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The Research And Development Performance Of Various EU Social Regimes[1]

Abstract

The paper provides a new approach to the classification of EU countries into innovation-performance groups, taking into account their social regime. In the Introduction, it draws on some empirical evidence of synchronised research and development (R&D) performance within a social regime. In the second and third parts it reviews the literature on measuring R&D performance, and in the fourth part it summarizes social regime classifications. The fifth and longest part of the paper proceeds to a comparative analysis of the empirical data, pointing out disparities, both respects to numbers and members, in the composition of innovation-performance groups. In the final part, the paper summarizes key findings.

Keywords: *R&D expenditures, patent application, total factor productivity, social regime*

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1. Introduction

The current state of literature demonstrates, based on a reasonably sizable amount of evidence, that EU countries may be divided into innovation leaders and innovation laggards. However, we have not so far witnessed any attempts to distinguish EU social regimes by research and development (R&D) performance, although there is empirical evidence that social regimes and innovation performance do interact (Puškárová 2012).

Innovation is of an intangible nature, which makes its quantification particularly tricky. The scientific literature agrees on three basic approaches:

1. Input,
2. Output,
3. Indirect effects.

The input and output methods draw on a model of the innovation process, while the indirect method is implied by the Cobb-Douglas production function.

In addition, the literature exposes (although maybe not explicitly) *parameters derived from input and output ones*, e.g. elasticity of R&D expenditures, productivity of R&D workforce, profitability of R&D inputs, etc.

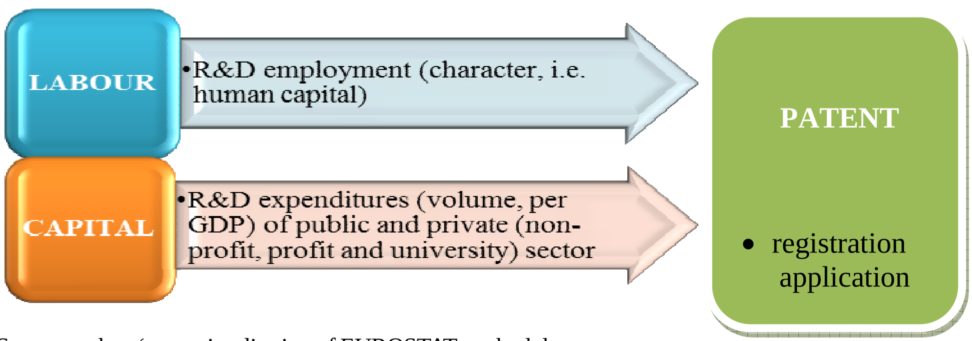
We decided to draw on this current state of the literature and summarize key findings, using comparative analysis of selected parameters.

Based on the data available, we decided to anchor our analysis in the data derived mainly from EUROSTAT, as explained further on in the paper.

2. Parameterization of innovation through inputs/output

The innovation process can be visualized by the following Figure 1.

Figure1. Innovation process



Source: authors‘ own visualisation of EUROSTAT methodology.

The model demonstrates that the two standard production inputs – labour and capital - are processed in order to deliver the desired outcome, i.e. a patent application leading hopefully to a patent. The labour input in the innovation process is required to demonstrate, however, a certain additional quality compared to the usual labour input. The nature of the innovation process implies that the labour must be both highly skilled and highly creative, i.e. that it possesses a certain level of human capital which can be transformed into a tangible product known as intellectual capital.

The creativity of labour input and its expertise in utilizing this creativity determine the quality and quantity of the innovation process outcome.

In the common scientific consensus, the innovation process results in a patent or a patent application. However, we need to bear in mind that a lot of creative work remains unprotected by a patent, and thus the outcome of creative labour and capital inputs cannot be measured by the limited terms of a patent alone.

Pros and cons of parameterization through input/output

One of the most often articulated defects of measuring innovation through R&D expenditures (capital input into the innovation process) is that it ignores the stochastic nature of the innovation process (Keller 2010, p. 804). Pertinent results of the R&D expenditures come mostly with some time delay, and thus often do not appear in the same year that the R&D expenditures were incurred. In other words, the results of R&D expenditures from a certain time unit (year) may emerge in the same or in several consecutive years.

Some researchers reduce the significance of this flaw in the analysis by applying only business R&D expenditures. It is arguable that returns on business R&D is empirically higher than public (and thus more or less also total) R&D. In our opinion however, this approach does not eliminate the impact of this defect completely (many business projects are split into several years), and further, it undermines the multiplication effect of public R&D, which accounts for the major R&D source in the "new" member countries.

The output method of innovation parameterization concentrates on innovation output, most commonly measured by patent volumes, i.e. the number of patent applications. Various patent offices maintain their own records on patent data, as well as providing information to the other statistical offices.

The advantage of patent data analysis is simple – a patent is an indisputable form of concrete evidence that the R&D is about to generate profits in the form of licene fees, fees for patent usage, etc.

The output parameterization of innovation has, nonetheless, its flaws too. Many patents are just upgrades of already existing patents, i.e. their value should be partially attributed to former R&D (e.g. Jaffe and Trajtenberg 2002). Besides, the decision whether to apply for a patent relates to the particular company, and the literature exhibits a fair amount of evidence that a lot of innovation is not protected by an official patent, even though it is in use (e.g. Griliches 1990).

One important practice can be observed in the current state of literature: in analysing R&D performance, the number of patent applications is preferred to the number of registered patents. The reason, in our assumption, lays in time delays attributable to the administration of a patent application – granting a patent may last up till several years and thus, the time coherence between R&D and its results deteriorates more than when a patent application is used for measurement of an output.

3. Parameterization of innovation through TFP

The most common technology parameterization is based on the thesis of its effect – i.e. increased productivity of production inputs. This effect is, in the literature, made equal to the parameter A = TFP (total factor productivity) from the Cobb-Douglas production function. Equation 1 below gives the calculation of TFP:

$$Y = AK^{\alpha}L^{1-\alpha} \approx A = TFP = \frac{Y}{K^{\alpha}L^{1-\alpha}} \qquad (1)$$

Contrary to the input and output parameters of technology, TFP is a derived indicator, i.e. its value is calculated from the primary data on production inputs and output.

Pros and cons of parameterization through TFP

The advantage of the idea of the Solow residual (how TFP is often addressed) is as follows: as a residual of the inputs productivity, it embodies all the innovation (even unregistered patents) that is effectively used and contributes directly to growth. Thus, it is the truest measure of innovation's effect on growth.

However, there has been a rather fierce discussion in the literature throughout the years regarding both the calculation of TFP nominal values, and its real impact on the growth.

The calculation of the TFP is rather ambiguous, due to the risk of measurement error and the risk of selected variable bias, whereby manipulation of primary data exerts a significant effect on the calculated TFP data, and as a result some part of TFP value can be neglected (Katayama et al 2009). Due to these difficulties, the literature also provides certain solutions. One of them suggests working with TFP growth rates instead of TFP nominal values. This approach is recommended especially by *ceteris paribus*. Another resolution might be derived from the application of nominal TFP values together with input parameters of technology, mostly R&D expenditures (Griliches 1984, Keller 2010).

However, the application of TFP growth terms may also not show the impact of innovation on GDP growth so purely. The concern is that when extracting human capital (parameterized by the education received) from TFP and considering it as a part of labour input (which is also commonly viewed as the most characteristic feature of the R&D workforce), the importance of TFP growth for economic growth drops rapidly (Manuelli and Seshadri 2010).

In the light of all the discussions over TFP mentioned above, and inasmuch as TFP is also a matter of technology spillovers (Eaton and Kortum 1999), we decided not to use TFP as the suitable indicator for analysis of a social regime's R&D performance.

4. Determination of social regimes

Although some empirical evidence shows that R&D performance and social regimes do interact (the EU's most innovative countries maintain the most generous social protection nets), the scientific literature seems reluctant to analyse this nexus. This phenomenon challenges the traditional theoretical assumption that individualism (and not solidarity) motivates a nation to innovate (this assumption is the key notion of liberalism).

In our analysis, we decided to distinguish EU countries by social regimes according to the analysis established by Esping-Andersen (1990, pp. 28-54), upgraded by Bohle and Greskovits (2007) and Ferrera (1996) and Bonoli (1997), as follows:

a) liberal (UK, Ireland)
b) social-democratic (Scandinavian countries – Denmark, Finland, Sweden)
c) conservative (Germany, France, Austria, Belgium, Netherlands, Italy)
d) southern (Italy, Spain, Malta, Portugal, Cyprus, Greece)
e) neoliberal (Estonia, Latvia, Lithuania)
f) embedded neoliberal (V4 countries)
g) neocorporativist (Slovenia).

Esping-Andersen defined the three models (a-c) based on decommodification indices and the implicit level of stratification, whereby the social-democratic regime demonstrates the strongest redistribution of income throughout the social groups, and the liberal regime demonstrates the lowest level of solidarity with the low-income and handicapped groups.

Despite numerous critiques of Esping-Andersen's categorization, based primarily on the limited number of countries in question, the over-estimation of the impact of social security benefits, and the neglect of gender implications, this classification is nonetheless widely preferred due to its easy and wide applicability.

Ferrera and Bonoli argued that the southern EU states cannot be defined by either of Esping-Andersen's social regimes because they are characterized by:

- high fragmentation and polarization of society, where pension system is generous but nonetheless many groups are excluded from the social protection;
- deviation from traditional corporate provision of health insurance;
- high degree of collision between the systems of private and public social institutions;
- unresolved nepotism in the distribution of social benefits.

Bohle and Greskovits further argue that the "new EU countries" cannot be classified by Esping-Andersen's social regimes since they still lack the tradition (i.e. experience) in terms of public social institutions, a market economy, social inclusiveness and macroeconomic stability.

5. Profiling EU social regimes based on selected innovation parameters

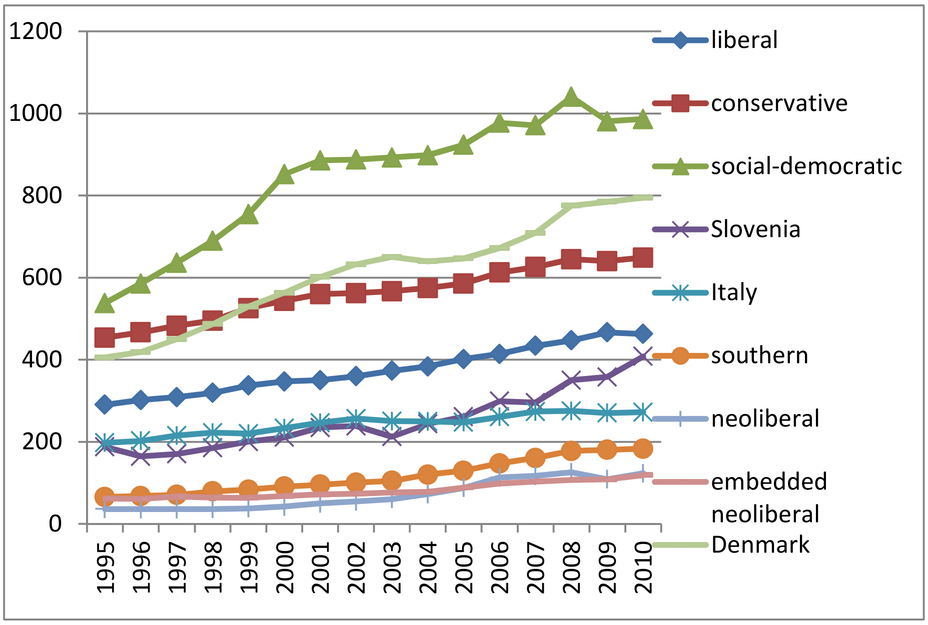
In this part, we proceed to visualisation of various innovation parameters on the level of EU social regimes, and in doing so detect disparities.

5.1. Performance of EU social regimes in terms of their average R&D expenditures

In terms of real average R&D expenditures, we register continuous growth in all social regimes. The most successful are the Scandinavian countries, which stand out against other social regimes (Figure 2).

By considering national deviations from the social regime average level, we can detect a few significant countries, although not among the countries and regimes with the highest R&D spending (Table 1).

Figure 2. Average R&D expenditures in EU social regimes, constant 2000 prices, PPS, p.c.



Source: author's own elaboration, calculation based on total social protection expenditures derived from EUROSTAT 2013 databases.

In the group of the six EU-founders, we can identify two development trajectories: Germany's strong convergence towards the Scandinavian countries in terms of R&D expenditures levels, and the trajectory of French-speaking countries – BENELUX[2] and France, which rank among the EU's average R&D spending countries. The lowest R&D spending country from this group is indisputably Italy, which converges in absolute R&D expenditures terms towards their more culture-similar countries of southern social regimes.

Throughout the observed period, Austria has had the role of most R&D accumulating country among all the EU countries, and not only in terms of R&D expenditures in PPS and in % GDP. Since 2002, it exceeds, in terms of inflation-free PPS, even its strong strategic partner – Germany. In terms of R&D expenditures as a share of GDP share, it is however still catching up to the level of Germany.

[2] Please note that in terms of R&D expenditures as a GDP share, Luxembourg does not demonstrate even the EU average level.

The liberal social regime shows a strong convergence between the R&D expenditures of Ireland and Great Britain.

The southern regime is also characterized by convergence. The below-average levels of R&D expenditures in this category put the countries of the southern regime into the position of innovation laggards, although still spending more on R&D than the countries of neoliberal or embedded neoliberal regimes. However, it is important to pay attention to Portugal, which managed to double its R&D spending between 2005 and 2009 from 0.75 % to 1.5 % GDP.

The "new" EU member states (i.e., those acceding to the EU in 2004 and 2007) are the lowest R&D spending group. The only exception is Slovenia, which has accelerated its R&D in 2009, despite its low starting R&D volume in 1995, up to the level of the liberal economies. In this group, the highest R&D spending countries are the Czech Republic, Estonia and Hungary. Slovakia is the only country from this group that has experienced severe cuts in R&D expenditures, which were only partially compensated for by the increase in R&D expenditures in the last two years of the observed period.

Table 1 clearly shows that among the highest R&D spending social regimes a strong convergence exists, while among the lowest R&D spending social regimes a strong divergence takes place throughout the observed period. This may imply a more general thesis that in the earlier stages of economic development, the R&D spending policies vary by country. However, more developed countries attain the R&D spending limits, and other countries do catch up.

Further, we assume that this R&D spending limit is determined by its culturally-shaped (biased) social regime.

Table 1. Convergence within EU social regimes, measured by standard deviation of national R&D expenditures

	SOC-DEM	CONS - German speaking	CONS - French speaking	LIB	SOUTH	NEOLIB	EMB. NEOLIB
1995	153.29	191.48	50.31	116.39	41.77	20.18	30.49
1996	152.52	189.38	39.32	91.50	45.04	17.02	34.92
1997	151.21	181.34	27.90	77.36	45.54	13.51	42.58
1998	154.06	175.65	17.92	77.50	53.58	9.90	42.78
1999	152.82	160.22	22.02	88.95	55.85	14.81	43.66
2000	196.77	151.81	13.57	92.42	62.37	10.53	50.08
2001	209.00	142.81	6.73	92.35	64.60	17.47	52.57
2002	182.81	143.27	13.11	87.68	68.55	19.36	55.11

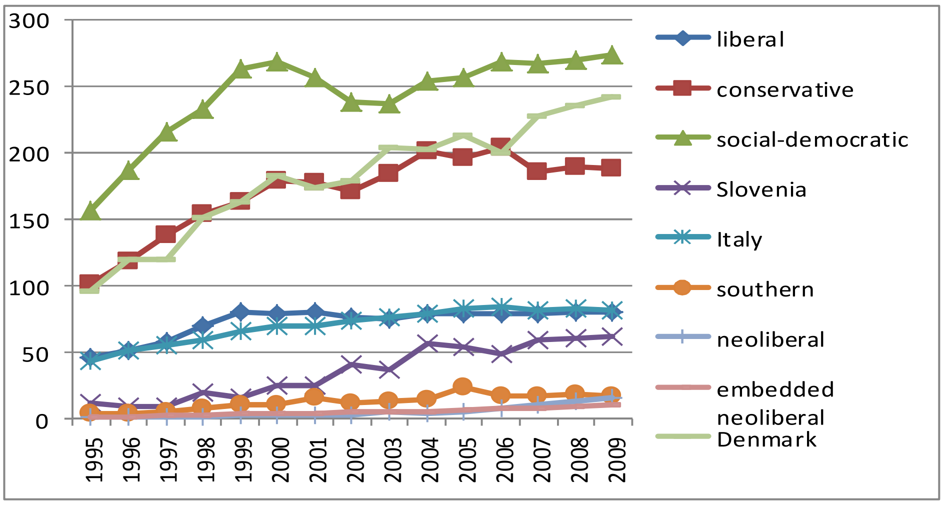
2003	161.90	136.67	17.96	69.23	73.68	25.67	58.49
2004	158.17	142.38	19.07	46.74	65.10	30.26	59.83
2005	167.38	124.66	20.44	47.66	68.97	29.88	73.92
2006	189.14	156.14	17.62	49.50	75.81	40.67	86.96
2007	152.62	141.09	10.91	46.53	85.31	43.69	89.31
2008	154.40	109.26	12.14	21.00	100.36	55.78	83.76
2009	113.52	104.32	8.02	14.71	99.99	66.20	84.58
2010	112.21	85.32	3.07	33.23	92.74	76.13	88.68

Source: authors' own calculations, based on the data used in Figure 2 derived from EUROSTAT 2013 databases.

5.2. Performance of EU social regimes in terms of EPO patent applications

This paper is aimed also at observing the development of the innovation output parameter (Figure 3). In the light of all the advantages and disadvantages of innovation output parameters mentioned in the second part of this paper, we decided to concentrate on only the number of EPO (European Patenting Office) patent applications (per population unit, i.e. per million inhabitants).

Figure 3. Average EPO patent applications in EU social regimes, per million inhabitants



Source: authors' own elaboration, calculations based on EPO patent applications data derived from EUROSTAT 2013 databases.

Figure 3 demonstrates a strong convergence of the number of EPO patent applications between the two groups of conservative and social-democratic regimes, which are the best performing groups in the EU in terms of EPO patent applications. However, since 2005 we may observe that the French-speaking countries seceded from the trajectory and did not manage to keep up to the pace of EPO patent applications of Germany and Austria.

In terms of the deviations in national data deviations compared to the social regime average (Table 2 below), we can summarize further as follows:

Although the countries of the social-democratic regime do converge in terms of EPO patent applications, there is still a great gap between Sweden and the catching-up countries of Denmark and Finland.

In the six EU-founders group, the EPO patent applications volume demonstrates a similar trajectory as the R&D expenditures volume. Germany safely ranks among innovation leaders, and despite quite a large distance Belgium and Luxembourg also do. Italy showed lower numbers of EPO patent applications, aligning almost perfectly with the trajectory of the southern regime countries.

Austria is again the best performing EU country throughout the observed period in terms of EPO patent applications accumulation (it reached the levels of the Scandinavian countries and Germany).

The southern regime countries has developed synchronously, with the worst results registered by Portugal.

With the exception of Slovenia, the "new" EU member states converge in terms of their low levels of innovation output, and thus fall into the category of innovation laggards. Slovenia is again the only "new" EU member that has managed to increase its innovation output (measured by EPO patent applications) up to the levels of the southern regime countries and Italy.

Table 2. Convergence within EU social regimes measured by standard deviation of national EPO patent applications

	SOC-DEM	CONS - German speaking	CONS - French speaking	LIB	SOUTH	NEOLIB	EMB. NEOLIB
1995	38.84	53.07	16.33	26.98	3.88	0.70	1.87
1996	43.25	66.81	21.68	29.85	4.27	1.73	2.32
1997	57.93	65.20	21.75	30.28	6.05	2.11	2.64
1998	46.98	83.88	33.63	27.00	6.58	1.78	2.63
1999	59.69	85.81	29.85	25.74	6.50	2.60	4.23
2000	49.73	85.63	46.81	34.21	6.68	1.50	4.52
2001	50.15	81.92	59.43	21.45	8.63	3.26	3.70

2002	35.42	74.49	46.00	26.35	7.99	1.71	4.50
2003	21.61	68.50	44.51	26.63	7.50	2.36	4.98
2004	30.81	71.93	58.38	18.67	10.27	1.70	5.63
2005	26.22	73.69	43.98	18.85	8.73	2.80	4.76
2006	42.70	56.67	52.70	18.05	10.20	6.55	6.41
2007	39.31	61.87	28.24	10.78	8.97	9.47	7.61
2008	49.75	58.52	24.72	8.17	8.54	11.57	8.24
2009	60.91	53.83	19.52	4.23	9.50	15.39	9.43

Source: authors' own calculations, based on the data used in Figure 4 derived from EUROSTAT 2013 databases.

In terms of EPO patent applications, convergence is not as visible as in terms of total R&D expenditures (Table 2), the only exception being the liberal social regime. This phenomenon may have its roots in the following:

- EPO patent applications account only for a part of total R&D output (as stated previously in the second part of this paper),
- EPO patent applications may also be subject to co-ownership.

The development of R&D expenditures (Figure 2) and of innovation product (Figure 3) in the EU during the period 1995 – 2010 implies a profiling of four innovation-performance groups.

1. *innovation leaders* (countries of social/democratic regime, German speaking countries of conservative regime – Germany and Austria),
2. *innovation followers* (French speaking countries of conservative regime),
3. *average innovators* (countries of liberal regime, Italy and Slovenia),
4. *innovation laggards* (countries of embedded neoliberal, neoliberal and southern regime, except Italy).

However, when considering R&D effectiveness (input-weighted output parameters), we come to different results.

5.3. Performance of EU social regimes in terms of R&D effectiveness

The effectiveness of innovation inputs can be measured using the incremental innovation output ratio (Rastogi 2009, pp. 45-50), or through the elasticity of innovation output on innovation inputs, following the equation:

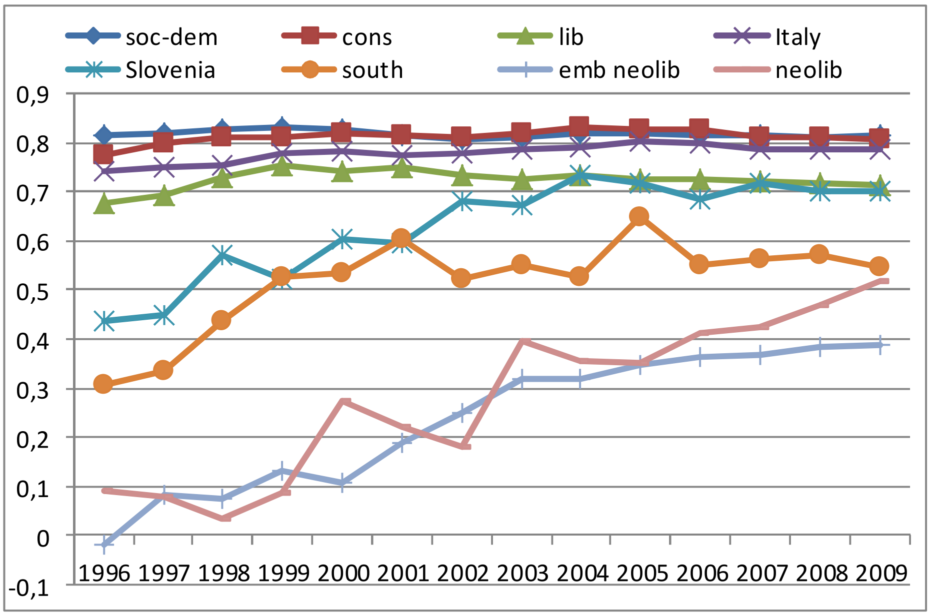
$$\varepsilon = log_{INNEX}\ PAT \tag{2}$$

where the PAT is the number of EPO patent applications and INNEX is the volume of R&D expenditures (total intramural expenditures in the R&D sector, including also the salaries of all R&D personnel).

Figure 4 demonstrates that the elasticity of EPO patent applications on total R&D expenditures in all social regimes is lower than one, and thus the number of EPO patent applications increase at a slower pace than R&D expenditures.

The most stable elasticity throughout the observed period is demonstrated by the countries of social-democratic and conservative regimes, Italy, and even the liberal countries. The emergence of Slovenia has converged steeply with the elasticity of liberal regime countries.

Figure 4. Elasticity of PAT on INNEX in EU social regimes



Source: authors' own calculations, data extracted from EUROSTAT 2013 databases.

Innovation laggards maintained their R&D effectiveness at a relatively lower level, although converging also against innovation leading countries.

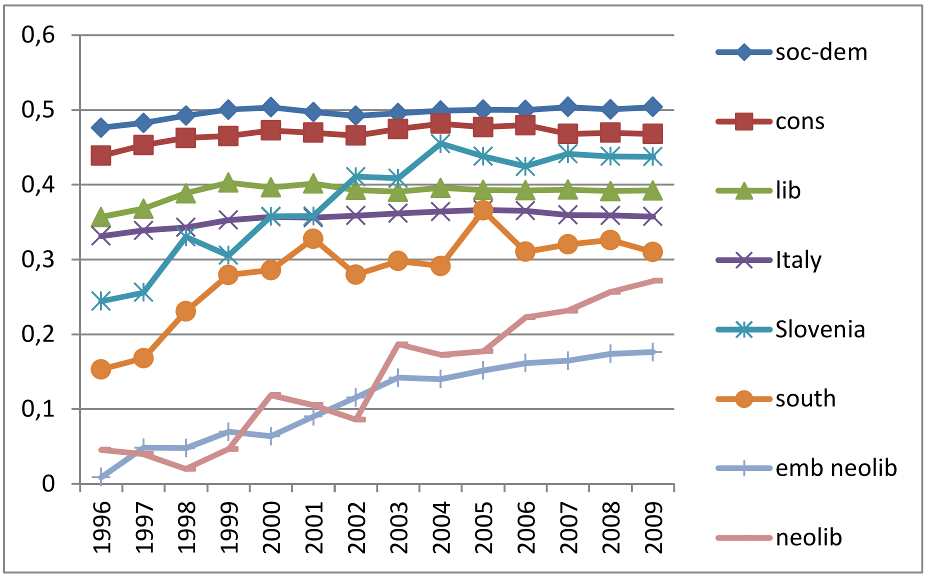
The same basic results are demonstrated (Figure 5) by the elasticity of EPO patent applications per million inhabitants (PAT) on workforce in R&D per million inhabitants (INNEMPL) following the equation:

$$\varepsilon = \log_{INNEMPL} PAT \tag{3}$$

Figure 5 confirms again that Slovenia is the only country from the "new" member countries that has managed to increase its R&D workforce efficiency, measured by the elasticity of EPO patent applications to the R&D workforce volume, up to the levels of the best performing innovation countries, i.e. regimes.

Figure 5 further proves that the elasticty of innovation output on R&D employment is lower than its elasticity on R&D expenditures – maximally at the level of 0.5.

Figure 5. Elasticity of PAT to INNEMPL in EU social regimes



Source: authors' own calculations, data derived from EUROSTAT 2013 databases.

The so-calculated results concerning R&D effectiveness thus distinguish between two innovation-performance groups:

1. *Innovation leaders* (innovation better performing countries),
2. *Innovation laggards* (innovation worse performing countries)[3].

The category of innovation leaders includes, besides countries of social-democratic and conservative regimes, also countries of liberal (Great Britain, Ireland), neocorporativist (Slovenia) and the southern regime of Italy. The Italian performance in terms of innovation and technology measures is better in comparison to their southern regime partners, and the reason may lay in its longer tradition in the European communities, i.e. 20 more years of association with the innovation leading countries of conservative regimes.

The other southern regime countries, as well as countries of neoliberal and embedded neoliberal, together with Romania and Bulgaria, can be put into the group of innovation lagging countries.

6. Conclusions

In this paper we have presented various measures that divide EU countries into innovation performance groups.

The primary measures of innovation (total intramural R&D expenditures, EPO patent applications) distinguish between four groups of social performance regimes. In terms of R&D effectiveness (measured by the elasticity of EPO patent applications to R&D expenditures), there are only two groups to be identified.

The best performing social regimes in terms of innovation are the social-democratic and conservative. The worse performing social regimes in terms of innovation are the regimes of most “new” member countries, with the exception of Slovenia, which is the only “new” member country that has managed to catch up with the innovation leading liberal countries, although only in terms of R&D effectiveness.

The development of R&D expenditures is, in fact, synchronized, converging within each social regime of innovation leaders (the only exception is maybe the southern regime), and diverging within the innovation lagging countries– several countries from the innovation laggards group have experienced a more rapid accumulation of R&D expenditures (Czech Republic, Hungary, etc.) than the others (Slovakia, Poland). This may imply the more

[3] We would like to point out that in other publications the terms „innovation leaders“ and „innovation laggards“ relate to other classifications based on other measures of innovation, and these are not to be mistaken for ours.

general thesis that in the earlier stages of economic development, R&D spending policies vary by country. In other words, more developed countries manage to attain the R&D spending limits and other countries have to catch up.

This paper can also shed some light on the thesis that R&D spending levels and limits are determined by the relevant culturally-shaped social regime.

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Streszczenie

OSIĄGNIĘCIA W OBSZARZE DZIAŁALNOŚCI BADAWCZO-ROZWOJOWEJ W RÓŻNYCH SYSTEMACH SPOŁECZNYCH KRAJÓW UNII EUROPEJSKIEJ

W artykule przedstawiono nowy sposób klasyfikacji krajów UE z punktu widzenia stopnia ich osiągnięć innowacyjnych z uwzględnieniem systemu społecznego. Wstęp nawiązuje do wybranych danych empirycznych, dotyczących powiązania osiągnięć badawczo-rozwojowych (B&R) z typem systemu społecznego. Część druga i trzecia zawiera przegląd literatury dotyczącej pomiaru osiągnięć badawczo-rozwojowych. Część czwarta to podsumowanie klasyfikacji systemów społecznych. Piąta i najdłuższa część artykułu zawiera analizę porównawczą danych empirycznych, wskazującą różnice dotyczące zarówno danych liczbowych jak i systemów społecznych wchodzących w skład poszczególnych grup. W końcowej części pracy przedstawiono streszczenie najważniejszych wniosków.