

REGIONAL POLICY OF THE EUROPEAN UNION, INNOVATION AND NEW MODELS OF ENDOGENOUS GROWTH

REGIONÁLNÍ POLITIKA EVROPSKÉ UNIE, INOVACE A NOVÉ MODELY ENDOGENNÍHO R STU

ING. PETR JI Í EK

Katedra ekonomických studií | Department of Economic Studies
Vysoká škola polytechnická Jihlava | College of Polytechnics Jihlava
✉ *Tolstého 16, 58601 Jihlava, Czech Republic*
E-mail: jiricek@vspj.cz

Annotation

The paper analyses new theories of economic growth based primarily on endogenous development and their impact on the concepts of the European Union regional policy. It testifies that supporting research, development and innovations as well as investment to human capital and environmental protection financed from the European funds are grounded in modern growth models.

Key words

innovation, growth models, endogenous development, science and research expenditures, regional policy of the EU

Anotace

P ísp vek analyzuje nové teorie ekonomického r stu, založené p eváfn na endogenním rozvoji a jejich dopad do koncepcí regionální politiky Evropské unie. Dokládá, že podpora výzkumu, vývoje a inovací, investice do lidského kapitálu a ochrany životního prost edí, financované z evropských fond , mají oporu v moderních modelech r stu.

Klí ová slova

inovace, modely r stu, endogenní rozvoj, výdaje na v du a výzkum, regionální politika EU

JEL classification: R11

1. Introduction

Innovation was considered an important growth factor already by significant Czech-Austrian economist Josef Alois Schumpeter. This was in the time when economic growth theories in their classical form only considered labour, land and physical capital. Schumpeter developed a theory of creative destruction in the entrepreneurial environment whose result is creating innovation with an impact on economic growth. The model is based on the assumption that the perfectly neoclassical market model is constantly being destroyed and not that it is in the state of market equilibrium because it does not substantially correspond to the monopolistic and oligopolistic organization of the market. Economic system are perpetually developing and we can talk about, for instance, changes in the population and its structure, technological development, changes in the amount of resources or political changes, but according to Schumpeter only the entrepreneur can transform these quantitative changes into qualitative economic development. The Schumpeterø entrepreneur innovates the production structure by creating a new product, innovates the production by inventing new production methods, and enters a new market (Holman, 2005). In the time when Schumpeter was constructing his innovation theory, a growth model was being created whose authors were economists Roy F. Harrod,

who published a study called *An Essay in Dynamic Theory* in March 1939, and Evsey Domar, who published the study *Capital Expansion, Rate of Growth and Employment* in April 1946 (Holman, 2005). Based on both the similar studies, the reputable Keynesian model was built, stressing exogenous sources of growth ó physical capital and labour, while considering natural capital a constant factor of production. The essence of the model was that if the economy wants to grow, it must raise capital ó i.e. invest. Until the 1980s, the reflection of this Keynesian growth theory in the European Union regional policy was the emphasis on exogenous factors, external investment and government regulation. In response to the growth model of the Keynesian direction the neoclassical Solow-Swan model of economic growth was created. The growth model is based on an adjustment of the classical Cobb-Douglas production function and in the equations it adds constant technological advancement to capital and labour (A). Next there is an assumption of substitution of capital (K) and labour (L) in a relation to the capital coefficient (α). The definition of the production function is in the form (Solow, 1956):

$$Y = A \cdot K^{\alpha} \cdot L^{1-\alpha} \quad (1)$$

The model also shows a conditional convergence ó a poorer economy converges to a stable state faster than a rich one, provided they have the same basic parameters. This conclusion reflects to the regionalist theory of the neoclassical economic school.

2. The goal and methodology

The goal of the presented paper is to capture the influence of modern economic growth theories based mainly on endogenous factors on the regional or innovation policy of the EU. The characteristic feature of endogenous growth theories is the premise that production function shows constant yields from additional capital inputs, unlike exogenous models which are reported with a production function with decreasing yields. Endogenous models assume that non-decreasing earnings are caused by the influence of positive externalities from new factors of economic growth ó human or technical capital (innovation). This assumption is utilized by the regionalist theory to justify methodologically its concepts aimed at decreasing regional disparities and convergence of regions using the above mentioned endogenous factors within a region. In the paper, development of individual theoretical concepts based on endogenous growth models will be described and also some theoretical models created in response to endogenously based concepts by representatives of the neoclassical school will be mentioned. Further we will briefly analyse the influence of endogenous growth models in particular on the European Union regional policy in its beginning till 1987 and then in individual programme periods of 1988-1992, 1993-2000, 2000-2006 and 2007-2013 and for the new programme period of 2014-20. The comparison of individual models will be carried out on the level of the basic shape of the production function with determining the meaning of individual parameters. To illustrate the significance of supporting endogenous growth factors for the economic growth in the countries of the European Union, graphs documenting the influence of financing research, development and innovation in the basic form will be presented.

3. Results

3.1 Romer-Rebelo's AK Model (1987)

After the collapse of the international financial system in the early 1970s and structural difficulties in the EEC economy due to growing inflation and a number of current exchange devaluations, the theoretical concepts based on both the dominating Keynesian growth model and purely neoclassical model were not sustainable any more. These changes manifested themselves as significant structural changes in afflicted regions with heavy industry, in the EEC countries especially in Lorraine, the Rhineland, Wallonia and central England. The starting point for the regional policy was the theoretical works which based economic growth on the internal resources of the region and technological progress and reflected starting qualitative changes in material and information technologies of the

1970s. The works were based on the original theory of institutionalism by Thorstein Veblen and Kenneth Galbraith (Holman, 2005). The first of these models was a neo-institutionalism concept of Portuguese economists Paul Romer and Sergio Rebelo which was mathematically based from the neo-classical Solow's model without exogenously introducing technological progress and for the technological constant equal to one. The production function of the model for the modified capital coefficient $\alpha = 1$ (constant yield from capital in relation to income) is in the following form (Rebelo, 1991):

$$Y = A \cdot K \cdot L \quad (2)$$

Economic output is proportional to capital stock and technological constant; if we increase the technological constant, we can increase social income Y without the influence on the change of capital and labour ($\alpha = 1$, $\beta = 1$).

3.2 Lucas's Endogenous Growth Model (1988)

Robert Emerson Lucas (*1937), an American economist, formulated a growth model that is based on theoretical postulates of the American neo-institutional school that emphasises the significance of both formal (private property, the law) and informal institutions as a fundamental framework for economic and social progress. Lucas created his model on the assumptions that investments into education, research and development financed from private or public sources lead to higher level of education. Its rising level creates positive externalities in economy leading to increasing economies of scale and those then lead to increasing productivity of work and growth of both product and income per capita. In the model, production function is created in the shape:

$$Y = A \cdot K^\alpha \cdot L^\beta \cdot h^\gamma, \quad (3)$$

where A is technological parameter, K physical capital, L labour, u production time, h stock of knowledge capital, α is capital coefficient.

The model predicts that positive externalities from human capital (knowledge) lead to endogenous growth of income due to their sharing (they have multiplicative effect) and the present value of knowledge capital influences its accumulation in future. Knowledge capital influences productivity of labour as well as physical capital creation, it is a reason of endogenous growth. Similarly to physical capital, where postponing consumption leads to investment and to higher consumption in future, incentives to study thus increase future economic growth. Both Lucas's and the following Romer's models appeared in the time when the EEC policy of the 1980s responded to technological lagging behind the USA and Japan; subsequently the first Framework Programme for Research and Technological Development was created in 1984 and the Eureka programme in 1985.

3.3 Romer's Endogenous Growth Model (1990)

In his model expanding the original AK model, Romer defined the influence of positive externalities in the field of science and research. He says that research and development results regardless patent secrets pervade economy and are intensified by the educational capacity of human capital, thereby creating endogenous growth factor. In his model Romer defines three sectors of economy σ the research sector, the sector of intermediate products, i.e. of means of production, and the sector of final production, i.e. of consumer goods or means of production. The definition of the production function is in the shape (Romer, 1990):

$$Y = A \cdot K^\alpha \cdot L^\beta \cdot H^\gamma \cdot A^\delta, \quad (4)$$

where K is physical capital corresponding to the amount of produced consumer goods, L labour reflecting the number of workforce, H human capital which creates rival knowledge resulting from education and training, A technological capital which is shown in the form of the technological index

and quantified by means of the number of patents and improvement proposals as a non-rival factor, substitution educational coefficient.

The essence of the model is that the consumer decides between consumption and savings under given interest rates, there are subsidies to the sector of science and research and holders of human capital decide whether to work or research, while the stock of knowledge, prices of improvement proposals and wages are given. The role of the state here is the necessary form of government regulation and namely creating and maintaining high-quality institutional environment (research, education, qualification). In the EU this concept manifested itself by creating innovation and technological agencies and common research institutions in the 1990s.

3.4 The Schumpeterian growth model (1992)

Howitt and Aghion's endogenous growth model is based on vertical innovations generated by competing research sector for the needs of entrepreneurial sector (Aghion, Howitt, 1992). The model works with J. A. Schumpeter's innovation theory and applies it on the present conditions of post-industrial economy. Market equilibrium at present is determined by expectations of future research results (future value of research results). One of these sources of expectation is creative destruction ó the outlook of future research results is influenced by the threat of destruction of the rent consequent on the present research results. The pace of growth is a growing function of the amount of innovation, the amount of knowledge capital and research work productivity. The model includes the falling discount rate as the rate of return of invested research capital. A reflection of this model can be traced in the principles of the EU Lisbon Strategy from 2000.

3.5 Jones's semi-endogenous model (1995)

Charles I. Jones in his article *Research and Development Based Models of Economic Growth* (Jones, 1995) presents a model which describes the influence of technical progress on the economic growth, which he perceives identically with previous models as an endogenous value. Technical progress is the result of scientific research and development by competing subjects based on profit. However, unlike the above mentioned models, this one does not perceive that economic growth is based only on technical progress, but it becomes a growth factor only in relation to exogenous factor of population growth. The production function definition is in the shape:

$$Y = \alpha \cdot \beta^{\beta} \cdot \gamma^{\beta} \cdot \delta^{\beta} \cdot \epsilon^{\beta} \cdot \zeta^{\beta}, \quad (5)$$

where Y is the final output of primary sector, α is production coefficient, β is work elasticity in the sector of final production, γ is the share of labour allocated to the final sector, K is physical capital, L is labour, A is technological index.

In Jones's model presentation, economic growth is influenced by the growth of productivity of factor of production of the research and development area, but this growth does not continue unless there is simultaneous accumulation of labour due to population growth. This model is a combination of endogenous and exogenous growth factors and according to detected empirical results is most closely related to present reality of the view of theories that do not accept the influence of environmental limits on economy. Jones's model influenced strongly the EU cohesion policy in the 21st century which, besides its emphasis on internal sources of the development of regions, does not ignore large Europe-wide infrastructural projects. It is also proven by the continued existence of the Cohesion Fund, originally limited until the emergence of the Eurozone, long-term EIB support of European Projects in the area of European infrastructural (transport, information, energetic) networks or the emergence of the CEF tool for the period of 2014-2020.

3.6 Green-Solow's environmental model (2004)

The model creators William Brock and Scott Taylor are representatives of the so called environmental economy grown from neoclassical roots, in case of this model from the classical Swan-Solow model supplemented with further factors such as the quality of the environment, pollution creation due to economic growth and introducing exogenous technological progress as a presumption of preventing the increase of environmental pollution. The model determines conditions of continuous growth when technologic progress is expected to have an impact towards decreasing pollution. The definition of production function is in the form (Brock, Taylor, 2004):

$$Y = e^{g_A t} B e^{n t} L \quad (6)$$

where BL is efficient labour given by technological progress B with growth rate g and labour L with the population growth n , K is physical capital.

Sustainable development is defined under the condition:

$$g_A > g + n, \quad (7)$$

where g_A is the pace of growth of pollution preventing technological progress, g is the pace of growth of polluting technological progress, n is the population growth rate.

The model reflects the situation in American industry when under the influence of technological progress in the 1990s there was a decline of pollution rate. In the EU policy, it had an impact on forming community programmes supporting renewable resources and energy savings (Altener, Save, Coopener in the period 1993-1999; in periods 2000-2006 and 2007-2013 complex programmes IEE, IEE 2).

3.7 Victor's low growth model (2006)

The author of the low growth model is Canadian economist Peter Victor, concerned with environmental economy. For mathematical description, Victor uses neoclassical Cobb-Douglas production function where the economic output Y is dependent on the stock of physical capital K , utilizing labour L and time t , which reflects growth of technological progress (Victor, 2006):

$$Y = e^{g t} \cdot K^{\alpha} \cdot L^{1-\alpha}, \quad (8)$$

where α is the share of capital in GDP (capital coefficient).

On the grounds of empirical research the author presents the relation for a sustainable growth rate:

$$\ln Y = \alpha \ln K + (1-\alpha) \ln L + g t \quad (9)$$

The low growth model reflects the situation when economic growth encounters biological and physical limits given by the influence of population growth on the world ecosystem, by limited natural resources, and by the fact that economic growth does not lead to higher well-being but poverty is growing. The model has become one of the bases for the sustainable development strategy, which is an important issue in the area of the EU policies.

3.8 The Directed Technical Change Model (2010)

The author of endogenous growth model is Turkish economist Daron Acemoglu. If in the previous environmental growth models technological progress was an exogenous value or a natural function of time, in this model technological progress is caused endogenously. It is implied in a directed way by means of technological change, which depends on individual characteristics of sectors inside the

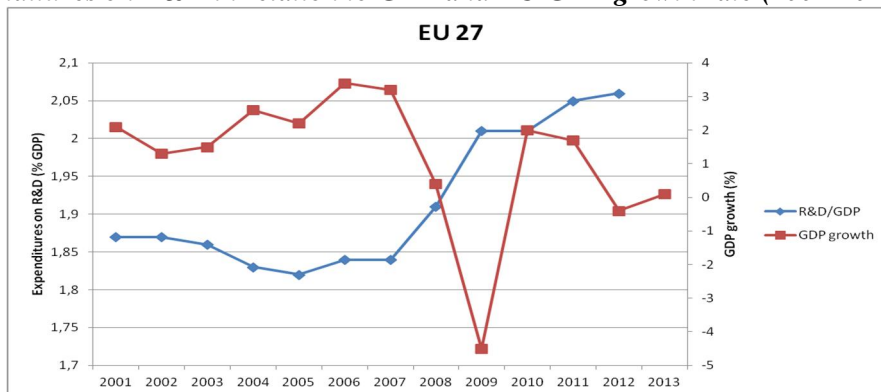
economy, such as supply of jobs and possibilities of substitution of one sector production with another. It works with empirical studies related to for example granting patents and their influence on production economies. The directed technical change model considers two sectors of economy: the first sector produces polluting technology and with its economic output contributes to growth of emissions and the other technologically advanced sector produces clean products not polluting the environment. There are research institutions which optimize their future profit from their activity by selling patents to the first sector. The total economic output is a function of the sum of sectors using as inputs polluting production and clean production. The production function definition is in the shape (Acemoglu et al., 2010):

$$Y = Y_c^{\alpha} Y_d^{1-\alpha} \quad (10)$$

where α is the elasticity between two sectors which can be both substitutes ($\alpha < 1$) and complements ($\alpha > 1$), Y_c is economic output of the polluting sector, Y_d is economic output of the sector preventing pollution.

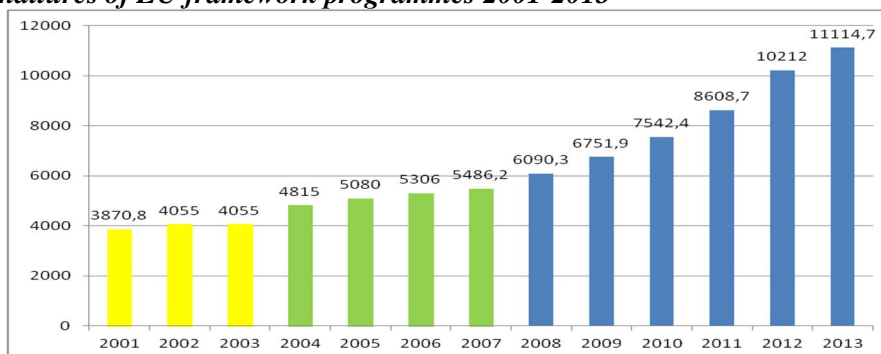
The author of the model says that if inputs are substitutes, then innovations occur only in the polluting sector where there are maximum profits. In case of complements of the inputs of the two sectors the price effect and the effect of the market size dominate and differences in both economic output and innovation rate decrease. Acemoglu shows that in case of functioning market economy in the first case the polluting sector and emissions increase above all limits and an environmental disaster occurs. Therefore it is necessary to change the rules of the game and subsidize the clean sector or introduce higher environmental taxes in the polluting sector and implement environmental policy. These principles can be traced e.g. in subsidy conditions and priorities of programmes financing cohesion policy or in the area of innovation programmes (for the period 2000-2007 namely the CIP and for the period 2014-2020 e.g. programmes COSME and HORIZON).

Fig. 1: Expenditures on R&D in relation to GDP and EU GDP growth rate (2001-2013)



Source: Eurostat

Fig. 2: Expenditures of EU framework programmes 2001-2013



Source: Europa

4. Conclusion

In its development, regional policy reflects basic theoretical models of economic growth in concepts of both Keynesian, neoclassical and neo-institutional schools. Until the end of 1970s exogenous theories of Keynesian type (Harrod-Domar model) or neo-classical orientation (Solow-Swan model) prevailed, preferring the significance of physical capital and workforce for regional development. Regional policy was created rather in accordance with national economic policy as its integral part. In connection with structural difficulties in economies of Western Europe, fundamental changes in regional and structural policy took place during the 1980s, when there was an emphasis on the role of internal sources of regions for their economic development and for creating institutions for their activation. Besides the convergence model of R. Barr and X. Sala-i-Martin from 1992 which had grown from neoclassical roots, endogenous theories further developed (Lucas, Romer). They were created namely in connection with the beginning information and communication revolution, which was the impetus of economic growth in developed countries in the 1980s and 1990s. In connection with that, innovation, research and development, and the need to increase education with the support in the area of regional policy as well with the goal to use local specifics proved to be an essential factor for the economic growth. However the practice showed in many cases that when exercising only endogenous factors in the development of regions their convergence does not occur but that it is necessary to preserve large national or European sources which will support from the outside significant national economic investments which regions will also benefit from. That was proven e.g. in the extension of functioning of the EU Cohesion Fund, which should originally have cease to exist with the entry of economically weaker EU countries to the Eurozone in 2000. Theoretical support of this concept is provided by Jones semi-endogenous growth model. At the beginning of the 21st century due to worsening global problems in the area of the environment and as a result of the Kyoto Protocol there were substantial changes in the European Union in the orientation of the cohesion policy support for the purpose of fulfilling obligations from the Kyoto Protocol and also increase of expenditures on science, research and innovation, as illustrated by figures 1 and 2. Growth theories accented this new phenomenon in sustainable development models by Brock and Taylor, Victor and Acemoglu, or by the exogenous model of Brock and Taylor, which deal with the environmental factor of economic growth. The task of innovations for sustainable development is dealt with by the model of Aghion and Howitt, which goes back in a modernized form to the Schumpeterian theory of creative destruction. We can say that also the present cohesion policy of the European Union strongly emphasizes this approach to the concept for the new programming period and creation of supports from European funds, as can be seen in the proposal of financial framework for 2014-2020.

References

- [1] ACEMOGLU, D., AGHION, P., BURSZTYN, L., HEMOUS, D., (2010). *The Environment and Directed Technical Change*. [online]. [cit. 2014-3-28]. Available at: <http://www.college-de-france.fr/media/nicholas-stern/UPL40052_aghion.pdf>
- [2] AGHION, P., HOWITT, P., (1992). A Model of Growth Through Creative Destruction. *Econometrica*, vol. 60, iss. 2, pp. 323-351.
- [3] BROCK, W., TAYLOR, S., (2004). *The Green Solow Model*. Working Paper, No. 2004-16. Madison: Social Sciences and Research Institute University of Wisconsin.
- [4] Europa. *Development of Community research - commitments* [online]. Available at: <http://ec.europa.eu/research/fp7/pdf/fp-1984-2013_en.pdf#view=fit&pagemode=none>
- [5] Eurostat, (2013). *Research and development expenditure, by sectors of performance* [online]. Available at: <<http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsc00001&plugin=1>, <http://apl.czso.cz/pll/eutab/html.h>>
- [6] HOLMAN, R. a kol., (2005). *D jiny ekonomického my-lení*. 3th. edition. Prague: C. H. Beck. ISBN 80-7179-380-9. p. 539.
- [7] JONES, Ch., (1995). Research and Development Based Models of Economic Growth. *The Journal of Political Economy*, vol. 103, iss. 4. DOI 10.1086/262002.
- [8] LUCAS, R., (1988). On the mechanics of Economic Development. *Journal of Monetary Economics* , vol. 22, iss. 1, pp. 3-42. DOI 10.1016/0304-3932(88)90168-7.
- [9] REBELO, S., (1991). Long-Run Policy Analysis and Long-Run Growth. *Journal of Political Economy*,

- vol. 99, iss. 3, pp. 500-521. DOI 10.1086/261764.
- [10] ROMER, P., (1990). Endogenous Technological Change. *The Journal of Political Economy*, vol. 98, iss. 5, Part 2: The Problem of Development: A Conference of the Institute for the Study of Free Enterprise Systems, pp. S71-S102. DOI 10.1086/261725.
- [11] SOLOW, R., (1956). Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* , vol. 70, iss. 1, pp. 65694. DOI 10.2307/1884513.
- [12] VICTOR, P., (2006). *Managing of Growth*. [online]. [cit. 2014-3-28]. Toronto: Faculty of Environmental Studies, York University. Available at:
<<http://www.yorku.ca/fes/wa/FacultyProfiles/app/profile/5174>>

The paper was prepared within the grant of the Internal Grant Contest of College of Polytechnics Jihlava No. 1200/4/6133 šManagement and financing of innovation projectsõ.