REVIEW ON INNOVATION DEVELOPMENT AND GROWTH

ОБЗОР ИННОВАЦИОННОГО РАЗВИТИЯ И РОСТА

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Abstract

This work analyzes the innovation growth in the economy in condition of an increase of natural resource extraction in the model framework. The main stylized fact for the model is that the economic growth in Russia in two last decades was not well balanced and a sufficient part of which was due to high prices of natural exhaustible resources (oil and gas). On the other side, there were also successful attempts to induce the growth based on the competences development.

The aim of the work is to develop endogenous growth model, which reflects both the growth of the resource extraction and the growth, connected with increase in technological level of the economy. This model may be useful for a number of developing countries, that budget is in direct dependence on oil and gas exports. The model is discrete and multi-periodic.

Аннотация

В данной работе анализируется инновационный рост экономики в условиях увеличения добычи природных ресурсов в рамках модели. Основным

стилизованным фактом для модели является то, что экономический рост в России в последние два десятилетия не был хорошо сбалансированным и достаточная часть которого была обусловлена высокими ценами на природные исчерпаемые ресурсы (нефть и газ). С другой стороны, были также успешные попытки стимулировать рост, основанный на развитии компетенций.

Целью работы является разработка модели эндогенного роста, отражающей как рост добычи ресурсов, так и рост, связанный с повышением технологического уровня экономики. Эта модель может быть полезна для ряда развивающихся стран, бюджет которых находится в прямой зависимости от экспорта нефти и газа. Модель дискретна и многопериодична.

Ключевые слова: инновации, природные ресурсы, исследования и разработки, эндогенные модели роста, компетенции.

Keywords: Innovation, natural resources, research and development, endogenous growth models, competences.

1. Introduction

It is a well-known fact, that Russian export today has crude natural resource bias. The profitability of resource (oil, gas, metals) sector surpassed the profitability of other sectors including manufacturing. This can result in favorable conditions for the start of the «Holland disease», when growing natural resource sector suppresses other branches (partly, due to the flow of investment and production factors) and becomes dominant in the whole economy. However, with good and adequate macroeconomic policy the natural resource extraction and export can become serious advantages of the country.

Besides the resource export, one of the main sources of the economic growth in Russia can be and now is the internal market. The growth of such sectors as food, trade, recreation, real estate, construction became significant and stable. However, this type of growth does not fully involve human and technological potential available in Russia, as these sectors borrow the most of technologies from world markets. Moreover, these

growing sectors produce goods and services, which are sold mostly inside the country and have a low export potential. One more, the most independent of exogenous factors, component of the growth is the increase in production of the domestic hi-tech and innovative goods for internal and foreign markets.

These stylized facts about Russia became the foundation for the models of endogenous innovation growth of the economy with natural resource sector, with constant saving rate, and with the absence of the external investment inflow. The models of this work are the attempts to enlarge the basic Solow model on multi-sector economy, which takes into account the flow of production factors and investment among sectors. It is shown in the framework of the models that the high prices of natural resource can, in some case, result in technical lagging behind, what can lead to negative effects not only on the size of total output but also on the growth of technological level.

1.1. Endogenous Growth

One of the main basic points of the growth theory is the Solow model, which establishes the link between the Gross domestic product (GDP) growth and the saving rate, in condition that all savings are transformed into investment. The basic model does not contain technological progress and the economy is supposed to be homogenous i.e. consisting of one sector. The main result of the Solow theory is the proof of the existence of the state of stable growth, to which the economy tends to converge. The growth rate in the steady state equals to the natural growth rate of the population. The ultimate steady state parameters of the economy depend on the saving rate, rate of the population growth and the production function.

The initial Solow model seems to be incomplete because it does not consider many important factors. A small modification of the Solow model allows introducing the variable, which accounts for the technological progress, which grows with constant rate over time. In steady state the rate of growth becomes equal to the sum of population growth rate and the technological progress rate (rate of the competence growth). This

allows a possible explanation why the rates of growth are not equal for different countries. It is so, because research and development (R&D) intensity and competences acquiring is not uniform all over the world.

Nevertheless, the Solow model with technological progress does not take into account the hypothesis of non-constant rate of technological progress and of its partially or fully endogenous character.

Another possible explanation of the stabilization of technological lag and even deindustrialization in some countries is the presence of distortions, which can be due to the increase in the intensity of the extraction of exhaustible natural resource, for example oil or gas.

In the work [1] the models which show the falling of the economy into the «Holland disease» are described. In the framework of these models it is proven, that in case of high natural resource prices deindustrialization does not occur only with a high rate of technological progress. Besides, it is shown, that in the situation of insufficient rate of technological adjustment the total GDP growth rate can fall in the long run.

Another approach to the inequality in the economic development of different countries is the idea that technological progress can be regarded, as the sequence of development existent and creation of new competences and the switching from one type of growth to another on a certain degree of development is necessary. This approach allows the explanation of some tendencies, which take place in many economies. For example, the fail of the «import-replacing» industrialization policy in many countries can be explained by the «overinvestment trap», when the rate of development becomes insufficient due to absence of competitiveness and dynamics and new competences creation.

At the end of the 60-ies an influential international group of professionals in the field of diplomacy, industry, the scientific community and civil society merged in Rome. The Club of Rome set a goal to explore next and distant consequences of large-scale solutions associated with selected humanity development paths. It was suggested

to use a systematic approach to the study of global issues, by adopting the mathematical method of computer simulation. The results of the study were published in 1972, the Club of Rome's first report entitled "Limits to growth" (Meadows 1972). The author of the report concluded that if current trends of population growth, industrialization, pollution, food production and resource depletion will continue, over the next century, the world will come to the limits of growth, an unexpected and not controlled by the decline in population and dramatically decreases the volume of production. However, they believed that it is possible to change the trend and come to a sustainable long-term economic and environmental sustainability due to the acquiring **new competences and new physical principles adoption**.

Ray Kurzweil is one of the world's leading inventors, thinkers, and futurists, with a thirty-year track record of accurate predictions.

The term "singularity" is a metaphor borrowed from physics. In [2] it means the period of the near future when the speed of technical development will be so high and changes of world around will be so fundamental that it will cardinally change all our existence for very short time. The law of acceleration of return, which sense in acceleration of rates of technical evolution is the main reason of singularity approach. Vernor Vinge proposes an interesting prediction in his essay titled "The Coming Technological Singularity: How to Survive in the Post-Human Era." He asserts that mankind will develop a superhuman intelligence before 2030.

So that, the singularity in real life can mean acceleration of technological progress in the developed countries and, therefore, the faster development of new competences.

1.2. Innovation Development and Growth

The innovation topic has become very developed in the economic theory. In the framework of the theory innovations are classified as local (within one country) and global (on the world market), product and process, large and small. The contrast between imitations (pure borrowings of technologies abroad to develop the exist competencies) and innovations (own R&D to create new competencies and entry into

the new markets) is also very important.

Early competency theory development stems from [3] economic framework that distinguishes the invention from innovation. Behavioral scientists tend to view innovation as a creative process that occurs within the self [4].

Innovative and creative organizations build capacity by extending “thinking outside of the box” to literally “breaking the box.” Many firms attempt to bridge workforce gaps by redefining competency when selecting the most qualified personnel [5].

According to the modern interpretation of the «open innovation» principle, for every corporate planning period (according to its planning cycle) a company should have a clear idea which competencies it should develop internally and which competencies should be planned to be bought or taken from outside [6].

A thorough analysis of innovations in developed economies is done in the paper [7]. It is stressed that the main type of competition in modern knowledge economy is not competition in price but competition in innovation speed. As the company, which has made an innovation the first, becomes a (temporary) monopoly, the economy cannot more be described as a pure competitive economy. Hence, the innovation process should be modeled in the frameworks of monopolistic competition or oligopoly. For the developing and transition countries the similar analysis is done in the work [8].

In the work [9] the implications of innovation and social interactions on economic growth are analyzed in a stylized endogenous growth model with heterogeneous research firms. A large number of research firms decide whether to innovate or not, by taking into account what competitors (i.e., other firms) do. This is due to the fact that their profits partly depend on an externality related to the share of firms, which actively engage in research activities. Such a share of innovative firms also determines the evolution of technology in the macroeconomy, which ultimately drives economic growth. The paper shows that when the externality effect is strong enough multiple BGP equilibrium may exist. In such a framework, the economy may face a low growth

trap suggesting that it may end up in a situation of slow long run growth; however, such an outcome may be fully solved by government intervention. [10]

One of the key features of innovation analysis is spillover effect: a company does not get all the profit from its R&D, as other companies will also get the access to the new technology (maybe, with a time lag). By that reason, many firms are prone to underinvest in their R&D. The spillover effect is the basic argument for the subsidies for companies-innovators. Besides, in the economy exists the cash-effect, the effect of the presence of big amounts of cash money in big monopolistic companies, what makes easier for them to finance both imitations and innovations with new competencies.

In [11] it is studied optimal liquidity management, innovation, and production decisions for a continuum of firms facing financing frictions and the threat of creative destruction. It is shown that liquidity constraints unambiguously lead firms to decrease their production rate but, surprisingly, may spur investment in innovation (R&D). The authors embed their single-firm dynamics in a Schumpeterian model of endogenous growth and demonstrate that financing frictions have an ambiguous effect on economic growth.

A very important part of the innovation theory is the theory of connections between innovations and competition [7; 12; 8]. In [7] it is shown that this connection is complicated. From one side, competition makes firms to innovate more, but, on the other side, in condition of strong competition, the stimuli to innovate become less strong, as a firm does not expect a long-run profitability from its innovation projects due to spillover (Shumpeterian effect). In [8] it is also outlined the importance of Shumpeterian effect, but it is stressed, that the growth of the competition can give a positive effect of the diminishing of the time period needed for innovation projects. In the paper it is also mentioned the competition escaping effect: due to competition a company starts to do more innovations to establish its share on the market more firmly.

The main result of all papers devoted to the interrelations between competition and

innovations is the firmly established inverse U-shape dependence of innovation rate on competition. The essence of this dependence is that the influence of the increase in competition on productivity (and innovation) is not monotonic: at the beginning it is positive, but starting from a certain level of competition the pressing on a company is too high, and the reverse tendency goes into force. This allows a possible explanation that on a market with a small number of players the competition in quality takes place (what is a favorable factor for innovations) and on markets with many players the competition in prices is dominant.

The theory of the inverse U-shape relation between innovations and competition has the best applications for the analysis of particular markets. Nevertheless, this theory is insufficient for modeling the innovation development in the whole economy, as it does not take into account the fact that different branches of an economy have different levels of development and the structure of every economy is not uniform. However, the relation between innovations and competition is a good starting point for further analysis. This relation is studied with taking into account the absence of uniformity of the economy (for the case of developing countries, where companies can differ significantly in structure and in level of development inside one economy) [8]. Hence, competition not only increases the productivity of all firms, but also makes feasible the selection of the most efficient structures. This selection and its efficiency depend on the quality and type of the institutes. In case of not «sufficiently competitive» environment the effect of competition increase on innovation is rather weak. The work also analyses the effect of scale and innovation costs, including spending on R&D. The main conclusion is that what poor countries really need is not an increase in R&D spending, but more investment, which simplifies the imitation of a completely ready foreign technology from developed markets. This affirmation coincides well with the main conclusion of the theory, which considers technical progress as the consequence of imitations and innovations.

The theory of imitations and innovations is a good tool for the technological

development analysis in the framework of endogenous growth theory and it suits well for the analysis of innovations in developing and transition economies. In recent years it was thoroughly developed and verified empirically. The main assumption of the theory is the conjecture that the economic growth consists of two stages: imitation and innovation stages. Companies can do both imitations (direct borrowings to develop the existent competencies) of the high-end technologies and their own R&D (the development of new advanced competencies). The fundamental model in the work [13] describes this two-stage growth. At the first stage (when a country is far from technological frontier) the optimal strategy is to increase the total amount of investment in existing firms and the main type of development is imitation. At the second stage (as the country approaches the technological frontier) the role of the amount of the investment becomes less important and competitive selection and adaptive capabilities of the market become the most important factors. The main obstacles on the way of growth and achieving the technological frontier level are underinvestment and overinvestment traps. The first trap appears when the economy attempts to jump to the innovation stage too early and stops supporting the increase in investment in traditional sectors. The overinvestment trap appears when industries of the whole economy are ready to transform to the innovation stage, but the economic policy still is more appropriate to the previous, investment and imitation, stage (tax relaxation for the strongest industries, competition restrictions, excessive concentration on the investment to traditional enterprises). The proofs of the existence of such traps are based on two effects: the effect of the insufficient profitability of the investment in innovations and rent-shield effect (a big amount of resources in the possession of insiders protects them from outside competitors). The first effect leads to the underinvestment trap (the majority of firms do not want to carry out big investment projects as they are not as profitable as they should be) and the second effect leads to the overinvestment trap (the companies-insiders stay firmly in the market and they prefer not to have high-risk innovation projects).

In the work [14] empirical results of cross-country regressions supporting the theory of two-stage growth [13] are described. It is asserted that pure import of technologies is the feature of the poor economies and is most profitable for them. As for countries with medium or high income per capita technology import should be combined with internal R&D, and the higher income per capita is, the higher should be the share of internal R&D.

In [15] it is also developed the two-stage growth theory of [13]. In this endogenous growth model innovations are subdivided into the categories of global and local innovations, and the assertion that companies borrow the technologies only from the frontier level is rejected. In difference with [13] here are three regimes of growth: imitation regime (characteristic for poor countries), innovation regime (characteristic for the most developed countries) and mixed regime which contains both imitation and innovation components. Improving the quality of institutes the country can go from the pure imitation strategy to innovation strategy through mixed regime. The work also contains the empirical subdivision of the countries based on the type of the growth. Also the authors discuss the hypothesis that a significant amount of R&D money is spent on local innovations.

The idea of the contrast between imitations and innovations can be useful in practical sense, for example in devising the optimal patent law. In work [14] it is stressed that a strong patent law (which satisfy to the World Trade Organization (WTO) standards) is not optimal for developing or transition economies, as it makes the diffusion of technologies weaker (especially on imitation stage). That fully corresponds to the conclusions of [8] that the problem of the defense of intellectual property rights is important mostly for developed countries. The ambiguous role of patent laws is also stressed [7]. These laws strengthen the monopoly power, and increase the revenues of companies, which have made innovations. On the other side, they allow a monopolist to take less care of further innovations. The importance of the last argument is supported by recent econometric research.

As in the development of the economy different traps are possible, the state influence during some periods of time seems reasonable. (Some measures of state influence can be avoided by appropriate institutional reforms.) This issue is studied in paper [16]. There are some models of endogenous innovation growth, which involve ideas and mechanisms, similar to the outlined above. Underdevelopment trap (due to spillover effect) can be a negative result of economy development without state influence. The one-sector model proposed in the work focuses on the choice between the necessity of partial subsidizing of the R&D and the distortions of the economy caused by the excessive subsidies The second, especially actual for Russia, model represents an economy consisting of two sectors: traditional sector and innovation sector. As in the previous model, the aim of the research is to find the optimal subsidy, which will assure that the country will escape the underdevelopment trap. The «new industry» argument supposes that the high-tech enterprises should receive R&D subsidies. The necessity of the subsidies is motivated by spillover effect. On the other side, the amount of subsidies should be seriously restricted, as in the case of generous subsidies the companies' main target becomes additional amount of transfers and they will seek opportunities to increase their influence on the state (rent-seeking argument) rather than to augment the profitability. The main conclusion of the work is that the size of subsidies to high-tech sector should increase with the growth of the profitability of the sector.

The table 1 consists of major scientific results in this area with the main findings.

Table 1. The major scientific results

Endogenous Growth	
Kuralbaeva and Eismont,1999 [1]	The models which show the falling of the economy into the «Holland disease» are described. In case of high natural resource prices deindustrialization does not occur only with a high rate of technological progress. Besides, it is shown, that in the situation

	of insufficient rate of technological adjustment the total GDP growth rate can fall in the long run.
Meadows 1972	If current trends of population growth, industrialization, pollution, food production and resource depletion will continue, over the next century, the world will come to the limits of growth, an unexpected and not controlled by the decline in population and dramatically decreases the volume of production
Kurzweil 2005 [2]	The "singularity". The speed of technical development will be so high and changes of world around will be so fundamental that it will cardinally change all our existence for very short time
Vinge 1993 [17]	Mankind will develop a superhuman intelligence before 2030.
Innovation Development and Growth	
Schumpeter 1939 [3]	Distinguishes the invention from innovation
Robertson 1967 [4]	Behavioral scientists tend to view innovation as a creative process that occurs within the self
Harrison 2015 [5]	Many firms attempt to bridge workforce gaps by redefining competency when selecting the most qualified personnel
Chesbrough 2003 [6]	for every corporate planning period (according to its planning cycle) a company should have a clear idea which competencies it should develop internally and which competencies should be planned to be bought or taken from outside
Morck and Yeung 2000 [7]	the main type of competition in modern knowledge economy is not competition in price but competition in innovation speed. The innovation process should be modeled in the frameworks of monopolistic competition or oligopoly
Marsiglio and	A stylized endogenous growth model with heterogeneous

Tolotti 2015 [9]	research firm. when the externality effect is strong enough multiple BGP equilibria may exist
Malamud and Zucchi 2015 [11]	Optimal liquidity management, innovation, and production decisions for a continuum of firms facing financing frictions and the threat of creative destruction
Carlin and Seabright 2003 [8]	Poor countries really need is not an increase in R&D spending, but more investment, which simplifies the imitation of a completely ready foreign technology from developed markets
Acemoglu et al. 2002 [13]	The fundamental model describes two-stage growth. At the first stage the optimal strategy is to increase the total amount of investment in existing firms and the main type of development is imitation. At the second stage the role of the amount of the investment becomes less important and competitive selection and adaptive capabilities of the market become the most important factors.
Polterovich and Popov 2003 [14]	The Cross-country regressions supporting the theory of two-stage growth (Acemoglu, Aghion, Zilibotti, 2002)
Polterovich and Tonis 2003 [15]	Three regimes of growth: imitation regime (characteristic for poor countries), innovation regime (characteristic for the most developed countries) and mixed regime which contains both imitation and innovation components
Tonis 2003 [16]	The high-tech enterprises should receive R&D subsidies

A large part of the analyzed works [6; 7; 9; 13; 14; 15] do not take into account the specific features of developing countries when analyzing growth and innovative development models.

In paper [8] the relation between innovations and competition is studied with taking into account the absence of uniformity of the economy in case of developing

countries, where companies can differ significantly in structure and in level of development inside one economy.

However, unlike the proposed model, this paper does not take into account the assumption that institutional and political risks in the economy are rather high; so all the investments (including spending on innovations) are financed by internal savings. This restriction seems realistic for Russia, as the total amount of strategic foreign investment in Russia is insufficient.

In paper [1] analytical solutions were derived, but the dynamics of technological progress in the economy was supposed to be homogeneous (with a constant growth rate or described a differential equation). An important difference of the proposed model is non-constant rate of change of technological level and its partially endogenous character.

The theory of imitations and innovations can explain well many peculiarities of economic growth, however in the case of Russia the analysis should start with special initial conditions. At first, the sufficient share of the total growth of Russia is based on the extensive growth of the natural resource extraction, and the crucial factor of this growth is the available stock of natural resources and innovations do not play here the first roles. Secondly, the most probable sector of the “innovation growth” in Russia is high-tech sector (MIC, heavy machinery), which is a long time in the innovation phase, and the study of its "simulation of dynamics" is not relevant.

This work contains a two-sector model of endogenous growth, which contains elements both from imitation-innovation theory of the works [15; 13] and from multi-sector models with the resource sector, described in the work [1]. In the framework of the model proposed the question, if an economy with resource sector and exogenous resource price can reach the world technological level, is studied. The peculiarities of this model are a constant saving rate, which makes it similar to the Solow model, and the absence of foreign capital inflow. The main mechanism of the models is the flow of the total investment between sectors and the inflow of capital to the most profitable

sector. Thus, the introduction of new options dramatically increases the possibility of practical application of the model in Russia and other countries from commodity dependence.

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