reducible to the elementary level. A new whole is not only larger than the total of its part, but it is not reducible to them. The term of emergence, especially in its strong variety, is closely related to many terms used in the economics of innovation and knowledge. These terms include: 1) qualitative change, 2) discontinuity, 3) a paradigm, 4) technological trajectories.

The statement that economic development is characterized by a qualitative change means that in its process new units emerge which are incomparable and thus cannot be explained or reduced to the units existing earlier. The emergence of such units lead to the discontinuity of the process. This is the type of discontinuity which is included in the term of a scientific and technical paradigm. The development of a paradigm starts from a revolutionary phase in which new issues or new research methods emerge. Then, the incremental phase follows where new principles of a paradigm can be applied in an increasingly wide range. In economic geography the transition to theoretical, quantitative and contemporary evolutionary geography can be recognized as the change in the paradigm.

The emergence of discontinuity and a qualitative change is closely related to a series of terms such as creativity, creative reaction, gradualism and saltationism, a punctuated equilibrium.

The innovative system consolidates when structural emergent properties leading to an organized complexity support the introduction of innovations as emergent properties, which in turn are able to support further improvements and new qualities of the organized complexity of the system (Antonelli 2011, pp. 39–45).

As seen in Fig. 7, each company directs the production of technological knowledge into a simple space of knowledge with two features (X_1 and X_2) depending on the ways the locally available external monetary results of knowledge are used. In the initial period, each company shifts from points *A, B, C* respectively, directs its technological strategy to *D* or *E, F* or *G, H*, or *I* depending on the external context. In turn, after being rooted in some of the points, a new direction inside the corridor can be chosen, determined by internal properties which include the earlier path.

Depending on the quality of interaction and the scope of knowledge, some directions are favourable, others are resistant. Fig. 7 shows that company *A* is forced to direct its innovative process in direction *E* rather than *D* as a result of the organized complexity of the *LMNOP* system. Company *B* will direct towards *F* rather than *G*. If other companies operate like firms *A* and *B*, the structure of the existing network

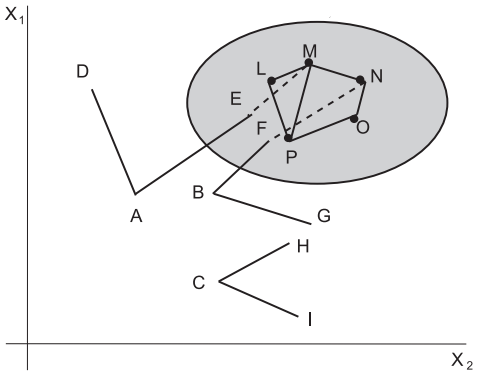


Fig. 7. Directions and shifts in the creation of technological knowledge.
Source: Antonelli (2011, p. 39).

will change. The new architecture of the network will appear. Its management will change in relation to the capability of each new member trying to enter and participate in a new flow of information inside the new architecture of the network.

If a structural change increases the real size of external effects of knowledge and interaction, self-driving processes occur. As long as additional changes strengthen this dynamics and consolidate the network, the process accelerates.

The organization and architecture of the network structure changing inside and between sectors, clusters and subsidiaries is the result of a collective process. Every company can shift in such a space of knowledge and create new knowledge, making use of greater closeness as well as strengthening information channels and interactions with other companies inside the knowledge coalition clustering in nodes (the darkened part of the drawing), where the complementarities of knowledge can be more valued. As a result, new innovative systems based on coalition and nodes, and a coherent complementarity emerge (others fall) whereas the direction of knowledge is formed by the tendency of each firm to the collective convergence of the research strategy. The levels of organizational complexity of an economic system emerging in this process are endogenous and are an emergent property themselves.

The emergence of new levels of organization and complexity occurs under the influence of new interaction systems. Yet, the interactions of decentralized and dispersed actors alone do not explain the creation of a new, better organized order. The order appears when actors have an appropriate capability of the absorption and creation of coherent entities from the elements of knowledge (Robert & Yoguel 2011, pp. 417–447).

The real implementation of technological and organizational innovations by each actor in each point of time results from a long process of feedback which enable creative reactions at the system level through constant changes on the market of goods and production factors and the appropriate strategic reactions of companies. Firms respond by expenses on research and development and also on the mobilization of the inner knowledge unarticulated and competence on the one hand, and changes in the interaction structure in the knowledge sphere and its surrounding area which give access to the external knowledge on the other. Therefore, the conversion of adaptive reactions into creative ones is not a point and single event which occurs in the isolation in time and space, but rather a collective process which is sustainable at the system level. Innovative capability of the system is its emergent property, a sensitive process which occurs when a certain amount of supplementary conditions and circumstances is formed and their cohesion enables constant activity and sustaining

in time. The dynamic coordination of structural technological changes becomes necessary, but very difficult due to the variability of each element of the system.

Resilience and resistance of the economic space

Discussion on the fluctuation taking place in the economic space brought many new elements to the knowledge on the variability and adaptiveness of the economy of cities and regions subject to harmful events and extreme pressures. Research interests focused on the issue how and why local communities react to considerable disturbances and how they move from the continuity of development to a change, and vice versa. Another area of interest was normative issues, i.e. how positive results can be increased, construed and described. It was considered at the same time what institutional instruments can be developed to make it possible to warn enterprises, regions and organizations and prepare them better for disasters and losses.

In the post-Keynesian literature, under the influence of economic achievements after the World War II and long-term prosperity, e.g. as a result of political regulations there appeared opinions declaring "the death of economic cycles". These opinions turned out to be premature. New studies dealing with economic cycles, simultaneity and asynchrony in the occurrence of economic developments, sources of variable sensitivity of regions, especially the structure and diversification of industry came into light. These kinds of studies were usually based on Keynes' theory of the economic cycle.

A new turn in research took place at the end of the 1970s. The studies of economic geographers turned in the direction of regional production networks, regional systems of innovation, regional competitiveness and many other issues related to inequality in the economic development of regions. In the several last years regional economic cycles and economic fluctuations became popular again in the research area (Martin et al. 2016). The main issue in those years was the degree of synchronization of regional economic cycles, i.e. the degree of co-occurrence of movements on regional paths of economic activity, identifying both trends and cycles. Some publications focused on the statistical identification of the relative participation of regional factors and factors particularly regional in spatial diversity of economic cyclicity. Others dealt with statistic methods enabling the isolation of trends and cyclicity and their interactions in the process of development.

Some authors claim that since the beginning of the 1980s a slowdown in the American economy had come to an end and it entered the period which was called great modernization. Yet, these kinds of studies dealt only with year-to-year changes in economic growth, which did not reveal the depth of subsequent recessions.

Great Britain debates about whether and to what degree economic fluctuations have left their mark on the economy over the last 40 years. Starting with the early 1970s, when the so-called post-war "golden age" came to an end, the economy has been subject to a series of deep recessions, deeper than those before the war. The opinion that economic cycles did not die was confirmed. Along with the slowdown in the economy that took place in the mid-1970s and especially in the first years of the '80s and '90s, economic cycles returned but with a stronger force. Four

recession periods were identified, namely 1974–1976, 1979–1983, 1990–1993 and 2008–2010. Beginning with the early 1990s to the late 2000s, the British economy entered a new "golden age" free of economic breakdowns, similar to American great modernization. However, both in Great Britain and in the USA, and also in many other countries, the boom of the 1990s and 2000s turned out to be unstable. It was followed by the financial crisis which caused a cyclical production breakdown, the largest since the Great Depression (1929–1933).

It is important how deep and diversified the influence of recession on regional economies is. The depth of recession and the pace of rebuilding the dynamics of the national economy reflect the recession and recovery of the economy of particular regions. What is more, spatial variability of recession can deepen interregional inequalities in terms of employment, household incomes and the well-being of the population. Some regions affected by negative consequences may not find sufficient power and means to regain the lost condition in the next phase of the economic cycle. A further effect is the emergence of regions with permanent depression. Leaving this condition is hard, because of hysteresis, i.e. the dependency of the development path on the previous states. In the long period, the development path of a region can be perceived as the succession of recession phases and the recovery with turning points in the form of peaks and troughs.

The term which is used in discussions on recession is resistance. It describes how recessions affect the economy of regions. The main idea of this notion is that it enables describing how an entity or a system reacts to unfavourable breakdowns and how it recovers from them. First of all, attention was paid to how long it takes the system to return to the condition preceding the breakdown and if it is really a return to this state or if it is shifted to another, better state. The term 'resistance' derives from physics, but it is also applied in biology, psychology and economics and it has been recently included in geographical and regional studies. Martin et al. (2016) distinguished four dimensions of regional resistance in case of the recession, namely: a) resistance to or the degree of sensitivity to or depth of the reaction to a shock, b) the pace and degree of recovery, c) reorientation or a change in the direction of development and the adaptation of the regional economy in the reaction to a shock, d) renewal or a degree in which the regional economy regains the condition it had before the shock on the development path or shifts to a new path.

Adapting the notion of resistance to the research on the regional economy, the authors mentioned developed these ideas in many ways. First, the authors emphasize that the resistance is not a simple, static, state of regional economy, but a complex, multilateral process, in which four steps can be distinguished: a risk or sensitivity to the shock of companies, industries, employees and institutions situated in a region; the resistance of these companies, industries, employees and institutions to the influence of shocks; vulnerability of companies, industries, employees and institutions to the adaptation which enables the recovery of main functions and activities or in other words, the susceptibility to reorientation; the degree and character of the improvement of the regional economy after a shock.

Second, this sequential aspect of the resistance process depends on the character, depth and duration of recession, on the earlier development path of a region and

on the other determinants of this development path (the structure of the regional economy, resources, capabilities and powers of local and national institutions along with other ways of support on their part, e.g. by the policy of well-being, the programme for supporting enterprises, etc.). These determinants influence the risk and resistance, recession disruptions, but they themselves can be subject to the changes produced by the shock and adjustments, giving in to the pressures of the shock or being the reaction to it.

Development code of the system of regions

Dendrinos prepared an in-depth conception of large cities' evolution deriving from the theory of high-complexity systems and mathematical ecology (Dendrinos & Mullally 1985; Dendrinos 1992). In short, it can be presented as follows. Correlations combining elements of the economic space stimulate multiple interactions (economic, social, political, cultural, ecological etc.), which manifest themselves as national, international and inter-period flows. The main types of such interactions are the population migrations, the exchange of goods, capital and information flows. Movements in time and space co-occur with them leading to the dissemination of such phenomena as new technologies, ethical standards, ideas or diseases. Other examples of interactions include spread of unemployment, poverty and environmental pollution, the exhaustion of natural resources, political dominations, cultural paradigms and demographic changes.

Interactions of the elements of the system sustain the resources distributed in particular points in space and time at levels which are not random. Spatial interactions result from social (individual and collective) effort taken to achieve reasonable, a relative net parity of attractiveness of the places constituting the system. This effort acts in the period of dynamics as a valve regulating the size, directions and specific flow paths of various resources located in different points in time and space. These flows act as equalizers of existing attractiveness between places.

Dendrinos documents the hypothesis that the evolution of each large metropolitan area is determined by a code which can be empirically attributed to it. This code is the result of the potentials of all the remaining metropolitan areas and calculated individual and collective, dynamic behaviour of particular areas. The basic principle determining this code is a parity of relative attractiveness prevailing in the national and international pattern. A continuous tendency of particular agglomerations to reach a favourable parity of attractiveness causes fast changes in their socio-economic structure in a short time horizon. In a long time horizon, the level of a relative parity is subject only to slow dynamics.

The results obtained by Dendrinos are interesting and foster other attempts in this field. This part of work presents the results of experimental research on the socio-economic dynamics of Polish voivodeships. The use of the term dynamics instead of evolution results from the fact that we have statistical data for a shorter period and as a result it will be hard to find the evidence for the existence of the aggregated development code of the regional system forming in a more distant time

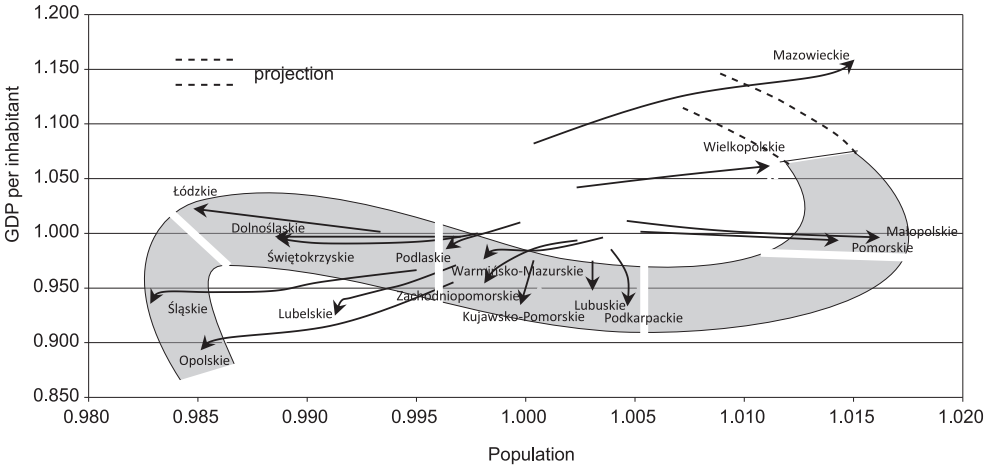


Fig. 8. Organization of the trajectory with the use of two frames of reference: Poland=1.000; 1995–1997=1.000. The symptoms of attractors.
Source: own study.

horizon. We perform this experiment with a hope that at least the *symptoms of such a code* will appear.

The phase portrait shows (Fig. 8) many information on the qualitative features of the system. It has also a heuristic meaning, because it suggests a way of discovering new facts and relations between them.

In particular, a hypothesis can be formed, according to which the distribution of the trajectories of regions can be mapped with a curve resembling a bell, i.e. a curve of normal distribution (statistical data may show the deviation from it, i.e. asymmetry). Let us notice that most trajectories in Fig. 8 are situated in a horizontal strip, i.e. expressing the most frequent mean values. Final sections of the strip, bottom and upper, show fewer extreme values (the lowest in Śląskie and Opolskie Voivodeships, the highest in Mazowieckie and Wielkopolskie); see also Fig. 9.

The information read from the portrait partly coincides with Dendrinos' results, others are different. The difference results from: 1) Dendrinos' observations involve a longer period (the third quarter of the 20th century), 2) this period is characterized by a relatively smooth line of development (disturbances were only caused by the 1974 oil crisis), 3) the period covered by this research indicates the duration of the consequences of radical system transformations from 1990, 4) in the Polish regional pattern there are still differences between the population inhabiting areas of the former partitions, and also the differences between the old areas and the western and northern ones. On the basis of the qualitative features deriving from the phase portrait, one can carry out and formulate conclusions extending the scope of acquired information. In reasoning, naturally, use must be made of the previous knowledge recognized by economists dealing with regional issues and economic geographers.

Dendrinos did not formulate a precise definition of the development code governing the spatial development of a country, but he wrote repeatedly about its

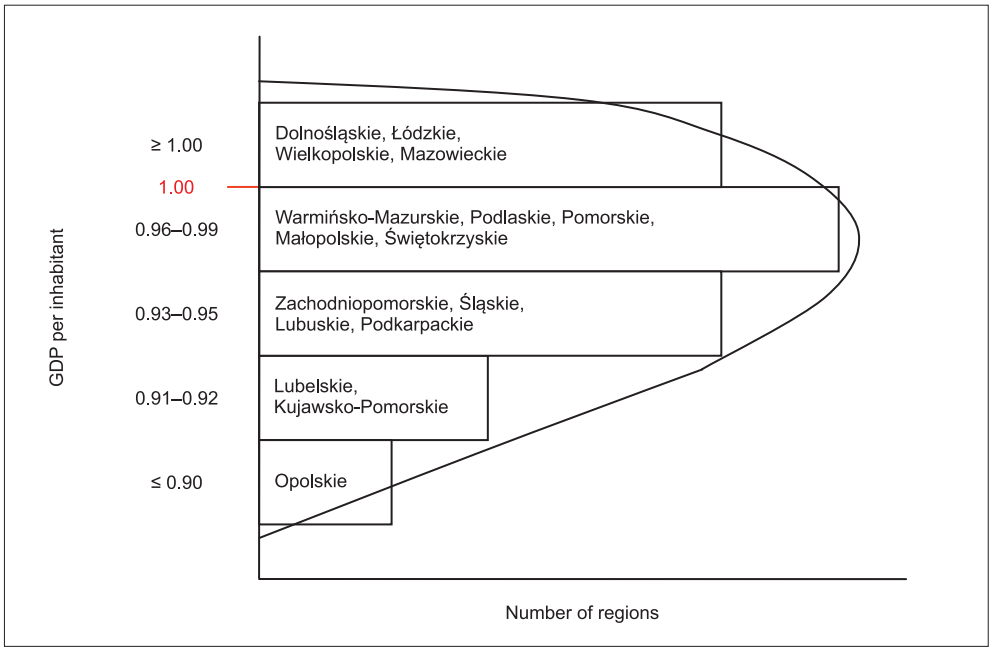


Fig. 9. Curve of frequency
Source: own study.

properties. He treated these properties not only as the metaphors for the biological code. He also searched for the elements common for evolutionary processes in different areas of economic, social, cultural and ecological life and in their temporal and spatial patterns, thinking about finding the conceptions useful in the research on socio-spatial evolution. Following the convention adopted by the present author, we will adopt its concise definition, which we will try to supplement in our subsequent works. The development code is a selected, non-random macrostructure of cities and regions, dominant in the spatial development of the country and determining its growth in a long period.

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