

Innovation Driven Economic Growth: Evidence for G7 Countries

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Abstract — The paper is devoted to the examining the influence of economic growth factor that determines the success in innovations production and to some extent reflects the level of human capital of the country - researchers in R&D (per million people) - on the cross-country income differences among G7 economies based on the economic and mathematical models construction. It was constructed panel data model to estimate the effect of number of researchers engaged in R&D sector on GDP per capita in G7 countries. According to model results, number of researchers in R&D sector affect GDP per capita of G7 economies with lag of 6 years.

Keywords — *sustained economic growth, economic growth models, innovation driven economic growth, panel data model*

I. INTRODUCTION

Evolution of economic development proves the high interdependence of sustained economic growth rates and achieving high standards of people's well-being.

The technological progress had been considered as a main trigger of sustained growth of economies around the world and is a "heart of economic growth" [18]. According to publications of economic growth researchers, sustained economic growth could be achieved only by increasing the total factor productivity. As an exception, some East Asian countries have demonstrated high growth rates over a quarter century mainly due to the rapid growth of capital and labor [18].

Nowadays, a human capital [1], [28], [29] and innovations [8-10], [12] are in the foreground in explaining economic growth across the countries.

The purpose of the paper is to estimate the influence of economic growth factor that determines the success in innovations production and to some extent reflects the level of human capital of the country – researchers in R&D (per million people) – on the cross-country income differences among G7 economies based on the economic and mathematical models construction.

II. LITERATURE REVIEW

Among the first neoclassical models of economic growth, we want to highlight such exogenous economic growth models as Harrod-Domar model [13], Solow model [29], [30] and its modification including natural resources, Ramsey-Cass-Koopmans model [4], [16], [22] and Diamond's model [6].

The pioneer among the exogenous economic growth models is the Harrod-Domar model [13] that allows analyzing the economic growth scenarios taking into account only an increase in capital stock as the main factor of output growth. The problem of ensuring sustained growth by Harrod is to compare the actual and guaranteed growth rates of the economy, the equality of which means a steady, long run development of the economy.

The economic growth model of Robert Solow, developed in 1956, dominated during the postwar period and served as the main tool for studying the problems of long-term economic growth, almost to the 1980's. Its main tasks are to study the opportunities for economic growth and convergence of poor countries to the richer ones. The central place in this model has been given to the capital dynamics and the description of economic growth in the process of adjustment to a balanced growth.

According to [29], the output in the economy is provided by two production factors – capital and labor. Solow also assumes the presence of neutral technological progress, which is "slowdown, acceleration, improvement in the training of the workforce" etc. [30]. In the long run only technological progress provides "a constant growth of the economy" [30].

Explanation of GDP growth per capita only by the accumulation of physical capital is considered a main disadvantage of the model as the difference in real incomes of countries is much greater than the difference of accumulated capital investments.

The Ramsey-Cass-Koopmans model is an exogenous model of growth as well, based on microeconomic foundation [4, 16, 22]. The model assumes the presence of competing firms that lease capital and hire labor for production and further sales of manufactured goods. Along with this, the economy operates a fixed number of households that live infinitely long period, offer labor, own capital (that is leased by firms), saves and consumes. Moreover, there are no market imperfections in the model (in particular, price and wage rigidity), rational expectations of households, intergenerational relations and heterogeneity of households [24].

Cass and Koopmans have modified the Ramsey model, assuming the endogeneity of savings, determined by the level of the interest rate. In turn, they have determined the optimal level of savings by maximizing the discounted utility function.

Contemporary models of economic growth are focusing on the study of economic growth factors that mainly reflect the “development of educational and scientific and technological factors” [10], [25]: innovations, for example [2], [27]; the accumulation of capital, both physical and human, for example [12]; external effects, such as [2] etc.

Economic growth models considering innovations as the driving force of economic growth, suggest its endogenous explanation [1]. They treat innovation as use of more efficient methods of producing goods, invention of new products that do not have substitutes on the market, etc.

Romer explains the economic growth by the increase in the production of new knowledge because of scientific and technological activities [25]. Based on the microeconomic background, the Romer’s model implies the impact of scientific developments on capital productivity and economic growth, which prompts the flow of resources into this sector. The peculiarity of this model is that, since “scientific projects exchange current expenditures on the flow of rewards in the future”, “the pace of technological change is sensitive to the interest rate” [25]. In addition, it is assumed that the researcher has rights to his ideas, setting the price for their use that exceeds the marginal costs and leads to stimulation of further research.

According to Romer, countries with a larger stock of human capital will grow at a faster pace, which implies that “free international trade can have an impact on the acceleration of growth”. The model also explains the fact that relatively closed economies with low levels of human capital do not show rapid economic growth and “why less developed countries with a large population can benefit from economic integration with the rest of the world” [25].

The main difference between the endogenous growth model proposed by Agion and Howitt is to take into account uncertainty [2]. Because of the inclusion of “creative destruction effect”, the model is Schumpeterian one by its nature. In addition, it is a model of vertical innovation when new inventions result in the aging of existing ones. Innovations are inventions of intermediate goods and inventions that promote the productivity of intermediate goods in the production of final consumption goods. The main factor of economic growth in the model is technological progress, which is the stimulus to competition between firms engaged in research activities and produce innovations.

Also, recently in the scientific literature much attention has been paid to the problem of sustainable economic growth modeling. In particular, it should be noted papers of Ukrainian economists which are devoted to ecological and economic systems modelling [11], [33], [34]. For example, in [33] mathematical theory of optimal control has been used to model the nonlinear economic growth.

However, described models of economic growth, according to some scholars, have significant disadvantages, in particular, the assumption of economic development “on the basis of the traditional structure of production, which is reflected by the empirically found ... production functions” [31]. This causes the impossibility of foreseeing the state of the economy under conditions of innovative technological changes.

Speaking about empirical evidence of innovations influence on economic growth, there are a number of papers devoted to the problem of estimating this impact in European countries, OECD economies and some other countries of the world, which prove its existence. In this case, we would like to mention such papers as [3], [7], [14], [19], [20], [21], [32], [36].

In this paper, we are attempting to prove empirically the existence of this impact in G7 countries.

III. RESEARCH METHOD

In order to examine the influence of economic growth factor that mainly determine innovations’ production effectiveness and to some extent reflects the level of human capital of the country – researchers in R&D (per million people) – on the cross-country income differences, we have used panel data models toolkit.

In the research, we have constructed panel data model of the following form:

$$y_{it} = \alpha_i + \beta_1 x_{1it} + \varepsilon_{it}, \quad (1)$$

where y_{it} – indicator of countries’ performance, x_{1it} – number of researchers engaged in R&D sector that are observed for N ($i=1, \dots, N$) (countries) during T periods ($t=1, \dots, T$), ε_{it} – perturbations that are independent, equally distributed random variables with zero mean and variance σ^2_{ε} . Influence of individual factors for i -th unit is constant and characterizes average levels for each unit of observation (country) by adding α_i to the model. The model is a fixed-effect panel model in the case of fixed α_i and random one when α_i are random variables with mean μ and variance σ^2_{α} .

Thus, random effects model has the following form:

$$y_{it} = \mu + \alpha_i + \beta_1 x_{1it} + \varepsilon_{it}, \quad (2)$$

where μ – free term [5].

IV. RESULTS

Thus, the purpose of this research is to examine the hypothesis of the impact of researchers engaged in R&D sector on economic growth of G7 economies.

The data source of the research is the World Bank data (World Development Indicators database) during 1996-2016 for G7 economies: Canada, France, Germany, Italy, Japan, United Kingdom and the United States (latest data is unavailable) [35].

As a measure of economic growth, we have considered GDP per capita (PPP) in constant 2011 international dollars. The factor that influences the gross domestic product per capita is a number of researchers in R&D sector (per million people).

Analyzing the dynamics of researchers in R&D (per million people) in G7 countries in the period 1996-2016 we can conclude that despite turbulent period of 2008-2009 the researchers in R&D sector are continuing to growth in the long run (Fig. 1).

As an exception, the USA economy with mainly constant number of specialists engaged in R&D sector during this period and Canada with volatile and decreasing number of researchers since 2008 that coincided with acquiring

specialists outside. Other countries have demonstrated sustained growth of researches accumulated in R&D sector.

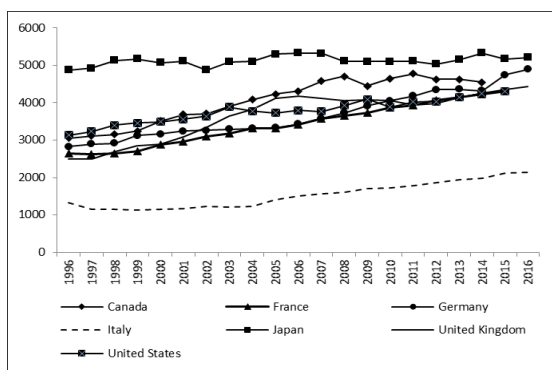


Fig.1. Dynamics of researchers in R&D sector (per million people) in G7 countries

At the same time GDP per capita, PPP, demonstrated upward trend during 1996-2016 except 2009 in almost all G7 countries (Fig. 2).

To model the impact of researchers in R&D sector on economic growth of G7 countries panel data model with fixed effect has been constructed based on results of Redundant Fixed Effect-Likelihood Ratio test. Estimated model is significant with sufficiently high value of R-squared, the normally distributed and non-correlated residuals.

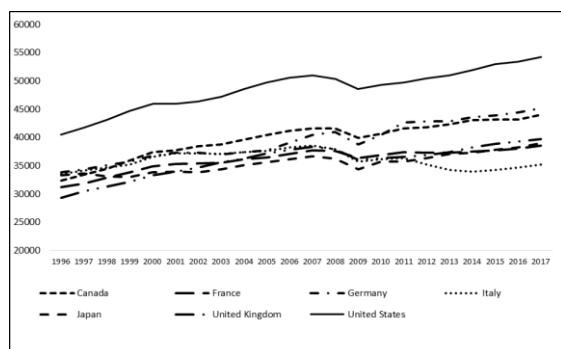


Fig.2. Dynamics of GDP per capita, PPP (constant 2011 international \$) in G7 countries

According to model results, number of researchers engaged in R&D sector affects GDP per capita of G7 countries with lag of 6 years.

Table 1 represents the fixed effects calculated for the model.

TABLE I. FIXED EFFECTS CALCULATED FOR PANEL DATA MODEL

Country	Fixed effects
Canada	1676.491
France	2067.875
Germany	7845.948
Italy	4447.054
Japan	8964.849
United Kingdom	2933.543
United States	9415.934

Thus, the obtained results demonstrate that an increase in number of researchers in R&D sector leads to accelerated economic growth of G7 countries.

V. CONCLUSIONS

To sum up the results of this research, we should note that the inalienable factor of gross domestic product per capita in G7 economies is a number of researchers in R&D sector, one of the factors that determines the success in innovations production and to some extent reflects the level of human capital of the country.

Increasing in a number of researchers in R&D sector leads to an increase in the gross domestic product per capita in G7 economies. Due to results of modelling, this impact has a lag of 6 years.

As a possible direction of future research, there should be considered the problems of convergence of poor countries to the wealthy ones in the world and estimating the speed of this convergence.

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