Study of the Problematic Issues of the Raw Material Orientation of the Economy: The «Dutch Disease» and its Influence on Innovative Development

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Abstract: This paper presents an analysis of innovative growth of the economy in terms of increase in production of natural resources held within the framework of the model. The aim is to study the problem questions commodity-oriented economy based on building models of endogenous growth. The models are built in the framework of the theory of endogenous growth and are a multi-sector extension of the Solow model with a constant rate of savings. In the proposed model to the economy added resource sector by developing its different from other companies, changes and non-tradable goods sector.

Key words: Endogenous growth theory • Technological armament • The "Dutch disease" • The commodity sector • The Solow model innovation development

INTRODUCTION

Russian economy has had a steady growth in many sectors in the last decade. However, the question, if this growth rate is stable and self-supporting, is still up to date. 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 [1]. 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. During the last years intensification of natural resource extraction and export took place in Russian economy, what seems to be well in accordance with the predictions of the theory. That can lead to the quick exhaustion of the available resources and the decline of country’s economy in the future. 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. The potential of this growth is still very high as the consumption and service sectors of the Soviet economy were far from the world standards. 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 [2].

One of the main negative factors for the development of Russian economy is the insufficient inflow of foreign strategic investment and underdevelopment of credit and loan market. The main source for the development are the own resources of enterprises and also subsidies and credits from state. However, in the last years the flow of capital between different branches (in particular, within multi-industry FIGs) became more active. The absence of big inflow of strategic foreign investment results in fact that most investment and innovation projects in Russia have internal financing [3].

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 and the «Holland disease» can lead to negative effects not only on the size of total output but also on the growth of technological level.

**MATERIALS AND METHODS**

The methodological basis of this study is an analysis of theories of innovation development of economy, historical, systematic scientific approaches, the complex economic and mathematical, statistical, abstract and logical methods.

One of the main basic points of the growth theory is the Solow model, which establishes the link between the 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. The model can be criticized from the point of view that there is no uniform convergence of the main macroeconomic parameters (GDP per capita, capital per capita) to the mean world values, as the model predicts, it the unique production function and saving rate are supposed for the entire world. In reality, the “club convergence” is more likely to take place, when the convergence of parameters occurs within different groups of countries to the values which are different for each group (for example, the EU, «new industrial countries» of South-East Asia, oil-extracting Arabic countries, Eastern Europe).

**Main:** 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. This allows a possible explanation why the rates of growth are not equal for different countries. It is so, because R&D intensity is not uniform all over the world.

The innovation topic has become very developed in the economic theory and there exist many works devoted to the innovation dynamics of developed, developing and transition countries.

A thorough analysis of innovations in developed economies is done in the paper [4]. 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 of Carlin, Seabright [5].

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) of the high-end technologies and their own R&D. The fundamental model in the work of Acemoglu, Aghion, Zilibotti [6] Distance to Frontier, Selection and Economic Growth. NBER Working Paper No. 9066. 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. In the work (Polterovich, Popov (2003)) [7] 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. That fully corresponds to the conclusions of [8]. Background paper for World Development Report. that the problem of the defense of intellectual property rights is important mostly for developed countries. These laws strengthen the monopoly power and increase the revenues of companies which have made innovations [9]. 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 [10].

This work contains a two-sector and a three-sector models of endogenous growth, which contain elements both from imitation-innovation theory of the works. In the framework of the models proposed the question, if an economy with resource sector and exogenous resource price can reach the world technological level, is studied. The peculiarities of these models are a constant saving rate, which makes them 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.

\[
A_{t+1}^e = \delta_A A_t + \text{im}(a_t) \overline{A} H_t., \text{ with } \text{im}(a_t) \overline{A} \geq \text{inn}(a_t) A_t
\]

\[
A_{t+1}^e = \delta_A A_t + \text{inn}(a_t) A_t H_t., \text{ with } \text{im}(a_t) \overline{A} < \text{inn}(a_t) A_t
\]

The model outlined below describes the economy which consists of two sectors: the manufacturing sector and the sector of exhaustible natural resource extraction. The stock of the resource is supposed to be very large, although the extraction of a unit quantity of the resource results in the loss in utility of the owner, as this quantity cannot be used in the future.

The model is discrete and multi-periodic. All equations describe the dynamics from the moment \( t \) to the moment \( t+1 \).

The economy is open for trade. The manufacturing sector produces the good \( M \) and the extracting sector produces the good \( R \). The goods \( M \) and \( R \) can be sold on external and internal markets. The price of the good \( M \) is constant and equals to 1 and the price of \( R \) is flexible. It depends on the situation in the world economy and equals \( p_t \) at the moment \( t \).

The economy is based on free market principles. The agents are manufacturing sector firms and natural resource extraction firms. The price of capital is endogenous and equals \( 1+r \) (The capital lives one period and its owner should get back the initial capital cost plus the interest rate after the end of the period).

Let \( Y_t \) be the total production (in terms of money) and \( K_t \) be the total amount of capital. The outputs in each sector are denoted as \( Y_{M,t}, Y_{R,t} \) (in terms of money) and \( Q_{M,t}, Q_{R,t} \) (in terms of real amounts of output). The quantities of capital in each sector are denoted as \( K_{M,t}, K_{R,t} \).

The utility of the manufacturing sector equals to its profit \( Q_{M,t} - (1+r)K_{M,t} = Y_{M,t} - (1+r)K_{M,t} \) and the utility of resource extraction sector equals \( \beta Q_{R,t} - (1+r)K_{R,t} = Y_{R,t} - \beta Q_{R,t} - (1+r)K_{R,t} \), i.e. its modified profit which takes into account the loss of the quantity of the resource which was extracted at the moment \( t \): nonzero coefficient \( \beta \) denotes the loss in utility from the fact that a unit quantity of the resource, extracted at \( t \), cannot be extracted at any future period of time. Large values of \( \beta \) correspond to the case when the owner of the resource «takes care about the future» i.e. considers the possibility of the exhaustion of the resource in defining the current amount of extraction. In the model it is also assumed that \( p_t > \beta \), i.e. in spite of fluctuations the world resource price is always higher than the minimal level \( \beta \), starting from which the extraction becomes profitable.

\[
Y_{M,t} = Q_{M,t} = A_t \sqrt{K_{M,t}}
\]

\[
Y_{R,t} = p_t Q_{R,t} = p_t B \sqrt{K_{R,t}}
\]

Here \( A_t \) is the multiplier corresponding to the technological level of the manufacturing sector, which changes from period to period, \( B \) is the constant parameter of production in the resource extraction sector (for example, the quality of deposits). The following type of production functions allows solving the model analytically.

If \( K_{M,t} > 0, K_{R,t} > 0 \) then the following first-order conditions is valid:

\[
\frac{\partial Y_{M,t}}{\partial K_{M,t}} = \frac{1}{2} \frac{A_t}{\sqrt{K_{M,t}}} = 1 + r
\]

\[
\frac{(p_t - \beta) Q_{R,t}}{\partial K_{R,t}} = \frac{1}{2} \frac{B(p_t - \beta)}{\sqrt{K_{R,t}}} = 1 + r
\]
The saving rate of the economy is constant and equals \( s \) and all savings transform to the investment:

\[
K_{M,t+1} + K_{R,t+1} = K_{t+1} = s(Y_{M,t} + Y_{R,t}) = sY_t.
\]

Then in condition \( p_t > \beta \) internal solution always exists.

This problem is equivalent to the GDP maximization problem with the restriction on the total amount of capital:

\[
Y_{M,t} + Y_{R,t} - \beta Q_{R,t} = A_t \sqrt{K_{M,t}} + (p_t - \beta)B \sqrt{K_{R,t}}
\]

\[
\max_{K_{M,t}, K_{R,t}} s.t. \quad K_{M,t} + K_{R,t} = sY_{t-1}.
\]

The Lagrange function equals to:

\[
A_t \sqrt{K_{M,t}} + (p_t - \beta)B \sqrt{K_{R,t}} + \lambda(K_{M,t} + K_{R,t} - sY_{t-1})
\]

If \( p_t > \beta \) then first-order condition is of the form:

\[
\frac{A_t}{\sqrt{K_{M,t}}} = B(p_t - \beta) \frac{1}{\sqrt{K_{R,t}}}
\]

or

\[
\left( \frac{A_t}{B(p_t - \beta)} \right)^2 = \frac{K_{M,t}}{K_{R,t}}.
\]

(In case \( p_t \leq \beta \) there exists a corner solution with \( K_{R,t} = 0 \).)

As \( K_{M,t} + K_{R,t} = sY_{t-1} \) then the solution always exists. Then

\[
K_{M,t} = \left( \frac{A_t}{B(p_t - \beta)} \right)^2 K_{R,t},
\]

\[
\left( \frac{A_t}{B(p_t - \beta)} \right)^2 + 1) K_{R,t} = sY_{t-1}
\]

The shares of capital in manufacturing and extracting sectors equal:

\[
K_{R,t} = sY_{t-1}\left( \frac{A_t}{B(p_t - \beta)} \right)^2 + 1) = sY_{t-1}\left( \frac{B^2(p_t - \beta)^2}{B^2(p_t - \beta)^2 + \lambda} \right)
\]

\[
K_{M,t} = sY_{t-1}\left( \frac{A^2_t}{B^2(p_t - \beta)^2 + \lambda} \right).
\]

These equations show that the greater is \( \beta \), the greater share of investment goes to the manufacturing sector. The total GDP of the economy after the end of period \( t \) in terms of money equals

\[
Y_t = A_t \sqrt{K_{M,t}} + p_t B \sqrt{K_{R,t}} = \left( \frac{A_t^2}{\sqrt{B^2(p_t - \beta)^2 + \lambda}} + p_t B^2(p_t - \beta) \frac{1}{\sqrt{B^2(p_t - \beta)^2 + \lambda}} \right) sY_{t-1}.
\]

In case of the wasteful resource extraction (\( \beta = 0 \)) the dynamical system has the appearance:

\[
Y_t = A_t \sqrt{B Y_{t-1}}.
\]

For the manufacturing economy (without resource extraction sector) the output is equal to

\[
Y_t = A_t B \sqrt{s Y_{t-1}}.
\]

The endogenous character of the technological progress in the manufacturing sector is one of the peculiarities of the model. For the problem of profit maximization for the period \( t \) the coefficient \( A_t \) is supposed to be constant. However, as the manufacturing sector develops new knowledge and technologies, the coefficient \( A_t \) changes over time. The evolution of the technological level \( A_t \) in the model has a complicated structure and depends on exogenous and endogenous factors.

The exogenous world technological progress is given by the equation [11].

\[
\overline{A}_{t+1} = \overline{A}_t (1 + g),
\]

where \( g \) is a constant rate of growth of the world technological progress. The crucial factor for the efficiency of the investment to the manufacturing sector is the level of development of the country \( a \). It is defined as the ratio of the technological level of the country to the world technological level

\[
a_t = \frac{\overline{A}_t}{\overline{A}}.
\]

With the development of production, the manufacturing sector accumulates knowledge and technologies which form the development potential \( H_t \). The development potential, accumulated at the end of period \( t \), equals to
\[ H_t = (\delta_H + (1 - \delta_H)C(a_{1})\sigma_{M,j})H_{t-1}. \]

The first term corresponds to the part of the development potential, which has remained from previous period \( t-1 \) and the second term corresponds to the knowledge and technologies, obtained and introduced during the period \( t \). Coefficient \( \delta_H (0 \leq \delta_H \leq 1) \) is the share of \( H \) from the previous period, \( C(a_{1}) \) is an exogenous function, corresponding to the educational level of the country and \( \sigma_{M,j} = \frac{K_{M,j}}{K_{M,j} + K_{R,j}} \) is the share of capital of the manufacturing sector in total capital amount in period \( t \) (in the model the unique generator and consumer of the technological progress is the manufacturing sector). The initial level \( H_0 \) is exogenous.

The development potential can be spent either on adaptation of new foreign technologies (imitation) or on own R&D activities (innovations). Both imitations and innovations result in growth of technological level \( A_{t,i} \), in comparison with \( A_{t} \). New value \( A_{t,i+1} \) becomes known at the beginning of the period \( t+1 \). The dynamics of the technological level is given by the equation:

\[ A_{t+1} = \delta_A A_t + im(a_{i})h_{1,t} + inn(a_{i})h_{2,t}A_t. \]

The coefficient \( \delta_A (0 \leq \delta_A \leq 1) \) corresponds to the share of technologies form previous period which are still not obsolete. The term \( im(a_{i})h_{1,t} \) corresponds to the imitation part and \( inn(a_{i})h_{2,t}A_t \) to the innovation part of the technology growth. Variables \( h_{1,t}, h_{2,t} = H_t - h_{1,t} \) correspond to the shares of development potential, spent on imitations and innovations. One of the main peculiarities of the model is the assumption, that with the growth of the technological level and the level of development of the country imitations become less efficient and innovations become more efficient. i.e. function \( im(a) \) is decreasing in \( a \) and \( inn(a) \) is increasing in \( a \).

It is also supposed in the model, that all countries on the technological frontier (\( a = 1 \)) have the pure innovation type of development, i.e. \( im(1) = 0 \).

Another natural restriction of the technological growth is the fact, that every country, including technological leaders, cannot «overcome» the rate of the world technological progress, i.e. there exists the additional restriction

\[ A_{t+1} \leq \bar{A}_{t+1} = (1 + g) \bar{A}. \]

or

\[ a_{i,t+1} = 1. \]

The problem of the optimal allocation of development potential is as follows:

\[ A_{t+1} = \delta_A A_t + im(a_{i})\bar{A}h_{1,t} + inn(a_{i})A_{t}h_{2,t} \longrightarrow \max \]

\[ s.t. \quad A_{t+1} \leq \bar{A}_{t+1} \]

\[ h_{1,t} + h_{2,t} = H_t \]

For the solution of this problem an explicit function \( A_{t+1}(H_t, A_t) \) should be found:

\[ A_{t+1} = \delta_A A_t + im(a_{i})\bar{A}h_{1,t} + inn(a_{i})A_{t}h_{2,t} \longrightarrow \max \]

\[ s.t. \quad h_{1,t} + h_{2,t} = H_t \]

\( A_{t,i} \) is given by the formula:

\[ A_{t+1}(H_t, A_t) = \min \left\{ \bar{A}_{t+1}, A^*_ {t+1} \right\} \]

The solution of the maximization problem is:

\[ A^*_ {t+1} = \delta_A A_t + im(a_{i})\bar{A}H_t \quad \text{if} \quad im(a_{i})\bar{A} \geq inn(a_{i})A_t \]

\[ A^*_ {t+1} = \delta_A A_t + inn(a_{i})A_{t}H_t \quad \text{if} \quad im(a_{i})\bar{A} < inn(a_{i})A_t \]

In the next section the dynamics of the economy and underdevelopment trap are considered.

**CONCLUSION**

The main purpose of the work was to describe the possible extensions of the Solow model with following additional assumptions:

- The economy consists of more than one sector (resource extraction sector, sector of non-tradable services)
- Technological progress is partly endogenous
- Technological progress is generated in one sector
- The development of the economy has imitation and innovation stage
- The model considers an institutional factor (education) which is favorable for technological modernization
One important feature of the model is non-constant rate of change of technological level and its partially endogenous character. This enables the «underdevelopment traps», when the technological level of the country grows, but the rate of growth is insufficient for achieving the world frontier. This can result in stabilization of the development level $q$, on a certain value, less than $I$, what is equal to the permanent underdevelopment of the country.

Inference: In the framework of these models the effects of the «Holland disease» and deindustrialization in case of high resource price were analyzed. It was shown, that high resource prices create externalities, which lead to the issue that in unfavorable conditions the market can go along an unstable in the long run development trajectory and become significantly dependent on resource prices. The greater is $\beta$, i.e. «considering the future», in the resource sector, the less is the size of the distortions.

The models showed a new negative effect of the «Holland disease», the slowdown of endogenous technical progress in the economy, which leads to the future decrease of profitability of the manufacturing sector and growth of dependence on the resource price.

The analysis of the examples showed that in condition of insufficient technological development of the economy introduction of the tax on the resource extraction and subsidizing the manufacturing sector may be favorable to overcome the underdevelopment trap. The main function of this tax is not to support the manufacturing sector, but to decrease the size of distortions in the economy which are due to high resource price and arise inevitably in the deregulated market.

In case of three-sector model with the labor-intensive non-tradable good (service) sector the deindustrialization effect connected with the «Holland disease» is present. With the growth of resource prices the consumers become richer, the prices of non-tradables go up and the non-tradable sector attracts more labor. It may occur a situation when the investment to manufacturing sector stops at once. In the two-sector model (without the non-tradable service sector) that effect was not present and the fall in the manufacturing sector was gradual. The deindustrialization effect can be explained by the increase in competition for the production factors: the manufacturing sector competes not only for capital but also for labor. Nevertheless, the main results for the two-sector model are still true also for the three-sector case.

These models are only the first step on the way to understand the growth and development of the multi-sector economy in conditions of the endogenous technological progress and the presence of exogenous price on one of the products (here on the resource). In the presence of more than one sector and the endogenous dynamic of the technical progress the character of the connections between sectors becomes complicated and to study it the numerical modeling of particular cases was used. However it seems rather possible that posing the additional conditions on functions, the dynamics of the model can be studied analytically in continuous time by use of maximum of Bellman principles. In the models of work the analytical dynamics was obtained but the initial dynamics of the technological progress was supposed to be homogenous (having a constant rate or described by one differential equation). This condition is not valid for the models in this work and the application of analytical methods seems much more complicated in this case.

REFERENCES