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PHENOMENON OF CONVERGENCE IN THE ANALYSIS OF ECONOMIC GROWTH

Summary: The analysis of issues of economic growth leads to the question about the abilities of an economy to adapt its development to the level of development of other economies. Formulated answers to the problem are provided by the analysis of the phenomenon of economic convergence. This approach examines both the causes and determinants of differences in the growth. This leads to the formulation of various measures of the same phenomenon, which takes the form of certain types of convergence. The article presents the essence and the conditions of economic convergence phenomenon and makes a synthesis of its measurement. The conducted considerations lead to the conclusion that within a given economy there should be found such a growth path which would be appropriate for it and which may coincide with the growth paths of economies having similar conditions.

Keywords: convergence, σ -convergence, absolute convergence, β -convergence, γ -convergence, convergence clubs, economic growth, stochastic convergence, technological convergence.

1. Introduction

The research on economic growth leads to the analysis of various aspects of the problem. One dimension of the research is the problem of convergence with a number of important questions: To what extent the growth trajectory of the economy is consistent with the path of growth of other economies? What factors determine the shape of this path and its continuity? Is there a category of measuring this phenomenon and what is its character? Formulated answers to the problem are provided by the analysis of the phenomenon of economic convergence. This approach examines both the causes and determinants of differences in economic growth. As a result, this leads to the formulation of various measures of the same phenomenon, which takes the form of certain types of convergence. The article presents the essence and the conditions of economic convergence phenomenon and makes a synthesis of its measurement. Deliberations are conducted to confirm the hypothesis that the problem in terms of growth trajectory and its dynamics for different economies is conditioned by the factors of both deterministic and stochastic nature. These factors determine the original path of growth of the economy. The convergence of the paths of growth of other economies is due to the similarity of their circumstances.

2. Causes and conditions of convergence

The problem of economic backwardness is the permanent part of the history of economic thought and the economic history of the world. Synthetic characteristics indicates the following background to this problem:

1. **The abundance of natural resources of the country determining the productive force of the country, both in quantitative and qualitative way.**

2. **The historical development of colonialism and imperialism.** As a result of robbery and exploitation of colonies a global model for the management of pole treating colonized countries as a source of cheap labour and resources developed, as well as an alternative outlet for goods processed within the home country of the colonizer. The passage of time deepened the inequalities leading the world to the distribution by the triad: highly developed countries (pole of development), moderately developed countries and the periphery (pole of backwardness.) The leaders of development also form a triad consisting of the following areas: Western Europe (countries of “the old” EU + EFTA), North America (NAFTA countries without Mexico) and the parts of South-East Asia¹ (among others: Japan, Singapore, South Korea).

3. **Fixation of an unfavorable economic structure within the underdeveloped countries as a result of blocking the diffusion of technology.** This phenomenon is associated with both the previously discussed effects of colonialism, but also the result of processes occurring in **the G. Myrdal theory of cumulative conditions.** According to these processes, underdevelopment as well as the development is subject to the starting position of the country, which is characterized by a tendency to be autofixed. As a result, backward countries without both proper positive external and internal shocks are doomed to a marginal position.

4. **Cultural and institutional autonomy of individual states.** As a result, economic development depends not only on the abundance of natural resources, but also on the force in the country’s economic – institutional system. This system can expand or block the mechanisms of efficient allocation and distribution of the created product (GDP). The characteristics of the economic system is a derivative of the dominant culture, covering various aspects of human intellectual activity, and institutions such as: a system of law, customs, property rights system, economic attitudes etc. An example of North Korea and South Korea shows how in similar geographical circumstances, but under very different institutional considerations, run the economic development of the country runs.

5. **Progress in the sphere of international trade.** International exchange is one of the most important sources of efficiency improvement and economic growth. It is not always, however, based on equitable criteria. Despite the increase in the total product, we often have to deal with asymmetric division, which also leads to the

¹ K. Ohmae, *Triad Power*, The Free Press, New York 1985, p. 24.

structural backwardness of weaker countries. As a result there is the perpetuation of civilization delay. Underdeveloped countries receive relatively outdated technologies so that they are not able to offset the competitive advantage of the leaders. Another way is to invest the resources of modern factors of production with full ownership of technology leaders, so that the latter being the predominant beneficiaries of international trade are based not only on mobility products, but also on the transfer of production factors.

In the context of the circumstances, the question arises about a real chance to overcome the development gap separating the countries lag from the leaders. The development gap is huge, and in addition to the differences in the dynamics of economic growth we can talk about its constant widening. In the analysis it seems that GDP *per capita* is significant and better expresses the developmental changes than the same absolute value of the total GDP. Differences in GDP *per capita* are few, and sometimes they even much more depend on the economy of the world region. The confirmation of stratification development is also apparent from the analysis of index HDI (Human Development Index). The difference in the value of this ratio among OECD countries and the poorest countries in the world is almost 50%².

3. The essence of convergence

The developmental gap was discussed in *the theory of convergence*. The convergence of the economies means approaching their levels of output *per capita*. The primary analysis in this regard were consistent with the assumptions of **neoclassical growth theory (NGT)** relating to:

- diminishing marginal productivity of capital *per capita*,
- exogenous nature of technological progress.

As a result, according to NGT, the effect of convergence may occur as a result of the following mechanisms:

1. The assumption of diminishing marginal productivity of capital shows that the accumulation of capital lowers the marginal product. The decline in the marginal product capital reduces the incentive to postpone consumption over time in rich countries. The result implies a decline in the savings rate and a decline in the growth of the product. Thus, backward countries – *ceteris paribus* – have a chance to catch up the gap. A critical element of this mechanism relates to the pace of convergence and the time needed to offset the levels of development. Without the activation of additional factors, this effect may occur only after a lot of decades. Moreover, in a situation when rich countries endeavor to maintain a distance of development, the convergence will continue to be dismissing.

² K. Czaplicka, *Wzrost i rozwój gospodarczy w krajach rozwijających się*, [in:] *Ekonomia rozwoju*, red. R. Piasecki, PWE, Warszawa 2007, p. 75-76.

2. Due to the fact that the marginal productivity of capital is lower in richer countries, capital should flow to the underdeveloped countries in order to obtain a higher rate of return. Thus – *ceteris paribus* – it gives the opportunity to catch up. As a result, open economies may enhance the effect of convergence. The described mechanism is strictly a model. In practice, business must also include a number of other important factors affecting the transfer of capital to underdeveloped countries. These factors include: social capital, the degree of development of capital markets, the political system of the country, regulations, etc.

3. As a result of diffusion of technological knowledge there is a gradual disappearance of the differences between countries. Thus, the convergence depends on the diffusion of knowledge³.

The problem of neoclassical theory in explaining the mechanisms of insufficient convergence lays in the assumption on the exogenous nature of technological progress. As a result, every country would have unrestricted access to knowledge and technology, and thus could function as a global public good. It is quite unrealistic. As a result, one of key factors responsible for the convergence is treated as endogenously technological progress. Purposeful allocation of resources in the area of research - development provides an opportunity to catch-up the development. This activity takes the form of technological diffusion due to the fact that imitation costs are lower than the costs of innovation. At a certain stage of development, reproduction technology for underdeveloped countries is a short cut in the process of convergence. Basic channels of diffusion of technologies include: international trade, foreign direct investment, import advanced production goods, cultural contacts between peoples of different countries, etc. However, the full effectiveness of the convergence process based on the diffusion of technology is required for an adequate level of social capacity for the assimilation of advanced technologies. Thus, it is necessary to guarantee adequate human capital, mobility of production factors, the structure and size of the market, as well as institutional arrangements⁴.

The presented considerations lead to the conclusion that both capital accumulation as well as **endogenousness** depend on the process of technological convergence and have a significant impact on economic convergence. In addition, endogenous growth theory successfully explain the fact that convergence is not borne out by the scale of the global economy, but only in case of regions with similar levels of development called convergence clubs (e.g. within OECD). The reasoning behind this fact is based on the phenomenon of external benefits associated with the total impact of investments

³ We must take into account that the spread of new knowledge as an element of competitive advantage is not in the direct interest of developed countries

⁴ For more information see: B. Horvat, *Welfare and the Common Man in Various Countries*, "World Development" 1974, No. 2 (7), p. 29-39; R.P. Nelson, E.S. Phelps, *Investment in Humans, Technological Diffusion and Economic Growth*, "American Economic Review" 1966, No. 56 (2), p. 69-75; W. Nowak., *Konwergencja w modelach endogenicznego wzrostu gospodarczego*, Kolonia Limited, Wrocław 2007, p. 68-70.

in human capital and physical capital. The accumulation of these positive effects may provide additional impetus for the investment in developed countries which have the resources of human and physical capital at a higher level in relation to the underdeveloped countries. It is recognized by G. Myrdal's theory of cumulative growth conditions, which in this case promotes the developed countries.

4. Types of convergence and methods of measurement

Analyzing the phenomenon of economic convergence can be divided into the following types and ways of measuring:

1. **σ -convergence.** It shows the dispersion of GDP *per capita* among the countries (regions) in the study group. In time, when it comes to convergence within the group, the dispersion of GDP *per capita* decreases. For testing σ -convergence applies in principle⁵ to two popular measures of dispersion:

a) *the standard deviation* of the logarithm of the product *per capita* of the countries surveyed⁶:

$$\sigma(t) = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\log y_i(t) - \bar{y}(t) \right)^2} \quad (1)$$

where:

$$\bar{y}(t) = \frac{1}{n} \sum_{i=1}^n \log y_i(t) \quad (2)$$

b) *the coefficient of variation*, which is the ratio of standard deviation and average:

$$CV = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\frac{y_i - \bar{y}}{\bar{y}} \right)^2} \quad (3)$$

where:

$$\bar{y} = \frac{1}{n} \sum_{i=1}^n y_i \quad (4)$$

⁵ In addition to these two measures to examine the σ -convergence is also used as: a) the Gini coefficient, taking values from the interval $\langle 0,1 \rangle$. A value of 0 means full compensation levels of *per capita* product, and 1 means extreme inequality. b) the method based on a comparison of incomes in the bottom and top quintile of the distribution of income *per capita*. Aligning the income of both bands indicates a progressive convergence.

⁶ X.X Sala-i-Martin., *The Classical Approach to Convergence Analysis*, "Economic Journal" 1996, No. 106, p. 1019-1036; B.R. Kolluri, M.J. Panik, F. Rassekh, *A test of the Convergence Hypothesis: the OECD Experience, 1950-1990*, "International Review of Economics and Finance" 2001, No. 10, p. 147-157.

2. **Absolute convergence.** It shows the dispersion of *per capita* among countries resulting from the saturation level of capital (human and physical) *per capita*. Consequently, the growth rate in countries with higher product level *per capita* (rich countries) is lower than in underdeveloped countries as follows – *ceteris paribus* – the difference in rates of return on successive units of invested capital. According to the hypothesis of absolute convergence of the target structure, the convergence of economies of different countries should occur⁷. The measurement of absolute convergence is based on:

a) **β -convergence**, expressing the correlation between the growth rate of *per capita* product and the initial level of *per capita* product. β -convergence shows a decrease in economic growth with the increase of the absolute value *per capita*. β -convergence is tested using the following equation:

$$\gamma_i(t+T) = \alpha - \beta \log y_i(t) + \varepsilon_i(t+T), \quad i = 1, 2, 3, \dots, n \quad (5)$$

where:

$$\gamma_i(t+T) = \frac{1}{T} \log \left(\frac{y_i(t+T)}{y_i(t)} \right) \quad (6)$$

is the average growth rate (logarithm) of the product *per capita* of *i*-the country within the time interval $(t, t+T)$;

$y_i(t)$ – the initial level of *per capita* product in *i*-the country; α, β – constant;
 $\varepsilon_i(t+T)$ – a series of random variables with a uniform distribution with zero expected value.

In the equation (5) the approximation of the value of coefficient β to unity confirms the existence of absolute convergence among tested economies.

b) **γ -convergence**, expressing the dynamics inside the distribution of the product *per capita*. This measure of the convergence accounts for the dynamics of the diversity of individual economies, making the distribution of the product *per capita*, by assigning a rank or serial numbers according to the increasing value of the product *per capita*. As a result, the absolute convergence test used **Kendall rank coefficient of concordance** in the form:

$$RC_t = \frac{\text{var} \left(\sum_{t=0}^T AR(Y)_{it} \right)}{\text{var} \left((T+1) * AR(Y)_{i0} \right)} \quad (7)$$

where: $AR(Y)_{it}$ – rank the level of *per capita* product in *i*-the country in year t ;
 $AR(Y)_{i0}$ – rank the level of *per capita* product in *i*-the country in the 0th year.

⁷ It should be noted that this proposal results from the very simplified assumptions concerning the functioning of the economy, reducing cultural and social aspect. Thus the absolute convergence in real terms may not always occur.

The factor (7) measures the compatibility of rank in the range $(0, T)$. Its value varies from zero to 1. If the value of the coefficient tends to be zero then the changes within the distribution are larger. In the event when it takes value 1 it means the absence of any changes. The group of countries is γ -convergence, if the value of Kendall's coefficient of concordance of ranks decreases over time, which means the occurrence of changes leading to convergence.

3. **Stochastic convergence.** This type of convergence implies the evolution of the distribution of *per capita* production levels over time. It is in addition to examining changes in the intensity of mutual positions of individual economies within the distribution. Given the stochastic nature of the shocks associated with different economic variables, it is assumed that the frequency and strength of these shocks have a greater impact on underdeveloped countries than developed ones, causing the effect of raising the levels of dispersion of output *per capita* in the group surveyed economies. In addition, it is assumed that individual economies have structural diversity, and thus there should not be studied classical methods relating to the measurement of convergence⁸. One of the methods of measurement in the concept of stochastic convergence approach is based on the respective time series co-integration (logarithms) levels of *per capita*. Co-integration shows that the series tend to balance in the long term, and long-term deviations balance from the path they are stationary. Developers⁹ have defined the methods of convergence between the investigated countries (i, j) as a state in which long-term forecasts of time series (logarithms) of product *per capita* levels show no differences, which can be written as:

$$\lim_{n \rightarrow \infty} E(y_i(t+n) - y_j(t+n) / I(t)) = 0 \quad (8)$$

where: $y_i(t), y_j(t)$ – lg product *per capita* at time t , in i and j of this country;
 $I(t)$ – information available at time t .

To sum up the approach in the stochastic convergence studies should emphasize its importance in the treatment of the economic dimension of time. This is reflected in the characteristics of time series on specific economic variables in different countries. For example, if such variables are: human capital or natural capital containing the elements of life, it should be noted that the specificity of the capital has a random nature such as associated with the distribution of certain diseases, predisposition, natural phenomena, etc. Talking about convergence, therefore, in absolute terms (eg, β -convergence) is partly absurd. It is not sufficient in any African country to create a seemingly identical conditions as in the management of a

⁸ As an alternative proposed for the latest econometric methods: 1. The unit root tests and 2. Cointegration analysis of time series. More on these methods, see: G.S. Maddala, *Econometrics*, PWN 2008, p. 300-302, 612-639.

⁹ A.B. Bernard, S.N. Durlauf, *Convergence in International Output*, "Journal of Applied Econometrics" 1995, No. 10, p. 97-108; A.B. Bernard, S.N. Durlauf, *Interpreting Tests of the Convergence Hypothesis*, "Journal of Econometrics" 1996, No. 71, p. 161-173.

developed European country because it has its regional specificity, which results in the incompatibility of such comparisons.

4. **Technological convergence.** This type of convergence is based on the level of technological advancing as a factor responsible for economic convergence. The methods of measuring this type of convergence is based on cross-sectional and panel regression, which can be written in the form of the sample regression equation:

$$\gamma_i(t+T) = \alpha - \beta \log y_i(t) - \lambda n_i(t+T) - \kappa I_{KF}(t+T) - \delta I_{KL}(t+T) \pm \varepsilon_i(t+T) \quad (9)$$

where: $\gamma_i(t+T)$ – the average growth rate (logarithm) of the product *per capita* of i -the country within the time interval $(t, t+T)$, considered as a technological gap between an economy and technological leader;

$y_i(t)$ – the initial level of *per capita* product in i -this country (the initial value of the technological distance);

$n_i(t+T)$ – the growth rate of labour force;

$I_{KF}(t+T)$ – the rate of investment in physical capital;

$I_{KL}(t)$ – the rate of investment in human capital;

$\alpha, \beta, \lambda, \kappa, \delta$ – constant;

$\varepsilon_i(t+T)$ – a series of random variables with uniform distributions, $i = 1, 2, \dots, n$.

As you can see the increases in the value of all explanatory variables are negatively correlated with the level of technological gap, which expresses the essence of technological convergence.

The alternative in the measurement of this type of convergence can also be an analysis of productivity changes and an analysis of total factors productivity (TFP). Thus, TFP can be regarded as a measure of technical progress, but we must remember that not in every case the levels of TFP convergence means the convergence of product *per capita* levels between economies, because TFP is not the only factor determining the growth rate of product *per capita*.

5. Conclusion

Presented considerations show the essence of the phenomenon of convergence. It is brought together in a number of factors having the deterministic or stochastic nature. Thereby it causes changes in the product *per capita*.

Implementing the demands of absolute convergence is more political than scientific. This follows from the assumptions in the convergence process taking into account changes not only in the cost of production factors, but also of institutional, cultural, etc. nature.

Stochastic character of convergence is the realistic contribution in its analysis. Given the stochastic nature of the shocks associated with different economic variables, it shall be adopted that the frequency and strength of these shocks have a greater impact on underdeveloped countries than developed ones causing the effect of raising the levels of dispersion of output *per capita* in the group of surveyed economies. In addition, it is assumed that individual economies have structural diversity, and thus classical methods relating to the measurement of convergence should not be studied.

An important interpretation of the phenomenon of technological convergence is its character. This type of convergence based on the level of technological advancing of the economy shows it as a factor responsible for economic convergence. The methods of measuring this type of convergence is based on cross-sectional and panel regression.

The considerations were carried out to confirm the hypothesis that the problem in terms of growth trajectory and its dynamics for different economies was conditioned by factors of both deterministic and stochastic nature. These factors determine the original path of growth of economy, the convergence of the paths of growth of other economies due to the similarity of their circumstances.

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ZJAWISKO KONWERCENCJI W ANALIZIE WZROSTU GOSPODARCZEGO

Streszczenie: Analiza wzrostu gospodarczego prowadzi do pytania o możliwości dotyczące danej gospodarki w zakresie dostosowania jej rozwoju do poziomu rozwoju innych gospodarek. Odpowiedzi na ten problem dostarcza analiza zjawiska konwergencji gospodarczej. W ramach tego podejścia bada się zarówno przyczyny oraz uwarunkowania różnic we wzroście gospodarczym. Prowadzi to do sformułowania różnych miar tego samego zjawiska, w postaci określonych typów konwergencji. W artykule przedstawiono istotę oraz uwarunkowania zjawiska konwergencji gospodarczej oraz dokonano syntezy jego pomiaru. Przeprowadzone rozważania prowadzą do wniosku, iż w obrębie danej gospodarki należy poszukiwać właściwej dla niej ścieżki wzrostu, która może być zbieżna ze ścieżkami wzrostu gospodarek o podobnych uwarunkowaniach.