TECHNOLOGICAL CHANGES IN ECONOMIC GROWTH THEORY: NEOCLASSICAL, ENDOGENOUS, AND EVOLUTIONARY-INSTITUTIONAL APPROACH

Dragoslava Sredojević

Business School of Applied Studies in Valjevo
✉ dragoslava.sredojevic@vipos.edu.rs

Slobodan Cvetanović

University of Nis, Faculty of Economics, Republic of Serbia
✉ slobodan.cvetanovic@eknfak.ni.ac.rs

Gorica Bošković

University of Nis, Faculty of Economics, Republic of Serbia
✉ gorica.boskovic@eknfak.ni.ac.rs

Abstract: The aim of the research in this paper is to analyse the issue of the treatment of the category of technological changes within the main aspects of economic growth theory. The analysis of the key positions of neoclassical theory (Solow), endogenous approach (Romer), and evolutionary growth theory (Freeman) advocates has pointed to the conclusion that these approaches agree on the fact that the category of technological changes is a key generator of economic growth. Neoclassicists were the first to explicitly analyse the category of technological changes in growth theory. They exerted a strong influence on a large number of governments to allocate significant funds for scientific and research development, to stimulate the creation and diffusion of innovation. Supporters of endogenous theory also see the category of technological changes as a key driver of economic growth. Unlike neoclassicists, they emphasise the importance of externalities, in the form of technological spillover and research and development activities, for the creation and diffusion of innovation. Finally, evolutionary and institutional economists explore the category of technological changes inseparably from the economic and social environment in which they are created and diffused. Recommendations of this research can be of particular use to economic growth and development policy makers in the knowledge economy, whose basic and substantial feature is the so-called fourth industrial revolution.

1. Introduction

The most important part of macroeconomic theory and policy is dedicated to the study of the category of economic growth, i.e. research of quantitative relations between the value of the final output and the quantum of production factors at the national level. Economic growth theory deals with the problems of dynamic equilibrium, and attempts to reach an acceptable answer to the question as to what kind of use of available production factors can provide for a sustainable increase in real gross domestic product per capita in the long run. The maximum economic growth rate is achieved with the greatest possible increase of production factors used and/or their most efficient use (Cvetanović, 1997, p. 11).

There are opinions that economic growth theory, in the true sense of the word, emerged in the mid-twentieth century, identifying the category of technological change as a key factor of economic growth of countries (Solow, 1956, 1957). Neoclassicists were the first to unambiguously recognise and analyse the category of technological changes as the driver of economic growth, and, after a number of empirical studies, concluded that this was by far the most important driver of economic dynamics.

The biggest drawback of neoclassical growth theory is a failure to respond to the question of how technological changes occur. As if they were "falling from the sky", making human labour more productive (Petit, 1995). However, despite these shortcomings, it is undeniable that it paved the way for the acknowledgement of knowledge as a generator of economic growth in modern economic conditions. Among other things, neoclassicists' attitudes during the nineteen-sixties made a large number of governments invest significant funds in research and development activities, in order to support technological progress.

Since the technological changes in the neoclassical growth model are of exogenous character, it appears that the model does not explain the most important determinant of growth rate. This situation has led a large number of researchers to try to "endogenise" the category of technological changes, as a result of economic and other processes.

Theoretical approaches that try to break with the neoclassical orthodoxy in order to explain the origin of technological changes appeared in the nineteen-eighties. Although this is a very heterogeneous group of explanations, they can be divided into endogenous theories and evolutionary-institutional theories of economic growth (Greenhalgh, Rogers, 2010, pp. 213-214).

During the ninth and the tenth decades of the twentieth century, there was an affirmation of endogenous and institutional-evolutionary explanations of the phenomenon of economic growth. The prevailing opinion was that knowledge, which leads to technological changes (innovation), was an elementary driver of

economic progress of countries. Endogenous growth theories developed approaches where the key growth factors are technological spillover, research and development activities, and international technology transfer.

On the basis of criticism of neoclassical attitudes, institutional and evolutionary explanations of the growth phenomenon promote the concept of national innovation system. The underlying assumption of the national innovation system concept is that the economic growth of the country is possible with technological progress, and that it is not predominantly affected by the quantity of research and development resources, but the quality of the organisation and efficiency of management of these resources at the microeconomic and national levels (Blanchard, 2005, p. 258). Such a starting point can be of particular importance for small countries and countries at lower levels of economic development, which do not have significant innovation potential. The ability to manage technological changes is primarily an endogenous social process. Creating innovation system in small countries with limited resources is a valuable alternative to conceiving their own technological development. The difference between innovation systems in developing countries and developed countries is the result of the fact that the former are characterised by scarcity of resources, and that they are in the catching up process with economically advanced countries.

The subject of this paper is the identification of the role of the category of technological changes in the most important theoretical approaches to economic growth. The aim is to employ descriptive analysis of the essence of main growth theory approaches in the last sixty years to come to the answer to the question as to what are the similarities and differences in the treatment of the category of technological changes in traditional (neoclassical) and in modern theories. This is seen as important for the simple fact that economics lacks the necessary unified opinion regarding the classification of the most important growth and development theories, on the one hand, and the treatment of the key drivers of technological changes, on the other hand. In doing so, we are fully aware of the fact that each growth theory has a certain value in respect of a specific time and place. Therefore, "they are unsustainable as a universal explanation of economic development" (Samuelson, Nordhaus, 2009, p. 584).

The above observations regarding the subject and goal of the research determine the corresponding structure of the work. After the introductory remarks, the first section focuses on identifying the role of technological changes in the neoclassical economic growth theory. The second section considers the role of technological changes in endogenous growth models, and the third focuses on the treatment of the category of technological changes in the institutional-evolutionary economic thoughts. The final part, given separately, provides the concluding remarks.

2. Neoclassical Growth Theory: Recognition of Technological Changes as a Key Factor of Economic Dynamics of Countries in the Long Run
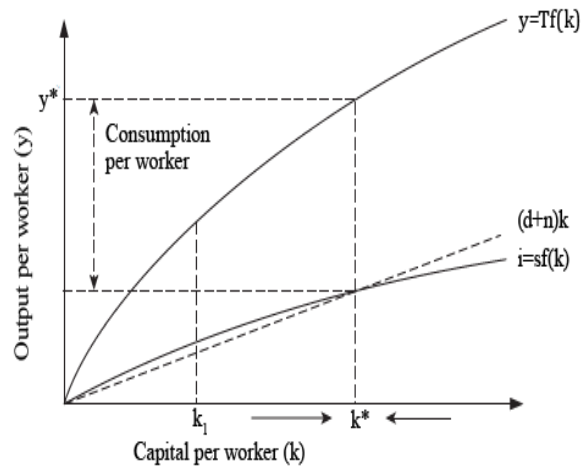
The economic growth theory has, in the true sense of the word, emerged with the publications of the American economist, Robert Solow (Solow, 1956, 1957). The analytical starting point of Solow's model is the production function, in the form $Y = TF (K, L)$, where Y is production (gross domestic product), T is technology, K is physical capital, and L amount of work. By dividing the left and right side of the function $Y = TF (K, L)$ by L, $y = Tf(k)$ is obtained, where y denotes gross domestic product per capita and k capital to labour ratio (Dragutinović et al., 2015, pp. 91-96). Diminishing returns of production factors are the basic assumption of the model, based on which all the main conclusions are derived. The economy in which different variables, such as production, capital, employment, and consumption, grow in the long run at equal rates is in a state of stable equilibrium.

The neoclassical growth model shows that, without technological changes, in a state of long-term stable equilibrium, there is no long-term growth in production per capita. Per capita income levels vary among countries,depending on the preferences of their residents. Because of the law of diminishing returns, in Solow's model, increasing production funds per capita cannot explain the growth of labour productivity in time, or significant differences in the growth rates of gross domestic product per capita in individual countries.

When the marginal labour product falls low enough, net investment falls to zero, so gross investment is sufficient only to maintain the existing stock of physical capital per employee, i.e. sufficient to annul the effect of depreciation of physical capital and growing labour force on decrease in capital to labour ratio. This equilibrium point is associated with the corresponding equilibrium level of production per worker, y*, which indicates the so-called steady state (Barro, Sala-i-Martin, 2004, p. 34). When the steady-state level of production per employee is reached, there are no more incentives for manufacturers to increase the level of capital per employee. In other words, economic growth stalls.

Line (d+n)k illustrates the category of new investment per worker, required to maintain capital to labour ratio at the same level, given that depreciation and growing workforce work towards the reduction of capital per worker in the economy. When i> (d + n) k, capital to labour ratios growing, as shown in Figure 1. In the opposite case, when i <(d + n), the value of capital to labour ratio decreases. Finally, when i = (d + n)k, capital to labour ratios constant, k*.
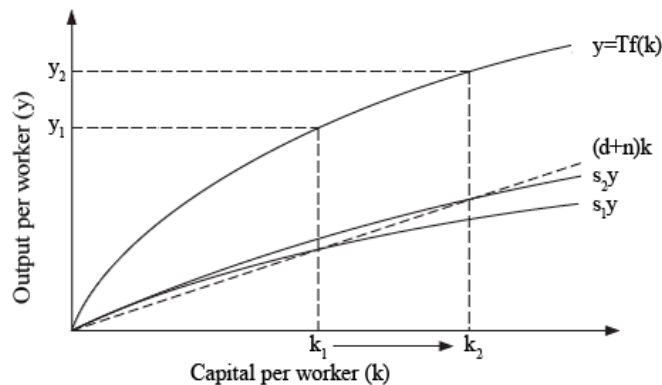
Figure 1 The equilibrium value of capital to labour ratio in Solow's model

The growth rate of savings from s_1 to s_2 in the model affects increase in investment per employee, from s_1y to s_2y (Figure 2). The result of the growth rate of savings is the change of the equilibrium value of the capital to labour ratio from k_1 to k_2, and finally, the growth of production per employee from y_1 to y_2.

Figure 2 Investment growth rate

It follows that the savings rate is a key determinant of the equilibrium value of capital to labour ratio. Thus, high savings rate leads to higher production per employee. However, the growth rate of savings and increased production per

employee on that basis will be temporary, i.e. will continue until the moment the economy reaches a new steady state.

Irrespective of the growth rate of savings and increased investment, growth in production per worker can be the result of technological changes. Figure 3 shows the effect of technological changes on the growth of production per employee. Improving technology T_1, T_2, and T_3 results in a change in the equilibrium value of the capital to labour ratio from k_1 to k_2 and k_3.

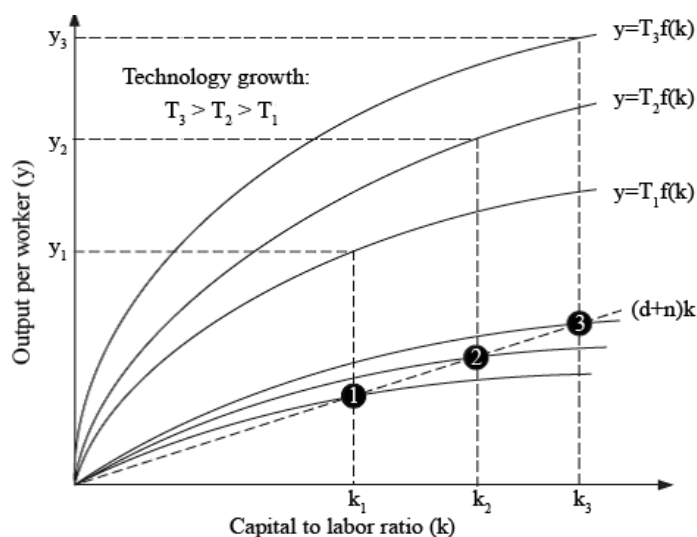**Figure 3 Technological changes in the growth model of Robert Solow**

Source: Modified according to: Greenhalgh, Ch. & Rogers M. (2010). *Innovation, Intellectual Property and Economic Growth*, Princeton: Princeton University Press. p. 224.

Neoclassical growth models suggest that markets are basically of extremely competitive nature and that they do not aspire to create a monopoly. Due to this fact, market processes, as a rule, lead to optimal allocation of production factors and maximum production. In addition, these models see little opportunity for the state to promote economic growth.

There are at least two conceptual shortcomings of this approach. First, the neoclassical framework makes it impossible to analyse the determinants of technological changes, which depend entirely on the decisions of economic agents. Second, neoclassical theory failed to explain the huge differences in growth rates in countries with similar technological development (Todaro, Smith, 2011). In short, neoclassical growth theory failed to explain the essence of emergence of the broadest diffusion of technological changes, and did not manage to, in an acceptable manner, quantify the contribution of this category to production growth at the national level. Although the technology is a central component of neoclassical theory, it remained unmodelled. Technological

improvements are introduced exogenously, which leaves differences in the level of technology among countries unexplained (Dragutinović et al., 2015, p. 167).

Although neoclassicists identified technological changes as the major source of economic growth and differences in economic development levels of countries, thus permanently indebting macroeconomic theory and policy, they, to tell the truth, did not offer specific practical solutions for achieving technological progress. In particular, they failed to do so bearing in mind the countries at low level of technological and economic development (Švarc, 2009, p.50).

3. Endogenous Growth Theory: Emphasis on the Role of Knowledge in the Processes of Creation and Diffusion of Technological Changes

Endogenous growth theory indicates an attempt to explain the long-term growth of the developed countries (Burda, Viploš, 2012, p. 92). Essentially, an endogenous approach to the research of economic growth is based on econometric analysis, which includes a number of variables and quantifies their impact on economic growth (Sala-I-Martin, 1997, p. 178).

The key postulate of endogenous growth theory is the elimination of the premise of diminishing returns on production factors. This creates the conditions for the growth of production per worker without limitations. "Under this assumption, endogenous growth models do not imply the likelihood of convergence, or reaching the steady-state growth equilibrium, having in mind that endogenous variables are determined within the economic model, and exogenous variables are taken as the given ones in the analysis of the economic model". (Cvetanović et al. 2011, p. 2).

There is a large number of divisions of endogenous growth models. One of them is their classification into: a) endogenous models based on externalities, b) models based on research and development activities, and c) the so-called AK models (Grossman, 1966). The most prominent authors of the models within the framework of the three groups are given in Table 1.

The first row relates to predecessors of a certain group of endogenous growth models.

In light of the defined subject and purpose of the research, it is certain that the most important are a) endogenous growth models based on externalities in the form of technological spillover (Romer, 1986) and b) growth models based on activities of applied research and development (Romer, 1990; Aghion, Howitt, 1992; Grossman, Helpman, 1991). What follows is their elementary explication.

Table 1 The main groups of endogenous growth model

Models based on externalities	Models based on research and development	AK models
Arrow (1962); Uzawa (1965); Nelson and Phelps (1966)	Schumpeter (1942); Uzawa (1965); Judd (1985)	King (1935; 1944); von Neumann (1945); Benveniste (1976); Eaton (1981)
Romer (1986; 1987)	Romer (1990); Grossman and Helpman (1990; 1991; 1992)	Becker, Murphy and Tamura (1990); Jones and Manuelli (1990); King and Rebelo (1990)
Lucas (1988)	Ahgion and Howit (1992)	Rebelo (1991)
Murphy, Shleifer and Vishny (1989)		
Azardis and Drazen (1990)		
Stokey (1991)		
Lucas (1993)		

Source: Modified according to: Grossman (1996) and Mervar (2003).

It is believed that Romer's model of 1986 has marked the emergence of endogenous growth theories (Romer, 1986). In this model, the accumulation of knowledge represents a by-product of company decisions to invest in physical capital. The accumulation of capital indirectly affects the increase in the knowledge base of the company due to the process of *learning through work*. Due to the effects of knowledge dissemination, i.e. spillover effect, other companies acquire benefits too, so that knowledge still has the characteristics of a public good. The transfer of knowledge to other companies, in the form of positive technological externalities, results in the increasing returns in these businesses. Taking into account the capital controlled by other companies, Romer assumes that the production function for each company can have a neoclassical form. In this regard, he assumes that the productivity of capital of each company individually can be increased in parallel with the increase in total physical capital which is owned by other companies. In short, investment in physical capital generates externalities, so that all companies, taken together, do not face diminishing return. In this approach, new knowledge that generates externalities is crucial. If one company acquires new knowledge, other companies experience a positive effect on production possibilities, because, in this model, knowledge cannot be kept a secret, i.e. be perfectly protected by a patent. Therefore, production of final products, as a function of the accumulated knowledge and other investment, exhibits increasing returns. Each company generates knowledge in the process of *learning through work*, and it instantly becomes available to all and completely free. In this way, the company's new

knowledge *spills*, but it cannot be said that the company itself does not benefit from this knowledge *spillover* to others (Cvetanović, Mladenović, 2015).

Although Romer managed to endogenise the category of technological changes, the model was not completely satisfactory, since the category of technological changes remained merely a secondary result of the company's economic activities, which is certainly not in line with actual events. Specifically, in this model, businesses, seeking to maximise profits, invest in capital without the explicit intention to do so, mainly due to the manifestation of a knowledge spillover effect, increasing the total fund of knowledge. In reality, it is different. New knowledge is, to a very small extent, incidental result of activities, and to a significantly greater extent, the result of the work of companies and their research and development activities, whereby they do their best to ensure monopoly rent. Thus, the assumption of free and broad diffusion of knowledge in this model, as well as the premise of the existence of perfect competition, are the biggest shortcomings of this model.

Another group of growth models, which stress the importance of the category of technological changes, are the models based on the activities of applied research and development. Building on some Schumpeter's ideas (1961), Romer developed the first model of sustainable growth that can be classified in this model group (Romer, 1990), and was followed by Agion and Howitt (1992), Grossman and Helpman (1994). Endogenous growth models in this group imply the existence of monopolistic structures, power, and the existence of a separate research sector in the economy, which, in a unique way, supplies other sectors with technology. By purchasing the new technology, manufacturers gain the legal right to its use. The price charged is higher than the marginal cost of production, to generate income sufficient to cover the costs caused by large initial investment in creating new technological solutions. Investment in innovation projects, in this regard, is not characterised by diminishing returns. Therefore, the productivity of new investment in innovative activity is not reduced, which is in the function of sustainable economic growth. In these model presentations, the growth rate depends on the amount of funds intended for research and development activities, the degree to which new technology can be used privately (degree of monopoly power), as well as the time horizon of investors.

In Romer's model, based on research and development, growth is driven by technological progress, resulting from investment decisions of companies that seek to maximise profits (Romer, 1990). In this regard, Romer prioritises technology over other goods, since it is non-competitive and only partly exclusive good. The degree of competitiveness of a good is solely its technological property.

The following endogenous growth models established direct mechanisms of creation and accumulation of knowledge in relation to the initial Romer's model. Although the models differ, all start from the position that the overall accumulation of knowledge is the result of the planned decisions of companies to invest in research and development activities. The implications of this approach are that knowledge ceases to be completely a public good. Specifically, in order for companies to be stimulated to invest, knowledge must be, at least to some extent, exclusive. By disabling other companies to copy their inventions and innovation, innovative companies gain a certain type of temporary monopoly power. Mechanisms that ensure a temporary monopoly are related to patent protection. At the same time, competitive companies can rely on available public knowledge, as an input in the production of new goods, or on employment of workers from companies that are innovation-leaders. The level of economic growth is then directly related to the strength of knowledge spillover, since knowledge spillover leads to innovation and growth (Romer, 1990).

The endogenous theory points to the importance of the institutional framework for stimulating innovation, as motivation for innovation depends on the ability of innovators to commercialise innovation. In recent decades, due to the popularity of endogenous growth theory, economists increasingly believe that differences in innovation capacity are largely responsible for large differences in development levels of individual economies (Grossman, Helpman 1991, pp. 46-51).

In endogenous growth models, the adequately defined higher level of investment does not only increase the per capita income, but may sustain high and rising growth rates in the future. This means that it is possible that countries continue to grow rapidly for a long period, even when they have already achieved a relatively high income per capita. There is no targeted equilibrium income level determined by the factors of production used. What is more, there is no predetermined maximum level of income that can be achieved on the basis of savings rates and limits of diminishing returns.

In endogenous growth theory, high economic growth rates can be maintained without increasing the savings rate. Growth is not just a development phase which ends when an equilibrium income per capita is reached. In contrast, continuous economic growth can become a feature of the functioning of the economy in the long run.

In a strictly empirical context, the problem Romer dealt with was that growth accelerated for more than a century instead of slowing down, as expected from the neoclassical growth model. He claims that it had something to do with the internal dynamics of science: the more you learn, the faster you learn. If knowledge is a source of increasing returns, then its higher

accumulation should mean faster growth – which really happened in the years of the last two centuries (Warsh, 2006, p. 207). The conclusion that the category of knowledge is of cumulative and dynamic character is essential for the understanding of endogenous growth.

What seemed new in endogenous growth models already existed in Smith's vision of economic growth mechanisms, especially in his concept of specialisation and division of labour. Endogenous growth models actually incorporate theories and concepts of rich past economic literature on decreasing costs and increasing returns, which, although not entirely ignored, is not fully understood in terms of importance in explaining the mechanisms of economic growth.

Although these models have some superficial similarities with neoclassical growth models concentrated on capital and savings, they do not provide for convergence of income levels, even among countries that have the same rates of savings, investment, and population growth rates. They also treat research and development activities, as well as creating new knowledge, as purposeful economic activities, to which, in the real world, profit companies and individuals who operate within specific institutional contexts aspire. The development of new technology and new products is an internally driven process, which is endogenous in each economy. The purposeful tendency of companies to realise large profit within a certain institutional context helps to understand the existence of economic growth in the long term, as well as the causes of the differences in the levels of per capita income and economic growth rates of countries in the real world.

Endogenous growth models also place quite different emphasis on factors and conditions necessary to intensify the economic development of countries, focusing on the creation of knowledge, education, and technology transfer. These theories deeply influenced the thought of a large number of economists in the policy of growth and recognition of the most serious obstacles to development.

The key document that signals a change of focus among the development economists has been the study of the World Bank, East Asian Miracle (World Bank, 1993). This critical examination of economic growth factors in the most successful Asian economies (Japan, Hong Kong, South Korea, Singapore, Taiwan, Indonesia, Malaysia, and Thailand) is based on endogenous growth theory methodology for identifying the crucial variables in growth policy. Endogenous growth models help to explain the strength of influence of the growth rate, and why growth can be cumulative. Thus, endogenous growth models can relatively easy explain the increase in the income gap between poorer and richer countries, since they break the link between economic growth and the law of diminishing returns. This effectively removes the upper limit of

income per capita with any particular rate of savings and investment. Countries that are already developed can continue to grow for a long time and relatively quickly in the future. They can also suggest what is needed if countries want to progress from the lower to the higher growth path. In other words, endogenous growth models can explain why some countries grow rapidly, reaching more equilibrium levels of income, while others remain permanently stuck in the poverty trap.

Endogenous growth models have determined the character of both technology and human capital, as basic and complementary determinants of economic growth rate and the level of per capita income. They show that the ability to apply technological knowledge drastically varies among economies, depending on the behaviour of economic agents and economic policy of the government (Beg et al., 2010, p. 525). Seeing the category of technological changes as something that requires social investment in specific human and organisational input that must be fully exploited indicates that there may be a technological gap among economies, and that every economy is developing its own technological base. Technology is the specific knowledge, not general knowledge that can be applied anywhere in the same way. Each country has to support investment in social and human resources if it is to create technological capacities. Endogenous growth models justify an active policy of the state in promoting growth through direct and indirect investment in the improvement of human capital and the support of foreign investors to invest in the development of the information and communication sector and the software industry (Todaro, Smith, 2011, p. 134).

4. Evolutionary-Institutional Theory of Technological Changes

The evolutionary approach tries to identify the determinants of the dynamics of technological changes, as well as the innovation level of society as a whole. Evolutionary theory is based on Schumpeter's theory on innovation, as a key factor of economic growth, and technological change, as a driver of innovation (Švarc, 2009. p. 56).

Representatives of this approach are Nelson, Winter (1982), and Dosi (1982). Their common feature is the analysis of the emergence and diffusion of technological changes at the company level.

Nelson and Winter criticise the two key premises of the neoclassical approach: market equilibrium and perfect rationality of companies in the implementation of their key objectives – profit maximisation. The authors are of the opinion that the profit realised on the basis of technological changes (innovation) is the phenomenon characteristic of a state of absence of

equilibrium. Innovation is, in fact, the phenomenon opposite to routine, and it, in the true sense, means the emergence of the new and unpredictable, which is why it is impossible to predict its results with certainty. Therefore, Nelson and Winter believe that the business skills of the company are of primary importance for the functioning of the organisation. The company and its business skills are adapted to the market through continuous innovation. Market rivalry is analogous to the process of natural selection in biology. Innovation in the economy is a mechanism that is identical to genetic mutation in biological world that leads to evolution. According to evolutionists, the business world is characterised by uncertainty, which means that it is impossible to anticipate all possible alternatives to some action. The only thing that is known in the business world is what is done, so with the introduction of new technology, one can only have an idea where this technology can bring them. The more fundamental the technology – the more different it is than the existing business structures – the higher the risk of failure, given that it is necessary to have more elements of new knowledge and more structural changes (Nelson, Winter, 1982).

Dosi (1982) gave his view of the category of technological changes in interaction with the social environment and the scientific system of the country. Evolutionary models point to the view that great scientific discoveries are the result of co-evolution of scientific and technological knowledge and their practical application, on which the market has a strong, directing, and selective effect.

A particularly important aspect of evolutionary growth theories refers to the concept of a national innovation system. The concept of national innovation systems has particularly gained in importance in the late nineteen-eighties (Freeman, 1987). National innovation system is a network of public and private institutions, whose activities and interaction determine the origin, import, transformation, and diffusion of new technology (Freeman, 1987, p. 4). National innovation system is the totality of interconnections and relationships of organisations working on the creation and diffusion of scientific knowledge and technology within national borders (Cvetanović et al., 2011).

A significant contribution to the subject of national innovation systems was given a few years later by Lundvall (1992, 2003) and Nelson (1993). Since that time until the present day, the concept of a national innovation system has triggered a lot of interest for two reasons: it has proven to be very powerful and flexible, and, in the era of globalisation, has made a significant insight into different contexts in the process of innovation.

The concept of national innovation systems stresses the fact that companies do not innovate in isolation, but in constant interaction with other organisations at the regional, sectoral, national, and supranational levels. It shifts the research

focus from the level of the individual and the isolated units within the economy (companies, consumers) to collective activities that stimulate technological changes. It looks at the entire knowledge and diffusion system, rather than its individual components. Technological changes are seen as outcomes of evolutionary processes within these systems.

The formation of the national innovation system is influenced by a multitude of factors, which vary among different countries, ranging from territorial size, abundance of natural resources, quality of human resources, historical development of the country, to the form of entrepreneurial activity. Their structure determines the speed of innovation evolution. Besides, any national innovation system has a unique structure and level of organisation, providing for sufficient stability of institutional connections (in fact, every country has the matching national configuration of institutional elements). Proponents of this theory argue that, at national level, there is a complex interaction of various processes, which have only a formal reflection in research and development activities in laboratories. This interaction is the result of the effect of educational institutions, links between producers and consumers through interactive learning, knowledge accumulation, acceptance of the imported technology and adapting to it, and the role of the state in the spheres concerning innovation. All these influences reveal the framework that determines the innovation capacity of the economy (Cvetanović, Sredojević, 2012).

5. Conclusion

The traditional (neoclassical) and contemporary (endogenous and evolutionary-institutional) theories have the almost identical position on the importance of technological changes for economic growth. In fact, both theoretical standpoints argue that the category of technological changes is a key driver of economic growth in the long term.

The neoclassical theory conceptualises growth as a deterministic process in which causality is clear, while policies can be conceived based on the understanding of the temporally invariant determinants of growth models. Endogenous and evolutionary-institutional explanations, in contrast, argue that different historical circumstances play an important role in the development process, which is why cause-and-effect mechanisms that prevail in one do not necessarily have a significant effect and importance in another period.

What all theories of endogenous economic growth have in common is the existence of various external effects and manifestation of non-diminishing returns on production factors at the aggregate level. In this way, endogenous growth models conceptually managed to overcome a stagnant neoclassical

economic theory, according to which economic growth, in the absence of technological changes, is a time-limited phenomenon.

The key drivers of technological changes in endogenous explanations are knowledge, research and development, and education. These factors, just like standard production factors, labour and capital, create new value. They rely on the expression of external effects, i.e. allow for non-diminishing returns on production factors at the aggregate level. In this way, endogenous models conceptually removed the key shortcoming of neoclassical theories, according to which economic growth, in the absence of technology shocks, tends towards zero growth.

Evolutionary-institutional theories attempt to overcome simplification of neoclassical growth models, especially in terms of their treatment of technological changes as a category outside the production function. According to evolutionary growth theorists, there are internal forces that drive the category of technological changes, and, more importantly, which can be stimulated through conscious control activity of the state.

References

Aghion, P. & Howitt, P. (1992). A Model of Growth Through Creative Destruction, *Econometrica*, 60(2), 323-351.

Baro, R. & Sala-I-Martin, X. (2004). *Economic Growth,* Cambridge: MIT Press.

Beg, D., Fišer, S. & Dornbuš D. (2010). *Makroekonomija*, Beograd: Datastatus.

Blanchard, O. (2005). *Makroekonomija*, Zagreb: Mate.

Burda, M. & Viploš, Č. (2012). *Makroekonomija: Evropski udžbenik*, Beograd: Ekonomski fakultet.

Cvetanović, S., Obradović S. i Đorđević M. (2011). Hipoteza o konvergenciji u endogenim teorijama rasta, *Ekonomske teme*, 49 (1), 1-13.

Cvetanović, S., Mladenović, I. & Nikolić, M. (2011). Theoretical basis of the concept of national innovation systems, *Ekonomika*, 57 (4), 14-23.

Cvetanović, S. Sredojević, D. (2012). Koncept nacionalnog inovacionog sistema ikonkurentnost privrede, *Ekonomske teme,* 50 (2), 149-167.

Cvetanović, S. Mladenović, I. (2015). *Ekonomija kapitala i finansiranje razvoja*, Niš: vlastito izdanje.

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggeste interpretation of the determinants and directions of technical change, *Research Policy*, 11(3), 147-162.

Dragutinović, D., Filipović, M. i Cvetanović, S. (2014). *Teorija privrednog rasta i razvoja*, Beograd: Ekonomski fakultet.

Freeman, Ch. (1987). *Technology Policy and Economic Performance: Lessons from Japan*, London and New York: Pinter Publichers.

Greenhalgh, Ch. & Rogers, M. (2010). *Innovation, Intellectual Property and Economic Growth*, Princeton: Princeton University Press.

Grossman G. & Helpman, E. (1991). *Innovation and Growth in the Global Economy*, MIT Press, Cambridge.

Grossman, G. (1996). Introduction. In: Grossman G. (Ed.), *Economic Growth: Theory and Evidence*. I, Cheltenham: Edward Elgar, pp. ix-xxxiv

Lundvall, B. A., (1992). (Ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers.

Lundvall, B. A., (2003). National Innovation Systems: History and Theory, *Working Paper*, Alborg University.

Mervar, A. (2003). Esej o novijim doprinosima teoriji ekonomskog rasta, *Ekonomski pregled*, 54 (3-4), 369-392.

Nelson, R. & Winter, S. (1982). *An Evolutionary Theory of Economic Change*, Cambridge: Belknap Press/Harvard University Press.

Nelson, R. (1993). *National Innovation Systems: A Comparative Analysis*, New York: Oxford University Press.

Petit, P. (1995). Employment and Technical Change. In: Stoneman, P. (Ed), *Handbook of the Economics of Innovation and Technical Change*, Oxford: Blackwell.

Romer, P. (1986). Increasing Returns and Long-Run Growt, *The Journal of Political Economy*, 94 (5), 1002-1037.

Romer, P. (1990). Endogenous Technological Change, *Journal of Political Economy*, 98, 71-102.

Sala-I-Martin, X. (1997). I Just Ran Two Million Regressions, *American Economic Review*, 87(2), 178-183.

Samjuelson, P. &Nordhaus, V. (2009). *Ekonomija*, Beograd: Mate.

Schumpeter, J. (1961). *The Theory of Economic Development*, New York: A Galaxy Book.

Solow, R. (1956). A Contribution to the Theory of Economic Growth, *Quarterly Journal of Economics*, 70(1), 65-94.

Solow, R. (1957). Technical Change and the Aggregate Production Function, *The Review of Economics and Statistics*, 39(3), 312-320.

Švarc, J. (2009). *Hrvatska u društvu znanja – prijepori i perspektive inovacijske politike*, Zagreb: Školska knjiga i Institut društvenih znanosti „Ivo Pilar".

Todaro, M. & Smith, M. (2011). *Economic Development,* London: Addison-Wesley.

Warsh, K.(2007). *Knowledge and the Wealth of Nations: A Story of Economic Discovery*, New York: Norton & Company.

World Bank (1993). *The East Asian Miracle: Economic Growth and Public Policy,* New York: Oxford University Press.

TEHNOLOŠKE PROMENE U EKONOMIJI RASTA: NEOKLASIČNI, ENDOGENI I EVOLUTIVNO-INSTITUCIONALNI PRISTUP

Apstrakt: Cilj istraživanja u ovom radu je dolaženje do odgovora na pitanje tretmana kategorije tehnoloških promena u magistralnim pravcima teorije privrednog rasta. Analizom ključnih stavova najznačajnjih reprezenata neoklasične teorije rasta (Solow), endogene teorije rasta (Romer) i evolutivne teorije rasta (Freeman), došlo se do zaključka da su ovi pristupi jedinstveni u tome da kategorija tehnoloških promena predstavlja ključni generator privrednog rasta. Neoklasičari su prvi eksplicitno analizirali kategoriju tehnoloških promena u teoriji rasta. Izvršili su jak uticaj na vlade mnogih zemalja da usmere značajna finansijska sredstva u naučna razvojna istraživanja, kako bi stimulisale nastanak i difuziju novacija. Pristalice endogenih objašnjenja, takođe, u kategoriji tehnoloških promena vide ključni pokretač privrednog rasta. Za razliku od neoklasičara, oni apostrofiraju važnost eksternalija u obliku tehnoloških prelivanja i aktvnosti istraživanja i razvoja za nastanak i difuziju inovacija. Konačno, teoretičari evolutivno-institucionalnog pravca u ekonomskoj nauci, kategoriju tehnoloških promena istražuju neodvojivo od privrednog i društvenog ambijenta u kome one nastaju i rasprostiru se. Poruke ovog istraživanja mogu biti od posebne koristi kreatorima politika privrednog rasta i razvoja u ekonomiji znanja, čije je osnovno materijalno obeleležje tzv. četvrta industrijska revolucija.

Ključne reči: tehnološke promene, privredni rast, teorija privrednog rasta, neoklasična teorija, endogena teorija rasta, evolutivna teorija rasta.

Authors' biographies

Dragoslava Sredojević graduated from the Faculty of Economics in Belgrade in 1986, at the Department of General Economics. She completed postgraduate studies at the Department ofTheory and Policy of Economic Development at the Faculty of Economics in Belgrade in 2003. Since 2004, she has been performing the teaching job at the Business School of Applied Studies in Valjevo, within the subject of Macroeconomics, and since 2005, within the subject of Economics. During education, she achieved outstanding results: she was the holder of two Vuk Karadžić diplomas and numerous awards in republic competitions in several subjects. At the Faculty of Economics, her grade point average was 9.52, and she was the winner of the Faculty of Economics awards for the results achieved and high grade point average. At the Faculty of Economics in Niš, in February 2016, she presented her doctoral dissertation, entitled Innovation capacity of the

economy as a limiting factor in improving the competitiveness of the countries of Southeast Europe.

Slobodan Cvetanović graduated from the Faculty of Economics in 1975. He received his M.Sc. (1981) and PhD (1985) at the Faculty of Economics in Belgrade. He is a full professor at the Faculty of Economics, University of Niš, teaching the subjects of Macroeconomics, Open economy macroeconomics, Economics of capital and financing development, and Macroeconomics and macroeconomic management. He is the author of more than forty books and over three hundred scientific and professional papers, of which more than twenty were published in journals of international significance, within the category M20. His fields of interest include theory and policy of economic growth and development, macroeconomic theory and policy, sustainable development, innovation economics, economics of health care.

Gorica Bošković graduated from the Faculty of Economics in 1992. She received her M.Sc. (1998) and PhD (2003) at the Faculty of Economics in Belgrade. She is a full professor at the Faculty of Economics in Niš, teaching the subjects of Industrial management, Industrial economics, Quality management, and Industrial economics. She has published over a hundred scientific and professional papers, of which the largest number was published in journals: Teme, Ekonomske teme, Facta Universitatis – Series: Economics and Organisation, Industrija, Ekonomija poljoprivrede, Ekonomika preduzeća, Strategijski menadžment, Ekonomski horizonti. Her fields of interest include industrial economics, industrial policy, industrial competitiveness, and quality management.