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Government Innovations and Economic growth: Evidence from Slovak Republic

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Abstract – Innovation is one of the key drivers of economic growth in many countries. Government innovation policy influences not only economic growth but also the behavior of economic agents, especially firms. Many studies have focused on estimating the relationship between innovations and Using covariance-correlation analysis, we estimate the relationship between economic growth and innovation (expressed as the share of government R&D expenditure in GDP) in the Slovak Republic over the period 1995-2022. We show that the correlation is both moderate and positive, representing the fact that innovation can boost economic growth in the Slovak Republic. The implication of the paper is that innovation can promotes economic growth in the short run, but not in the long run. The contribution is also the finding that, to a limited extent, government innovation policy mitigates cyclical fluctuations and acts as a stabilizer in the economy.

Keywords – Economic Growth, Government Innovation Policy, Innovations, R&D Expenditures, Correlation

I. INTRODUCTION

Today, innovation is given great importance, as evidenced by the adoption of provisions in the U.S. and the European Union. The White House Office of Science and Technology Policy on 25th of August 2022 issues guidance to make federally funded research freely available without delay. Within the European Union, a New European Innovation Agenda was adopted through the European Commission to position Europe at the forefront of the new wave of deep tech innovation and start-ups on 5th of July 2022. An innovation is a new idea, which may be a recombination of old ideas, a scheme that challenges the present order, a formula, or a unique approach which is perceived as new by the individuals involved. (Rogers, 1983)

The innovation policy of a country represents one part of economic policy through which the overall direction of the country can be influenced. The main thesis is that innovation generally promotes economic growth, and there is empirical evidence where even the phase of the business cycle influences the overall rate of innovation in a country. There are many explanations for these facts in the economic literature, which focus not only on the innovation policy of the state but also on the innovation policy of private agents. Our main research question is whether there is a correlation relationship between economic growth and innovations in the Slovak Republic during the period of 1995 - 2022.

Currently, two basic approaches on the relationship between innovation and the business cycle exist. The first approach assumes that innovation leads to supply shocks that increase economic growth and

subsequently result in an economic crisis. This assumption is based on Schumpeter's (1927) notion of business cycles where positive externalities related to innovation play a significant role and where pre-existing innovations condition the emergence of new innovations that result in economic growth. As increasing R&D spending will cause a reduction in corporate profits in several sectors, there will be a decline in economic activity resulting in a recession. Consequently, the economy will restructure, inefficient investments will disappear, and only efficient innovations will come to the fore, stimulating economic growth. Bazhal (2013) pointed out that this concept was developed by M. I. Tugan-Baranovsky in 1894, which was subsequently followed up by Schumpeter. Solow (1956) also contributed to this issue by highlighting the importance of R&D as a major factor promoting technological change, innovation, and economic growth, and gave a major impetus to theoretical and empirical research on the economic impacts of R&D investments.

Another explanation for the impact of innovation on economic growth is offered by the real business-cycle theory, which posits that changes in demand and supply are induced by technology shocks. At the same time, this theory elaborates on the concept of when an employee prioritizes work and leisure and vice-versa. During economic expansions when wages are rising, workers prefer work and during recessions when wages are falling, they prefer more leisure. These facts in turn affect product innovation in firms (Kydland, Prescott, 1982; Plosser, 1989).

The neoclassical model emphasises the fact that the economic cycle of individual countries is influenced by global variables and there is a so-called World Business Cycle. This model also focuses on knowledge spillovers between firms and thus increases the likelihood of developing innovations that will in turn lead to economic growth (Minárik, Vokoun, Stellner, 2018).

The second approach, however, focuses on the inverse relationship, namely that innovation is influenced by the phase of the business cycle and economic growth. An explanation is offered by linking innovation together with the level of demand during the different phases of the business cycle. During a recession, it is easier for firms to innovate because overall demand for output falls and innovation expenditure is cheaper on an opportunity cost basis. Conversely, during an expansion, firms struggle to meet increased aggregate demand and prefer to redirect expenditure towards increasing their production capacity. If a firm were to try to increase R&D expenditure, it would be depriving itself of potential profits. At the same time, the costs associated with operations are reduced, leaving the firm with more financial resources to innovate (Penrose, 2009). Thus, innovation could become a counter-cyclical tool.

At the same time, there are several theories that, on the contrary, confirm the pro-cyclical character of innovation. During expansion, a firm has a greater incentive to innovate because it makes more profit and because the population is more willing to pay for it. Rafferty (2003) explained that procyclicality of innovation in terms of small firms and their cash flow. In most cases, small firms do not have spare cash that they can divert into R&D expenditures. The only case may be the expansion phase, when even small firms make above average profits and can afford to increase R&D expenditures. Shleifer (1986) came up with a model that explained the impact of the business cycle on innovation through firms' expectations. If the firm expected the crisis to continue, it cut back on R&D expenditures because of the persistent uncertainty about the future. Conversely, if a firm had an optimistic view of the future, it was more willing to allocate more resources to innovation. Barlevy (2014) also argues that entrepreneurs increase R&D expenditures during expansions, which he also considers short-sighted and should be increased during recessions. He points out that recessions play an important role in promoting economic growth, but R&D is primarily pro-cyclical.

Empirical studies dealing with the relationship between economic growth and innovation can be divided into several groups based on the type of models and data they use. As demonstrated in OECD (2015), most of the econometric evidence points to positive and substantial effects of R&D on productivity and economic growth at all levels (firms, sectors and countries).

The first group is concerned with confirming the relationship between innovation and economic growth based on cross-sectional data. Das (2019) addressed the idea of how innovation changes the limits to economic growth. He showed that the effect of the size of the economy on economic growth and the effect of economic growth on GDP across the world is convex at some point. Economic growth increases

with GDP and declines after it reaches a peak, which he justified by the existence of certain outliers. These outliers could be augmented by technological innovation some countries could move into an area of innovative growth with higher outliers. Razzak (2022) demonstrated through macroeconomic pooled time series-cross sectional data for the G7 countries from 2000 to 2017, research effort has a positive effect on total factor product growth.

In the case of time series data analysis, several methods such as Granger causality test or vector error correction model (VECM) are used. Maradana, Pradhan, and Dash (2017) examined the relationship between innovation and per capita economic growth in 19 European countries during the period 1989-2014. They used patent-residents, patent-nonresidents, research and development expenditure, researchers in research and development activities, high-technology exports, and scientific and technical journal articles as proxies for innovation. Based on the empirical results, they showed that the causal relationship between innovation and per capita economic growth is present in each country but varies in its intensity based on the indicator used. Geroski, Walters (1995) also confirmed that economic activity do Granger cause changes in innovative activity in the UK during the period 1948-1983, but the fact that innovation can affect economic activity has not been confirmed. They also demonstrated that innovation shows a tendency to cluster in economic booms and also the long-run relationship between innovation and economic activity

Nazir, Tan, and Nazir (2020) examined the causal relationship between financial innovation and economic growth in China, India, and Pakistan over the period of 1970-2016. Using Autoregressive Distributed Lag (ARDL) bound testing and Granger causality-based Error Correction Model (ECM), they showed that financial innovation has a positive and statistically significant fit to economic growth in both the short and long run.

Using single multiple regression, Pece, Simona, and Salisteanu (2015) demonstrated a positive relationship between economic growth and innovation (quantified by multiple indicators) in CEE countries (Poland, Czech Republic and Hungary) over the period 2000-2013.

The third group of empirical studies focuses on examining the relationship between innovation and economic growth using panel data with the help of several econometric methods and models. Ouyang (2009) demonstrated on a panel of 20 U.S. manufacturing industries from 1958 to 1998 that R&D have a procyclical character. He also pointed out liquidity constraint is a driving force of procyclicality of R&D. Nguyen (2018) also used panel data-based models (Ordinary Least Squares, Pooled Model (OLS), OLS with Dummy Variable, Fixed Effects within group (Demeaned), and Random Effects. The representative sample of countries consisted of 195 states during the period 2007-2016. Based on the results of regression analysis, it demonstrated a positive relationship between economic growth (GDP per capita) and Innovation (Patent Applications of Residents), and Technology (Fixed Broadband Subscriptions).

Sarangim Pradhan, Nath, Maradana, Roy (2022) via autoregressive distributive lag framework confirmed, that grid of short-run and long-run causal relationships between innovation and growth, including long-run unidirectional causality from innovation to economic growth in G20 countries over the period 1961-2019. Ahmad (2021) examines the non-linear and asymmetries of innovation activities in thirty-six OECD countries for the period 1981Q1-2019Q4. Among his findings we can include a) R&D expenditures moves procyclically in response to the gross domestic product (GDP), exports, imports, and gross fixed capital formation in both the boom and recession periods; b) patents (residential and non-residential) move pro-cyclically in response to GDP, exports, imports, labour force, R&D expenditures, and gross fixed capital formation shocks in the boom and recession periods; c) R&D expenditures, GDP, exports, labour force, imports, and gross fixed capital formation shocks significantly affected patents (residential and non-residential) during the boom and recession periods across the sampled OECD states; d) the international collaboration in technology development moves procyclically in response to GDP, R&D expenditures, exports, imports, labour force, and gross fixed capital formation shocks in the boom and recession periods.

Other methods were used by Ulku (2004) in verifying the relationship in question. Using OLS, fixed effects model and General Methods of Moments (GMM), he demonstrated a positive relationship

between GDP per capita and innovation on a sample of 20 OECD and 10 Non-OECD countries (1981-1987). On the other hand, innovation was shown not to lead to long-run GDP growth.

II. MATERIALS AND METHOD

We examined the correlation relationship between innovations (measured as R&D expenditures of government as a %-share of GDP), and economic growth (per capita) (expressed as annual % change in real GDP) in Slovak Republic during the period of 1995 - 2022. Our assumption in this case is that there should be positive relationship, so when government R&D expenditures of government increase, the economic growth increase as well.

The following table lists the variables used, along with their definition and source / database, from which the data were extracted.

Table 1. List of variables

Variable	Abbreviation	Expression	source/database
Economic growth	GDPgrowth	GDP growth (annual %)	a)
Economic growth per capita	GDPgrowthPC	GDP per capita growth (annual %)	a)
Gross domestic expenditure on Research and Development (Government sector)	GERD_G	Gross domestic expenditure on Research and Development (% of GDP)	b)

Source: a) World Bank national accounts data, and OECD National Accounts data files.; b) Eurostat; Organisation for Economic Cooperation and Development (OECD)

We present basic and summary statistics for all variables in the following table.

Table 2. Summary statistics

Metrics/Variable	GDP growth	GDP p. c. growth	GERD_G
Mean	0,035282935	0,034665679	0,001910714
Standard Error	0,006448126	0,006451166	0,000109029
Median	0,035240975	0,035468355	0,00175
Mode			0,0018
Standard Deviation	0,034120274	0,034136363	0,000576926
Sample Variance	0,001164193	0,001165291	0,00000033
Kurtosis	1,58683559	1,673267075	3,987822375
Skewness	-0,679103871	-0,696563271	2,210069256
Range	0,162875627	0,163811319	0,0021
Minimum	-0,054555337	-0,055814372	0,0015
Maximum	0,10832029	0,107996947	0,0036
Sum	1,1267	0,970639005	0,0535

Source: own calculations

To test the relationship in question between economic growth and government expenditure on R&D, we used several metrics such as covariance and correlation. Covariance measures whether variables evolve in a common direction or inversely proportional. In other words, covariance expresses the linear relationship of two variables and whether as one variable increases, the values of the other variable also increase and vice versa. The basic formula for calculating covariance can be written as follows:

$$Cov\ (x,y) = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{n} \quad (1)$$

, where x represents the values of the x-variable and y represents the values of the y-variable, where $\bar{x}$ and $\bar{y}$ represent the mean values of these variables, n represents the number of observations.

From the covariance value, we can determine the direction of the linear relationship, but we cannot determine the strength of the linear relationship, so in the next step, we also calculate the Pearson correlation coefficient (. The equation for calculating the correlation coefficient can be written as

$$r = \frac{\sum x_i y_i - n \times \bar{x}\bar{y}}{\sqrt{(\sum x_i^2 - n \times \bar{x}^2)(\sum y_i^2 - n \times \bar{y}^2)}} \quad (2)$$

, where r can take values ranging from 1 (full direct dependence) to -1 (full indirect dependence). If r is equal to 0, there is no dependence between the variables. To capture not only the short-run relationship but also the long-run effect of government R&D expenditure, we incorporate time lags of economic growth (lag+1, lag+2, lag +3).

III. RESULTS

As mentioned in the Materials and Method section, for our purpose we use covariance and correlation analysis, the results of which we present in the following table.

Table 3. Correlation matrix

Covariance	**GDP growth**	**GDP per capita growth**
GERD_G_%	0,0000033836	0,0000030066
Covariance	**GDP growth (lag+1)**	**GDP per capita growth (lag+1)**
GERD_G_%	-0,0000007001	-0,0000009772
Covariance	**GDP growth (lag+2)**	**GDP per capita growth (lag+2)**
GERD_G_%	-0,0000024498	-0,0000025691
Covariance	**GDP growth (lag+3)**	**GDP per capita growth (lag+3)**
GERD_G_%	-0,0000028240	-0,0000029547
Correlation	**GDP growth (annual %)**	**GDP per capita growth**
GERD_G_%	0,178254358	0,158320517
Correlation	**GDP growth (lag+1)**	**GDP per capita growth (lag+1)**
GERD_G_%	-0,043641317	-0,060803139
Correlation	**GDP growth (lag+2)**	**GDP per capita growth (lag+2)**
GERD_G_%	-0,202135593	-0,211497523
Correlation	**GDP growth (lag+3)**	**GDP per capita growth (lag+3)**
GERD_G_%	-0,253047768	-0,263988926

Source: own calculations

As we can see from Table 2, so the correlation between these two variables is moderate but positive, both when GDP growth (annual % change) and GDP growth per capita (annual % change) are considered. This fact already creates the assumption that government-supported innovation promotes economic growth or, on the contrary, economic growth promotes government innovation in the short run. However, the situation may change if time lags of economic growth are incorporated, so that in the long run we can observe opposite correlation effect, which gain higher power.

IV. CONCLUSION

The present article deals with the relationship between innovation and economic growth in the Slovak republic during the period 1995-2022. We have shown that in the short run, there is a positive relationship between innovation and economic growth, but its impact fades over time. On the other hand, between

economic growth and government R&D spending prevails negative correlation relationship in the long run. Based on these findings, it is possible to be inclined towards Schumpeter's explanations of the emergence of business cycles. An important finding is that government innovation policy can mitigates cyclical fluctuations in the economy and can act as a stabilizer in the economy in the long run, opening further doors in the design of the focus of economic policy.

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