

EVALUATION METHOD OF THE RELATION BETWEEN THE INVESTMENT IN TECHNOLOGY AND THE ECONOMIC CHANGE

Justina Banioniene¹, Loreta Valanciene²

^{1,2}*Kaunas University of Technology, Lithuania*

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Abstract

Economists argue that investment stimulates economic growth. Investment in technology as one of the investment components should also stimulate economics of the countries. But the real relation between the investment in technology and the changes in macro-economic indicators is not deeply analysed.

The main purpose of the paper is to create the model for evaluation of the relation between the investment in technology and the economic change. The literature analysis shows that different neoclassical models could be used for different kind of evaluation of the relation between investment in technology and the macro-economic growth. Besides, a theoretical method is created to evaluate how the various investments in technology influence the economic growth.

The method consists of five main research goals: to evaluate the trends of investment in technology and economic indicators; to evaluate the influence of external factors on the economic change; to evaluate the influence of internal country's resources on the economic change; to assess the opportunities to catch up with advanced countries by investing in technology; to assess the country's ability to influence economic growth by investing in technology. Different research results and benefits could be received depending on the chosen goal.

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Keywords: *technology, investment, economic growth, investment in technology.*

JEL Classification: *O11, O32, O46.*

1. Introduction

In modern economies investment decisions are made both in the country's government and in business companies. On the country's management level, the investment decisions are related to the political framework and strategies, and contribute to the national economic development goals. The European Union (EU) countries combine investment plans and decisions with the EU economic development strategies such as "Europe 2020", in which effective investment in innovation is one of the priorities. The investment decisions of business companies are focused on value creation and enterprise risk management. Recently, active technological progress and innovation-based competition are among the main characteristics of business environment. There is no doubt that the results of political and business decisions lead to the creation of country's economic wealth and they still influence each other.

Economic research and studies present investment's (foreign direct investment) relation to technological progress and economic change. Moreover, these studies are based on the economic growth analysis and the selection of indicators for growth stimulation. The relation between technological progress and economic change is also the object of the scientific research.

However, the impact of the investment in technology on economic growth and development is not a well analysed sphere. Investment in technology as one of the investment components should stimulate economics of the countries. But the real relation between the investment in technology and the changes in economic indicators is not known.

In addition, it is an open question, which sources and spheres of investment in technology have the biggest impact on economic indicators in a country. Moreover, countries have limited investment resources and need to use them efficiently. The decisions to invest in technology creation and/or technology adoption should be done depending on the resources and development goals of countries. There is an opinion, that economically developed and financially strong countries should invest in the technology creation. Whereas the use of the created technology is efficient for financially unstable and less economically developed countries.

Also, country's ability to influence economic change by investing in technology is one of the most problematic issues. Governments have different instruments for the management of investment, which could be used for the investment in technology management. But before, the relation between the investment in technology and the countries' economic indicators should be analysed and the ways of the investment in technology (creation and/or adoption) should be chosen.

The research problem is formulated as a question: what is the relation between the investment in technology and the economic change?

The main purpose of the paper is to create a model for the evaluation of the relation between the investment in technology and the economic change. For the implementation of this goal, the theoretical models and empirical studies, related to the evaluation of this relation, should be analysed.

The first part of the paper presents the literature review of neoclassical growth models and the theoretical analysis of different empirical studies. The second part introduces research methodology, which is based on positivism. The relation between the investment in technology and the economic change is analysed using constructive research approach by applying systematic review, analysis, deduction and other methods. The result of this theoretical research is the method for the evaluation of the relation between the investment in technology and the economic change.

2. Theoretical background

Before the creation of theoretical method for the evaluation of the relation between the investment in technology and the economic change, it is important to get acquainted with the scientific aspects of the literature. In this chapter the review of neoclassical growth models is presented and its applicability to the created theoretical method is based. Also, different empirical studies are presented, and the indicators of economic growth and investment in technology are selected according these studies.

The selection of economic models

The economic change is a complex process and economic models are used for its analysis. The practical models of the economic growth were created in the middle of 20th century. According to Sachs and McArthur (2001), economic development was analysed by economists such as Harrod (1939), Domar (1946), Solow (1957) and his followers. These economists pointed out the savings, the investment and the capital accumulation as the main factors of the economic growth. However, there was a little emphasis on the economic growth as a result of technological change.

In 1956, Solow created a neoclassical model in which technological progress was recognized as an influential factor for the long-term economic growth and its maintenance. Since 1980, the technological innovation has been analysed in the economic growth theory as a key stimulus of growth. Various scientists analysed the importance of the technological innovation as well as Lucas (1988), Romer (1990), Grossman & Helpman (1991) and Aghion & Howitt (1992) and many others (Sachs, McArthur, 2001). The goal of the modern growth theory was to understand when the technological progress is an "exogenous" economic characteristic, when technological progress is an "endogenous" economic characteristic, and how to move from one phase to another. Also, it was argued, that the time of investment results technology of a country. Moreover, Armstrong and Taylor (2000) improved the neoclassical model and recognized the value of human capital as a determinant of economic productivity.

Comparative analysis of the neoclassical growth models shows that H. Armstrong and J. Taylor model allows a complex assessment of the technological progress influence to the economic change. The complex assessment is useful for the evaluation of creation conditions of technological progress, which is created as a result of investment in technology. However, different experimental studies were done on the basis of the technology transfer model and the exogenous growth model. These experimental studies examined foreign direct investment (one of sources of investment in technology) contribution to the creation of the technological progress. Moreover, in the technology transfer model, the technological progress is measured with one indicator, while assumptions of H. Armstrong and J. Taylor model require the creation of a complex indicator. Meanwhile, the technological progress created due to country's internal factors could be estimated using the endogenous growth model. This model could be applied to the internal investment in technology and the internal economic growth assessment.

To sum up, the R. M. Solow's neoclassical growth model and modern interpretations of this model identify the technological change as the essential factor of the economic change in the long term. Therefore, the neoclassical growth models suggest that investment in capital, labour, technology development, created technologies adoption and knowledge for technology creation ensure an appropriate macro-economic growth of a country.

Experimental studies and scientific research

Review of experimental studies and scientific research was done on the basis of the neoclassical models and the investment analysis. The assumptions, main data and results of these experimental studies are presented in the paper. According to this review, the indicators were selected and assumptions were raised in the created method of the evaluation of the relation between the investment in technology and the economic change.

Dewan and Hussein (2001) analysed *economic growth indicators in 41 middle-income developing countries* and sought to create an empirical model of economic growth. The study was based on model created by Knight, Loayza and Villanueva (1993), in which the assumptions of the neoclassical growth model and the exogenous model were used. The results of Dewan, Hussein (2001) research indicated that the labour force growth, investment in human and physical capital, low inflation and the remove of trade barriers were essential for the economic growth. In addition, the ability of a country to take advantage from technological progress (to increase efficiency) was very important. The theoretical and empirical analysis showed that macro-economic policy was among the key factors of country's economic growth.

In 1998 *Technology and Economic Growth Survey* was done by P. Hanel and J. Niosi. The project goal was to identify the factors that influence education and investment in Canada, and to create a systemic model. Statistical analyses were carried out in five areas: innovation system, innovation, government science and technology activities, industry, and human resources including employment and higher education. The results of study showed, that the technology was a key factor in the growth of both the company and industry levels. However, the technology was not the only indicator for macro-economic growth. Resources of capital and labour force had a significant influence on the economic growth. According to Hanel and Niosi (1998), the relationship between technology and economic growth was the strongest in knowledge creating activities.

In 2002 McArthur and Sachs introduced the Global Competitiveness Report, according empirical analysis of countries. Significant empirical evidence was obtained that there are *limits of technologies' geographical spread*. Therefore, it is important to invest in technology creation not only technology adoption if the country seek to get closer to high level income countries.

In the same year J. D. Sachs and J. W. McArthur presented a study in Asian countries - *"Advances in technology and long-term economic growth in Asia"*. This study was based on the Global Competitiveness Report and the endogenous and exogenous growth models. According Sachs and McArthur (2002), the number of patents was selected as the indicator of technological progress. The results showed that 10 countries having the largest number of patents, with population

of 13% of the world's population, generated 69% of the world's GNP. Meanwhile, 20 countries having the highest number of patents, with population of 15% of the world's population, generated 77% of the world's GNP. Among these 20 countries, 99% of patents were from the United States. This study distinguished countries into technology developers and technology importers.

Qi and Li (2008) analysed *knowledge transfer channels' affect to foreign direct investment* and the knowledge development in Chinese large and medium-sized industrial enterprises. The study was done in 28 companies, in which data of 2001-2005 period was analysed. Several econometric models were applied, but all the results showed, that foreign direct investment had positive and significant impact for the knowledge development in China during analysed period. According the data of study, in enterprises the knowledge creation depended on the contribution of labour force and capital investment in the sphere of scientific research and technological development.

In OECD area differences of the economic growth were analysed by Verspagen (2001). The scientist made the empirical study of economic growth and technological change in 1980-2000. The results of analysis showed that the United States was over the OECD countries and the gap from the OECD average was large. In addition, the convergence of countries' economic growth was due to faster import of foreign technologies. So, the investment in scientific research and technology development is very important for the economic growth, but not the only way to achieve technological progress. Verspagen (2001) argues that national differences in technological competencies (e.g., issuance of patents) are becoming one of the most important factors for explanation of growth. These trends suggest that the adoption of imported foreign technologies requires effort, and the technological differences between countries are becoming the growth differences of the economies.

Wang (2010) analysed *the main factors that determine investment of a country for the scientific research and technology development* in 26 OECD countries. Results of this study showed, that the analysed growth rates of technology output (foreign direct investment and technology import) were negatively correlated and statistically significant. Thus, the investment in scientific research and technology development (created in foreign countries) was a substitute for the country's investment in technological progress.

Also, a study in developed and developing countries was done by Alvi and others (2007). The researchers analysed the impact of intellectual property rights and *technology transfer on the scientific research and technology development*. The data from 21 countries was analysed including 6 rapid-developing countries from 1997 to 1981. According to the results, the foreign direct investment had a positive impact only in countries, where the rate of foreign direct investment was 3% or more of GDP. In these countries, the indicators of scientific research and technology development were increasing, while the revenue was growing. Alvi and others (2007) revealed the technology transfer problem, that only countries with the large inflow of foreign direct investment had the benefit from the technology transfer. This indicates the relationship between open economies and scientific research and technology development.

The relation between investment in technology, technological progress and economic change

It should be mentioned, that the factors of investment in technology and technological progress are closely related. The technological progress is the result of investment in technology.

Investment in technology theme is not only scientific, but also the topic of journalists publications. The benefit, the time directions and the resources of investment into technology are analysed. Few ways of investment can be stated: to buy created technologies; to create technologies; to invest in shares of companies creating technology; to buy created technologies and to create a new technological product. Investors and economists argue, that the investment in technology gives high return, so this investment is attractive, but risky (Sood, 2009; "The Growth Coach of the Brazos Valley", 2011).

The amount of investment in technology is largest during the economic boom period. There is an opinion, that in recession the investment in technology would cause the maximum investment effect (Sood, 2009; “The Growth Coach of the Brazos Valley”, 2011). In recession period, technologies cost lower and such investment would increase the growth of economic indicators. Thus, the appropriate time of investment in technology is also important.

Whereas, the relation between technological progress and economic change is presented in the neoclassical growth models review. On the basis of the experimental studies and scientific research, the indicators were selected for the analysis of the relation between investment in technology and economic change. So, the relation between the investment in technology, the technological progress and the economic change could be expressed as showed in Figure 1.

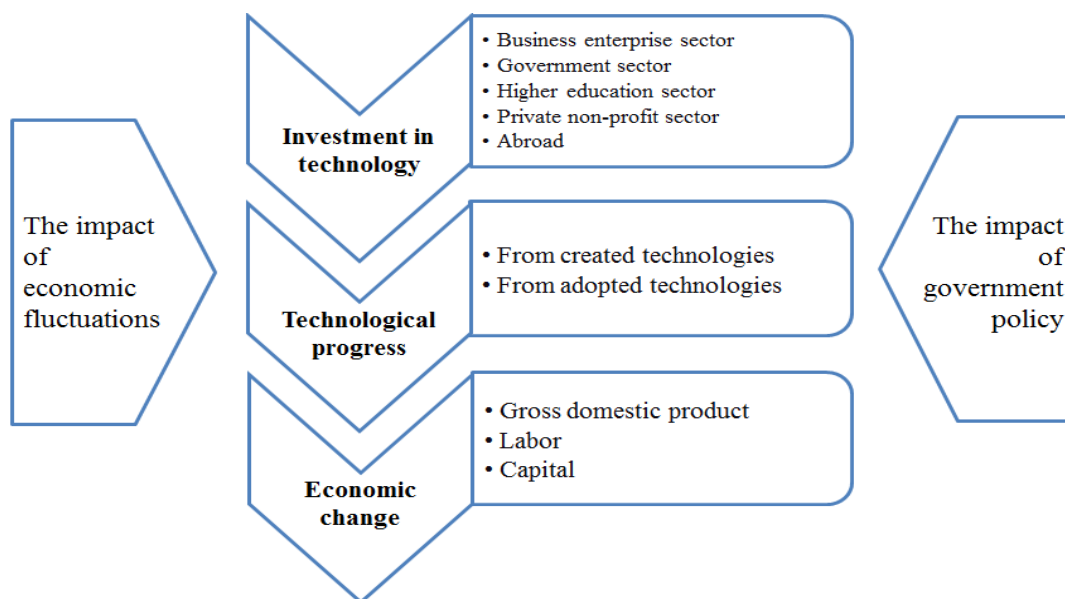


Figure 1. The relation between investment in technology, technological progress and economic change

Referring the scientific literature, it can be said that the investment in technology results the technological progress, which stimulates the economic growth (see Figure 1). The technological progress can be understood as a new technological knowledge, or the rate of creation of new ideas. Moreover, the technological progress is not only influenced by the economic growth, but also complexly depends on the country's economic growth, human resources, geopolitical situation and macro-economic policy.

3. Research Methodology

The positivist methodology was used for the theoretical research of the relation between the investment in technology and the economic change. The paper is based on the tradition research and existing scientific theories where research object and researcher is independent. The relation between the investment in technology and the economic change is analysed using constructive research approach and deduction method by evaluating the relation between the investment in technology and the technological progress, as well as the relation between the technological progress and the economic change.

Several stages were used for the analysis of the relation between the investment in technology and the economic change. The stages of method creation are presented in Figure 2.

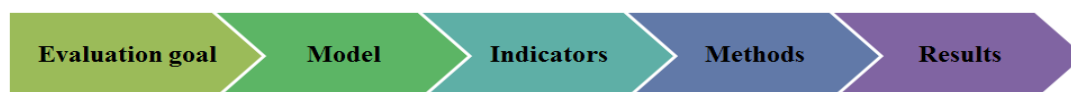


Figure 2. The stages of method creation of the relation between the investment in technology and the economic change

After the systemic review and comparable analysis of the theoretical methods and the empirical studies, evaluation goals were raised. Then, five different neoclassical models were chosen (R. M. Solow neoclassical growth model, exogenous growth model, P.M. Romer's endogenous growth model, technology transfer model and generalized H. Armstrong and J. Taylor neoclassical model) and their theoretic assumptions were adapted for the goals implementation.

Referring the empirical studies and the evaluation goals, the statistic indicators were chosen. Moreover, an investment in technology index was integrated (beside the indicators of chosen neoclassical growth models) to express the relationship between the indicators of investment in technology, technological progress and economic change. The amount of the analysis of selected indicators and the research methods depend on the evaluation goals stated. The comparative, systematic and complex analysis methods were used by applying mathematic methods of correlation and regression. The results of each evaluation goal vary from evaluation of situation to highlighting of opportunities.

The option of the goals leads to the neoclassical growth model's selection, the indicators and the methods of their analysis, and also the research results. This lets complex and systematic analysis of the relation between the investment in technology and the economic change taking closer to specific situations.

4. Results

After the literature review and the analysis of the neoclassical growth models, the method for the evaluation of the relation between the investment in technology and the economic change was created. The comparative analysis of R. M. Solow neoclassical model, exogenous growth model, P. M. Romer's endogenous growth model, technology transfer model and generalized H. Armstrong and J. Taylor neoclassical model was made. The analysis shows that different neoclassical models could be used for the different kind of the evaluation of the relation between the investment in technology and the economic change.

The goal of the created theoretical method is to evaluate the relation between the investment in technology and the economic change. Consideration should be given to the fact, that neo-classicists believe – the technical progress (the result of investment in technology) is the key factor of economic stimulus. However, such factors as capital and labour force are also important for the economic change. According the literature review, the latter factors determine the amount of investment in technology and the ability to take advantage of available technologies. Meanwhile, the investment in technology is related to macro-economic policy of the country and reacts to changing political conditions as the analysed experimental studies shows.

Thus, the relation between the investment in technology and the economic change can be analysed using different aspects – the trend analysis of indicators, or the analysis of the indicators' relationship as a complex problem. The choice of evaluation model and the complexity of the assessment depend on the research goal. The complex evaluation methods are used for broader and deeper analysis of the relation between the investment in technology and the economic change. For situation evaluation of the relation between the investment in technology and the economic change, the comparative and system analysis are used. The created method's visualisation for the evaluation of the relation between the investment in technology and the economic change is presented in Figure 3.

Evaluation goal	To evaluate the trends of investment in technology and economic indicators	To evaluate the influence of external factors on the economic change	To evaluate the influence of internal country's resources on the economic change	To assess the opportunities to catch up with advanced countries by investing in technology	To assess the country's ability to influence economic growth by investing in technology
Model	R. Solow neoclassical growth model	Exogenous growth model	Endogenous growth model	Technology transfer model	H. Armstrong and J. Taylor model
Indicators	GDP, GDP/population; Labour force; Capital; Technological knowledge; Investment.	GDP/population; Population; Migration; Labour force; Capital; Technological knowledge; Investment by resources.	GDP/labour force; Labour force; Capital; Technological knowledge; Investment by spheres; Investment by resources.	GDP/population Labour force; Capital; Technological knowledge; High technology; Investment by spheres.	GDP/population Labour force; Capital; Technological knowledge; High technology; Investment by spheres and by resources; Investment change rate; Interest rate.
Methods	Indicators trends comparative analysis. Countries comparative analysis.	Indicators systematic analysis. Countries comparative analysis.	Indicators systematic analysis. Countries comparative analysis.	Indicators systematic analysis. Countries comparative analysis.	Indicators complex and cyclical analysis. Countries comparative analysis.
Results	Evaluation of situation	Evaluation of situation	Evaluation of situation	Evaluation of situation. Highlighting the opportunities	Evaluation of situation. Highlighting the opportunities

Figure 3. The created method for the evaluation of the relation between the investment in technology and the economic change

As can be seen in Figure 3, the created method consists of five main research goals: to evaluate the trends of the investment in technology and the economic indicators; to evaluate the influence of external factors on the economic change; to evaluate the influence of internal country's resources on the economic change; to assess the opportunities to catch up with advanced countries by investing in technology; to assess the country's ability to influence economic growth by investing in technology.

Following Figure 3, different neoclassical growth model can be applied to the different evaluation goal, and also the indicators are selected according to the chosen model as described earlier. However, not only the indicators of neoclassical growth models are used, but also the contribution of the investment in technology for the technological progress should be evaluated, because the neoclassical growth models do not include the investment indicators. The analysis of indicators (investment in technology and technological progress) determines the amount of investment needed for the technological progress and the efficiency of investment spheres and sectors. In addition, the evaluation of the investment in technology efficiency lets to draw conclusions on the macro-economic policy and the trends of investment in technology.

So, by the chosen research goal, the evaluation of the technological progress is primarily done, and its significance for the economic change of a country is assessed. Then, the assessment of what and how the investment in technology changes lead to the changes of the technological progress level is done.

The first goal of the created method is used for the superficial analysis of the investment in technology and the economic change. The tendencies of indicators of the investment in technology, the technological progress and the economic change should be assessed and compared. Also, the comparison of different countries could be done. The second and the third goals allow evaluating the impact of different investment sources on the economic change. The external factors and

internal country's resources could be separately assessed, that the origin of the investment in technology and the technological progress would be evaluated.

The opportunities to catch up with advanced countries by investing in technology are evaluated in the fourth goal. This goal lets to assess the differences of the investment in technology and the technological progress in different economies and to distinguish the causes of the inequality of economic changes. The fifth goal lets to compare countries and estimate countries ability to influence the economic growth by investing in technology. The complex analysis is used for the evaluation of the impact of fiscal policy on the investment in technology, the technological progress and economic change indicators.

Summing up, the presented analysis revealed, that different research results and benefits could be received depending on the chosen goal of the evaluation of the relation between the investment in technology and the economic change. The assessment and comparison of tendencies are used for the superficial analysis of investment in technology and economic change. Also, the impact of different investment sources could be estimated by evaluating external factors and internal country's resources. The evaluation of opportunities to catch up with advanced countries by investing in technology lets to assess the gap between different economies. Finally, some countries could be compared and strategic decisions could be chosen by estimating country's ability to influence economic growth by investing in technology.

The created method for the evaluation of the relation between the investment in technology and the economic change presents a conceptual approach of the evaluation. Logic and validity of the results will be tested in practical research based on the created method. This method could be applied to the assessment of economic changes and the strength of its connection with the investment in technology, as well as the relation changes in the long term. Moreover, the method is useful for making investment decisions at the government level, seeking to highlight the potential of the country by investing in technology, or choosing from investment alternatives.

The assessment of the relation between the investment in technology and the economic change is the complex problem, because the time of the technological progress (got from investment) is different from the investment moment and it is difficult to evaluate the time gap. Elimination of other factors' impact on the economic change is also problematic.

5. Discussion

The relation between the investment in technology and the economic change is not a well analysed sphere. The investment in technology as one of the investment components should stimulate economics of the countries. But the real relation between the investment in technology and changes in economic indicators is not known.

The originality of this paper is the created method for the evaluation of the relation between the investment in technology and the economic change by combining the investment theory and the neoclassical growth models. The literature review and the analysis of neoclassical growth models showed that different neoclassical models could be used for different kind of the evaluation of the relation between the investment in technology and the economic change. The indicators of economic change and investment in technology are included, and various analysis methods are applied to the created method. The method consists of five main research goals. Different research results and benefits could be received depending on the chosen goal.

The theoretical method for the evaluation of the relation between the investment in technology and the economic change should be verified empirically using quantitative and qualitative methods. Each goal of created method could be validated separately or together on the basis of the range of empirical test.

The limitation of the created method is the objectivity of indicators for the technological progress evaluation, but there is no more objective statistical indicators found in the databases. Also, in the databases, the data of investment in technology indicators is limited by countries and by categories of the investment in technology.

Nevertheless, the theoretical method for the evaluation of the relation between the investment in technology and the economic change is adaptable for the analysis of changes of various indicators (investment in technology and economic indicators), of complexity and the dynamics of the relation of these indicators. As well as the assessment of investment in technology impact on the countries economic changes is possible by sources and spheres. Vice versa, there is an opportunity to evaluate which sectors and spheres of the investment in technology react sensitively into changing economic conditions. The created model lets to assess government decisions and shows related changes of the basic economic indicators, which have an impact on the creation processes of technological progress. The more objective assessment of political decisions could be got by integrating more political sensitive indicators in the model, but their sensitivity research should be done before.

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