Hafezali Iqbal Hussain; Azlan Ali; Thaker, Hassanudin Mohd Thas; Mohsin Ali

Article

Economic growth and investment in R&D: Contemporary challenges for the European Union

Contemporary Economics

Provided in Cooperation with:
University of Finance and Management, Warsaw

Suggested Citation: Hafezali Iqbal Hussain; Azlan Ali; Thaker, Hassanudin Mohd Thas; Mohsin Ali (2020) : Economic growth and investment in R&D: Contemporary challenges for the European Union, Contemporary Economics, ISSN 2300-8814, University of Finance and Management in Warsaw, Faculty of Management and Finance, Warsaw, Vol. 14, Iss. 1, pp. 38-57, https://doi.org/10.5709/ce.1897-9254.331

This Version is available at:
https://hdl.handle.net/10419/297463

Primary submission: 31.01.2019 | Final acceptance: 04.11.2019

Economic Growth and Investment in R&D: Contemporary Challenges for the European Union

Rūta Banelienė and Borisas Melnikas

ABSTRACT This paper presents new approaches to investigating economic growth and innovation activity as well as analyzing investment in R&D needs and efficiency in the context of contemporary challenges for European integration. Our research modeled the impact of R&D investment on GDP growth under broad conditions of globalization. In addition to capital and labor factors, we took into account factors that influence climate change, keeping in mind their relation to economic activity. Additionally, we paid particular attention to other factors driving sustainable economic growth, such as consumption of scarce resources as well as inequality and poverty. Herein, we proposed new modeling conceptions for evaluating the impact of R&D investment on economic growth. The suggested method was adapted to analyze the case of development processes in the European Union. Our research confirmed the hypothesis that R&D expenditure has a positive impact on economic growth, and the impact is much higher in well-developed EU economies under conditions of sustainable economic development and globalization. The research was based on the case of the European Union economies. The panel least squares method was applied for the modeling and estimations.

KEY WORDS: economic growth, R&D investment, European Union, sustainable development.

JEL Classification: A10, E17, F01, F39, O39.

Vilnius Gediminas Technical University, Lithuania

1. Introduction

Economic growth processes and their acceleration are widely perceived to be essential in solving current social and economic problems and improving the quality of social and economic life in the context of the contemporary challenges of globalization and European integration. Therefore, priority should be given to problems, needs and opportunities in activating economic growth.

Innovation and innovation stimulation, as well as related economic policy decisions, are a very wide and complex area of practice and scientific study. This area could be considered particularly difficult: in the real world, innovation research has to constantly respond to new and increasingly complex challenges arising from globalization and growth in international competition, and existing early-stage scientific knowledge is becoming inadequate for rapidly changing needs.

One of the most complicated and essential issues requiring both serious scientific research and knowledge, as well as informed economic policy decisions, is the role of R&D investment and its impact on economic growth. Answering this question requires the ability to measure the impact of R&D investment on economic growth properly, purposefully and comprehensively.

Correspondence concerning this article should be addressed to: **Rūta Banelienė**, Vilnius Gediminas Technical University, Lithuania. E-mail: ruta.baneliene@vgtu.lt

The answer determines the ability to select in a well-grounded way the most viable and highest-priority directions for innovation activity and, at the same time, develop and implement effective economic policy decisions.

These objectives could be furthered by comprehensive modeling of various investments in R&D processes and alternatives, including the specific contexts of different countries and regions.

In turn, relevant instruments must be developed and used with an eye toward understanding and solving a double-faceted scientific and practical problem: (a) R&D investment needs and the impact of R&D on economic growth are not properly taken into account in either current innovation stimulation practices and activity or economic policy development and implementation, and (b) R&D investment modeling often does not adequately reflect the specificities of the situation in different countries and regions.

Obviously, this problem is important in both scientific and practical terms, especially under the contemporary conditions of social and economic development in the European Union. There are many specific challenges that are especially relevant in achieving priority goals in social development, enhancing economic growth and R&D investment efficiency, and increasing competitiveness in the EU.

This problem could be analyzed and solved in two directions by (a) analyzing and prioritizing innovation activity and investment in R&D processes, taking into account the contemporary challenges for social and economic development and technological progress in the EU and (b), analyzing and improving the assessment and modeling of the impact of R&D investment on economic growth, especially under the current development conditions in the European Union.

This paper presents a theoretical investigation and the results of empirical research in these directions in more detail.

2. Theoretical Approach and Empirical Background

Research on economic growth processes and scientific and technological progress, enhancement, and acceleration covers a wide range of topics and issues (Spetzler et al., 2016). This research has become essential—especially under the current conditions of globalization, European integration and development of knowledge-based societies and knowledge economies—and should focus on the following:

— orientation towards solving the progress problems that are most important for contemporary societal development (Boldrin & Canova, 2001; Calori et al., 1999; Chortareas & Pelagidis, 2004; Currie, 2000; Drews et al., 2018; Garrett & Mitchell, 2001; Grace & Butler, 2005; Hayo & Seifert, 2003; Huseman & Godman, 1999; Krugman & Obstfeld, 1997; Leydesdorff, 2004; Melnikas, 2002, 2011, 2013; Melnikas & Reichelt, 2004; Perraton, 2001; Rosenzweig, 2001; Steinmueller, 2002; Tomaselli et al., 2019);

— development of conditions, assumptions, and effective tools, measures, and applications to purposefully enhance social and economic prosperity, scientific and technological progress, and economic growth (Alexiou et al., 2018; Armstrong, 2006; Carlaw & Lipsey, 2003; David & Foray, 2002; Ein-Dor et al., 2004; Feng & Ji, 2018; Hummels et al., 2001).

The following particularly significant social and economic problems could be defined in contemporary society, especially the EU:

— limited supply and efficient use of raw materials and energy resources. These problems are particularly relevant in the EU and the European Economic Area in general because the European economy is heavily dependent on natural raw material and energy imports.

At the EU level, the following 20 raw materials (European Commission, 2014) were listed as critical for the EU because the risk of supply shortages and the resulting impacts on the economy is higher than for most other raw materials: antimony, beryllium, borates, chromium, cobalt, coking coal, fluorspar, gallium, germanium, indium, magnesite, magnesium, natural graphite, niobium, phosphate rock, platinum group metals, heavy and light rare earth elements, silicon, and wolfram (for which China is the most influential country in terms of global supply).

Additionally, the EU is highly dependent on imports of energy products. According to Eurostat (2019a), the EU-28's dependency on energy imports increased from slightly more than 44% of gross available energy in 1990 to 52.9% in 2007 and then to 55.1% by 2017. Since 2004, the EU-28's net imports of energy

 DOI: 10.5709/ce.1897-9254.331

have been greater than its primary production; in other words, more than half of its gross available energy was supplied by net imports. The situation is much more critical in the cases of oil and petroleum products, where the dependency rate was 86.7% in 2017, and natural gas, where the dependency rate was 74.3%. According to Eurostat (2019b), crude oil is the largest imported energy product (70% of total EU energy imports in the first half of 2018), ahead of natural gas in the gaseous state (19%). Russia and Norway are the largest suppliers of petroleum and natural gas to the EU: In 2018 Russia provided 27.9% and 41.5% by net mass of all EU petroleum and natural gas imports, respectively, and Norway 10.9% and 32.7%.

— Problems of social, economic, and ecological development sustainability, including economic growth and focusing adequately on the needs for social stability and high quality of life throughout the process of economic development. These problems are particularly relevant in the context of growing social and economic disparities in the world, including contemporary European society.

According to the Eurostat report (2016a) on achieving targets set in the Europe 2020 strategy, almost every fourth person in the EU remained at risk of poverty or social exclusion in 2014. Therefore, the challenge of fighting poverty is still on the EU policy agenda. The situation is better in the field of environmental protection, where EU achievements are significant. In 2014, EU greenhouse gas emissions were down by 23.0% compared to 1990 levels. The EU is thus expected to exceed its Europe 2020 target of reducing greenhouse gas (GHG) emissions by 20% by 2020. However, the average global surface temperature continues to rise, with 2015 being the warmest year on record, and climate change is still a global, not regional, problem.

— New competition and competitiveness problems arising in the context of contemporary globalization and economic internationalization. Particularly significant are the problems caused by excessive differences in productivity, purchasing power and economic and business conditions in different regions and countries, including in different regions and countries of the European Union. According to Eurostat (2019c; 2019d), in 2018, labor productivity per working hour in the EU varied from 46.2% of the EU-28 average in Bulgaria to 177.3% in Ireland; compensation of employees per hour worked varied from €5.5 in Bulgaria to € 46.6 in Luxemburg.

— A rising gap between expectations and opportunities to realize them in many areas of social and economic life. They create preconditions for conflicts and unsustainable development in many areas of social and economic life, in various economic and business sectors and in many regions and countries.

It is obvious that the solutions to these problems should be based on innovations and scientific and technological tools, measures and capabilities oriented towards:

— finding and implementing various alternatives for efficient use of scarce raw materials and energy resources (Voudouris et al., 2015);

— implementing sustainability goals, in particular achieving sustainable social, economic and ecological development (Bond et al., 2001; Drews et al., 2018; Kim & Shin, 2002; Liu et al., 2019; Olsen & Osmundsen, 2003; Ott & Soretz, 2018; Ouyang et al., 2019);

— achieving a high level of competitiveness in all areas of economic activity, as well as implementing various ambitious quality, prosperity and social comfort standards (Hofbauer, 2003; Hunt, 2000; Melnikas & Reichelt, 2004);

— reducing social and economic disparities and eliminating the preconditions for various kinds of conflict and exclusion (De Dominicis, 2014; Dell'Anno & Amendola, 2015; Caraballo et al., 2017; Ghose, 2004; Goeransson & Soederberg, 2005).

These needs and aspirations to solve the social, economic and other problems described underline the priority of developing conditions and assumptions and preparing effective tools and measures for use in purposeful social and economic development, economic growth and scientific and technological progress. These priorities reflect the prospects for R&D activities, scientific and technological progress, and research in social and economic development and economic growth in general (Melnikas, 2011, 2014).

The basic concept is to assess the impact of R&D investment on economic growth, which could allow rational identification of R&D investment needs and priorities. An investment in the identification of R&D priorities could be defined as the first crucial phase in the multilevel processes of initiation and enhancement of economic growth and social and economic develop-

ment–oriented innovations.

These circumstances illustrate the necessity of the impact of R&D investment on economic growth assessment and modeling, taking into account contemporary conditions.

This impact, as well as the main estimation results based on modeling the impact for European Union economies, is presented in this paper in more detail.

3. Methodology: Model and Data

The model is based on the theoretical approach described in the previous section and focuses on economic growth, which could be driven by:

(1) The indicators set in the Europe 2020 strategy, which are in line with five major directions for enhancing EU competitiveness: employment, R&D investment, climate/energy targets, education, and fighting poverty; and

(2) Indicators covering the broader innovation and economic growth context: intellectual property rights protection, material consumption, and inequality.

The major idea was to develop a model for evaluating R&D investment impact on economic growth in the European Union by using indicators that reflect contemporary challenges for the European Union under sustainable economic development and globalization conditions.

Therefore, indicators are divided into four separate fields: capital indicators, labor and labor force quality indicators, intellectual property protection indicators, and sustainability indicators, which are based on the idea of sustainable societal and environmental development, including management of scarce resources.

For modeling, we used annual Eurostat data for the EU-28 countries for the period 2007–2016 (Eurostat 2016b). In the field of capital indicators, we used Eurostat data on R&D investment, including separate data on business investment. These indicators are in line with the directions of the Europe 2020 strategy. Additionally, Eurostat data used in the category of labor and labor force quality included the employment rate, early leavers from education and training, and tertiary educational attainment, which related to targets set in Europe 2020 strategy as well; other indicators, such as persons with tertiary education and/or employed in science and technology, and persons employed in science and technology, are closely related to enhancing innovation.

With the intention of better reflecting the real innovation environment, we also used other Eurostat data on patent applications to the European Patent Office (EPO) and sustainability indicators on climate and energy, inequality, and poverty, which also reflect the directions of the Europe 2020 strategy. Additionally, as mentioned in the Theoretical Approach section, where we discussed scarce materials and effective consumption, we used the domestic material consumption indicator provided by Eurostat for modeling. In addition, we used a few indicators calculated by the World Bank (GINI index) and NASA (annual European temperature deviation) (see Figure 1). All data were expressed per capita or as share of the total to estimate the impact of the independent variables on GDP per capita.

Hypothesis: R&D expenditure has a positive impact on economic growth, and its impact is higher in well-developed economies under conditions of sustainable economic development and globalization.

Our target is to make a broader estimation focusing on the innovation environment and impact on GDP growth by using a wider spectrum of data on sustainable economic growth.

The major equation of our model uses R&D investment as the major indicator whose impact on GDP is estimated. Our model uses early leavers from education and training (ELET) as a labor force quality indicator. As independent environmental variables, the model includes domestic material consumption (DMC) per capita in tons and greenhouse gas emissions (GHGE) per capita. Finally, one of two poverty indicators is used for modeling in separate equations: mean equivalized net income (MENI) in euros is used as the independent variable in the main equation; in another equation, the inability to face unexpected financial expenses (IFUFE) is the independent variable used. Other indicators, provided in Table 1, are also used for the modeling process but extracted from the equations due to their insignificance or better representation of other indicators in the same field.

 DOI: 10.5709/ce.1897-9254.331

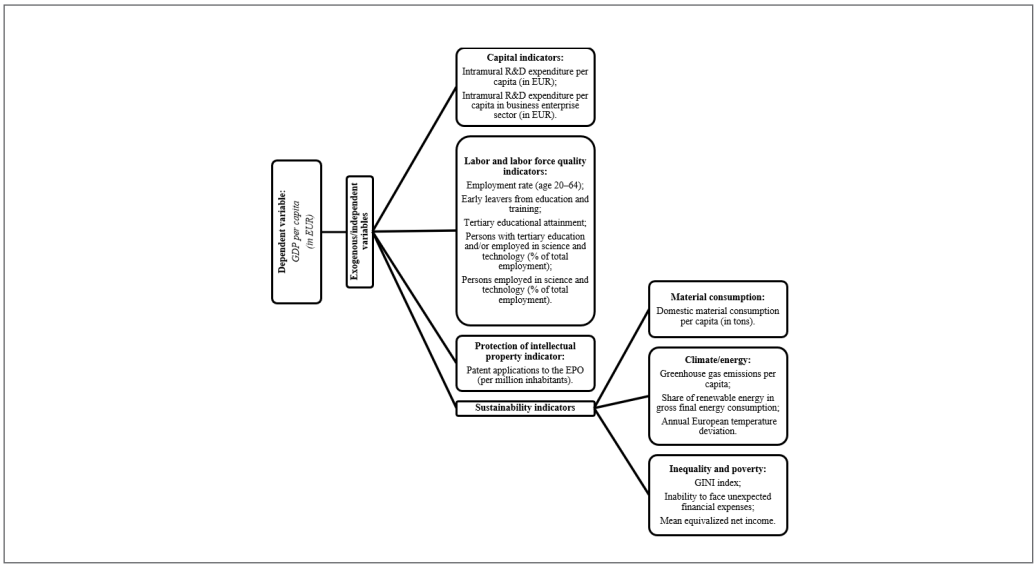

Figure 1. Used for modeling independent variables.

Table 1. Variables description.

Variable	Description
GDP/capita	Gross domestic product at market prices in euros per capita
R&D/capita	Total intramural R&D expenditure in euros per inhabitant
R&DB/capita	R&D expenditure of business enterprise sector in euros per inhabitant
ER	Employment rate, age group 20–64
ELET	Early leavers from education and training, % of the population aged 18–24
TEA	Tertiary educational attainment, % of the population aged 30–34
PTEEST	Persons with tertiary education and/or employed in science and technology, % of total employment
PEST	Persons employed in science and technology, % of total employment
PA	Patent applications to the European Patent Office (EPO) per million inhabitants

Table 1. Variables description (Continued).

Variable	Description
PA	Patent applications to the European Patent Office (EPO) per million inhabitants
DMC/capita	Domestic material consumption per capita in tons
GHGE/capita	Greenhouse gas emissions per capita in units of CO2 equivalents
RE	Share of renewable energy in gross final energy consumption
AETD	Annual European temperature deviation (GISTEMP; from NASA Goddard Institute for Space Studies)
GINI	GINI index
IFUFE	Inability to face unexpected financial expenses, % of persons in the total population who are in the state of enforced inability to face unexpected financial expenses.
MENI	Mean equivalized net income, in euros per person in household

Table 2. Review regression estimation: case of low GDP.

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
C	13075.31	1279.887	10.21599	.0000
R&D/capita	6.561917	1.097982	5.976341	.0000
ELET	-115.2338	22.56934	-5.105766	.0000
DMC/capita	274.2973	21.97771	12.48071	.0000
GHGE/capita	-429.8853	83.15100	-5.169935	.0000
MENI	0.661375	0.059637	11.09007	.0000

 DOI: 10.5709/ce.1897-9254.331

Table 2. Review regression estimation: case of low GDP (Continued).

Effects Specification			
Cross-section fixed (dummy variables)			
Weighted Statistics			
R-squared	0.996389	Mean dependent var	42752.61
Adjusted R-squared	0.995921	Standard deviation dependent var	19049.15
Standard error. of regression	1641.131	Sum squared resid	6.65E+08
F-statistic	2129.704	Durbin-Watson stat	1.254255
p(F-statistic)	0.000000		
Unweighted Statistics			
R-squared	0.989693	Mean dependent var	25367.14
Sum squared resid	7.93E+08	Durbin-Watson stat	0.706025

The main equation of our model, reflecting the estimation conditions for lower GDP per capita, is:

$$\frac{GDP}{capita} = c + \frac{R\&D}{capita} + ELET + \frac{DMC}{capita} + \frac{GHGE}{capita} + MENI + \varepsilon \quad (1)$$

The second equation, reflecting the estimation conditions for higher GDP per capita, is:

$$\frac{GDP}{capita} = c + \frac{R\&D}{capita} + ELET + \frac{DMC}{capita} + \frac{GHGE}{capita} + IFUFE + \varepsilon \quad (2)$$

where GDP/capita is gross domestic product at market prices per capita in euros; R&D/capita is total intramural R&D expenditure in euros per inhabitant; ELET is the labor force quality indicator of early leavers from education and training (% of the population aged 18-24); and the three sustainable economic growth indicators for material consumption, climate and energy, and poverty are, respectively, DMC/capita (domestic material consumption per capita in tons), GHGE/capita (greenhouse gas emissions per capita), and MENI (mean equivalized net income in euros). In the estimation in equation 2, MENI is replaced by the poverty indicator IFUFE (inability to face unexpected financial expenses).

4. Results

The panel least squares method with cross-section weights and fixed cross-section variables (dummy variables) was used for the estimations. We used annual data from the period 2007–2016 for 28 European Union countries with 280 observations. Modeling was done using the Eviews10 program.

The modeling results prove our hypothesis that R&D expenditure has a strong positive impact on GDP growth and a higher impact in well-developed economies under conditions of sustainable economic development and globalization.

When the GDP per capita starting point is 13,075 euros, every euro per capita invested in R&D will increase GDP per capita by 6.6 euros (see equation 3 and the modeling results provided in Table 2).

$$\frac{GDP}{capita} = 13075.31 + 6.5619\frac{R\&D}{capita} - 115.2338\,ELET + 274.2973\frac{DMC}{capita} - 429.8853\frac{GHGE}{capita} + 0.6614MENI + \varepsilon \quad (3)$$

R-squared (R^2) = 0.9964; adjusted *R*-squared (R^2) = 0.9959; D-W = 1.2543.

In addition, the modeling results show a positive impact of labor force quality growth by decreasing the level of early leavers from education and training. The sustainability indicators have a positive impact on economic growth, as the domestic material consumption per capita is in line with the logic that to produce higher gross added value, which is part of GDP and has an impact on GDP growth, more materials could be needed. The other indicator that is important for modeling is greenhouse gas emissions per capita, which has a positive impact on sustainable GDP growth by shrinking the value of GDP per capita growth due to strict European Union policies on environmental protection and reducing greenhouse emissions to slow climate change. The last sustainability indicator—which represents sustainable development of society, the mean equivalized net income poverty indicator—also has a positive impact on economic growth.

The modeling results using equation 2 show the same relationships. However, in this case, we have a GDP level that is twice as high as the starting point of 26,468 euros per capita, and twice the multiplication effect of R&D investment on GDP growth. Every euro per capita invested in R&D will increase GDP per capita by 13.1 euros. The results show that investment in R&D in well-developed EU economies has almost twice the impact on GDP growth in comparison with EU economies in which GDP per capita is around 13 thousand euros.

$$\frac{GDP}{capita} = 26468.35 + 13.0878\frac{R\&D}{capita} - 165.1856\,ELET + 294.5110\frac{DMC}{capita} - 757.6589\frac{GHGE}{capita} - 68.9334\,IFUFE + \varepsilon \quad (4)$$

R-squared (R^2) = 0.9959; adjusted *R*-squared (R^2) = 0.9954; D-W = 1.1334.

As in the first estimation, early leavers from education and training have a positive impact on GDP growth when their numbers are reduced. In addition, domestic material consumption grows when GDP grows. Greenhouse gas emissions per capita decline when GDP grows due to the strict EU rules on environmental protection. The last sustainability indicator in the equation reflects sustainable development of society and has a positive impact on GDP growth by reducing the share of people who are unable to face unexpected financial expenses (see equation 4 and the modeling results provided in Table 3).

Our modeling proved the hypothesis that the multiplication effect of R&D expenditure on economic growth is higher in well-developed economies under conditions of sustainable economic development and globalization and has half the impact on GDP growth in EU economies where the GDP level is near 13 thousand euro per capita in comparison to economies whose GDP starting point is twice as high. In other words, each euro per capita invested in R&D in Bulgaria, Romania, Croatia, Poland, Hungary and Latvia, where GDP per capita is below 13 thousand euros (see Appendix A) will have a high impact on GDP growth (one euro per capita invested in R&D will increase GDP per capita by 6.6 euros), but this will be half the impact of R&D investment in well-developed EU economies where GDP per capita reaches 26,000 euros, such as Italy and France.

5. Conclusions and Discussion

The developed concept of assessing and modeling the impact of R&D investment on economic growth could be successfully used in various analyses of the situation

 DOI: 10.5709/ce.1897-9254.331

Table 3. Review regression estimation: case of higher GDP.

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
C	26468.35	2138.056	12.37964	.0000
R&D/capita	13.08776	1.590171	8.230414	.0000
ELET	-165.1856	24.79300	-6.662588	.0000
DMC/capita	294.5110	25.15382	11.70840	.0000
GHGE/capita	-757.6589	106.0518	-7.144235	.0000
IFUFE	-68.93342	13.31886	-5.175624	.0000
Effects Specification				
Cross-section (dummy variables)	fixed			
Weighted Statistics				
R-squared	0.995929	Mean dependent var	42773.59	
Adjusted R-squared	0.995402	Standard deviation dependent var	26589.12	
Standard error of regression	1616.601	Sum squared resid	6.46E+08	
F-statistic	1888.294	Durbin-Watson stat	1.133436	
p(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.988499	Mean dependent var	25367.14	
Sum squared resid	8.85E+08	Durbin-Watson stat	0.653776	

of the European Union economy. This concept would make it possible to identify in detail and justify innovation activities and R&D investment priorities in accordance with the needs of economic growth and sustainable social, environmental and economic development.

Our modeling under conditions of sustainable economic development and globalization proved the hypothesis that the multiplication effect of R&D expenditure on economic growth is higher in well-developed economies and has half as much impact on GDP growth in EU economies where the GDP level is low (near 13 thousand euros per capita). In other words, each euro per capita invested in R&D in Bulgaria, Romania, Croatia, Poland, Hungary and Latvia (where GDP per capita is below 13 thousand euros) will have a high impact on GDP growth (one euro per capita invested in R&D will increase GDP per capita by 6.6 euros), but this will be half the impact of investment in R&D in well-developed economies where GDP per capita reaches 26 thousand euros, such as Italy and France.

Further research and comprehensive analysis of the processes of R&D investment and an integrated analysis of the processes of economic growth in the European Union are considered important preconditions for solving contemporary problems, enhancing social and economic development, and advancing science and technology.

References

Alexiou, C., Vogiazas, S., & Nellis, J. G. (2018). Reassessing the relationship between the financial sector and economic growth: Dynamic panel evidence. *International Journal of Finance & Economics*, *23*(2), 155–173. https://doi.org/10.1002/ijfe.1609

Armstrong, M. (2006). *A handbook of human resource management practice.* Kogan Page Ltd.

Boldrin, M. & Canova, F. (2001). Inequality and convergence in Europe's regions: reconsidering European regional policies. *Economic Policy*, *16*(32), 206–253.

Bond, E. W., Syropoulos, C., & Winters, L. A. (2001). Deepening of regional integration and multilateral trade agreements. *Journal of International Economics*, *53*(2), 335–361. https://doi.org/10.1016/S0022-1996(00)00064-7

Buede, D.M. & Miller, W.D. (2016). *The engineering design of systems: Models and methods*. John Wiley and Sons, Inc.

Burns, P. (2016*). Entrepreneurship and small business: start-up, growth and maturity.* Palgrave Macmillan.

Calori, R., Atamer, T., & Nunes, P. (2000). *The dynamics of international competition: from practice to theory*. Sage Publications.

Caraballo, M.A., Dabus, C., & Delbianco, F. (2017). Income inequality and economic growth revisited. *Journal of International Development*, *29*, 1025–1029. https://doi.org/10.1002/jid.3300

Carlaw, K.I. & Lipsey, R.G. (2003). Productivity, technology and economic growth: What is the relationship? *Journal of Economic Surveys*, *17*(3), 457–495. https://doi.org/10.1111/1467-6419.00201

Chortareas, G. E. & Pelagidis, T. (2004). Trade flows: a facet of regionalism or globalisation? *Cambridge Journal of Economics*, *28*(2), 253–271. https://doi.org/10.1093/cje/28.2.253

European Commission. (2014). The review of the list of critical raw materials for the EU and the implementation of the raw materials initiative. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0297

Currie, W. (2000). *The global information society*. John Wiley & Sons.

David, P. A. & Foray, D. (2002). An introduction to the economy of the knowledge society. *International Social Science Journal*, *54*(171), 9–23. https://doi.org/10.1111/1468-2451.00355

De Dominicis, L. (2014). Inequality and growth in European regions: Towards a place-based approach. *Spatial economic analysis*, *9*(2), 120–141. https://doi.org/10.1080/17421772.2014.891157

Dell'Anno, R. & Amendola, A. (2015). Social exclusion and economic growth: An empirical investigation in European economies. *The Review of Income and Wealth*, *61*(2), 274-301. https://doi.org/10.1111/roiw.12096

Drews, S., Antal, M., & Van den Bergh, J. C. J. M. (2018). Challenges in assessing public opinion on economic growth versus environment: considering European and US data. *Ecological Economics*, *146*, 265–272. https://doi.org/10.1016/j.ecolecon.2017.11.006

Ein-Dor, P., Myers, M., & Raman, K.S. (2004). IT

industry and the knowledge economy: A four country study. *Journal of Global Information Management*, *12*(4), 23–49. https://doi.org/10.4018/jgim.2004100102

European Commission. (2010). Europe 2020 A strategy for smart, sustainable and inclusive growth. Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

Eurostat. (2016a). Smarter, greener, more inclusive? Indicators to support the Europe 2020 strategy. Luxembourg: *Publications Office of the European Union*.

Eurostat (2016b). Data: GDP per capita, intramural R&D expenditure per capita, intramural R&D expenditure per capita in business enterprise sector, employment rate, early leavers from education and training, tertiary educational attainment, persons with tertiary education and/or employed in science and technology, persons employed in science and technology, patent applications to the EPO, domestic material consumption per capita, greenhouse gas emissions per capita, share of renewable energy in gross final energy consumption, inability to face unexpected financial expenses, and mean equivalized net income; annual European temperature deviation (GISTEMP; from NASA Goddard Institute for Space Studies). Retrieved January 31, 2019, from http://ec.europa.eu/eurostat/data/

Eurostat. (2019a). Energy production and imports data. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports

Eurostat. (2019b). EU imports of energy products - recent developments. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php/EU_imports_of_energy_products_-_recent_developments

Eurostat. (2019c). Labour productivity and unit labour costs. Retrieved from https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_lp_ulc

Eurostat. (2019d). Labour productivity per person employed and hour worked. Retrieved from https://ec.europa.eu/eurostat/databrowser/view/tesem160/default/table?lang=en

Farnsworth, K. (2005). Promoting business-centred welfare: International and European business perspectives on social policy. *Journal of European social policy*, *15*(1), 65–80. https://doi.org/10.1177/0958928705049163

Feng, F. & Ji, X. (2018). An empirical study on economic growth driving forces in onshore area. *Journal of coastal research*, Special Issue, *83*(sp1), 204–211. https://doi.org/10.2112/SI83-032.1

Garrett, G. & Mitchell, D. (2001). Globalization, government spending and taxation in the OECD. *European Journal of Political Research*, *39*(2), 145–177. https://doi.org/10.1111/1475-6765.00573

Ghose, A. K. (2004). Global inequality and international trade. *Cambridge journal of economics*, *28*(2), 229–252. https://doi.org/10.1093/cje/28.2.229

Göransson, B. & Söderberg, J. (2005). Long waves and information technologies—On the transition towards the information society. *Technovation*, *25*(3), 203–211. https://doi.org/10.1016/S0166-4972(03)00115-9

Grace, A. & Butler, T. (2005). Beyond knowledge management: Introducing learning management systems. *Journal of cases on information technology*, *7*(1), 53–70. https://doi.org/10.4018/jcit.2005010104

Hayo, B. & Seifert, W. (2003). Subjective economic well-being in Eastern Europe. *Journal of economic psychology*, *24*(3), 329–348. https://doi.org/10.2139/ssrn.304041

Hofbauer H. (2003). *Ost Erweiterung: vom Drang nach Osten zur peripheren EU-Integration*. Promedia.

Hummels, D., Ishii, J., & Yi, K. M. (2001). The nature and growth of vertical specialization in world trade. *Journal of international economics*, *54*(1), 75–96. https://doi.org/10.1016/S0022-1996(00)00093-3

Hunt, S.D. (2000). *A General theory of competition: resources, competences, productivity.* Sage Publications.

Huseman, R. C. & Goodman, J. P. (1999). T*he emergence and growth of the knowledge economy. Leading with knowledge: the nature of competition in the 21st century.* Sage Publications, Inc. http://dx.doi.org/10.4135/9781452220673

Kim, S. & Shin, E. H. (2002). A longitudinal analysis of globalization and regionalization in international trade: A social network approach. *Social*

Forces, *81*(2), 445–468. https://doi.org/10.1353/sof.2003.0014

Krugman, P. & Obstfeld, M. (1997). *International Economics.* Addison Wesley Longman.

Leydesdorff, L. (2004). The university–industry knowledge relationship: Analyzing patents and the science base of technologies. *Journal of the association for information science and technology*, *55*(11), 991–1001. https://doi.org/10.1002/asi.20045

Liu, X., Wen, T., Liu, S., & Zhong, X. (2019). Evaluating economic growth efficiency and its determinants under low carbon economy in the Chinese context. *Applied ecology and environmental research*, *17*(3), 6429–6444. http://dx.doi.org/10.15666/aeer/1703_64296444

Melnikas, B. (2011). *Transformacijų visuomenė: ekonomika, kultūra, inovacijos, internacionalizavimo procesai [Transformation society: Economy, culture, innovation, internationalization processes.].* Technika.

Melnikas B. (2013*). Žiniomis grindžiamos visuomenės kūrimas: globalizacija, darni plėtra, ekonominiai sprendimai [Building a knowledge society: globalization, sustainable development, economic solutions]*. Vilniaus universiteto leidykla.

Melnikas, B. (2017). Development of global economy and international business: New network and networking ideas. *International Business and Global Economy*, *36,* 21–30. https://doi.org/10.4467/23539496IB.17.001.7449

Melnikas, B. & Reichelt, B. (2004). *Wirtschaft und Mentalitaet: Tendenzen der EU-Osterweiterung [Economy and Mentalities: Tendencies of the EU Enlargement].* Leifim–Verlag.

Mougayar, W. (2016). *The Business blockchain: promise, practice, and application of the next internet technology.* John Wiley & Sons, Inc.

Olsen, T. E. & Osmundsen, P. (2003). Spillovers and international competition for investments. *Journal of international economics*, *59*(1), 211–238. https://doi.org/10.1016/S0022-1996(02)00086-7

Ott, I. & Soretz, S. (2018). Green attitude and economic growth. *Environmental and resource economics 70*(4), 757–779. https://doi.org/10.1007/s10640-016-0061-z

Ouyang, X., Shao, Q., Zhu, X., He, Q., Xiang, Ch. & Wei, G. (2019). Environmental regulation, economic growth and air pollution: Panel threshold analysis for OECD countries. *Science of the total environment, 657*, 234–241. https://doi.org/10.1016/j.scitotenv.2018.12.056

Perraton, J. (2001). The global economy—myths and realities. *Cambridge journal of economics*, *25*(5), 669–684. https://doi.org/10.1093/cje/25.5.669

Rosenzweig, P. M. (2001). *Accelerating international growth.* John Wiley & Sons, Inc.

Spetzler, C., Winter, H., & Meyer, J. (2016). *Decision quality: value creation from better business decision*. John Wiley & Sons, Inc.

Steinmueller, W. E. (2002). Knowledge-based economies and information and communication technologies. *International social science journal*, *54*(171), 141–153. https://doi.org/10.1111/1468-2451.00365

The World Bank database, Indicator: GINI index. https://data.worldbank.org/indicator/SI.POV.GINI

Tomaselli, M. F., Sheppard, S. R. J., Kozak, R. & Gifford, R. (2019). What do Canadians think about economic growth, prosperity and the environment? *Ecological Economics*, *161*, 41–49. https://doi.org/10.1016/j.ecolecon.2019.03.007

Voudouris, V., Ayres, R., Serrenho, A. C. & Kiose, D. (2015). The economic growth enigma revisited: The EU-15 since the 1970s. *Energy Policy*, *86,* 812–832. https://doi.org/10.1016/j.enpol.2015.04.027

Appendix

Table A. Statistical data used for modeling .

Country	Year	GDP/ capita (in EUR)	R&D/ capita (in EUR)	ELET (% of the population aged 18-24)	DMC/ capita (in tons)	GHGE/ capita (in units of CO2 equivalents)*	MENI (in euros per person in household)	IFUFE (% of persons in the total population)
Belgium	2007	32400	600.6	12.1	16.9	13.5	19143	20.9
	2008	33100	638.7	12.0	16.8	13.4	19986	23.9
	2009	32300	644.0	11.1	15.1	12.1	21002	23.8
	2010	33500	690.7	11.9	15.1	12.6	21353	25.4
	2011	34500	742.8	12.3	15.8	11.5	21628	26.1
	2012	35000	795.3	12.0	14.1	11.1	21897	25.2
	2013	35300	822.1	11.0	13.6	11.0	23279	24.2
	2014	35800	854.3	9.8	13.1	10.5	23429	24.0
	2015	36600	900.4	10.1	12.9	10.8	23673	25.7
	2016	37600	955.6	8.8	12.9	10.6	24256	25.9
Bulgaria	2007	4200	18.4	14.9	18.8	9.1	1721	79.2
	2008	4900	22.2	14.8	20.4	9.0	2662	57.4
	2009	4900	24.7	14.7	16.4	7.8	3278	58.4
	2010	5100	29.0	12.6	16.3	8.3	3498	65.0
	2011	5600	29.8	11.8	18.2	9.0	3429	65.3
	2012	5700	34.6	12.5	17.6	8.4	3276	68.6
	2013	5800	36.6	12.5	17.1	7.7	3509	64.1
	2014	5900	46.9	12.9	18.8	8.2	3907	49.6
	2015	6300	60.4	13.4	21.3	8.7	4093	53.4
	2016	6800	52.5	13.8	18.9	8.4	3857	54.2
Czechia	2007	13400	175.6	5.2	19.1	14.8	6148	38.5
	2008	15500	193.3	5.6	18.6	14.2	6810	37.9
	2009	14200	184.6	5.4	16.9	13.3	8262	37.9
	2010	14900	200.3	4.9	16.0	13.5	7981	37.9
	2011	15600	243.4	4.9	16.9	13.3	8440	40.4
	2012	15400	273.9	5.5	15.0	12.9	8765	42.4
	2013	15000	285.0	5.4	14.8	12.4	8695	41.7
	2014	14900	294.0	5.5	15.2	12.2	8600	40.8
	2015	16000	308.4	6.2	15.9	12.3	8345	36.0
	2016	16700	280.8	6.6	15.6	12.4	8808	32.1
Denmark	2007	42700	1077.7	12.9	28.4	13.2	25113	18.7

Denmark	2008	44000	1223.8	12.5	27.0	12.4	26030	24.4
	2009	41900	1282.0	11.3	22.5	11.8	25897	25.6
	2010	43800	1281.6	11.0	21.0	11.8	26915	23.7
	2011	44500	1312.7	9.6	23.3	10.8	29347	24.2
	2012	45500	1360.0	9.1	23.3	10.0	29690	27.3
	2013	46100	1371.8	8.0	21.9	10.2	30082	27.0
	2014	47100	1376.2	7.8	21.9	9.5	31108	28.5
	2015	48000	1473.7	7.8	22.6	8.9	31518	26.5
	2016	49200	1534.2	7.2	23.8	9.3	32141	24.5
Germany	2007	30900	747.1	12.5	16.3	12.1	20270	36.5
	2008	31500	810.0	11.8	16.2	12.2	21086	34.9
	2009	30400	818.0	11.1	15.4	11.4	21223	34.6
	2010	31900	855.9	11.8	15.5	11.8	21470	33.7
	2011	33600	942.0	11.6	17.0	11.8	21549	34.5
	2012	34100	984.8	10.5	16.4	11.8	22022	33.4
	2013	34900	990.1	9.8	16.3	12.0	22471	32.9
	2014	36100	1043.1	9.5	16.8	11.5	22537	32.6
	2015	37100	1093.4	10.1	15.6	11.4	23499	30.4
	2016	38100	1121.7	10.3	15.7	11.4	24020	30.0
Estonia	2007	12100	129.3	14.4	29.0	16.7	5304	22.2
	2008	12300	155.4	14.0	26.3	15.1	6333	19.7
	2009	10600	147.8	13.5	24.7	12.6	7207	29.6
	2010	11000	174.6	11.0	25.0	16.0	6782	43.6
	2011	12500	289.1	10.6	26.9	16.1	6570	44.7
	2012	13500	287.3	10.3	27.0	15.4	7119	44.7
	2013	14300	247.0	9.7	28.8	16.8	7846	41.9
	2014	15200	217.9	12.0	28.3	16.2	8820	39.1
	2015	15700	230.3	12.2	27.0	13.9	9490	36.7
	2016	16500	205.4	10.9	26.8	15.1	10102	31.6
Ireland	2007	44800	560.4	12.0	41.2	16.2	25988	39.1
	2008	41800	584.5	11.7	35.5	15.6	26809	41.0
	2009	37500	605.0	11.8	26.9	14.1	25635	48.6
	2010	36800	586.8	11.9	22.9	13.9	23965	49.1
	2011	37300	583.2	11.1	21.4	12.9	22886	54.4
	2012	38100	595.7	9.9	19.6	12.9	22781	56.4
	2013	38900	610.3	8.7	21.6	12.9	23392	55.3
	2014	41900	629.9	6.7	20.6	12.7	23723	54.5
	2015	56000	669.8	6.8	20.6	13.1	24837	50.0

DOI: 10.5709/ce.1897-9254.331

Ireland	2016	57200	686.2	6.0	22.0	13.4	25586	45.2
Greece	2007	21100	121.6	14.3	22.2	12.5	12130	29.6
	2008	21800	144.8	14.4	21.0	12.2	12766	26.6
	2009	21400	133.9	14.2	17.8	11.5	13505	26.6
	2010	20300	121.6	13.5	15.9	10.9	13974	28.2
	2011	18600	125.1	12.9	14.3	10.6	12626	34.4
	2012	17300	120.7	11.3	13.2	10.4	10676	40.5
	2013	16500	133.2	10.1	12.3	9.6	9303	47.1
	2014	16400	136.2	9.0	12.7	9.4	8879	51.8
	2015	16400	156.9	7.9	12.2	9.1	8683	53.4
	2016	16400	162.7	6.2	11.5	8.8	8673	53.6
Spain	2007	23900	297.9	30.8	20.6	10.1	13266	30.8
	2008	24300	321.9	31.7	17.7	9.2	16190	29.9
	2009	23300	315.4	30.9	14.3	8.3	17042	36.5
	2010	23200	313.8	28.2	12.6	7.9	16922	38.7
	2011	22900	303.9	26.3	11.1	7.9	16280	37.7
	2012	22200	286.0	24.7	8.8	7.8	16119	42.1
	2013	22000	278.5	23.6	8.3	7.2	15635	42.1
	2014	22300	275.6	21.9	8.4	7.3	15405	42.7
	2015	23300	283.6	20.0	8.8	7.6	15408	39.8
	2016	24100	285.5	19.0	8.6	7.4	15842	38.7
France	2007	30300	617.5	12.8	14.3	8.6	18383	34.5
	2008	31000	641.6	11.8	13.9	8.5	22462	34.1
	2009	29900	665.7	12.4	12.4	8.1	23191	32.5
	2010	30700	672.3	12.7	12.1	8.1	23421	33.0
	2011	31500	694.3	12.3	12.4	7.7	23882	33.0
	2012	31800	712.6	11.8	12.0	7.7	24499	33.0
	2013	32100	722.0	9.7	12.0	7.6	24713	34.0
	2014	32400	726.7	8.8	11.7	7.1	24612	33.4
	2015	33000	750.0	9.2	11.1	7.2	24982	32.8
	2016	33400	750.8	8.8	10.9	7.2	25278	31.8
Croatia	2007	10200	80.7	4.5	13.6	7.4	6291**	60.8**
	2008	11200	98.7	4.4	15.6	7.2	6401**	61.3**
	2009	10500	88.3	5.2	12.3	6.7	6512**	61.8**
	2010	10500	77.9	5.2	10.4	6.6	6622	62.3
	2011	10500	78.4	5.0	10.3	6.6	6217	64.4
	2012	10300	77.2	5.1	9.4	6.1	5988	67.4
	2013	10300	83.2	4.5	10.0	5.9	5817	65.1

Croatia	2014	10300	80.0	2.8	9.1	5.7	5799	63.7
	2015	10600	88.7	2.8	9.7	5.8	6070	59.8
	2016	11200	96.0	2.8	10.1	5.9	6337	57.7
Italy	2007	27400	313.1	19.5	14.2	9.8	17314	32.2
	2008	27600	323.8	19.6	13.7	9.5	17711	31.9
	2009	26400	325.6	19.1	12.3	8.5	17983	33.4
	2010	26800	331.6	18.6	11.5	8.7	18221	33.8
	2011	27300	333.7	17.8	11.1	8.5	18149	38.2
	2012	26700	345.2	17.3	9.5	8.1	18267	42.1
	2013	26500	351.6	16.8	8.3	7.5	17932	40.2
	2014	26700	358.3	15.0	7.8	7.2	17914	38.8
	2015	27200	364.5	14.7	8.3	7.3	17890	39.9
	2016	27900	382.0	13.8	8.1	7.3	18286	40.4
Cyprus	2007	22900	92.9	12.5	27.3	14.0	18565	42.0
	2008	24200	94.5	13.7	40.1	13.8	18571	40.1
	2009	23100	104.1	11.7	30.7	13.1	19103	41.3
	2010	23300	105.2	12.7	27.8	12.4	18929	49.9
	2011	23200	107.0	11.3	26.6	11.7	19621	52.9
	2012	22600	99.0	11.4	19.2	10.9	20218	50.5
	2013	21000	101.0	9.1	13.9	10.0	19426	54.3
	2014	20700	104.3	6.8	14.0	10.6	18418	59.8
	2015	20900	100.7	5.2	14.2	10.7	16944	60.5
	2016	21700	116.5	7.6	15.7	11.3	16943	56.6
Latvia	2007	10300	56.9	15.6	15.0	5.7	4080	61.3
	2008	11200	64.6	15.5	13.5	5.6	5798	57.0
	2009	8800	39.2	14.3	8.2	5.4	6479	71.4
	2010	8500	51.2	12.9	9.5	6.0	5466	78.1
	2011	9800	67.8	11.6	11.2	5.8	5131	80.4
	2012	10800	71.7	10.6	11.4	5.8	5463	73.6
	2013	11300	69.1	9.8	12.4	5.8	5732	69.5
	2014	11800	81.3	8.5	12.0	5.8	6324	67.4
	2015	12300	76.6	9.9	13.0	5.9	6970	60.4
	2016	12800	56.1	10.0	11.6	6.0	7526	60.0
Lithuania	2007	9000	71.6	7.8	15.1	7.9	3938	42.4
	2008	10200	80.2	7.5	16.2	7.7	4902	40.1
	2009	8500	70.2	8.7	11.0	6.3	5843	53.3
	2010	9000	69.9	7.9	12.4	6.7	4975	62.3
	2011	10300	92.6	7.4	13.8	7.1	4503	61.3

DOI: 10.5709/ce.1897-9254.331

Lithuania	2012	11200	99.3	6.5	12.8	7.2	5124	60.4
	2013	11800	111.9	6.3	15.7	6.8	5648	56.9
	2014	12500	128.0	5.9	14.8	6.9	5975	54.7
	2015	12900	133.4	5.5	15.0	7.0	6558	53.2
	2016	13500	113.4	4.8	15.7	7.1	7033	53.2
Luxem-bourg	2007	77300	1242.4	12.5	26.5	28.2	34223	21.5
	2008	77900	1279.0	13.4	22.7	27.5	35448	19.6
	2009	74200	1256.9	7.7	21.8	25.8	36475	25.4
	2010	79200	1202.4	7.1	21.6	26.5	36410	24.4
	2011	83100	1233.6	6.2	21.0	25.6	36662	23.0
	2012	83000	1069.6	8.1	20.3	24.3	36925	24.8
	2013	85300	1127.9	6.1	20.8	22.7	38442	23.8
	2014	89200	1145.8	6.1	21.3	21.5	38555	23.8
	2015	90600	1176.5	9.3	24.0	20.4	39707	23.0
	2016	91300	1198.1	5.5	23.9	19.8	39415	21.9
Hungary	2007	10200	97.1	11.4	11.8	7.3	4363	67.0
	2008	10800	105.4	11.7	13.3	7.1	4827	67.6
	2009	9400	106.4	11.5	10.7	6.5	5201	75.2
	2010	9900	112.4	10.8	9.8	6.6	4631	73.9
	2011	10200	120.6	11.4	9.9	6.4	5055	74.4
	2012	10000	126.6	11.8	8.7	6.1	5250	75.0
	2013	10300	142.8	11.9	10.0	5.8	5027	74.9
	2014	10700	144.7	11.4	12.9	5.9	5124	75.9
	2015	11300	153.3	11.6	12.7	6.2	5165	72.2
	2016	11600	139.5	12.4	12.2	6.3	5396	50.8
Malta	2007	14200	77.9	30.2	8.8	8.2	10200	33.7
	2008	15000	80.1	27.2	7.7	8.2	11165	32.8
	2009	14900	77.3	25.7	8.2	7.6	11866	29.4
	2010	15900	96.7	23.8	7.0	7.8	11794	28.2
	2011	16400	111.0	22.7	9.1	8.0	12097	27.2
	2012	17100	141.9	21.7	10.3	8.3	12663	25.0
	2013	17900	139.8	20.8	8.9	7.5	13438	23.0
	2014	19600	141.0	20.9	11.9	7.4	14315	24.6
	2015	21700	162.6	20.2	13.7	5.7	15172	21.4
	2016	22700	130.3	19.2	13.7	5.0	15505	20.8
Nether-lands	2007	37800	632.2	11.9	11.7	13.4	20809	21.3
	2008	39400	640.2	11.4	12.4	13.3	22303	19.4
	2009	37800	631.3	11.3	11.6	12.8	22790	18.7

Nether-lands	2010	38500	657.1	10.1	11.5	13.5	22692	22.2
	2011	39000	734.6	9.2	11.2	12.6	22556	21.7
	2012	39000	747.9	8.9	10.7	12.3	22951	22.0
	2013	39300	759.6	9.3	10.1	12.3	23125	23.4
	2014	39800	788.4	8.7	10.3	11.8	23190	23.7
	2015	40700	810.4	8.2	11.0	12.2	23925	22.9
	2016	41600	833.0	8.0	9.9	12.2	25366	22.5
Austria	2007	34200	829.1	10.8	21.4	10.8	20342	28.7
	2008	35300	908.5	10.2	20.3	10.7	21681	28.7
	2009	34500	897.4	8.8	18.9	9.9	22756	24.4
	2010	35400	965.9	8.3	19.2	10.4	23576	25.0
	2011	37000	988.2	8.5	20.3	10.1	23922	23.6
	2012	37800	1104.6	7.8	19.3	9.7	24423	22.2
	2013	38200	1132.4	7.5	18.8	9.7	24366	23.2
	2014	39000	1207.7	7.0	18.6	9.2	26080	23.9
	2015	39900	1223.0	7.3	18.2	9.4	25958	22.6
	2016	40800	1279.6	6.9	19.0	9.4	26054	22.6
Poland	2007	8200	46.3	5.0	16.5	11.0	4150	54.4
	2008	9600	57.6	5.0	16.9	10.8	4940	50.7
	2009	8200	55.0	5.3	16.2	10.3	5984	50.0
	2010	9400	68.6	5.4	17.0	10.9	5116	50.6
	2011	9900	74.5	5.6	21.0	10.8	5813	51.2
	2012	10100	90.1	5.7	18.3	10.6	5902	54.1
	2013	10300	90.3	5.6	17.3	10.6	5976	50.5
	2014	10700	101.6	5.4	17.2	10.2	6163	48.6
	2015	11200	113.6	5.3	16.9	10.3	6376	42.3
	2016	11100	108.3	5.2	17.7	10.6	6659	37.9
Portugal	2007	16600	187.3	36.5	21.2	7.7	9929	19.7
	2008	16900	245.0	34.9	22.2	7.5	10288	26.2
	2009	16600	262.4	30.9	20.0	7.2	10393	27.8
	2010	17000	260.8	28.3	18.6	6.8	10540	27.2
	2011	16700	242.7	23.0	17.3	6.7	10407	29.1
	2012	16000	220.1	20.5	15.9	6.5	10227	35.9
	2013	16300	215.4	18.9	14.0	6.4	9899	43.2
	2014	16600	214.1	17.4	14.8	6.4	9856	42.2
	2015	17400	215.4	13.7	15.0	6.9	9996	40.7
	2016	18100	231.0	14.0	14.9	6.7	10562	38.3
Romania	2007	6100	30.9	17.3	20.5	7.4	1940	46.2

DOI: 10.5709/ce.1897-9254.331

Romania	2008	7100	39.2	15.9	22.2	7.3	2318	41.9
	2009	6100	27.2	16.6	17.4	6.4	2524	41.6
	2010	6200	28.2	19.3	13.7	6.1	2371	44.8
	2011	6500	32.5	18.1	19.0	6.4	2401	50.8
	2012	6600	32.1	17.8	18.0	6.3	2356	53.9
	2013	7200	27.9	17.3	18.0	5.8	2324	53.0
	2014	7600	28.8	18.1	18.8	5.9	2443	52.7
	2015	8100	39.4	19.1	22.5	5.9	2674	51.4
	2016	8600	41.4	18.5	22.9	5.8	2746	54.5
Slovenia	2007	17400	249.0	4.1	23.7	10.4	10724	41.6
	2008	18800	306.9	5.1	20.8	10.7	11709	44.5
	2009	17700	323.2	5.3	17.0	9.6	12743	40.6
	2010	17700	364.4	5.0	16.0	9.6	12653	45.1
	2011	18000	436.2	4.2	14.4	9.6	12885	46.7
	2012	17500	451.6	4.4	12.5	9.3	12972	45.7
	2013	17600	454.1	3.9	12.2	8.9	12706	45.8
	2014	18200	431.9	4.4	13.1	8.1	12843	45.8
	2015	18800	413.5	5.0	13.3	8.2	13211	42.9
	2016	19500	393.4	4.9	12.8	8.6	13193	41.7
Slovakia	2007	10400	46.9	6.5	14.0	9.2	4378	43.3
	2008	12200	56.7	6.0	15.4	9.3	5180	38.5
	2009	11800	56.3	4.9	13.6	8.5	6290	36.0
	2010	12400	77.2	4.7	13.3	8.6	6785	38.2
	2011	13100	86.9	5.1	13.5	8.5	6979	35.8
	2012	13400	108.3	5.3	11.9	8.0	7556	36.1
	2013	13700	112.9	6.4	11.4	7.9	7266	39.5
	2014	14000	123.6	6.7	12.6	7.5	7484	38.9
	2015	14600	171.0	6.9	12.7	7.7	7293	36.7
	2016	15000	118.1	7.4	13.4	7.8	7391	37.9
Finland	2007	35300	1183.0	9.1	38.8	15.4	20787	30.2
	2008	36500	1296.3	9.8	39.0	13.8	22008	29.7
	2009	33900	1274.1	9.9	32.0	13.0	23119	29.7
	2010	34900	1302.7	10.3	34.4	14.4	23528	28.1
	2011	36500	1332.7	9.8	34.6	13.0	24150	27.4
	2012	36900	1264.9	8.9	33.1	11.9	25148	27.9
	2013	37400	1231.7	9.3	37.3	11.9	25901	27.5
	2014	37600	1194.6	9.5	31.0	11.1	26130	27.2
	2015	38300	1109.5	9.2	30.5	10.4	26240	28.4

Finland	2016	39300	1080.0	7.9	31.5	10.9	26379	29.4
Sweden	2007	39000	1273.7	8.0	22.9	7.3	20178	18.0
	2008	38300	1341.0	7.9	22.7	7.1	21544	21.3
	2009	33300	1154.1	7.0	19.6	6.5	22050	21.3
	2010	39400	1270.8	6.5	22.1	7.1	20070	18.8
	2011	42900	1397.4	6.6	23.1	6.6	23001	19.4
	2012	44500	1464.9	7.5	22.8	6.2	25353	20.7
	2013	45400	1507.6	7.1	23.3	6.0	27094	21.0
	2014	44700	1411.3	6.7	23.6	5.8	27935	20.4
	2015	45800	1504.3	7.0	23.1	5.7	27218	19.8
	2016	46700	1537.0	7.4	23.4	5.6	27347	20.7
United kingdom	2007	36700	598.1	16.6	11.7	11.5	24823	26.6
	2008	32100	523.0	16.9	10.9	11.1	22805	28.6
	2009	27700	467.9	15.7	9.5	10.1	19391	31.1
	2010	29500	491.6	14.8	9.2	10.2	20517	34.7
	2011	29900	500.6	14.9	9.2	9.4	20788	36.7
	2012	32800	524.5	13.4	8.8	9.6	22395	42.9
	2013	32400	532.0	12.4	8.9	9.3	21654	41.1
	2014	35400	589.9	11.8	9.1	8.6	24136	39.0
	2015	40100	671.7	10.8	9.0	8.3	25022	38.4
	2016	36600	618.3	11.2	8.7	7.9	24602	38.0

Source: prepared by authors using Eurostat data.
* This indicator shows trends in man-made emissions of the 'Kyoto basket' of greenhouse gases. The 'Kyoto basket' of greenhouse gases includes: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and the so-called F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride (NF3) and sulphur hexafluoride (SF6)). These gases are aggregated into a single unit using gas-specific global warming potential (GWP) factors. The aggregated greenhouse gas emissions are expressed in units of CO2 equivalents.
** Estimated by authors.

 DOI: 10.5709/ce.1897-9254.331