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GOVERNMENT SUPPORT OF SCIENCE AND THE IMPACT OF THE CRISIS: THE CASE OF THE EU COUNTRIES

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Abstract

The paper investigates government R&D spending during the business cycle. When analyzing this expenditure, it is important to mention two opposing aspects: on the one hand, government spending on R&D can be seen as a stimulus measure for the government to mitigate the effects of the recession on the economy, – governments can decide to increase public spending on R&D. However, on the other hand, the recession reduces public budget revenues and prompts governments to reduce public spending, which very often negatively affects R&D spending. Using panel data from 22 European Union countries for the period 2005 to 2019, we examine how government R&D expenditure varies over the business cycle. Four estimates were performed in which explanatory variables were gradually added to the model (OLS approach). The GMM approach includes all the variables at once. The coefficient for government R&D expenditure is positive, high, and remains stable. This implies that expenditure changes only gradually. The estimates give us evidence regarding the pro-cyclical effect on government R&D expenditure and the Keynesian approach to economic policy.

Keywords: government R&D expenditure, business cycle, recession, EU, panel data.

JEL Classification: H54, H61

Introduction

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Science represents an important part of human activities that contribute to the development of society. Research and development (R&D) as its essential part can be perceived as fundamental, applied, or experimental. According to Sheehan and Wyckoff (2003), R&D produces technology as a form of knowledge that is used to enhance the productivity of the factors of production. Based on this context, R&D is one of the most important drivers for achieving economic growth, and ultimately it leads to an increase in the living standards. In other words, it means that allocating resources to R&D will increase productivity and wages in the future. Wang (2010) mentioned that countries with a satisfactory level of R&D investment can achieve the main objective of economic policy - economic growth based on promoting productivity and expanding their knowledge base. According to Marino et al. (2016) economic theory and empirical findings support a positive relationship between R&D investment and economic growth.

Moreover, it is a key financial source for innovation, and it can be public or private in nature. If we look at R&D expenditure by source of funds, Eurostat statistics shows that more than half (59 %) of the total expenditure within the EU in 2019 was funded by business enterprises, while almost one third (29.3 %) was funded by government, and a further 9.4 % from the rest of the world (foreign funds). Funding by the higher education and private non-profit sectors in 2019 was relatively small, 1.2 % and 1.1 % of the total, respectively.

R&D amount varies over time depending on the business cycle or other factors. As a general rule, during the recession, these expenses are reduced as a result of a decrease in economic activity. In general, tax revenues usually fall during an economic slump, and the need to consolidate public budgets increases. However, their level is not only affected by the economic recession, but also by other factors like institutional environment of the country or other non-political and non-economic shocks like the COVID-19 pandemic, which represents a major challenge for global science and innovation activities. Assuming that R&D is the key driving force of economic growth, the question is which opposing goal of economic policy to choose in times of the recession: (i) whether to increase public R&D spending, or (ii) whether to consolidate public budget. If there is an economic downturn, governments pragmatically focus their support on those areas of economic policy that threaten negative social impacts or high unemployment.

According to Pellens et al. (2018) precipitous cuts in R&D activities in response to a crisis can also hamper knowledge flows and reduce the positive spin-offs of R&D. These short-term changes may ultimately reduce the long-term positive effects on productivity growth. Therefore, maintaining R&D investments at a high level should be one of the priorities of economic policy, even in a situation where the economy is in the recession. Governments may use several measures to reduce the negative effects of the recession on R&D. According to Sylwester (2001), governments should not hesitate to actively support and fund R&D activities, especially if R&D in the private sector is lacking. One option is to maintain the level of spending by private enterprises by providing additional subsidies or using other forms of direct or indirect R&D support (e.g., tax incentives). Another measure to keep R&D spending at an appropriate level is to expand the research activities of the public sector, especially universities, which would compensate for the reduction in R&D spending in the private sector.

One of the indisputable indicators of R&D support in the country is the gross domestic expenditure on R&D (GERD) as a percentage of GDP. OECD defines GERD as the total intramural expenditure on research and development performed on the national territory during a given period. This includes both current costs and capital expenditure. It contains

R&D performed within a country and funded from abroad, but excludes payments for R&D performed abroad. In the context of the business cycle, a very important part of this indicator is government R&D spending (GovERD) as a percentage of total expenditure. The research in this paper covered 22 EU countries, observed in the timeframe 2005-2019. Using the panel regression method, except for the GovERD indicator, the following have been used as explanatory variables: gross domestic product in EUR and chain linked volumes based 2015 (natural log), surplus (deficit) of general government (GDP ratio), debt of general government (GDP ratio), and the recession as so-called dummy variable.

The main aim of the paper is to find out how the business cycle and the recession influence government R&D expenditure among the selected European Union countries. The paper is structured as follows: (i) in the first part, the paper deals with theoretical-methodological background; (ii) the second part refers to the employed data and methods; (iii) the third part is focused on empirical results; and the last part concludes.

1. Review of literature

This part of the paper deals with main approaches in this field of research and previous findings. For this purpose, this chapter is divided into two parts: (i) government R&D expenditure and (ii) the business cycle and R&D expenditure.

1.1. Government R&D expenditure

In the existence of market competition, enterprises need the ability of dynamic technological innovation to help them adapt to changes in the environment and create a permanent innovation advantage. R&D activities usually require a large amount of funds and time, which ultimately means that the process of investing in R&D involves a certain degree of risk. Hall et al. (2016) stated that R&D investment differs from other types of corporate investment for some other reasons, including uncertainty, opportunistic behavior, moral hazard, and adverse selection. In this sense, the R&D investment is not without risk, and the return is perceived in the long-term. Moreover, due to spillovers and other externalities, the private rate of return to R&D investment is lower than the social rate of return. The existing literature has found a positive relationship between R&D and firm performance (Eberhart et al., 2004; Yeh et al., 2010). However, Alam et al. (2019) found that this relationship may be strengthened or weakened by country-level factors like government effectiveness, regulatory quality, rule of law, the presence of corruption, or political instability.

As mentioned above, R&D investment requires a lot of long-term funds, which enterprises generate mainly from internal sources or external financing. Wang et al. (2016) argue that it is very often difficult to satisfy the financial needs of R&D activities with internal financing, and enterprises often need to use external financing to supplement funds for these activities. Yet, market failures generally cause enterprises to underinvest in research. According to Hud and Hussinger (2015), uncertainty increases considerably during recessions, which affects the decision-making of enterprises – they are relatively cautious regarding further R&D investment. Other significant determinants are asymmetric information and imperfect competition. All of these factors lead to fluctuations in R&D spending. As the market is not able to provide optimal conditions for private investment in R&D, government support in various forms is essential. Becker (2014) argues that private R&D expenditure has positive externalities and may therefore be lower than a socially optimal level. This implies the need

to subsidize the activity that creates a positive externality. Sheehan and Wyckoff (2003) identified four main objectives of public support for business R&D: (i) quantitative and qualitative effects on firms' R&D activities: stimulus effect; (ii) impact on the economic performance(s) of firms: productivity effect; (iii) impact on the economic performance(s) of industries: spillover effect; (iv) impact on the economy as a whole: global effect.

We can find these basic ways of R&D support financed from public budgets: (i) direct support, which consists of public (government or university) research and government funding of R&D carried out by firms, and (ii) fiscal incentives (e.g., tax credits). While direct support allows governments to target funding to specific research projects that can be expected to have a significant social return, tax incentives provide the means to partially finance R&D carried out in all relevant organisations. Unlike tax credits, which are provided ex post, direct subsidies are usually provided ex ante or during the implementation of private R&D investment. Both forms of support have their advantages and disadvantages: (i) while tax credits are available to all eligible firms, subsidies are targeted at specific projects with a high social return and their selection for financing depends mainly on available information and the discretion of the public institution that the subsidy provides; (ii) while tax credits are relatively immune to political inefficiency because they are based on firms' optimization decisions, the provision of subsidies is conditioned by the existence of a selection process, which is often bureaucratically demanding, and is also more prone to policy inefficiency due to information asymmetry between recipient firms and program beneficiaries managers and – according to public choice theory – the potentially selfish goals of program managers (Dimos et al., 2022). Based on panel data in the period 1995 – 2016, Szarowska (2018) observed a trend of combining direct public and indirect public funding instruments.

Figure no. 1 shows channels between government R&D spending and technological innovation. Tang et al. (2022) identified three effects within this framework: (i) effect of the channel of government subsidies on monetary capital; (ii) effect of the channel of government subsidies on human capital; and (iii) effect of the channel of government subsidies on management institution.

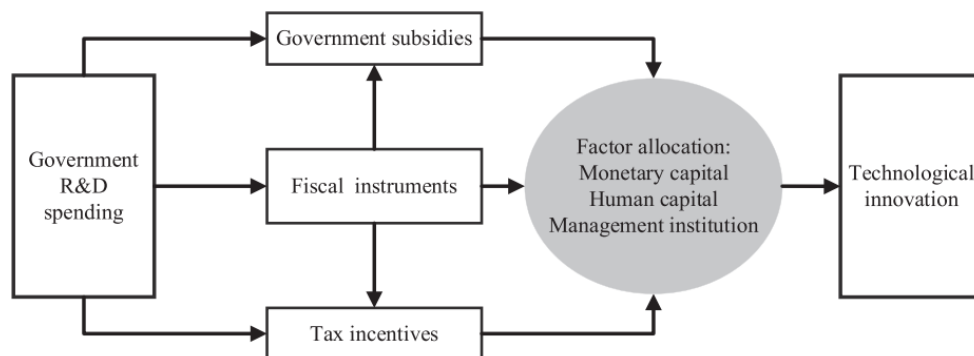


Figure no. 1. Channels between government R&D spending and technological innovation
Source: Tang et al. (2022)

As mentioned above, the deficit of economic resources or financial resources and credit constraints are important factors that disrupt the adoption of innovation in periods of the recession. According to Ahmad and Zheng (2022), it is the responsibility of the government and financial institutions to ensure enterprises' access to finance for innovative measures in

times of the recession. In addition to the already mentioned government financial support, the central bank, as part of its monetary policy, can, for example, encourage commercial banks to introduce lower interest rates for innovative businesses and try to give them access to finance in periods of the recession.

The literature has for long also focused on whether public support is characterized by either (i) crowding-in effect in a sense of additional investment by recipient enterprises compared to those who do not receive public support – or (ii) crowding-out effect in a sense of recipient firms substitute their own resources with external funding (Bianchini et al., 2019). Guellec and Van Pottelsberghe (2000) mentioned a leverage effect by government funding on business funding – government financial support and the knowledge gained from these sources can improve the private return on investment in R&D, prompting higher R&D spending in the economy.

Guellec and Van Pottelsberghe (2000) found that both major government policy instruments, i.e. fiscal incentives and direct funding, stimulate business-funded R&D. On the contrary, research carried out by the government and universities tends to have a crowding-out effect.

1.2. Business cycle and R&D expenditure

Schumpeter has already described the recession as one of the fundamental phases of the business cycle. Basically, it is a process of adaptation and re-tuning towards innovative goods and production technologies. While in times of economic boom most products are easy to sell and most enterprises achieve prosperity, on the contrary, in the recession, the competitive environment changes radically, creating large differences between companies. Spescha and Woerter (2016) argue that those firms that have timely introduced a new consumer product, a new production technology, or a new form of organization will be better prepared to face the consequences of the recession. The authors also claim that the positive sales growth achieved by premium innovators is mainly rooted in downturns in the macroeconomic business cycle.

We can find many studies investigating the impact of business cycles on R&D investment and vice versa, both theoretically and empirically. Previous studies focused mainly on the influence of individual phases of the business cycle on R&D investment. To explain R&D investment behavior, two opposing forces must be considered: (i) demand aspects and (ii) opportunity costs (Arvanitis and Woerter, 2014). According to these authors, R&D investment can behave in three basic ways: (i) counter-cyclical; (ii) pro-cyclical and (iii) non-systematic with respect to the fluctuation of overall economic activity as measured by a standard composite indicator of the business conditions at industry level. Counter-cyclical character of R&D investment is associated with the fact that the cost of labour and other inputs related to science and research will be high in a boom phase and low in the recession. Therefore, the opportunity costs will be lower in recession phases, and if companies transfer resources to science and research, they could benefit from this situation in the future - after the recession fades away and demand increases, companies could offer new products resulting from investment in R&D.

On the other hand, we can find some studies which argue that there is stronger evidence for procyclical rather than countercyclical behavior of R&D expenditure. The pro-cyclical behavior of R&D spending has been estimated by many studies, including Wälde and Woitek

(2004). They used annual data for the period from 1973 to 2000 and argued that aggregate R&D expenditure in G7 countries tends to be procyclical.

According to Sedgley et al. (2018), pro-cyclical character of R&D means that the incentives to pursue R&D and adopt new innovations stimulate economic growth. Furthermore, Ahmad and Zheng (2022) suggest the nexus between R&D spending, patents, and economic growth in OECD countries is pro-cyclical.

In addition, Hud and Hussinger (2015) using German data over the period 2006 -2010 show that there is evidence of a crowding-out effect during the crisis year 2009. A year later, when the economy began to recover, the effect was smaller than in the pre-crisis years, but still positive and significant. Using a panel dataset of Spanish manufacturing firms for the period 1990–2006, Beneito et al. (2015) argue that firms' R&D spending is countercyclical when firms do not face credit constraints. In addition, their findings also suggest an asymmetric response of R&D to the business cycle. Fabrizio and Tsoolmon (2014) show that R&D spending was more procyclical in industries characterized by faster rates of obsolescence, but not in industries with weaker patent protection.

Yalamov (2021) found that enterprises' behavior as a reaction to exogenous crises such as the global financial crisis (2007-2008), the sovereign debt crisis (2009-2010) and the most recent covid-19 crisis (2020-2021) is dependent on country and institutional specific factors. In addition, using binary logistic regression on a sample of 247 Norwegian manufacturers, Lome et al. (2016) discovered that firms that allocated significant resources to R&D activities performed significantly better than other firms during the financial crisis of the late 2000s.

Izsak et al. (2013) found that the crisis did not cause changes in the priorities of R&D policy. However, in association with lower revenues for public budgets, the crisis negatively affected financing, especially institutional financing. In addition to short-term effects, this can also have long-term effects in the form of brain drain. Ahmad and Zheng (2022) deduced that during the boom phase, a positive shock to R&D and residential patents leads to higher economic growth.

2. Data and research methodology

2.1. Data and variables

To fulfil the aim of the paper we employed data on R&D spending (years 2005 till 2019), especially government R&D spending, which are available on Eurostat's publicly accessible website. We can distinguish two types of these indicators: (i) R&D expenditure by sectors of performance, (ii) R&D expenditure by source of funds. The first indicator includes all expenditure for R&D performed by four institutional sectors of performance (business enterprise, government, higher education, and private non-profit institutions) regardless of the source of funds. On the contrary, the second one matters the source of funds (business enterprise, government, higher education, private non-profit institutions or financed from abroad) regardless of the sector of performance.

The key indicator for our purposes is government R&D expenditure. Annual R&D expenditure financed by the government regardless of the sector of performance is employed.

As mentioned in the previous part, the government's ability to finance R&D expenditure is influenced by budgetary development. There, we can distinguish short-run and long-run perspective. In the short-run, government R&D expenditure depends likely on the public budget surplus or deficit. A raising deficit means that overall government spending has raised too, and vice versa. However, high deficits constrain further R&D expenditure. According to Pellens et al. (2018), from a long-run perspective, an increasing debt tends to spending restrictions due to additional deficits and interest payments. Therefore, public budget surplus/deficit and public debt are included in the model (both lagged of one period). All three mentioned explanatory variables are expressed as GDP ratio.

As the main aim of the paper is to find out how the business cycle and the recession influence government R&D expenditure, we must consider two opposing effects. Government R&D expenditure is not the only government spending; it includes e.g., unemployment benefits, which increase during an economic recession; therefore, there is diminishing pressure on government R&D expenditure. On the other hand, government should raise R&D expenditure during recession to stimulate private investment (as a Keynesian-style stabilizing factor). Gross domestic product (GDP) in EUR and chain-linked volumes (based 2015) in natural logs and lagged of one period is employed as a proxy variable of a business cycle.

In general, recession is a period of reduced economic activity. In addition, so-called technical recession is considered a quarter-on-quarter decrease in seasonally adjusted real quarterly GDP at least in two successive quarters. Recession is expressed as a year with negative growth rate of annual GDP (due to annual data). Recession is the so-called dummy variable, which equals 1 if recession, or 0 if not.

Data employed in this paper were collected from the Eurostat database for the European Union 27 countries (without United Kingdom) from 2005 to 2019. Denmark, Greece, Luxembourg, the Netherlands, and Sweden were dropped due to lack of data in some years in the model.

2.2. Model

To examine the abovementioned relationship, panel data analysis was performed. Panel data cover both, time series and cross-sectional dimension. In general, a simple linear panel data model can be written as follows (1):

$$Y_{it} = \alpha + \beta X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where:

- Y – dependent variable;
- X – vector of explanatory variables;
- α, β – coefficients;
- i – cross-sectional unit (country);
- t – time dimension;
- μ_i or γ_t – unobserved country specific or time specific effect;
- ε_{it} – error term.

Thus, above mentioned goals can be expressed as follows (2):

$$GovERD_{it} = \alpha + \beta_1 GovERD_{it-1} + \beta_2 GDP_{it-1} + \beta_3 SURPLUS_{it-1} + \beta_4 DEBT_{it-1} + \beta_5 REC_{it-1} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

where:

- GovERD – annual R&D expenditure financed by the government (GDP ratio);
- GDP – gross domestic product in EUR and chain linked volumes based 2015 (natural log);
- SURPLUS – surplus (deficit) of general government (GDP ratio);
- DEBT – debt of general government (GDP ratio);
- REC – recession.

3. Results and discussion

Figure no. 2 shows R&D expenditure by source of funds over time. The left graph represents the year 2005 and the right one the year 2019. For both reference years, a similar distribution of resources is evident in the case of the EU-27 – more than half of the total expenditure within the EU-27 was funded by business enterprises (56.3 % in the year 2005, respectively 59.0 % in 2019). General government sector was the second most important source of R&D spending – this share has slightly decreased over the years from 34.8 % to 29.4 %. However, significant differences between individual countries were found. The largest decrease in the share of government expenditure was indicated in the case of Bulgaria (40.3 percentage points), Cyprus (31.6 percentage points), and Lithuania (30.4 percentage points). On the contrary, in the case of Finland, a slight increase in the share of 2.1 percentage points and in the case of Malta by 5.3 percentage points were detected.

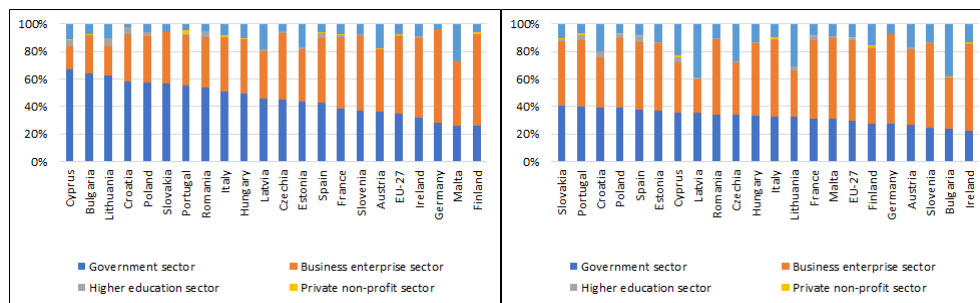


Figure no. 2. R&D expenditure by source of funds (as % of total expenditure, year 2005 left side, year 2019 right side)

Source: Eurostat database, Research and Development, own calculations

Figure no. 3 shows government R&D expenditure as % of GDP over time for the EU-27. It can be seen from the figure that government R&D expenditure varies over time between 0.61 and 0.69 % of GDP. This share reaches higher values during and after the crisis period and is similar to other developed economies such as the USA or Japan.

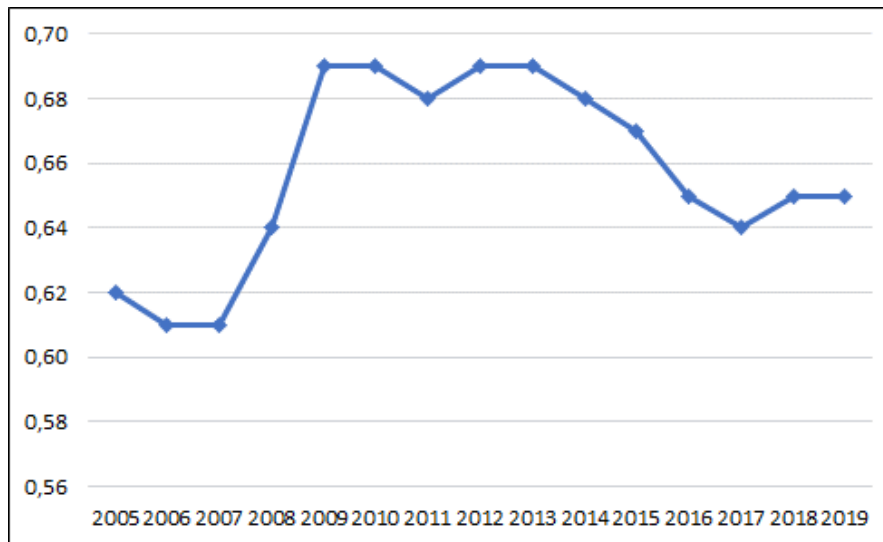


Figure no. 3. Government R&D expenditure (as % of GDP, EU-27)

Source: Eurostat database, Research and Development, own calculations

In order to find out how the business cycle and the recession influence government R&D expenditure, the above-mentioned model is used. Table no. 1 summarizes the results. The explanatory variables were employed stepwise, pooled ordinary least squares (pooled OLS), and panel generalized method of moments (GMM method) were performed. The effects become stronger and significant when unobserved country heterogeneity is incorporated into the model.

Table no. 1. Impact of Factors on Government R&D Expenditure

| Factor | (1) Pooled OLS | (2) Pooled OLS | (3) Pooled OLS | (4) Panel GMM |
|------------------------|-------------------|-------------------|-------------------|------------------|
| Constant | -0.0199 | -0.0275 | -0.02817 | - |
| GovERD _{t-1} | 0.9661*** | 0.9650*** | 0.96457*** | 0.7687*** |
| ln GDP _{t-1} | 0.0039** | 0.0052** | 0.00525** | 0.0698*** |
| SURPLUS _{t-1} | 0.0030*** | 0.0027*** | 0.00281*** | 0.0013*** |
| DEBT _{t-1} | - | -0.0001 | -0.00009 | -0.0008*** |
| REC _{t-1} | - | - | 0.00196 | 0.0196*** |
| R ² | 0.958 | 0.958 | 0.958 | - |
| J (p-value) | - | - | - | 0.461 |
| AR1 (p-value) | - | - | - | 0.081 |
| AR2 (p-value) | - | - | - | 0.371 |
| Number of observations | 300 | 300 | 300 | 278 |
| Number of countries | 22 | 22 | 22 | 22 |

Source: Eurostat database, Research and Development, own calculations.

Note: *** significant at 1% level ** significant at 5% level, * significant at 10% level.

Our first estimation output includes lagged GovERD and lagged GDP in natural logs and lagged SURPLUS. DEBT or REC are gradually added to the model. The GMM approach incorporates all the variables at once.

The coefficient for lagged GovERD is positive and almost always above 0.9. This implies that government R&D expenditure changes only gradually. The GDP coefficient varies between 0.004 and 0.005 based on OLS estimates. This implies that an increase in GDP by 1 % tends to increase in GovERD in next period between 0.004 % and 0.005 % on average (OLS approaches) or 0.07 % on average (GMM approach). Overall, these estimations tend us to confirm a quite strong effect of the business cycle on government R&D expenditure.

Lagged SURPLUS gives us information about government's short-run financial capacity. Our estimated coefficients are positive and show us the effect of surplus/deficit on government R&D expenditure. This implies that an increase in the surplus to GDP ratio by 1 percentage point or reduction in the deficit to GDP ratio leads to an increase in GovERD in next period by around 0.003 percentage points on average (pooled OLS approach).

Lagged DEBT considers long-run financing conditions. The estimated coefficient is not statistically significant by means of the OLS approach. However, negative, significant but low coefficient estimated by GMM approach implies that increasing debt to GDP ratio by 1 percentage point leads to decrease GovERD in next period by 0.0008 percentage point on average.

Estimation no. 5 additionally incorporates the recession indicator. Thus, we can differ recession and non-recession periods. The European Union countries reflected two periods of the economic crisis or the recession. The 2008 financial crisis or the global financial crisis caused economic decline in 2009 and 2012 on average. The next economic decline is caused by the COVID-19 pandemic and the recession began in the European Union countries in 2020. Recession coefficients are not significant for OLS approach. However, the significant and positive coefficient estimated by the GMM approach implies that a Keynesian economic policy approach is applied.

Conclusions

The paper investigates government R&D spending during the business cycle. When analysing this expenditure, it is important to mention two opposing aspects: on the one hand, government spending on R&D can be seen as a stimulus measure for the government to mitigate the effects of the recession on the economy - governments can decide to increase public spending on R&D. However, on the other hand, the recession reduces public budget revenues and prompts governments to reduce public spending, which very often negatively affects R&D spending. Using panel data from 22 European Union countries for the period 2005 to 2019, we examine how government R&D expenditure varies over the business cycle.

The main aim of the paper was to find out how the business cycle and the recession affect government R&D spending. Thus, R&D expenditure financed by government regardless of the sector of performance was employed as dependent variable. Gross domestic product, surplus/deficit, debt, and recession were used as lagged explanatory variables. All variables were expressed as GDP ratio, except GDP and the recession. GDP was expressed in EUR and chain-linked volumes (based 2015) and natural logs, the recession is the so-called dummy variable.

Four estimates were performed where explanatory variables were gradually added to the model (OLS approach). The GMM approach includes all the variables at once.

The coefficient for government R&D expenditure is positive, high, and remains stable. This implies that expenditure changes only gradually. The estimates give us evidence about procyclical effect on government R&D expenditure and the Keynesian approach to economic policy. Increasing surplus or reducing deficit tend to positive effects too, but debt raising means spending restrictions.

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