Streimikiene, Dalia; Kyriakopoulos, Grigorios L.

Article

Comparative Assessment of Research & Development and Quality of Life Indicators in Lithuania and Greece

Amfiteatru Economic Journal

Provided in Cooperation with:
The Bucharest University of Economic Studies

Suggested Citation: Streimikiene, Dalia; Kyriakopoulos, Grigorios L. (2022) : Comparative Assessment of Research & Development and Quality of Life Indicators in Lithuania and Greece, Amfiteatru Economic Journal, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 24, Iss. Special Issue No. 16, pp. 1014-1033, https://doi.org/10.24818/EA/2022/S16/1014

This Version is available at:
https://hdl.handle.net/10419/281686

COMPARATIVE ASSESSMENT OF RESEARCH & DEVELOPMENT AND QUALITY OF LIFE INDICATORS IN LITHUANIA AND GREECE

Dalia Streimikiene[1*] and Grigorios L. Kyriakopoulos[2]
[1)] *Lithuanian Sports University, Kaunas, Lithuania*
[2)] *National Technical University of Athens, Athens, Greece*

Please cite this article as:
Streimikiene, D. and Kyriakopoulos, G.L., 2022. Comparative Assessment of Research & Development and Quality of Life Indicators in Lithuania and Greece. *Amfiteatru Economic*, 24(Special Issue No. 16), pp. 1014-1033.

DOI: 10.24818/EA/2022/S16/1014

Article History
Received: 9 July 2022
Revised: 29 July 2022
Accepted: 5 August 2022

Abstract
In recent years, it has been widely accepted that research and experimental development (R&D) is leading innovations and economic growth, as they are supposed to provide an increase in the well-being of the population. The paper analyses the scientific literature on the linkages between research and development expenditures to advance and promote the quality of life of the population.
The comparative assessment of two countries – Lithuania and Greece – was performed based on the analysis of indicators such as the share of R&D financing intensity; human resources management in a new knowledge orientation; share of high-tech products in total exports, jointly with well-being indicators representing quality of life such as consumption level, productive activity; education and natural and living environment. The comparative assessment approach consists of comparative analysis of trends in R&D and the evolution of the quality of life indicator in two selected countries and comparison with a benchmark – the EU-27 average level, in addition to the identification of similarities and differences and their main reasons. To this end, a survey of experts in the selected countries defined the most relevant indicators for R&D and quality of life and constructed a framework for R&D performance and quality of life. The comparative assessment of Lithuania and Greece showed that Lithuania has a higher R&D financing intensity, but lower R&D resources and higher R&D financing outcomes compared to Greece. However, in both countries, the efficiency of R&D financing in terms of high technology products sharing in total exports is less than half than the EU-27 average. Subsequently, both countries should strengthen R&D financing outputs by implementing additional measures. Quality of life indicators related to R&D performance in Lithuania were higher than in Greece during the entire investigated period (2011-2020), demonstrating the need for greater R&D financing for national growth and the well-being of citizens. Finally, policy recommendations were proposed to increase the efficiency of R&D financing for Greece and Lithuania.

[*] Corresponding author, **Dalia Streimikiene** – e-mail: dalia.streimikiene@lei.lt

Keywords: research and development indicators; quality of life indicators; comparative assessment; case study; Greece; Lithuania

JEL Classification: I00; I20; I30; I39; H50

Introduction

Research and experimental development (R&D) entail systematic and creative actions undertaken in order to increase the stock of cultural and societal knowledge among citizens, to encourage industrial competitiveness, job creation, labour productivity, and new and efficient ways of utilizing resources. Within the last decade, the Europe 2020 strategy established the EU's agenda for growth and jobs, fostering ways to strengthen the EU economy and to achieve smart, sustainable, and inclusive growth for the next decade. Subsequently, R&D and innovation are key policy determinants of the Europe 2020 strategy that is committed to improve "the conditions for innovation, research and development" (Eurostat, 2017), while "increasing combined public and private investment in R&D to 3% of GDP", in the 2020 time frame (Eurostat, 2017).

These investments in R&D are expected to increase the competitiveness of the EU and to ensure steady growth of innovative, high value-added industries, as well as export of knowledge-intensive goods. Innovation is primarily associated with the innovation chain that entails R&D investments among the EU Member States. Education, and certainly tertiary education in the fields of science and technology, plays a decisive role in supporting a knowledge-centred society. Moreover, R&D intensity and innovation refer to a) innovative business front-runners, b) technological output achieved and affiliated with commercialisation and internationalisation, and c) the determination of the economy's capacity in terms of skilled workforce. While there are many scientific papers and empirical studies dealing with R&D and innovation effects on nations' economic growth, the links between R&D and quality of life are rarely addressed. The authors (Frantzen, 2000; Blackburn et al., 2000; Ballot et al., 2001; Lee, 2005; Khan, 2005; Kwack and Lee, 2006; Grossman, 2007) agree that R&D increases productivity while launching new products and services and positively impacts economic growth. R&D subsidies allocated to publicly taught science education can positively impact economic growth and public welfare. However, there is a knowledge gap on the impact of R&D on quality of life (Grossman, 2007).

As quality of life at a national level of analysis is expected to be primarily determined by economic growth, leading to increased productivity and high innovativeness, this paper applies a comparative assessment of two selected EU Member States based on the joint-indicators' framework of R&D and quality of life. The compositional steps of the comparative assessment developed are those of the trends of R&D and quality of life indicators development. In particular, research results were compared and discussed between the developed indicators. These indicators were developed while identifying the similarities and differences reported, also providing a reason for their existence. The positive characteristics of such a comparative assessment approach are its simplicity and its application adaptation to both qualitative analysis and quantitative data in the analysis. Therefore, the strength of this approach is the ease of tracking the results of countries in R&D financing. Performance outcome and a flexible analysis of those main drivers were also determined. Contrarily, the constraint of such a methodology was related to the subjectivity of the applied approach.

1. Literature review

Well-being persuasion is a lifetime goal for humanity. Since the time of the ancient Greeks, humans have wondered about the characteristics of 'good life', including the definition of high quality of life and desirable features of life, which make people feel and think that their lives are desirable. This quality of life attribute is called subjective well-being, which refers to the fact that a person subjectively believes that their life is desirable, pleasant, and good (Diener, 2009). The 'good life' as a subjective goal implies that the most desirable life can be defined by 'positive' characteristics such as virtue. In the same line, other approaches suggest that pleasurable feelings are the essence of the good life. In such empirical studies, the linkages between science and well-being are the following (D'Souza, 2011): a) In-depth analysis on scientific findings and theories related to subjective well-being; b) Basic theories of well-being; c) Focus on culture and well-being, showing the multicultural characteristics of well-being, as well as the universal causality of culture-specific well-being; d) Measuring well-being under a variety of several new and useful measures; e) Approaching different definitions and components of well-being, including investigation of causes, functionality, and relationships of well-being.

Well-being is associated with industry and technology applications, including robots for household and personal care tasks, autonomous manufacturing, and drones. These diverse anthropocentric technologies are also affected by safety, ethical, legal, and societal issues (Ferreira et al., 2019). In this respect persuasive technologies adopt the principles of social psychology – respectively, credibility, trust, reciprocity, authority – to influence people. Therefore, the role of social psychologists is to better understand how attitude and behaviour change comes about, focusing on the effectiveness of human persuaders, and the persuasive power of messages delivered through non-interactive mass-media, such as newspapers or television. Persuasive technologies are evidenced by computer design and are considered the fifth major wave in computing (IJsselsteijn et al., 2006).

In the relevant literature, there are some striking advantages of R&D, including the achievement of high productivity or the installation of new product lines (OECD, 2015). Blackburn et al. (2000) stated that R&D should update existing manufacturing technologies by adopting appropriate innovations. Frantzen (2000) outlined the interplay of R&D and human capital toward high productivity and economic growth in richer countries, compared to the less developed ones. Similarly, Ballot et al. (2001) showed the pronounced role of human and technological capital in determining firm's productivity in Sweden and France, while R&D showed more significant affection in Sweden (return for R&D 38%), compared to France (return for R&D 32%). In another similar study, it was argued that subsidy to innovation can push economic growth (Zeng, 2001). However, no straightforward relationship on the welfare consequences of innovation was found. In the relevant literature, it was stated that economic growth in Australia was associated with local and global R&D (Chou, 2022), while long-term economic growth can be interrelated to globally developed ideas, being also proportional to the global research and to the size of that economy (Jones, 2002). Similarly, it was shown that the Korean economy developed in the long run due to the increase in R&D expenditure for innovation and in technology, and to the improvement of the quality of education (Lee, 2005). In this context, the investment rate, R&D, education, and the size of the government were proven to be the main factors of long-term economic growth of Korea (Kwack and Lee, 2006).

In the Asian context, Jin (2009) analysed the causal relationship between increasing research productivity and economic growth in five Asian countries by using the Granger causality framework. The study revealed a bidirectional interrelation in Hong Kong, which is characterized as a small open economy offering numerous services and opportunities of tertiary education that have direct and immediate effect on services in management and other sectors of the national economy. In the fast-emerging economy of Pakistan, Afza and Nazir (2007) suggested that it was necessary to improve skills, to expand education and training, and to ensure R&D in order to obtain better economic consequences. It is important to increase manpower, exports, reduce poverty, improve macroeconomic indicators, and reduce regional economic disparities. Similarly, Falk (2007) developed a dynamic empirical model to examine the significance of R&D investment in the economic growth of OECD countries in the long-run, using panel data set, offering, this way, new evidence for the R&D-economic growth relationship. In particular, increased R&D investment was positively related to GDP growth (Falk, 2007). Khan and Khattak (2013) also suggested the development of R&D in Pakistan for sustained economic growth. Kuo and Yang (2008) also examined the knowledge capital effects and technology spillover on Chinese regional economic growth, showing that R&D, capital, and technology import are primary contributors of economic growth in China (Sterlacchini, 2008).

Public and household expenditures on education and R&D investment have been shown to be the major contributors to innovation and improved quality of labour (Ornaghi, 2006). The same author analysed the role of knowledge spillovers in the productivity and demand of firms, showing the difference between technology innovation (having a greater effect) and process innovation (having a lower effect). Furthermore, since subsidies to R&D increase income inequality, a model on R&D subsidies was developed and publicly provided science education to economic growth (Grossman, 2007). Education that targets higher skills in science and technology can positively contribute to the economic growth of a country (Grossman, 2007). It was also shown that economic growth has a strong relationship to defence R&D instead of non-federal R&D (Goel et al., 2008). The primary goals of science development for well-being need to be valued to make possible the development of policies and measures that actually improve the quality of life. Subsequently, the multifaceted dimensions covered by treating science as a means of well-being are influencing policies and measures targeting life advancements, including financing of R&D activities (Yonk and Smith, 2018).

2. Indicators of R&D and quality of life

Among highly industrialized countries, there are indicators quantifying and validating technological activities and advancements. Subsequently, while comparing education, patents, and R&D as technology indicators, significant conclusions can be drawn regarding the following: a) the distribution of innovative activity between large and small firms and b) the technological competence of a set of firms. R&D data, occasionally, overstate the concentration of technological activities in larger firms, while understate the total technological activities between small manufacturing firms and service sector firms. Moreover, it is noteworthy to point out that data on education can better capture the character and the technological competence of firms, than patents. Furthermore, data on education can also capture both the fullness of the breadth of the technology base and the technological efforts of firms (Jacobsson et al., 1996).

In another follow-up and indicator-based analysis, the nature, history, and status of 160 of the world's economically advanced and developing countries were included in the worldwide development trends among especially vulnerable population groups, such as children and youth, the elderly, women, persons with disabilities, sexual minorities, and economic migrants. The specific R&D social indicators were classified into four analysis units: individuals, nations, world regions, and world as a whole (Estes, 2019).

In the context of social indicators research (dating back to 1980s'), the relationship of military activities with the larger society was examined. Military activities were divided into seven categories, respectively: 1) economy and labour force, 2) education, 3) crime and deviance, 4) science and technology, 5) health and health care, 6) population and family, and 7) politics and government. The relevant topics discussed were the following: 1) impacts of civilian social changes on the military, 2) patterns of internal military change, and 3) impacts of changes in the military on civilian society. In general, such multisectoral research analyses can classify topics and relevant categories as interrelated (Evans, 1980). The critical point is the better and broad conceptualization of quality of life that encompasses different dimensions that can be measured through a set of subdimensions and associated indicators. Subsequently, a scoreboard of indicators, covering a number of relevant dimensions, it is needed to measure the quality of life for different populations and countries in a comprehensive manner (Evans et al., 1980).

Discussions on how to measurably improve the progress of societies and their well-being and how to sustain quality of life in the future led to several important initiatives, including the reports developed by Stiglitz et al. (2009) and by the European Commission (2009). The objective was to develop specific, clear, and coherent sets of indicators that respond to the challenges described in the reports. Important needs for the European Statistical System were outlined, respectively: to use a multidimensional approach when defining and trying to measure quality of life, to develop indicators for measuring sustainability, and to use complementary indicators to the GDP coming from National Accounts that would better reflect the situation of households. Eurostat structured a list of indicators that was set up with the help of an Expert Group of the dedicated section on 'Quality of Life'. Based on academic research and several initiatives, the following 8+1 dimensions/domains were defined as an overarching framework for the measurement of well-being. These dimensions/domains can be simultaneously considered because of potential trade-offs among them that are relevant to living conditions, productivity, health, education, governance and basic rights, economic security, natural environment, leisure, and social interactions (Eurostat, 2017). Similarly, Numbeo (2020) developed the Quality of Life Index (the higher, the better) as an estimation of overall quality of life by using an empirical formula considering the indexes of: purchasing power (the higher, the better), pollution (the lower, the better), house price to income ratio (the lower, the better), cost of living (the lower, the better), safety (the higher, the better), health care (the higher, the better), traffic commute time (the lower, the better), and climate (the higher, the better). Numbeo archives the values of old data, too, especially for historical-related reasons. All national data are aggregating all entries for all cities, to calculate average country data. Since there are higher numbers of inputs for a country than for a city, aggregate data shown at the country level generally consists of many more data points (Numbeo, 2022).

3. Methodology and data

A comparative evaluation of two selected countries was performed based on the developed R&D and quality of life indicators framework. The trends of indicators from this framework allow for developing comparative assessments of countries in terms of their achievement in promoting R&D and quality of life.

Indicators of policy makers and effective monitoring should disclose specific information on specific problem-solving areas but also provide a general frame of the investigated situation. A well-developed indicator system can support the comparability within complex situations by condensing large amounts of information into low-dimensional aggregates, thus enabling international comparisons to better identify benchmarks, progress achieved, and underlying shifts. Therefore, indicator systems can support policy makers in making the right decisions on the promotion of R&D expenditures and the improvement of quality of life. For the production of relevant literature, it is of high relevance to select indicators that are suitable to address the links between R&D and quality of life, especially among frameworks developed by the European Commission and provided by Eurostat.

Based on these two frameworks, the main indicators for the analysis of the main drivers of quality of life and the evaluation of the effectiveness of R&D in terms of their impact on quality of life were selected by an expert survey conducted in Lithuania and Greece. The new framework was developed. Each country invited its own expert panel to score and weight the relevant significance of indicators, based on available information about trends of quality of life. In this context, the carried out expert-based surveys revealed the opinions of various stakeholders in the fields of R&D and quality of life. Specifically, six expert surveys were conducted in each country from June 15 to June 30, 2022. The research framework consisted of six highest ranked R&D and six quality of life indicators selected to develop a new framework.

In Table no. 1 the framework of R&D and Quality of life indicators is provided, being based on system performance indicators, performance indicators, and impact indicators, developed for health protection system and health status assessment (Patrick and Erickson, 1993). The same approach was applied for the evaluation of the performance of the R&D system and its results. System performance indicators include the financing of R&D and R&D resources indicators. R&D resources are related to R&D financing indicators. Impact indicators represent the effectiveness of R&D financing and resources and reflect the outcomes of supporting R&D in the analysed countries.

Table no. 1. Indicators framework developed to assess R&D system performance and quality of life

Code	Indicator	Units of measurement
R&D financing indicators		
R&D1	Percentage of governmental expenditures on R&D	%
R&D2	The share of R&D expenditures in GDP	%
R&D3	R&D expenditure per capita	EUR2015/inhabitant
R&D resources indicators		
R&D4	The share of employment in knowledge intensive activities in total employment	%

Code	Indicator	Units of measurement
R&D5	The share of researchers in total employment	%
R&D outcome or impact indicators		
R&D6	The share of high technology products in total exports	%
R&D outcome indicators linked to quality of life		
LQ1	GDP per capita	Purchasing power standard (PPS, EU27 from 2020) per capita
LQ2	Tertiary educational attainment	%
LQ3	Unemployment rate of people with tertiary education	%
LQ4	Crime, violence, and vandalism in the area	%
LQ5	Pollution, grime, or other environmental problems	%
LQ6	Quality of Life index	

Source: created by the authors, based on Eurostat, 2022; Numbeo, 2022

R&D financing indicators include 3 indicators showing R&D financing intensity and range.

The percentage of governmental expenditures on R&D shows the importance of R&D for public policies. A high share of R&D expenditures in total government expenditures shows that R&D is at high priority in governmental policies.

The gross domestic expenditure on R&D is the main indicator for the Europe 2020 strategy, also known as the intensity of R&D, showing the proportion of gross domestic product (GDP) dedicated to R&D.

R&D expenditure per capita shows the R&D expenditures per inhabitant in the country. Usually, more developed countries, especially from an economic perspective, with high GDP per capita, also have the highest R&D spendings per inhabitants.

R&D resources indicators include the share of employment in knowledge-intensive activities in total employment and the share of researchers in total employment as R&D financing allows to maintain a certain level of R&D resources.

It is also noteworthy that increased employment in knowledge-intensive activities does not imply that a country is directed toward a more knowledge-based economy. Also, in sectors that are not knowledge-intensive, increased employment would lead to lower values for the analysed indicator, even if this is a joint result of significant investments devoted to innovation.

The share of researchers in total employment shows the percentage of researchers of total employment, in full-time equivalent (FTE). Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems, as well as in the management of the projects concerned.

The main R&D outcome or impact indicator is the share of high-tech products in total exports. The prospects of extroversion and commercialization of R&D innovation output among EU enterprises are determined by the volume of high-tech trade. This volume of high-tech trade also impacts the specialty of countries in producing medium- and high-tech products fabricated through innovation, contributing to the balance of trade of national economies, and disclosing the competitiveness of internationalization. In such a multifaceted context of

production, the exploitation and commercialization of high-tech commodities is also associated with high value-added economic performance and the adoption of knowledge-intensive and remunerative jobs. In a general context, high-tech trade fosters strategic developmental priorities for smart and inclusive growth within the Europe 2020 goals (Eurostat, 2017).

The main quality of life indicators linked to R&D performance in the country selected by experts are: from the 4 main areas related to R&D: material living conditions, productive activity; education; natural and living environment. Among material living conditions, the GDP per capita was selected as the main indicator representing the consumption level in the country. Among the indicators of productive activity, the unemployment rate of people with tertiary education was selected as the main indicator of quality of employment. Among the education indicators, the share of the population with tertiary education was selected as the main indicator of educational attainment. The main indicators representing natural and living environment selected by experts were the following: crime, violence and vandalism in the area; pollution, grime, or other environmental problems in living environment.

4. Case study

The dynamics of the R&D indicators for Greece, Lithuania, and the EU-27 average are shown in a graphical form below to identify the best performing country and to compare the trend.

In Figure no. 1 the dynamics of the share of governmental R&D expenditures in total governmental expenditures in Lithuania, Greece, and the EU-27 is presented.

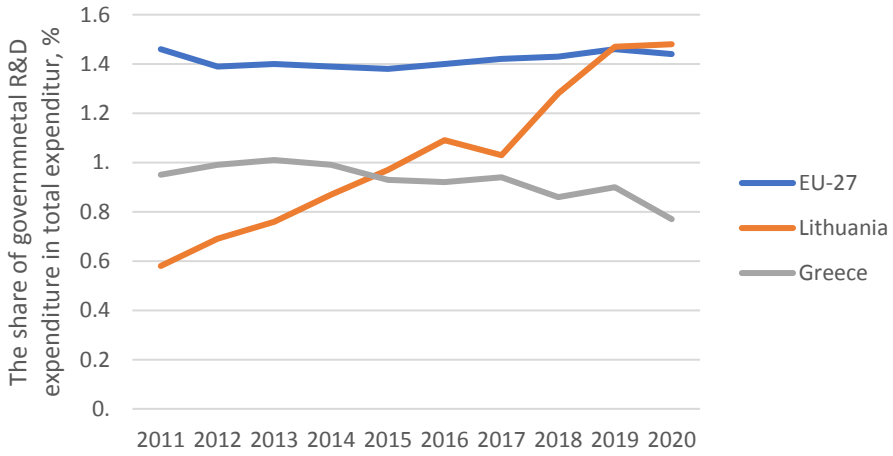

Figure no. 1. The share of governmental R&D expenditures in total governmental expenditures in Lithuania, Greece, and the EU-27

As it can be derived from Figure no. 1, in Lithuania, the share of governmental R&D expenditures in total governmental expenditures, generally, faced an increasing trend starting with 2011, and in 2020 it reached a value of 1.48%, exceeding the EU-27 level (1.44%). At the same time, in Greece, since 2014, the share of governmental R&D expenditures has

decreased, and in 2020, this reached a value of 0.77%, half of Lithuania's level. At the same time, this indicator was stable in the EU-27 during the investigated period.

In Figure no. 2 the dynamics of the share of R&D expenditures in GDP in Lithuania, Greece, and the EU-27 is provided.

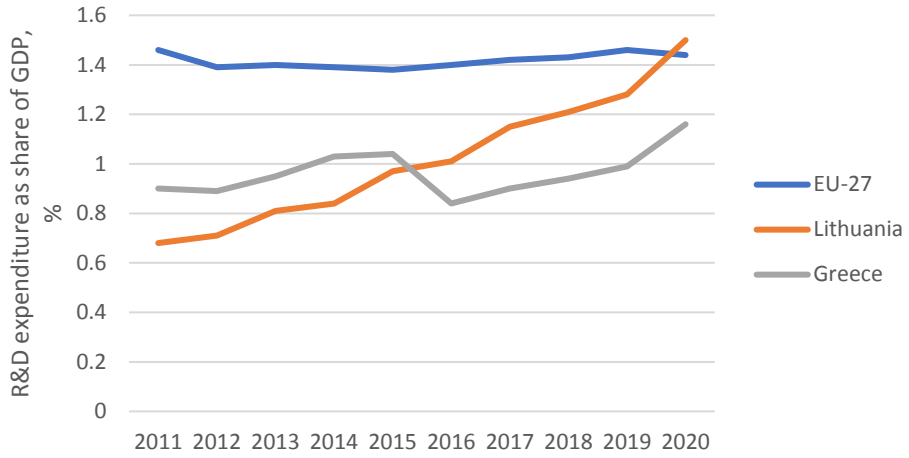

Figure no. 2. The development of R&D expenditures as the share of GDP in Lithuania, Greece, and the EU-27 average

As one can notice from the information outlined in figure no. 2, the share of R&D expenditures in GDP was steadily growing in Lithuania, and in 2020 it reached a value of 1.5%, surpassing the EU-27 level (1.44%), which was stable during the investigated period. In Greece, the share of R&D expenditures in GDP has been growing since 2015. However, in 2020, this was still more than 20% lower than in Lithuania.

The dynamics of R&D expenditures per capita in Greece and Lithuania were very similar during the investigated period. This indicator increased during the investigated period. However, in 2020 it was more than 3 times lower than the EU-27 average (Figure no. 3).

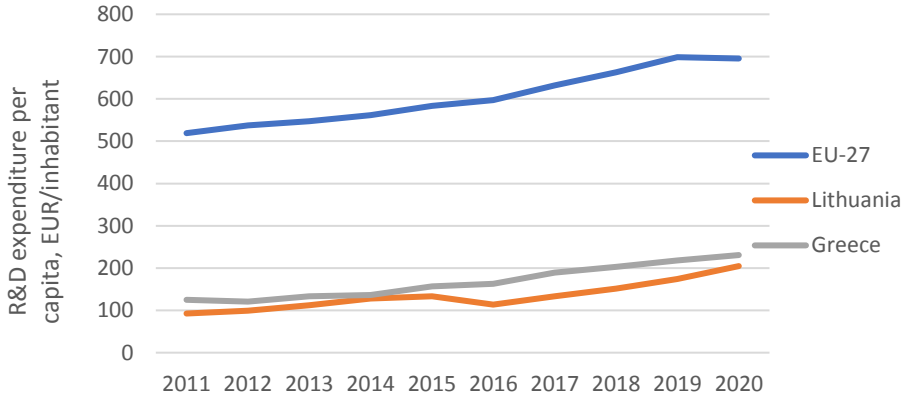

Figure no. 3. Dynamics of R&D expenditures per capita in Lithuania, Greece, and the EU-27 average

The dynamics of the share of employment in knowledge intensive activities in total employment is provided in Figure no. 4, for Lithuania, Greece, and the EU-27.

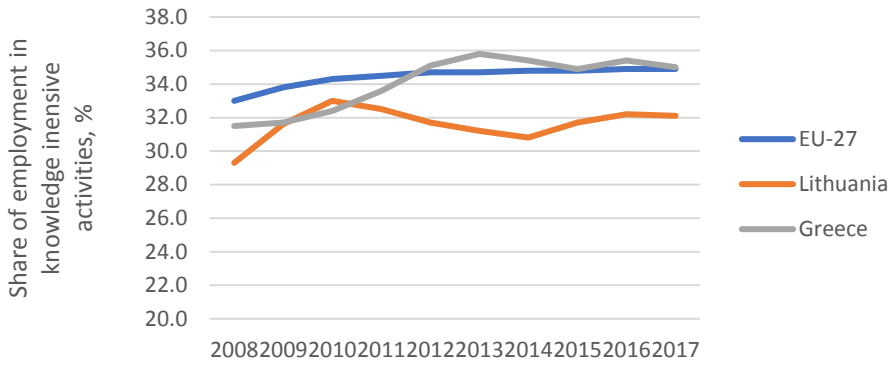

Figure no. 4. Dynamics of the share of employment in knowledge intensive activities in total employment in Lithuania, Greece, and the EU-27 average

As one can notice from figure no. 4, the share of employment in knowledge-intensive activities increased in Greece and Lithuania. In 2017, the share of employment in Greece (35%) was slightly higher than in Lithuania (32%) and very similar to the level of the EU-27 (35%). Greece, Spain, Italy, and the Netherlands experienced a reduction in both total employment and in employment in knowledge-intensive activities in absolute values between 2008 and 2015; therefore, the higher share of employment in knowledge-intensive activities is related to the fact that employment in knowledge-intensive activities reduced less than total employment in the country.

The dynamics of the share of researchers in total employment in Lithuania and Greece and the EU-27 average is outlined in Figure no. 5.

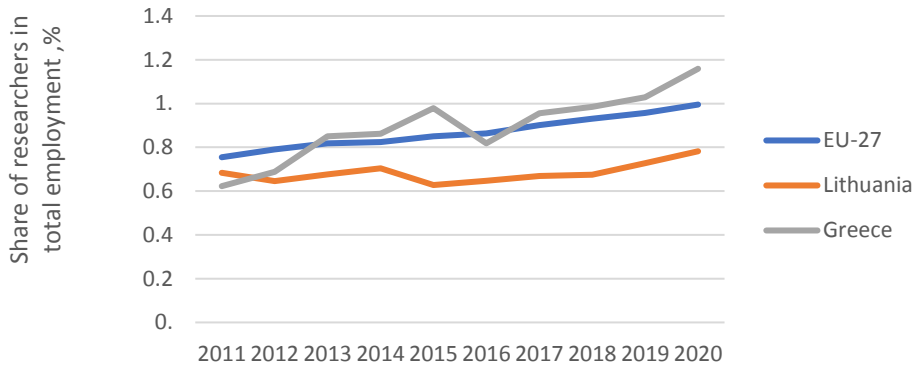

Figure no. 5. The dynamics of the share of researchers in total employment in Lithuania, Greece, and the average EU-27

The share of researchers in total employment grew in Lithuania, Greece, and the EU-27 during all investigated periods, with a drop in 2015 for Greece. The share of researchers in

total employment in Greece in 2020 reached 1.16% and this was 1.5 times higher than in Lithuania (0.78%) and 14% higher than the average of the EU-27 (0.995%). The main reason for the growth of the share of researchers in total employment is the same as in the case of the share of employment in knowledge-intensive activities.

The dynamics of the main outcome indicator of R&D financing – the share of high technology products in total exports is presented in Figure no. 6 for Lithuania, Greece, and the EU-27 average.

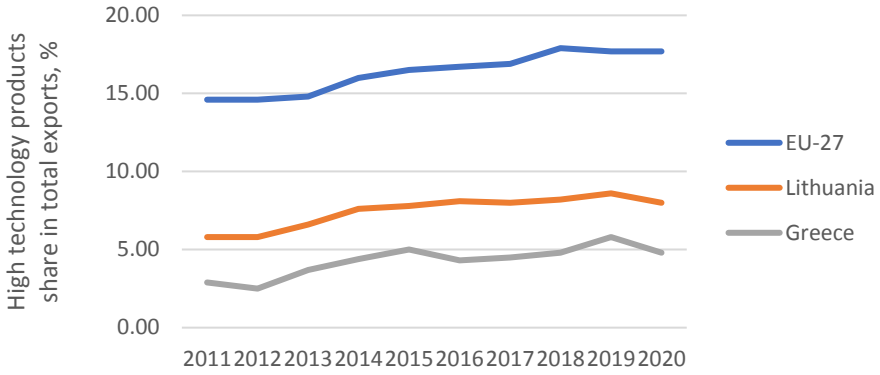

Figure no. 6. The dynamics of the share of high technology products in total exports in Lithuania, Greece, and the EU-27 average

As outlined in figure no. 6, the share of high-tech products has declined in 2020 in Lithuania and Greece, though it was steadily growing during the investigated period. This is linked to the COVID-19 pandemic, which had a negative impact on international trade due to lockdowns and other restrictions imposed by countries worldwide. Lithuania distinguishes itself with higher results in R&D financing compared to Greece, as the Lithuanian share of high technology products in total exports decreased from 8.6% in 2019 to 8% in 2020, while in Greece it dropped from 5.8% to 4.8% during the same period. Another important finding was that the EU-27 average share of high-tech products in total exports was more than twice higher than in Greece and Lithuania and amounted to 17.7% in 2019 and 2020.

Taking into account the fact that the intensity of R&D financing on average in the EU-27 was similar to Lithuania and the R&D expenditures in GDP reached a value of 1.4% in 2020, Lithuania distinguishes itself with low results of R&D financing. In Greece, the low intensity of R&D financing (1.16%) led to low R&D outcomes, showing a similar situation to Lithuania. Both countries show quite low R&D performance. The main difference between Lithuania and Greece is that the former, with lower intensity of R&D has higher R&D resources, such as higher shares of researchers and people employed in knowledge-intensive industries.

The dynamics of the quality of life indicators are analysed in Lithuania, Greece, and the EU-27, in figures no. 7, 8, 9, 10, 11, and 12.

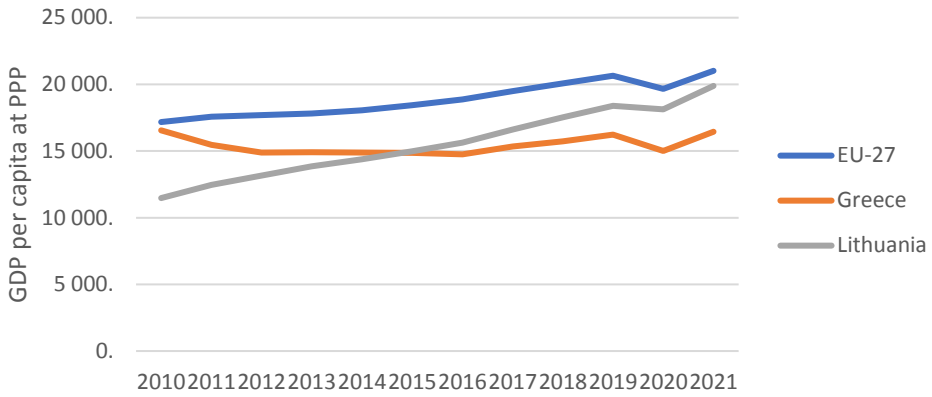

Figure no. 7. Dynamics of GDP per capita in Lithuania, Greece, and the EU-27 average

Lithuania has a higher GDP per capita in comparison with Greece. Furthermore, Lithuania experienced a steady growth of the GDP per capita, except for the decline faced in 2020, because of the COVID-19 pandemic. Therefore, Lithuania distinguishes itself with high consumption levels in terms of quality of life, though the GDP per capita level in 2021 was slightly lower than the EU-27 average.

The dynamics of tertiary educational attainment is provided in figure no. 8 for Lithuania, Greece, and the EU-27 average.

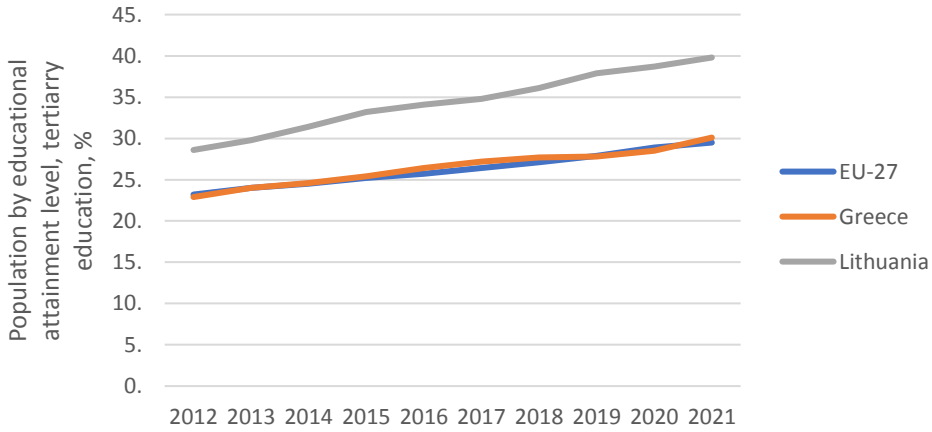

Figure no. 8. The dynamics of tertiary educational attainment in Lithuania, Greece, and the EU-27 average

The share of the population by educational attainment level (tertiary education) was almost 40% in Lithuania and significantly exceeded the level of Greece (30%) and the EU-27 average (29%). This indicator was steadily growing in all investigated countries during the period 2012-2021.

The dynamics of the unemployment rate of people with tertiary education in Lithuania, Greece, and the EU-27 average is illustrated in Figure no. 9.

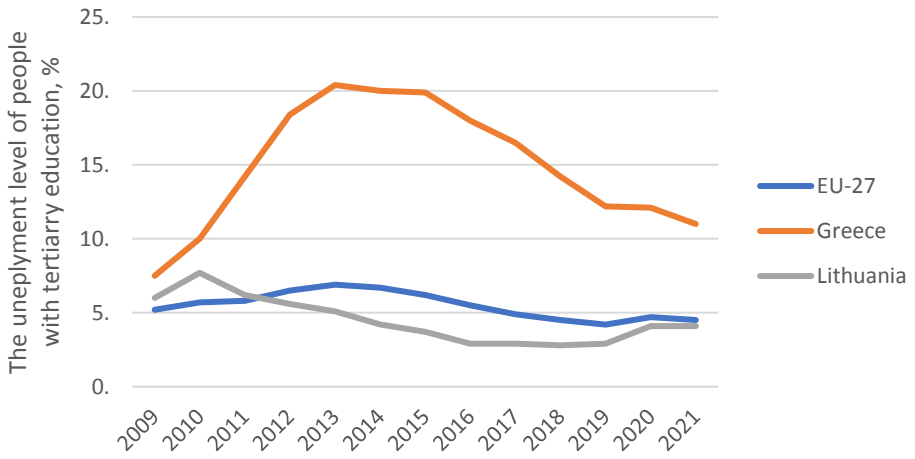

Figure no. 9. The dynamics of the unemployment rate of people with tertiary education in Lithuania, Greece, and the EU-27 average

The dynamics of the unemployment rate of people with tertiary education in Greece shows a steady decline since 2013. However, the level of unemployment of people with tertiary education was significantly higher in Greece than in Lithuania and the EU-27. Especially in 2013, this was 20% in Greece compared to 5% in Lithuania and 7% in the EU-27. This reveals the huge negative impact of the 2008 global crisis on Greece, which caused a sharp increase of unemployment and economic decline.

Figure no. 10 outlines the share of people experiencing crime, violence, and vandalism in the area for Lithuania, Greece and EU-27 average, an indicator developed by SILC that provides information on living conditions and environment.

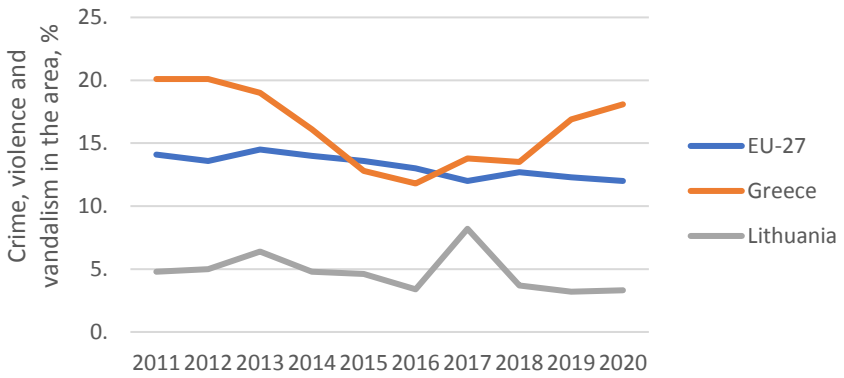

Figure no. 10. The dynamics of the share of people experiencing crime, violence, and vandalism in the area, in Lithuania, Greece, and the EU-27 average

The situation of crime, violence, and vandalism in the area is significantly better in Lithuania than in Greece and the EU-27 average. Therefore, in terms of quality of life related to living conditions, Lithuania is an attractive country.

Figure no. 11 illustrates the dynamics of the share of people experiencing pollution, grime, or other environmental problems in the area, for Lithuania, Greece and EU-27 average. These are indicators developed by SILC and provide information on living conditions and the environment.

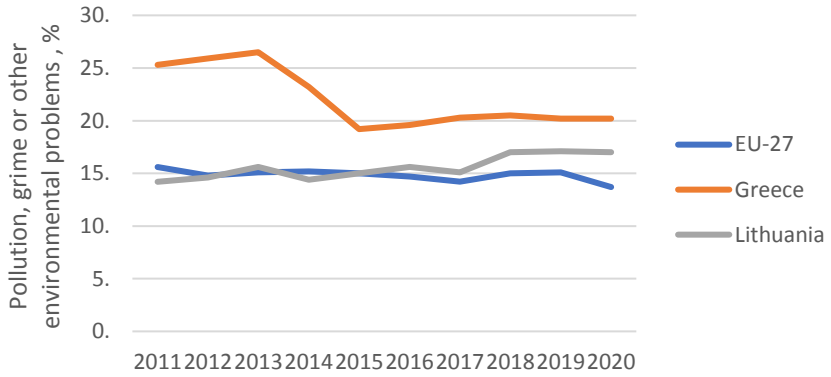

Figure no. 11. The dynamics of the share of people experiencing pollution, grime, or other environmental problems in the area in Lithuania, Greece, and the EU-27 average

As outlined in figure no. 11, the share of people experiencing pollution, grime, and other environmental problems in Greece was higher than in Lithuania and the EU-27 during all investigated years. Starting with 2016, this indicator increased in Greece, while in Lithuania it had a very similar level and trend as in the EU-27 and it was almost stable during the investigated period.

The dynamics of the quality of life index developed by NUMBEO for Lithuania and Greece was also compared and discussed to reveal the overlapping trends in the progress of the R&D indicators in the two selected countries. The data of the quality of life index for Lithuania and Greece in 2021 is given in Table no. 2.

Table no. 2. Quality of life index and its structure in Lithuania and Greece in 2021

Lithuania		
Purchasing Power Index	54.58	Low
Safety Index	67.39	High
Health Care Index	73.08	High
Climate Index	69.86	High
Cost of Living Index	44.99	Low
Property Price to Income Ratio	12.03	High
Traffic Commute Time Index	25.28	Very Low
Pollution index	25.11	Low
Quality of Life Index	162.14	Very High

Greece		
Purchasing Power Index	37.37	Very Low
Safety Index	52.07	Moderate
Health Care Index	57.21	Moderate
Climate Index	93.83	Very High
Cost of Living Index	52.40	Low
Property Price to Income Ratio	12.05	High
Traffic Commute Time Index	33.68	Low
Pollution Index	51.78	Moderate
Quality of Life Index	126.49	Moderate

Table no. 2 reveals that Greece has a moderate quality of life indicator compared to Lithuania. In a more specific regard, the 'Safety' and 'Health Care' Indexes are high in Lithuania compared to Greece. The dynamics of the quality of life index in Lithuania and Greece is given in Figure no. 12.

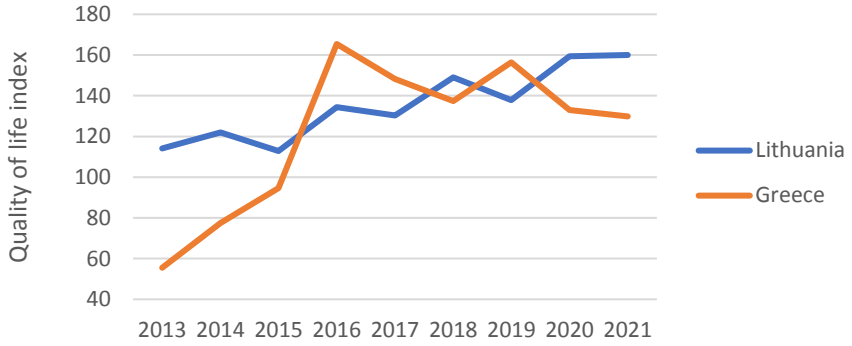

Figure no. 12. Dynamics of the Quality of Life Index in Lithuania and Greece

As reflected in Figure no. 12, the quality of life index was steadily growing in Lithuania. On the other side, in the case of Greece, high fluctuations can be noticed. In Greece, in 2016, this index has declined and it slightly increased in 2019, starting to decrease again with 2020.

The selected quality of life indicators related to R&D performance also showed the superior position of Lithuania in terms of quality of life. In general, it is clear that all indicators of quality of life in Lithuania were higher than in Greece during the investigated period. The trends of quality of life indicators in Lithuania are positive. In Greece, there were some indicators such as crime, violence, and vandalism in the area that were increasing; this indicator was more than 30% higher in Greece than in Lithuania and 6 times higher than in the EU-27.

5. Discussion

The R&D efficiency changed in the EU28 Member States in the period 2010-2015, while utilizing the non-radial and non-oriented Malmquist index. This index composes R&D indicators among EU28 Member States (five inputs and two outputs) by focusing on six intra-national EU-based groups in alignment with three indexes: efficiency shift, frontier shift, and Malmquist index. The best group of countries that registered a progress in both efficiency

shift and frontier shift (Malmquist index >1) was composed of Italy and Germany. The worst countries in terms of efficiency shift, frontier shift, and Malmquist index (< 1) were: the Netherlands, Greece, Malta, Poland, Luxembourg, and Portugal. A nonparametric test showed that post-socialist countries were not different from capitalist EU countries regarding efficiency change in the period 2010-2015. In this period, the most notable change in R&D efficiency using the Malmquist index was found in Spain, Latvia, Denmark, and Ireland. On the contrary, Poland, Luxembourg, and Portugal showed the smallest R&D efficiency change (Halaskova et al., 2020). In our study, it was shown that post-socialist countries were similar to capitalist European countries regarding the efficiency change in 2010-2015. All comparable domains of R&D and Quality of Life are represented in Table No. 3.

Table no. 3. Key domains in R&D and Quality of Life indicators: Lithuania, Greece

Key domains for the period 2010-2015	Lithuania	Greece
Employment in knowledge intensive activities	+	+
High technology products	-	-
R&D resources and R&D intensity	+	-
GDP per capita/determinant of quality of life	+	-
Unemployment rate of people with tertiary education	- (positive characteristic)	+ (negative characteristic)
Social marginalization (crime, violence, vandalism)	- (positive characteristic)	+ (negative characteristic)
Environmental awareness and sensitization on problems regarding living conditions and environment	+	+
Safety, Health Care and Climate Indexes	+	-
Life indicators linked to R&D performance in terms of quality of life	+	-

Table no. 3 reveales that the key determinants of the trends in R&D and quality of life are driven primarily by social imbalance, the moral values of mass media and social media, environmental depletion, the competitiveness of adaptation and mitigation of climate changes, the global economic recession, and the Covid-19 pandemic. These determinants are common among all European countries, and although each country maintains its own traditional characteristics and cultural assets, a common 'behavioural convergence' is realistic, especially among the 27 EU member states. However, it cannot be undermined the fact that R&D expenditures heavily complicate the strategic investments of firms made by the financial departments. Consequently, it can signify the challenge for R&D professionals within firms to develop improved measures of R&D success and to communicate this information to senior executives (O'Connell et al., 2018).

In the EU context, a cross-region R&D collaboration measured the discrepancies between two types of collaborative R&D activities, those generating output in terms of scientific publications and those that do not. Subsequently, the geographical distance can act as a collaborative deterrent if collaborations do not generate scientific output. Furthermore, institutional barriers were not significant for collaborations with scientific output, while

language and technological barriers consisted of smaller but not noticeable discrepancies between the two types of collaborative R&D activities (Fichet de Clairfontaine et al., 2015). R&D measurements are widely used to increase a country's innovation performance in developed economies, while in developing economies there are methodological constraints due to scarcely collected credible data and a lack of synergy between the phenomenologically coordinating sectors: businesses, central governments, higher education institutions of engineering and technology, agriculture and environment (Madhou et al., 2021).

R&D funding in developing economies prioritizes physical products rather than service products (Broström and Giertz, 2021). R&D and Innovation (R&D&I) in global value chains (GVC) offer the opportunity to numerous established and new stakeholders from business, politics, science and society across EU Member States, regions, and cities to develop radical and enlightening ideas for new products, services, processes, and employment, and to work in a well-structured and open-minded environment. Such an approach might be necessary for an ambitious policy to improve the European industry and R&D&I capabilities in order to take advantage of the GVC of transnational corporations to create a process that engages, assesses, and responds continuously (Malanowski et al., 2021).

Conclusions

The literature review showed the importance of R&D for increasing quality of life, especially for developed countries. The indicators framework linking R&D performance and quality of life was developed based on literature review and experts survey in Lithuania and Greece. The comparative assessment of R&D and quality of life in Lithuania and Greece was performed based on the created indicators framework.

A comparative analysis in the trends of R&D and quality of life indicators was performed in Lithuania and Greece and compared with the benchmark – EU-27 average level. The similarities and differences and their main reasons for them are discussed, showing that:

- A country having higher R&D financing intensities has the higher associated quality of life indicators; therefore, the importance of R&D for increasing quality of life can be confirmed by conducting a case study analysis.

- All quality of life indicators linked to R&D performance in Lithuania were higher than in Greece during the investigated period (2011-2020) showing the importance of higher R&D financing for increasing of the quality of life.

- Policy recommendations were developed to increase the R&D financing intensity for Greece and the R&D financing efficiency in both countries. Lithuania distinguishes itself with higher R&D financing intensities and higher R&D financing outcomes compared to Greece. Although the positive trends in R&D growth can be noticed in both countries, the R&D financing efficiency is low in both countries compared to the EU-27 average.

Research limitations were pointed out since more robust models, such as multiple regression can be applied to investigate the linkages between R&D financing and quality of life. Based on the conducted study, future research can identify relevant indicators on relating between R&D and quality of life, which the panel of data of the EU Member States will be plausibly applied in the long run.

References

Afza, T. and Nazir. M.S., 2007. Economic Competitiveness and Human Resource Development: An FDI Perspective. *Political Economy and Social Review*, 45(2), pp.167-180. http://www.jstor.org/stable/25825313.

Ballot, G., F. Fakhfakh, F. and Taymaz, E., 2001. Firms' Human Capital, R&D and Performance: A Study on French and Swedish Firms. *Labour Economics*, 8, pp.443-462. http://dx.doi.org/10.1016/S0927-5371(01)00038-0

Blackburn, K., Hung. V. T. Y. and Pozzolo. A. F., 2000. Research, Development and Human Capital Accumulation. *Journal of Monetary Economics*, 22, pp.189-206. http://dx.doi.org/10.1016/S0164-0704(00)00128-2.

Broström, A. and Giertz, E., 2021. Service development accounts for an even smaller share of European R&D investments than we may think. *Journal of Technology Transfer*, 46(4), pp.1256-1267. https://doi.org/10.1007/s10961-017-9592-x

Chou, Y. K., 2002. The Australian Growth Experience (1960-2000), R & D based, Human Capital-Based or Just Steady State Growth? Research Paper 855, ISSN 0819-2642, Department of Economics, University of Melbourne. [online] Available at: http://econpapers.repec.org/RePEc:mlb:wpaper:855.

Diener, E., 2009. Introduction—The Science of Well-Being: Reviews and Theoretical Articles by Ed Diener. In: E. Diener ed., 2009. *The Science of Well-Being*. *Social Indicators Research Series*, vol. 37. Dordrecht: Springer, pp. 1-10.

D'Souza R., 2011. S10-03 The Science of Well-being – The Evidence of the Need to Foster Spiritual Values and Well-Being in Clinical Practice. *Asian Journal of Psychiatry*, 4(1), pp.13-14.

Estes, R.J., 2019. The Social Progress of Nations Revisited, 1970-2020 – 50 Years of Development Challenges and Accomplishments. *Social Indicators Research Series (SINS)*, 78, pp.253, Springer International Publishing.

European Commission, 2009. *GDP and beyond Measuring progress in a changing world*. https://ec.europa.eu/eurostat/cros/content/gdp-and-beyond-measuring-progress-changing-world_en

Eurostat, 2017. Archive:Europe 2020 indicators - R&D and innovation, [online] Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Europe_2020_indicators_-_R%26D_and_innovation&oldid=335438 [Accessed 02 July 2022].

Evans, M.D., Felson, M. and Land, K.C., 1980. Developing social indicators research on the military in American society. *Social Indicators Research*, 8, pp.81-102. https://doi.org/10.1007/BF00364603

Falk, M., 2007. R & D spending in the high-tech sector and economic growth. *Research in Economics*, 61, 140-147 http://dx.doi.org/10.1016/j.rie.2007.05.002

Ferreira, M.I.A., Sequeira, J.S., Virk, G.S., Tokhi, M.O. and Kadar E.E., 2019. Robotics and Well-Being. *Intelligent Systems, Control and Automation: Science and Engineering (ISCA)*, p.95. Springer International Publishing.

Fichet de Clairfontaine, A., Fischer, M.M., Lata, R. and Paier, M., 2015. Barriers to cross-region research and development collaborations in Europe: evidence from the fifth European framework programme. *Annals of Regional Science*, 54(2), pp.577-590. https://doi.org/10.1007/s00168-015-0667-z.

Frantzen, D., 2000. R&D. Human Capital and International Technology Spillovers: A Cross-Country Analysis. *The Scandinavian Journal of Economics*, 102(1), pp.57-75. https://doi.org/10.1111/1467-9442.00184.

Goel, R. K., Payne J. E. and Ram, R., 2008. R&D expenditures and U.S. economic growth:A disaggregated approach. *Journal of Policy Modeling*, 30, pp.237-250. http://dx.doi.org/10.1016/j.jpolmod.2007.04.008.

Grossmann,V., 2007. How to promote R&D-based growth? Public education expenditure on scientists and engineers versus R&D subsidies. *Journal of Macroeconomics*, 29, pp.891-911. http://dx.doi.org/10.1016/j.jmacro.2006.01.001.

Halaskova, M., Gavurova, B. and Korony, S., 2020. Change of EU28 countries research and development indicators between 2010 and 2015. *Economics and Sociology*, 13(1), pp.230-248. https://doi.org/10.14254/2071-789X.2020/13-1/15.

IJsselsteijn, W.A., Kort, Y.A.W., Midden, C., Eggen, B. and Hoven, E., 2006. Persuasive Technology for Human Well-Being: Setting the Scene. *Persuasive Technology First International Conference on Persuasive Technology for Human Well-Being*, PERSUASIVE 2006, Eindhoven, The Netherlands, 18-19 May 2006. Proceedings. Lecture Notes in Computer Science (LNCS), p.3962.

Jacobsson S., Oskarsson C. and Philipson, J., 1996. Indicators of technological activities – comparing educational, patent and R&D statistics in the case of Sweden. *Research Policy*, 25(4), pp.573-585. https://doi.org/10.1016/0048-7333(95)00855-1

Jin, J. C., 2009. Economic research and economic growth: Evidence from East Asian economies. *Journal of Asian Economics*, 20, pp.150-155. http://dx.doi.org/10.1016/j.asieco.2008.12.002.

Jones, C.I., 2002. Sources of U. S. Economic Growth in a World of Ideas. *The American Economic Review*, 92(1), pp.220-239. http://dx.doi.org/10.1257/000282802760015685.

Khan, J., 2005. The Role of Research and Development in Economic Growth: A Review. MPRA Paper No. 67303. https://mpra.ub.uni-muenchen.de/67303/

Khan, J. and Khattak, N. U. R. 2013. The Significance of Research and Development for Economic Growth: The Case of Pakistan, *City University Research Journal*, pp.175-186. http://www.cityuniversity.edu.pk/curj/Journals/Journal/July%202013/Article%203.pdf

Kuo, C.C. and Yang. C.H., 2008. Knowledge capital and spillover on regional economic growth: Evidence from China. *China Economic Review*, 19, pp.594-604. http://dx.doi.org/10.1016/j.chieco.2008.06.004.

Kwack, S. U. and Lee, Y. S., 2006. Analyzing the Korea's Growth Experience: The application of R&D and Human Capital Based Growth Models with Demography. *Journal of Asian Economics*, 17, pp.818-831. http://dx.doi.org/10.1016/j.asieco.2006.08.002.

Lee, J. W. 2005. Human Capital and Productivity for Korea's Sustained Economic Growth. *Journal of Asian Economics*, 16, pp.663-687. http://dx.doi.org/10.1016/j.asieco.2005.06.009.

Madhou, M., Moosun, S.B. and Nagowah, D.N.-M., 2021. Using research and development indicators to shape innovation in Mauritius. *African Journal of Science, Technology, Innovation and Development*. https://doi.org/10.1080/20421338.2021.1985947.

Malanowski, N., Tübke, A., Dosso, M. and Potters, L., 2021. Deriving new anticipation-based policy instruments for attracting research and development and innovation in global

value chains to Europe. *Futures*, 128:102712. https://doi.org/10.1016/j.futures.2021.102712.

Numbeo (2022). *Numbeo: Quality of Life Index*. https://en.ac-mos.ru/ratings/numbeo-quality-of-life-index/ [Accessed 02 July 2022].

O'Connell, V., Abu Ghazaleh, N. and Kintou, A., 2018. The impact of R&D programme success on the decision to capitalise development expenditures in European firms. *Technology Analysis and Strategic Management*, 30(1), pp.15-30. https://doi.org/10.1080/09537325.2016.1278139.

OECD, 2015. Working Party of National Experts on Science and Technology Indicators. The Impact of R&D Investment on Economic Performance: A Review of the Econometric Evidence, Paris, OECD, Headquarters, 27-28-29 April 2015. Online: https://one.oecd.org/document/DSTI/EAS/STP/NESTI(2015)8/en/pdf

Ornaghi, C., 2006. Spillovers in product and process innovation: Evidence from Manufacturing Firms. *International Journal of Industrial Organization*, 24, pp.349-380. http://dx.doi.org/10.1016/j.ijindorg.2005.07.002.

Patrick, D. L. and Erickson, P. (1993) *Health Status and Health Policy. Quality of Life in Health Care Evaluation and Resources Allocation*. New York: Oxford University Press.

Sterlacchini., A. 2008. R&D, higher education and regional growth: Uneven linkages among European regions. *Research Policy*, 37, pp.1096-1107. http://dx.doi.org/10.1016/j.respol.2008.04.009.

Stiglitz, J.E., Sen, A. and Fitoussi, J.P., 2009. *Report by the commission on the measurement of economic performance and social progress*. https://ec.europa.eu/eurostat/documents/8131721/8131772/Stiglitz-Sen-Fitoussi-Commission-report.pdf

Yonk R.M. and Smith J.T., 2018. *Politics and Quality of Life – The Role of Well-Being in Political Outcomes*. Springer International Publishing.

Zeng, J., 2001. Innovative vs. imitative R&D and economic Growth. *Journal of Development Economics*, 64, pp.499-528. http://dx.doi.org/10.1016/S0304-3878(00)00148-6.