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The fundamentals of innovativeness – a comparative analysis of European Union countries

Abstract

Innovativeness is one of the key determinants of total output and welfare used by contemporary economists to measure economic performance. The aim of the article is to assess the position of European Union (EU) countries in terms of selected indicators characterizing their potential for innovativeness. This paper proposes the application of taxonomic tools for the study of the differentiation within the level of fundamentals of innovativeness in EU countries on the basis of the chosen model.

Keywords: innovativeness, innovations, productivity, economic growth, the European Union, linear method ordering.
JEL Classification: O310, 0400, O520, C430.

Introduction

Much of empirical and theoretical research work in the field of economic growth has been concerned with answering the question that explains differences in levels and rates of change in productivity among countries. For economists, one of the most commonly appreciated factors driving growth is innovativeness. The existing correlation between both phenomena has an impact on strategies of development created by most countries – it is desirable that their economies are innovative. A similar tendency is clearly observed in the European Union. The main reason for the want of Europe to become a smart and innovative economy (declared in the Europe 2020 strategy) is that the last crisis has made the task of securing future economic growth much more difficult whereas realities are mov-

ing faster and faster. Since the beginning of its function the EU has faced many challenges. There has been an ongoing saga of competition with the United States and Japan, and nowadays new players have appeared on the global stage, namely emerging markets such as China and India.

The economies of EU countries are increasingly interlinked, thus performances of the whole group are determined by achievements on national levels. The debate between economists, journalists and politicians over this topic has been fuelled by controversy connected with the diversity among the Member States (the MS). Sometimes it is imputed that the so-called "New Union" (the EU-12 or the EU-13 including Croatia) falls behind in many fields and suffer from institutional deficiencies and from a lack of the factors urgently in demand for the process of building an innovative economy (Pinder, Usherwood 2009, p. 137; Grosse 2007, pp. 30-31). Allegedly, it has a negative influence on the performances of the EU considered as a whole.

The main priority of this paper is to evaluate the fundamentals of innovativeness of EU countries. According to the hypothesis, the duration of membership in the EU does not expressly determine the innovativeness of the particular Member States. Thus, the hypothesis deflates the imputation mentioned above. The article has been structured into five parts. After the introduction, the opening part first provides a concise overview of the key definitions. This is followed by a character sketch of the relationship between innovativeness and economic growth indicated by theorists of economics. The main fundamentals of innovativeness are discussed in the second section. The final section (three) presents results based on calculations which show how successful EU members are in terms of building up the fundamentals of innovativeness. The analysis is completed by the display of the main findings leading to the conclusion of the article.

1. Economic growth and innovativeness

Gross Domestic Product (GDP) per capita measures both the output and income generated from the goods and services produced, on average, per head in a given year. It is commonly used to compare output across countries and continues to be regarded as the best proxy of a country's level of welfare. An argument supported especially by trickle-down theorists is that countries with higher levels of GDP per head are more advanced, comparatively better developed and, as a result, should also enjoy higher levels of welfare, income and better standards of living (Cotis 2005). As a result, a process of economic growth is the desired phenomenon. It is defined and measured by the increase in GDP or GDP

per capita or, alternatively, by the average increase in output per worker employed or man-hour worked (average productivity of labor). In the short run, there is little difference between the alternative groups of indicators, although they may diverge in the long run. The productivity of labor to some extent abstracts from cyclical changes (only labor that is engaged is counted) and is therefore a better indicator. In addition, this measure gives a better impression of long-run growth because it allows for the shortening of the workweek. When an economy gets richer, households consume some of their incomes in the form of leisure. Hence, output per man-hour worked will rise faster than total output or per capita output (Haberler 1974, pp. 16-17).

A process of economic growth can be described as balanced (steady, proportional) if certain key ratios mentioned above remain constant over time (Woźniak 2008). The fact of technological innovation, by which some input disappears and new types come into play, means that the growth paths real economies follow are unbalanced. For example, Kondratieff's waves refer to possible bursts of innovation activity and growth some 50-60 years apart (Rostow 1990, pp. 306-308) – though in contemporary times such waves would be only relatively small fluctuations on the surface of a wave of the world's innovation activity.

Renewal and reorganization of production is normally accompanied by the destruction of old product lines, organizations and institutions. This "cleaning up" is essential for growth and is called "creative destruction". According to the author of this well-known concept, J.A. Schumpeter, the driving force behind progress is the entrepreneur with an idea for a new product or a new way to produce an old good. It follows that innovation should be understood to mean both an act of qualitative change in an economy when a new product (process) starts to be produced (used), and the product (process) itself. When the entrepreneur's firm enters the market, it has some degree of monopoly power over its innovation; indeed, it is this prospect of monopoly profits that motivates the entrepreneur. The entry of the company is positive for consumers having an expanded range of choices, but it can be harmful for incumbent producers, who may find it hard to compete with the entrant. Over time, the process keeps renewing itself. The entrepreneur's firm becomes an incumbent, enjoying high profitability until its product is displaced by another entrepreneur with the next generation of innovation (Screpanti, Zamagni 2005, pp. 262-266).

The one who found Schumpeter's theory of innovations invalid was S. Kuznets. Kuznets could not understand why innovations necessarily had to come in "swarms" and they could not equally well come in a continuous stream. He also found Schumpeter's empirical proof for Kondratieff waves unconvincing (Swedberg 1991, p. 58). Not even trying to judge this disputation, one may say

that Kuznet's reproach does not challenge the correlation between innovations and economic growth – quite the contrary and it is relatively easy to prove. Every innovation is preceded by an invention which in its first prototype version usually undergoes a lengthy and costly process of improvement before it is ready for commercial application. An invention may never be adopted by producers (inventors take risks connected with costs, time, energy, etc. and then may face failure), but when it is implemented an innovation takes place (Gomulka 1990, p. 11). Kuznets claims that innovations breed other innovations because one innovation may raise the economic payoff to the introduction of another, bringing those which are known to be technically feasible but economically unattractive to the point of adoption (Kuznets 1972, pp. 437-438). The whole process may boost productivity and growth.

Schumpeter's vision, though criticized, has inspired some recent work in the theory of economic growth. P.S. Segerstrom, D.C.A. Anant and E. Dinopoulos (1990) presents a model of North-South trade in which research and development races between firms determine the rate of innovation in the North. One line of endogenous growth theory, pioneered by Ph. Aghion and P. Howitt (1990), builds on Schumpeter's insights by modelling technological advances as a process of entrepreneurial innovation and creative destruction. A list of names of economists inspired by Schumpeter is indubitably long (Kozłowska 2010, pp. 23-71). In view of this, it is worth noting that the first observer of links between inventive activity and economic forces is not Schumpeter, nor Kondratieff but Ch. Babbage. He claims that a firm would invest in those technological improvement activities that offered the highest payoff in terms of costs reduction. Babbage also suggests a highly valuable research project on the relationship between market glut and technological improvement (Rosenberg 1994, pp. 32-33). Thus, born in 1791 an English polymath can be perceived as a pioneer economist in the fields of innovations.

In spite of the differences in assumptions, premises and approaches supplied by theory of economics, the full panoply of existing theories and models shares one common feature, namely emphasizing the positive implications of innovation for growth.

2. The fundamentals of innovativeness

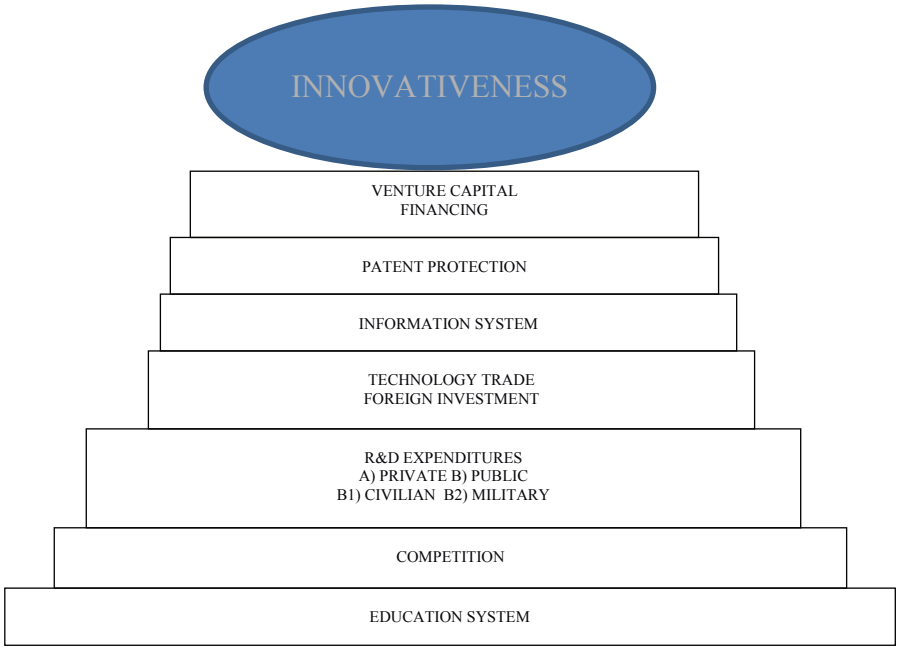
Economics is not an exact science and the eternal problem is that no one knows exactly how the variables are related. Instead, there exist a number of models that try to explain various observations and relationships between variables. The additional dilemma is that not everything can be measured or estimated. For example, the growth of technological knowledge and the speed at which

improved methods of production and new goods are invented and introduced involve complicated social processes which transcend the realm of economics. They have their roots in mental attitudes and beliefs, and are conditioned by social developments. It implicates that every model has flaws which are unavoidable. Nevertheless, some models assist in the understanding of economic reality and conclusions on the basis of them may offer some solutions to economic politicians. The idea presented below seems to be one of these concepts.

The group of economists (Welfens et al. 1999) points out that the phenomenon of innovativeness cannot exist without its fundaments. Cornerstones are always indispensable (literally and figuratively), but especially when reality teeters and changes. These words seem to be symptomatic nowadays, when some economies (including the European ones), still struggle with turbulences and the consequences of the last crisis which, as indicated in the current EU's strategy Europe 2020: "has wiped out recent progress", "has made the task of securing future economic growth much more difficult" and "halved our growth potential" (European Commission 2010). It suggests that some fundamentals in the EU economy might have been not solid enough.

The formulated concept by the authors mentioned above is shown in Figure 1.

Figure 1. Fundamentals of innovativeness



Source: Welfens et al. (1999, p. 153).

One may say that the presence of foundations presented in Figure 1 create a propitious environment for innovativeness. It means that fundamentals do not inform about the level of innovativeness and do not preordain that new products or new ways of production will inevitably appear, but without these preconditions innovations will not have a chance to develop or be introduced. In other words, the fundamentals are purely "sine qua non".

According to the presented concept, the crucial basis for innovations and their diffusion is a modern education system which allows the number of skilled workers, engineers and managers to increase. The term "diffusion" refers essentially to the spread in space or acceptance in a human environment of some specific item or pattern. Education in schools and universities is only one aspect, whereas retraining and training are also indispensable considering that qualifications often fail to match labor market needs. How does the data for the whole EU refer to raised issues? For the time being, some 25% of European school children have poor reading skills, too many young people drop out of school leaving them without qualifications and under a third of Europeans aged 25-34 have a university degree – considering 40% in the US and over 50% in Japan (Europe 2020 in a nutshell). It does not look promising given that the education system is the first of the fundamentals and the basis for the rest of them.

Competition is a progenitor of economic change and a process driven by rivalrous behavior. One of the interesting features of increased competition is its dynamic being a matter of innovation and adaptation on various levels (micro-micro, micro, mezzo and macro). F. Knight makes the point that participation in business is stimulated not simply by the desire to satisfy wants but by the desire for action: the search for achievement and the satisfaction derived from participation (Metcalfe 2000, p. 19). The increasing level of globalization over the past twenty years has led to the situation of a more open economic playing field stimulating an innovative approach. Gaining, keeping and enhancing a competitive position of any subject requires the ability to think strategically and the Union economies are no exception. Actually, one of the wake-up calls for the EU was the fact that emerging markets are investing heavily into research as well as technology in order to "leapfrog" into the global economy and they are successful in this field. This fact is also highlighted in the contents of the Europe 2020 strategy.

Research and experimental development (R&D), the following fundamentals of innovativeness comprise "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications" (Frascati Manual 2002, § 63). "Creativity" seems to be a key to innovativeness given the popularity of the notion of "creative" destruction. Moreover,

discussing about economies and their sectors, M. Porter claims that competitiveness understood as productivity is never inherited but always created, what suggests a kind of research and creative action which must be permanently taken (1998, pp. 71-81). Tracing this way of thinking, the EU's comparative lower growth seems to be largely due to a productivity gap caused partly by lower levels of investment in R&D. The forces of globalization and the mentioned competition dictate that European R&D policy needs to shift away from mature industries and towards new industries. Combined public and private investment levels should reach 3% of the EU's GDP within 2020 as well as better conditions for R&D and innovation must be provided (currently it is about 2,65%-2,72%, Europe 2020 in a nutshell).

Another stage in the presented scheme is technology trade and foreign investments. "Technology" is usually understood as science application know-how, it can also be embodied and transferred in products. Thus, free trade is considered to be the natural way for expanding knowledge and prosperity. In the context of the process of imitation and catching-up, the trade in high-tech goods has a crucial meaning. Rising foreign direct investment can also stimulate growth to the extent that it contributes to technology spillover, improves use of know-how and a higher investment output ratio as well as a higher marginal product of capital. The EU is considered as the region open for flows of goods, services and capital and all of the states are the common market. It means that Europe, the world's largest trading bloc, has huge innovation potentiality.

The next fundamental of innovativeness is information system. The telecommunications revolution has drastically reduced the cost of transmitting information across geographic space, it has also played a hand in shaping contemporary societies. The information system of a society is crucial for innovation as well as the diffusion process. With advanced communication networks there are abundant opportunities to learn about new technologies and products, store knowledge and disseminate know-how. Thus, the new digitized information highways improve prospects for imitators. The pioneering innovations open up large opportunities within new or renewed industries. The basic innovations are followed by a series of significant improvement innovations. These processes are crucial for catching-up countries. Not mentioning access to telecommunication infrastructure which enables diffusion processes, it is worth noting that diffusion involves people in an essential way. It is developed thanks to education (the first described fundamental) and human skills and abilities, values and attitudes come into play, and these are inevitably heterogeneous.

In view of the facts presented above, it turns out that what is imputed to the EU is insufficient use of information/communications technologies (ICT) and

hard to obtain access to innovation in some sectors of society. For example, European companies currently account for just a quarter of the €2 trillion global market for ICT. Moreover, slow implementation of high-speed internet affects the EU's ability to innovate, spread knowledge and distribute goods and services, and leaves some rural areas isolated (Europe 2020 in a nutshell). These circumstances are tantamount to waste of potential productivity growth.

One may see a slight contradiction in the patent system which is a further foundation of innovativeness. On the one hand, the number of newly registered patents identifies the basic aspect of intellectual property protection which is crucial for innovators desiring extra profits – as Schumpeter argued, monopoly power is an important incentive to undertake innovative activity. On the other hand, this measure ignores the rate of the actual application of the innovations and the extent of their diffusion. Thus, the number of newly registered patents is thought to be deficient as an indicator of inventive activity, although it provides a rough indication of its size and is often used for that purpose. Here, being focused on the friendly environment for innovativeness, it can be stated that a guarantee of protection might encourage hesitating individuals to take an action and to work on some new solutions.

Within the operating the European Patent Office (EPO) examiners are in charge of studying European patent applications in order to decide whether to grant a patent for an invention. As the patent office for Europe, they declare support innovation, competitiveness and economic growth across Europe (EPO 2014).

Venture capital investment (VCI), the last presented basis of innovativeness, is private equity raised for investment in companies not quoted on the stock market and developing new products and technologies (Eurostat 2014). Venture capital has an important role in bringing innovation to the market because it often backs entrepreneurs who have just the germ of a business idea. It is intended to fund an early-stage, so it is crucial for technology-oriented newcomers.

When it comes to the EU, 29 years ago at the instigation of the European Commission it was founded the EVCA – European Private Equity and Venture Capital Association which represents 650 member firms and 500 affiliate members. According to their assumptions, the EVCA shapes the future direction of the industry, while promoting it to stakeholders such as entrepreneurs, business owners and employee representatives. Private equity investments in large European companies improved their productivity by 7% per year, not mentioning small and medium enterprises which are the main and natural object of EVCA's interest (European Private Equity and Venture Capital Association 2014). It let conclude that its activity boosts economic growth.

3. Are the European Union Members building their foundations of innovativeness?

Some of the achievements and existing failures of the EU as a whole in the context of innovativeness were mentioned in the previous part, but the subject of interest is also the situation in particular Member States. Without the described fundamentals built in every country, smart growth, which is the desirable phenomenon in Europe, becomes infeasible.

This work will now discuss the technique required for exploring the topic. Namely, the application of taxonomic tools have been proposed in order to study the differentiation in levels of the described fundamentals of innovativeness in EU countries. The aggregate distance between given countries is the basis for ranking the states in terms of their structure of the chosen measurable characteristics (data mainly comes from 2012; their description is included in the Table 1, Appendix). Of the many methods of multivariate analysis Hellwig's method of linear ordering was used (Panek 2009, pp. 68-70). All of the diagnostic variables refer to the fundamentals from Figure 1[1]. This method allows for the creation of a "ranking" of objects in terms of several variables. The closer Hellwig's synthetic measure is to one, the closer the analyzed object is from the reference object.

The measure is defined as:

$$SMI_i = 1 - \frac{d_{0i}}{d_0} \tag{1}$$

where:

SMI_i – synthetic measure of development for i-th object $SMI_i \in [0; 1]$, $i = 1,2, \dots, n$.

d_{0i} – distance of i-th object from model object given by:

$$d_0 = \bar{d}_0 + 2S_0 \tag{2}$$

where:

$$\bar{d}_0 = \frac{1}{n}\sum_{i=1}^{n} d_{0i} \tag{3}$$

$$S_0 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(d_{0i} - \bar{d}_0\right)^2} \tag{4}$$

[1] There are two exceptions: venture capital financing (it was impossible to count it because of the serious deficits in database) and competition (given the European common market the considered countries are not diversified in terms of taking part in competition, so this fundamental has no impact on the ranking order).

Objects are ordered based on their distance between a given object and the reference object. Coordinates of the reference object were determined objectively using the formula:

$$x_{0j} = \begin{cases} \max_i\{x_{ij}\} \text{ for stimulants} \\ \min_i\{x_{ij}\} \text{ for destimulants} \end{cases} \quad (5)$$

where:
x_{0j} – reference for j-th variable,
x_{ij} – variable value for i-th object and j-th variable.

Hellwig's method of linear ordering orders objects based on Euclidean distance of i-th object from the reference object:

$$d_{0i} = \sqrt{\sum_{j=1}^{m}\left(x_{ij} - x_{0j}\right)^2} \quad (6)$$

The EU countries have been put in descending order according to the level of calculated Hellwig's measure (Table 2, Appendix). It turns out that the biggest potential for innovativeness has been cumulated mainly by Scandinavian countries – they occupy the first and the second position (Sweden and Denmark), as well as fourth place (Finland). Some of the Benelux countries are pretty high in the rank (Luxembourg – 3rd , The Netherlands – 5th). It can be firmly stated that the period of membership does not determine the level of the analyzed phenomenon, because some of the so-called "New Union" countries, such as Slovenia and Estonia landed in the top ten, whereas some "old Members" were classified on lower positions. In the EU-15 Greece, Italy, Portugal and Spain turned out to be the worst and in the group of "new Members" – Romania and Bulgaria. Their position is even worse than that of the brand new member – Croatia. The order of the countries is not only the one issue which should be commented. The other controversial case is the size of the gap between the leaders and the rest of the explored group which can be spotted by analyzing the level of the synthetic measures. It is not a problem when some countries forge ahead while others catch-up – the prospects of some of the latter group are usually promising. Those countries can take advantage of the position of emerging markets and catch-up on the forging ahead economies, inter alia thanks to the process of diffusion. The serious matter is when some of the countries fall behind. It seems that the countries closing the ranking, like Romania, Bulgaria or Greece will have serious deficits in terms of the fundamentals of innovativeness. The probable scenario is also that some of the countries will keep on falling behind, because the process of reduction for such a significant gap requires much time.

Conclusions

The question of growth is nothing new but an age-old issue, which has always intrigued and preoccupied economists. Given the significance of the level of GDP per person it is desired that the possibly high growth rate should lead to potentially high GDP per capita. What lies behind a particular country's growth rate and its variation over time are i.a. innovations. Contemporary innovativeness is perceived as one of the key determinants of total output and welfare used to measure economic performance and it has become the subject of extensive empirical research and data collection. The impact of innovativeness on economic growth is much more complicated than has been captured in theoretical models. Anyway, by basing the research on one of the concepts of the fundamentals of innovativeness some results have been obtained, thus conclusions can be presented.

The conducted research shows that there is no clear link between the duration of a country's participation in the European integration and the degree of its capabilities for innovativeness. Indubitably, there are some bottlenecks to tackle, but they seem to concern all of the Member countries. It can be stated that the so-called "old Union" countries have achieved better results in the area of building the fundamentals of innovativeness, but some of the Central-Eastern Europe countries are better than France and Germany. More comparisons on the basis of Table 2 could be put forth, but the above mentioned is enough to confirm the hypothesis.

Appendix

Table 1. The variables considered in the research

Fundamental	Diagnostic variables	Explanation and remarks	Stimulant/ /destimulant
1	2	3	4
Education system	lifelong learning	Persons aged 25 to 64 who have stated that they received education or training in the 4 weeks preceding the survey	S
	early leavers from education and training	% of the population aged 18-24 with at most a lower secondary education and not in further education or training	D
	tertiary educational attainment	The share of the population aged 30-34 years who have successfully completed university or university-like education	S
	public expenditure on education (% of GDP)	The public sector funds education either by bearing directly the current and capital expenses of educational institutions or by supporting students and their families with scholarships and public loans as well as by transferring subsidies for educational activities to private firms or non-profit organizations. Both types of transactions are included	S
R&D expenditures	GERD (% of GDP)	Expenditure from business enterprise, higher education, government and private non-profit expenditure on R&D	S
Technology trade foreign investment	high-tech exports (% of exports)	Share of exports of all high technology products of total exports (Aerospace, Computers – office machines, Electronics-telecommunications, Pharmacy, Scientific instruments, Electrical machinery, Chemistry, Non-electrical machinery, Armament)	S
	FDI flows (% of GDP)	This category of international investment made by an entity resident in an economy to acquire a lasting interest in an entity operating in an economy other than that of the investor. The lasting interest is deemed to exist if the investor acquires at least 10% of the voting power of the investment enterprise	S
Information system	household Internet connection type: (% of households)	Fixed broadband access in households	S
	enterprises Internet connection (% of enterprises)	Fixed broadband access in all enterprises, without financial sector (10 employees or more)	S
	individuals' high level of computer skills (% of the total number of individuals aged 16 to 74 who have carried out 5 or 6 of the 6 computer-related items)	A self-assessment approach, where the respondent indicates whether he/she has carried out specific tasks related to computer use. Six computer-related items were used to group the respondents into levels of computer skills: copy or move a file or folder; use copy and paste tools to duplicate or move information within a document; use basic arithmetic formulas (add, substract, multiply, divide) in a spreadsheet; compress files; connect and install new devices, e.g. a printer or a modem; write a computer program using a specialized programming language	S

Table 1 cont.

1	2	3	4
	individual high level of Internet skills % of the total number of individuals aged 16 to 74 who have carried out 5 or 6 of the 6 Internet-related items	The respondent indicates whether they have carried out specific tasks related to Internet use (use a search engine to find information; send an e-mail with attached files; post messages to chatrooms, newsgroups or any online discussion forum; use the Internet to make telephone calls; use peer-to-peer file sharing for exchanging movies, music, etc.; create a web page)	S
Patent protection	patent applications to the EPO (applications per million inhabitants)	Data refer to applications filed directly under the European Patent Convention or to applications filed under the Patent Co-operation Treaty and designated to the EPO (Euro-PCT). Patent applications are counted according to the year in which they were filed at the EPO and are broken down according to the International Patent Classification (IPC). They are also broken down according to the inventor's place of residence, using fractional counting if multiple inventors or IPC classes are provided to avoid double counting	S

Source: Eurostat (2014).

Table 2. The fundamentals of innovativeness – the ranking of European Union countries

Position	Country	SMI_i
1	Sweden	0,476720895
2	Denmark	0,445981906
3	Luxembourg	0,428321860
4	Finland	0,418916812
5	the Netherlands	0,374267595
6	Estonia	0,337526598
7	Great Britain	0,325683564
8	Slovenia	0,325459624
9	Austria	0,314671042
10	France	0,312672917
11	Ireland	0,284546820
12	Belgium	0,275490540
13	Lithuania	0,250817590
14	Germany	0,226684283
15	Hungary	0,225903565
16	the Czech Republic	0,222625020
17	Latvia	0,211885366
18	Malta	0,211371820
19	Spain	0,207571185
20	Cyprus	0,205439503
21	Portugal	0,170205386
22	Slovakia	0,164209101
23	Poland	0,155163693
24	Italy	0,143775204
25	Croatia	0,131454434
26	Greece	0,080861998
27	Bulgaria	0,046009490
28	Romania	–0,072680501

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