

Do social and economic factors affect the technical efficiency in entrepreneurship activities? Evidence from European countries using a two-stage DEA model

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ABSTRACT

This article aims to address whether, and to what extent, socioeconomic conditions influence entrepreneurship-based activities in 18 European countries grouped into subregions (North, South, East and West) during the period 2008–2018. We conducted the empirical study under a two-stage DEA model. The results of scores of technical efficiency of the first stage of DEA show inefficiency in Northern Europe for Finland, Ireland and Sweden, while, Belgium, Germany, France and Luxembourg are also inefficient countries in Western Europe. Finally, Spain and Italy are inefficient in Southern European group of countries. In the second stage of DEA, through the parametric fractional regression model (FRM), which consolidated results of one-part and two-part models, the results show that the Expenditure on Social Protection produces positive (high magnitude coefficient) statistical significance on TEA of Eastern, Western and Southern EU countries, while generates a negative (high magnitude coefficient) statistical significance on TEA of Northern EU countries. Moreover, in the Eastern, Western and Southern EU countries, in contrast with Northern EU countries, presumably the dimensions of the social welfare (employment/unemployment protection and so on) are used to encourage individuals to invest in specific skills and/or new businesses. Furthermore, the results in this second stage of DEA helps gain a thorough perspective on how economic and social impacts result from TEA efficiency.

1. Introduction

Literature debating the relationship between business cycles and entrepreneurship is still scarce and deserves further research [1]. Moreover, there are few longitudinal studies about the influence of the dynamics or configuration of factors on entrepreneurship and framed on the economic development of the country [2] or regional entrepreneurship [3,4]. In fact, entrepreneurial activity varies widely across countries and over time [5], and even within the same country, across regions [6,7]. Thus, the regional context is an important variable that should not be overlooked when addressing entrepreneurship [8]. For instance Ref. [9], suggest separating EU countries into regions with the purpose of seeing whether there are differences between groups/regions of countries, since the European Union is composed of countries with unique socioeconomic characteristics. Consequently, the understanding of how socioeconomic factors impact entrepreneurship is relevant,

especially the comparison of the results between countries with different structural characteristics [10], because economic and social contexts are important drivers of entrepreneurship [5].

As entrepreneurship is the act of creating, developing, driving and changing businesses, many studies often use the establishment of new companies or the entrepreneurial activity index as alternative measures of entrepreneurial activity [9,11]. In this study, the entrepreneurial activity index is used.

This paper aims to appraise the performance of EU countries based on the outcomes of the entrepreneurial activity measured by total early-stage of entrepreneurship and newly formed companies, whose responses were associated with some shocks of economic and social determinants, selecting inputs as unemployment, human capital, investment and household disposal income.

This nonparametric function is maximised using Data Envelopment Analysis (DEA), which presents scores of technical efficiency for each

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Decision-Making Unit (DMU) – in this case, each European country – showing the highest and lowest level of that efficiency. It represents an opportunity to provide useful insights for stakeholders and policymakers to increase entrepreneurial activity successfully. As such, this paper aims to respond to the next two central questions: (i) How differently efficient European groups of countries are in terms of entrepreneurial activities?; (ii) What are the effects of the main socioeconomic determinants on relative efficiency at regional level? For that matter, this paper applies the second-stage DEA using Fractional Regression Models (FRMs). First, to study the countries efficiency on entrepreneurial activity and measures, considering constant returns to scale (overall technical efficiency), the DEA was utilised. Following that, the obtained scores of efficiencies were utilised as the dependent variable in the FRM to evaluate the importance of the main determinants, including labour policies, international trade of goods and services, income and innovation. Therefore, with the use of FRM one can endogenise some factors and calculate their implications for entrepreneurial activities. To the best of our knowledge, when addressing the literature on the proposed research problem, no studies were found examining the efficiency of countries' entrepreneurial activity using FRMs in the second stage of DEA efficiency approaches. As such, this is one of the main contributions to the literature.

The originality of this study stems from two contributions: firstly, it overviews of the performance of entrepreneurial activities in Europe during the period 2008–2018, of demanding challenges. Secondly, it assesses the impact of socioeconomic variables on entrepreneurial activities.

The remaining of the article is structured as follows. Section 2 presents the theoretical framework and research model. Section 3 presents the methodology used. Section 4 presents the results and discussion. The paper ends with the conclusions, limitations and suggestions for further studies.

2. Theoretical framework and research model

2.1. Socioeconomic determinants

2.1.1. Unemployment as a/the driver of entrepreneurship

The study of effects of unemployment on entrepreneurship is an important topic [8]. According to Ref. [12]; in the European Union the unemployed are individuals aged between 15 and 74 who are out of work during a certain period of time, but are available to work and/or actively seeking employment.

In the entrepreneurial context, one can be faced with both opportunity-based and necessity-driven (self-employment) entrepreneurship [13], because, generally, the higher the unemployment rate, the higher the self-employment rate [14]. Nevertheless, the relationship between the variation in unemployment and business creation is dynamic and non-linear, varying from country to country [15], which makes public policies very important [16]. In general, the role of government is crucial in promoting entrepreneurship [17]. For instance, in France, the introduction of policies to combat unemployment – namely, supporting unemployed workers when starting a business – has made it possible to increase business creation significantly [18]. However, countries with low levels of development have a significantly higher rate of business activity [5], in contrast, in certain developed countries, unemployment restricts business activity [8]. This probably occurs, because in developed countries the coexistence of excellent social protection and strong risk aversion discourages entrepreneurship, unlike what occurs in less developed countries [8]. The “long-term unemployment rate (%)” and “Young people neither in employment nor in education training (%)” were the indicators used to analyse. It should be noted that young individuals without jobs, education or training run a very high risk of being socially excluded [19] as their incomes may fall below the poverty line and, without the necessary skills, their economic situation will not likely improve.

2.1.2. Human capital as a/the driver of entrepreneurship

[4] suggest a longitudinal study about entrepreneurship, including human capital as an influencing factor throughout the period of analysis. Human capital is understood as the economic value of the professional skills that a person has [20].

[21] consider human capital as an important ingredient of the entrepreneurial ecosystem. In fact, human capital is a necessary resource for entrepreneurship [4] because the entrepreneur (in addition to other factors) is the central actor of entrepreneurship [22], much like people's capabilities, skills and motivations are catalysts for new firms [23]. In this sense, training and education are important to foster entrepreneurship [24], in other words, higher education institutions must act as proactive institutional entrepreneurs [25]. For instance Ref. [26], highlight that entrepreneurship training can help develop three key capabilities: attitude (related to ambiguity tolerance), knowledge and skills (namely, marketing-, finance- and management-based skills). In general, the higher (lower) the level of education, the more (less) capable entrepreneurs are identifying entrepreneurial opportunities [27,5]. Concomitantly, professional experience is also relevant, because individuals generate new skills and knowledge when they are engaged in business networks that support their learning and innovation [28]. Consequently, the effectiveness of management processes accelerates entrepreneurship [29].

Taking the abovementioned perspective into consideration, this paper uses the “employment rate of recent graduates” as an explanatory variable as a proxy for human capital, which is supported by: [30]; who use education as the variable to measure human capital [31]; who use the rate of university graduates in the workforce, and [32]; who applies gross total enrolment in tertiary education. Nevertheless, “employment rate of recent graduates” is a variable that encompasses recent education and also professional experience acquired in a business context. As such, this indicator gives a clear indication of how recent graduates manage their way to the job market among (at last in the first three years after graduation).

It should be noted that there are differences between “employment rate of recent graduates” and “Young people neither in employment nor in education training”. While the latter represents young individuals with high risks of not being engaged with the job market or with education challenges, the former represents young individuals still strongly engaged with these challenges. Therefore, it is frequent in some studies to use both indicators, thus, analysing different perspectives [33].

2.1.3. Household disposable income as a/the driver of entrepreneurship

Household disposable income is an indicator that includes wages and salaries, self-employed income, social benefits, among others [34]. [35] reveal that household disposable income is a concern for families and can affect family happiness and stability, being one of the main variables used for social stratification [27]. For instance, the wealthier individuals are, the higher the likelihood of becoming entrepreneurs [2,36], because, in general, they have greater access to social networks that provide them good business opportunities [27]. Moreover, high-income households have financial resources that allow them to seek business opportunities [36]. In addition, families with high financial capital invest more in higher education and consequently, students with a large social capital (networks) tend to follow entrepreneurship as a career [37]. Unfortunately, this situation challenges the just distribution of wealth [38,2] or generate a social rigid stratification [2], including differences between physical and mental health of the entrepreneur [39].

From a different perspective [5], reveal that entrepreneurship is significantly higher in less developed countries with greater income inequality than in more developed countries. As most low-income families have low education and have limited access to resources (i.e., social, financial support), these families generally depend on income from microenterprises, so entrepreneurship is necessary in these communities [40]. Consequently [41], add that necessity-driven

entrepreneurial activities are strongest in developing countries while opportunity-driven entrepreneurship is higher in developed countries. Similarly, entrepreneurs originating from families with high incomes tend to use opportunity-driven entrepreneurship, whereas those originating from poorer families tend to resort to necessity-driven entrepreneurship [36].

Based on this evidence, it is possible to argue that there are mixed evidences regarding the relationship between household income variables and entrepreneurship. In this respect, this paper uses the “household disposable income ratio S80/S20, in (%)” as an independent variable to measure household disposable income [42].

2.1.4. Investment as a/the driver of entrepreneurship

Investment is the act of allocating resources, which implies time, money, and effort, with the expectation of generating an income or profit [43]. From a macroeconomic perspective, investment is the expenditure on goods and services that will be used in the future for producing other services and goods. Therefore, the gross fixed capital formation is an indicator that shows how investments in fixed assets increase the production capacity of a country [44].

In the current context, with the growth of digital transformation, rapid technological changes involving artificial intelligence, green energy, among others, require complex investment choices/policies for entrepreneurs to thrive [45]. Entrepreneurship is a particularly risky process [46], in which the control of investment is a key factor [47]. In fact, entrepreneurship depends on the resources entrepreneurs gather to combine the production factors [48]. For instance, although Research and Development (R&D) expenditures generate innovations, they normally do not involve expenditures in fixed capital [49]. However, when small and medium-sized enterprises (SMEs) are considered, generally with limited resources, they need to invest in material/immateral resources to implement the R&D processes effectively [50]. Moreover, R&D activities are important drivers of productivity and innovation alike [51].

2.2. Explanatory variables

Entrepreneurship is an extensively researched topic, as a result of both its socioeconomic and intrinsic complexity. The literature emphasises that entrepreneurship depends on several interrelated determinants [52]. Therefore, this paper includes some explanatory variables to assess their influence on the dependent variable [53], in this case it is the Total Early-stage Entrepreneurial Activity (TEA).

2.2.1. Globalisation

The first aspect to consider in this study is globalisation. As global market integration and low trade barriers not only create opportunities, but also increase competition, the effect of globalisation on entrepreneurship is unclear [54,55]. For instance, globalisation leads to pro-entrepreneurial policies, in order to make foreign entrepreneurs less aggressive [56], as not all countries can equally benefit from Foreign Direct Investment (FDI) [57].

Normally, FDI not only offers capital, but also provides access to new foreign markets, advanced technologies, more effective management methods, among others, because the mobility of factors (e.g. production factors, goods, and services) promotes investment growth and generates business opportunities [58]. However, the effectiveness of foreign investment in domestic entrepreneurship is confusing [54] or even non-existent or negative [59], since this effectiveness depends on several aspects, for example: institutional and governance quality [60,61]; the institutional capacity to create specific entrepreneurial conditions [57], and the type of investments or partnerships [62], among other factors. Simultaneously, economic liberalisation also offers opportunities for entrepreneurship; however, it similarly depends on several factors such as structural, legal, political conditions, among others, in the country concerned [63].

To address the complex phenomenon of globalisation, this paper includes “Foreign Direct Investment” and “Trade Freedom” as explanatory variables.

2.2.2. Social conditions

The social conditions of the countries need to be under scrutiny. For instance, social protection/security has gained increasing recognition in global and national development policy agendas [64]. In fact, although social protection programmes are important for reducing poverty, they also generate concern, because such social subsidies can drive beneficiaries to overdependence on subsidies, dissuading them from looking for new jobs or embracing entrepreneurial activities [65]. The results are mixed, as social security expenses may influence negatively the rate of entrepreneurial activities or influence positively technology-based entrepreneurship activities [66]. The solution is perhaps to create potential and successful synergies between various social protection programmes in a more inclusive and sustainable way [65].

Similarly, the family context can have an influence on entrepreneurship [36]. For instance, social stratification based on income [27,2] can generate different entrepreneurial activities for countries, generally, the families with the best incomes are also those with the best resources for capturing business opportunities [36]. As such, if entrepreneurship were about discovering opportunities instead of having resources, the rich would not have any advantages over the poor [67]. Moreover, as training facilities, subsidies and support institutions are usually absent in middle/low-income countries, consequently, these shortages can have a negative impact on entrepreneurial attitudes [68].

To deal with those social aspects, the present study introduces the “Expenditure on Social Protection in PPS” and “GINI” as explanatory variables.

2.2.3. Economic growth and development

The third context included in this paper is economic growth and development. Generally, greater entrepreneurial activity increases economic activity; however, economic activity also encourages entrepreneurship [69]. For instance, Emerging countries bet on entrepreneurship as engines of economic growth and structural change [70], but, from another perspective [71], show that advanced entrepreneurial economies are characterised by having a high economic dynamism.

In fact, entrepreneurs in wealthier economies tend to be more innovative, internationalised and focused on growth than entrepreneurs in less prosperous economies [68]. Thus, the present study proposes the “Median Income in PPS” as the explanatory variable.

2.2.4. Innovativeness

Innovation and entrepreneurship are two highly interconnected concepts [72]. Concomitantly, entrepreneurship success is strongly related to innovation [73], even entrepreneurs themselves recognise the importance of innovation when they aim to carry out entrepreneurial activities [74]. Therefore, the study also employs “Total Patent Applications” as an explanatory variable.

In summary, this paper uses four contexts or circumstances in its analysis and for each context, explanatory variables are used: (1) globalisation (Foreign Direct Investment and Trade Freedom), (2) social conditions (Expenditure on Social Protection in PPS and GINI), (3) economic growth and development (Median Income in PPS), and (4) innovativeness (Total Patent Applications).

2.3. Research model

Based on the previous arguments, Fig. 1 presents the model that outlines the variables.

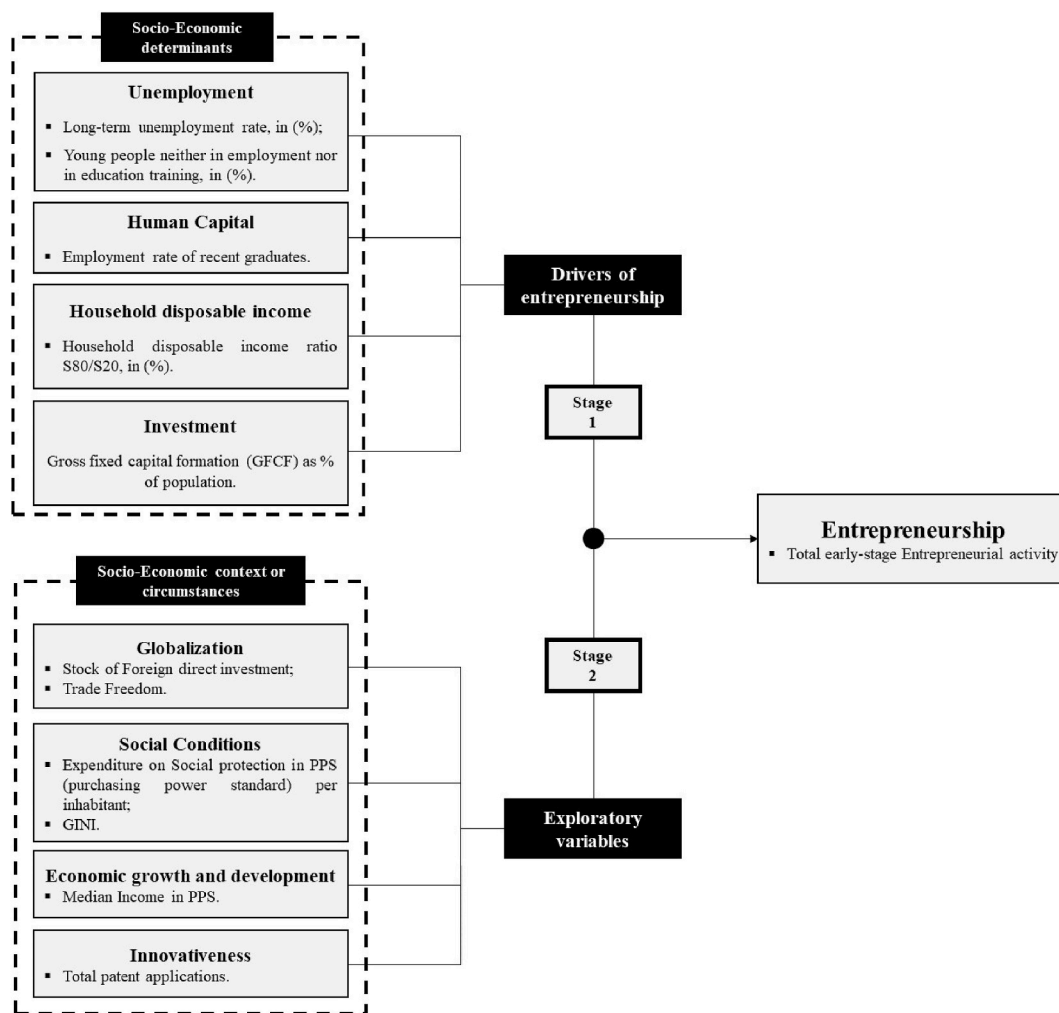


Fig. 1. Research Model. Source: Own elaboration.

3. Data and research methodologies

3.1. Period of analysis, data sources, and variables

The years 2008–2018, i.e., 11 years, is period of analysis. It was chosen because it was a decade after the subprime crisis and coincided with major social and technological changes.

The 2008/09 crisis shook markets and its impact on debt markets was unprecedented, starting with US subprime mortgages and culminating in a European sovereign default. This post 2008 period was a unique and frightening experience [75]. The responses of countries to the crisis were similarly unprecedented. For instance, the eurozone implemented austerity measures, which revealed structural weaknesses that remain unresolved, such as high pay gaps [76].

The financial crisis and its aftermath coincided with a historic change in the technological environment: e.g., the arrival of smartphones and dissemination of “big data” [77] and social networks [78], automation, artificial intelligence [79], among others. These changes are disrupting and revolutionising entrepreneurship.

There are two relevant sub-periods of analysis: between 2008–2012 and 2013–2018. The sub-prime crisis of 2008–2012 that affected Europe economically and financially triggered major changes in the European economic governance [80]. The following period bears the effects of the measures and also represents a phase in which Europe had to respond to the toughest migratory challenge since WWII [81].

Based on this argument, this study considers two main sub-periods:

one between 2008 and 2012 and the other between 2013 and 2018. The sample includes 18 European countries. Europe was one of the regions in the world that faced the most challenges in the post-subprime crisis [76]. The 18 countries are divided into sub regions according to the United Nations (UN) criteria, as presented in Table 1.

Table 2 describes the variables considered in the first stage of this study. Table 3 describes the variables considered in the second stage of this study. The variables were obtained from several sources: Eurostat, Global Entrepreneurship Monitor (GEM), Heritage Database, Organisation for Economic Co-operation and Development (OECD), World Bank and WIPO IP Statistics Data Centre.

Table 1 Sample of countries studied.

Europe Sub-region	Countries
Eastern Europe	Hungary; Poland; Romania; Slovakia.
Northern Europe	Estonia; Finland; Ireland; Sweden.
Southern Europe	Greece; Italy; Portugal; Slovenia; Spain.
Western Europe	Belgium; France; Germany; Luxembourg; Netherlands.

Note: Initially the study was intended to include more countries belonging to the European Union, such as Austria, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Latvia, Lithuania and Malta. But due to the lack of data in this period (2008–2018), namely from TEA, these countries were excluded.

Table 2
Outputs and Inputs used in first stage DEA.

Indicators	Definitions	Sources
Output	Total early-stage Entrepreneurial activity (TEA)	Percentage of (age range: 18–64) population who are either a nascent entrepreneur or an owner-manager of a new business. GEM
Inputs	Long-term unemployment rate (%)	It is the percentage of individuals who have been unemployed for 12 months or more. OECD
	Young people neither in employment nor in education training (%)	This indicator presents the share of young people who are not in employment, education, or training (NEET). Young people in education include those attending part-time or full-time education but exclude those in non-formal education and in educational activities of very short duration. Employment is defined according to the OECD/ILO guidelines. This indicator also covers all those who have been in paid work for at least 1 h in the reference week of the survey or were temporarily absent from such work. Eurostat
	Employment rate of recent graduates (%)	It presents the employment rates of people aged between 20 and 34 years old who have recently graduated from either upper secondary or tertiary levels of education (as defined by the international standard classification of education (ISCED)). Eurostat
	Household disposable income ratio S80/S20 (%)	Household disposable income in a particular year and S80/S20 is the ratio of the average income of the 20% richest to the 20% poorest. OECD
	Gross fixed capital formation (GFCF) as % of population	The acquisition of produced assets (including purchases of second-hand assets), including the production of such assets by producers for their own use, minus disposals. It is also called “investment”. OECD

3.2. Research methodologies - first stage: Data Envelopment Analysis (DEA) method

In the first stage of the analysis, this article uses the DEA method to evaluate the relative (or comparative) technical efficiency of entrepreneurship activities developed by European countries and their respective performances. It is used to estimate production frontiers and to evaluate the relative and technical efficiency of the Decision-Making Units (DMUs). The DEA model has the advantage of not imposing an explicit functional arrangement, as it does not demand a priori input and output weights [82]. Nonetheless, in our sample of EU countries, the weight of each input and output varies, as it results from cross-data and varies between each DMU (European country) throughout the period of the time considered. Arguably, a DMU is considered inefficient when compared to the so-called “benchmark DMUs” when its ranking score is below 100% [83]. The assessment of the relative efficiency requires a common set of weights to be applied to all units, which is difficult to achieve [83]. Despite this limitation, each DMU should adopt the most favourable set of weights when compared to others [83]. Consequently,

Table 3
Variables used in FRM in DEA second stage.

Indicators	Definitions	Sources
Dependent variable	Scores Technical Efficiency	DEA–first step
Independent variables	Expenditure on Social protection in PPS (purchasing power standard) per inhabitant	Social Protection encompasses all interventions from public or private bodies intended to relieve households and individuals of the burden of a defined set of risks or needs, provided that there is neither a simultaneous reciprocal nor an individual arrangement involved. The list of risks or needs that may give rise to social protection is, by convention, as follows: Sickness/Health care, Disability, Old age, Survivors, Family/children, Unemployment, Housing and Social exclusion not elsewhere classified. Eurostat
	Foreign direct investment	Foreign Direct Investment (FDI) stocks measure the total level of direct investment at a given point in time, usually the end of a quarter or of a year. OECD
	Trade Freedom	A measure formed by the absence of tariff and non-tariff barriers that affects the import and export of goods and services. Heritage Database
	Median Income in PPS (purchasing power standard)	The median income is the point where half of the people make more, and half make less. World Bank estimate
	Total patent applications (direct and PCT- Patent Cooperation Treaty national phase entries)	International patent application, which complies with the minimum requirements for obtaining an international filing date, has the effect of a national patent application (and certain regional patent applications) in or for all PCT Contracting States. The PCT - Patent Cooperation Treaty is an international treaty with more than 150 Contracting States. WIPO IP Statistics Data Center
Gini index	Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. World Bank estimate	

the relative efficiency (RE) of unit j_0 requires the following conditions and restrictions and can be calculated as a maximising function (1):

$$RE_{j_0} = \max \frac{\sum_{p=1}^s v_p y_{pj_0}}{\sum_{q=1}^m w_q x_{qj_0}}$$

Subject to:

$$\frac{\sum_{p=1}^s v_p y_{pj}}{\sum_{q=1}^m w_q x_{qj}} \leq 1, j = 1, \dots, n; v_p \geq \varepsilon, p = 1, 2, 3, \dots, s, w_q \geq \varepsilon, q = 1, 2, 3, \dots, m \tag{1}$$

In equation (1), RE_{j_0} represents the score of the relative efficiency of the unit j_0 , x_p and y_p are the inputs and outputs, respectively. p represents the number of outputs ($p = 1, 2, \dots, s$); q characterises the number of inputs ($q = 1, 2, 3, \dots, m$); the weights of outputs and inputs are represented by v and w , respectively and the number of DMUs of the sample is n .

It is possible to follow two different approaches to convert the above fractional model (1) into a linear programming model [83]: the input-oriented and the output-oriented approaches. The former maximises the numerator of the fractional models while considering the denominator as one unit, i.e. as the restriction of the model. Inversely, the latter minimises the denominator and considers the numerator as the restriction of the model. This paper follows the output-oriented approach since it was considered that European countries should aim at maximising their entrepreneurship activities and their metrics performance levels. Therefore, in order to linearise expression (1) with output orientation, the denominator must be minimised, and the numerator need to be equal to 1:

$$RE_{j_0} = \min \sum_{q=1}^m w_q x_{qj_0}$$

Subject to:

$$\sum_{p=1}^s v_p y_{pj_0} = 1; \sum_{p=1}^s v_p y_{pj} - \sum_{q=1}^m w_q x_{qj} \leq 0; v_p \geq \varepsilon, p = 1, 2, 3, \dots, s, w_q \geq \varepsilon, q = 1, 2, \dots, m; \tag{2}$$

Based on the output-oriented DEA model, the results disclose the output amount that could be enlarged by utilising the same inputs to accomplish a 100% level of relative efficiency, i.e. the ratio of the weighted sum of both of the outputs considering the weighted sum of both of the inputs should be equal to 1. Moreover, when constant returns are assumed to scale, the $RE_{j_0}^*$ is the optimal relative efficiency score for DMU j_0 and the ε is an infinitesimal positive number and the input(s) change may cause output(s) change in similar direction and percentage. As this paper uses the case of DEA-CCR, the DMUs are matched with all the DMUs of the sample and appraised based on the entrepreneurship performance of other countries of the sample. Subsequently, this non-parametric model basically represents a global technical efficiency measure.

3.3. Research method - second stage: fractional regression model (FRM)

The main advantage of the FRM is that it circumvents the problems related with Tobit and linear models during the second stage of DEA models, as the dependent variables, which result from the first-stage DEA scores. The functional form of the dependent variable is confined to a [0,1] interval, where $G(\cdot)$ is a non-linear function fulfilling the following condition: $0 \leq G(\cdot) \leq 1$ [84]. Based on [85]; the estimation of FRMs is given by:

$$LL_i(\theta) = y_i \log \Phi[G(x_i; \theta)] + (1 - y_i) + \log[1 - G(x_i; \theta)]$$

Logit and Probit functional forms are very common for specifying the $G(\cdot)$ function, although the log-log and the complementary log-log, namely cloglog, are possible alternatives (Raheli et al., 2017; [84].

There are partial effects related to each of the mentioned FRM alternatives. Those partial effects are given by $\frac{\partial E(y|x)}{\partial x_j} = \theta_j g(x\theta)$, where $g(x\theta) = \frac{\partial G(x\theta)}{\partial x\theta}$. Since $g(x\theta)$ is positive, the direction and significance of partial effects in the above mentioned models are observed from both, the θ_j signal and the statistical analysis, as in the Tobit model. There are two alternative generalised models that use an extra parameter, α , in which $\alpha > 0$ such that $0 < E(y|x) < 1$ [84]. Furthermore, when there is a large probability of the DEA score being equal to one – which indicates that the sources of DMU efficiency and of DEA inefficiency are different – two part-models could be used [84].

A standard binary choice model completes the first part of the two-part model. It influences the likelihood of detecting an efficient DMU in which z is a binary variable that takes the value of 0 (i.e. $0 < y < 1$), for an inefficient DMU, or 1 (i.e. $y = 1$) for an efficient DMU. The conditional probability of observing an efficient DMU (calculated using the maximum probability of the whole sample) is given by $\Pr(z = 1|x) = E(z|x) = F(x\beta_{1p})$, where β_{1p} represents a vector of variable coefficients and $F(\cdot)$ follows a cumulative distribution function. The second part of the two-part model is calculated using the sub-sample of inefficient DMUs, as it underpins the evaluation of the DEA scores on the interval] 0, 1[and $\langle y|x, y \in]0, 1[\rangle = M(x\beta_{2p})$, where $M(\cdot)$ may be any of the considered for $E(y|x)$, and β_{2p} is another vector of coefficients [84]. The calculation of the two-part fractional regression model is of added value *vis-à-vis* the one-part model as the latter considers all EU countries in the same estimation regardless their efficiency, whereas with the former it is possible to separately analyse the causes for some countries to be (or not) on the efficiency frontier, and how distant inefficient countries are from the efficiency frontier [86,84].

4. Results and discussion

4.1. Results of Data Envelopment Analysis

Table 4 presents the correlation matrix between the single output and the five single inputs for the first-stage DEA.

If the absolute value of Pearson correlation coefficients is larger than 0.8, then severe multicollinearity may be present; however, if it is lower than 0.8, it shows that collinearity is hardly present [87]. According to the Pearson correlation values presented in Table 4, the collinearity problem is not problematic between the inputs and the output in all European groups considered. However, the Pearson correlation coefficient helps to assess the collinearity of the inputs variables selected in DEA, whose results may lead to higher collinearity concerns between: input 1 and input 3 in the Northern group and Western group; input 1 and input 4 in the Western group; and input 3 and input 4 in the Western and Southern groups.

In first stage of DEA, the score levels of relative efficiency of TEA are considered on average in individual regional geographical localisation in Europe. Bearing that in mind, this paper performs an output-oriented DEA model, considering four European groups of countries (Eastern, Northern, Western and Southern) with different geographical and socioeconomic conditions and policies. In accordance with the different levels of regional socioeconomic development among the European countries, we hope to find, during the 2008–2018 period analysed, a significant effect of the variables (TEA; Long-term unemployment rate in %; Young people neither in employment nor in education training in %; Employment rate of recent graduates; Household disposable income ratio S80/S20 in %; Gross fixed capital formation as % of population) on technical efficiency scoring of TEA in different Geographical European groups of countries. For instance, according to Table 5, through an output-oriented DEA model, the results show the maximum efficiency level of scoring of 100%, in the Eastern European group analysed, is

Table 4
Correlation Matrix among variables included in first-stage DEA.

Eastern Group						
Ouput 1	1.0000					
Input 1	0.415***	1.0000				
Input 2	-0.0713	-0.533***	1.0000			
Input 3	0.2565	0.1319	0.562***	1.0000		
Input 4	-0.335	-0.436***	-0.3292	-0.772***	1.0000	
Input 5	0.2719	0.520***	-0.694***	-0.409***	0.415***	1.0000
Northern Group						
Ouput 1	1.0000					
Input 1	0.1086	1.0000				
Input 2	0.7127***	0.4283***	1.0000			
Input 3	0.0849	0.855***	0.3653	1.0000		
Input 4	-0.1586	-0.744***	-0.2793	-0.726***	1.0000	
Input 5	-0.471***	-0.2526	-0.5409***	-0.2263	0.554***	1.0000
Western Group						
Ouput 1	1.0000					
Input 1	-0.543***	1.0000				
Input 2	-0.189	-0.087	1.0000			
Input 3	-0.649***	0.886***	-0.026	1.0000		
Input 4	0.365***	-0.825***	0.031	-0.843***	1.0000	
Input 5	0.519***	-0.531***	0.095	-0.435***	0.145	1.0000
Southern Group						
Ouput 1	1.0000					
Input 1	0.065	1.0000				
Input 2	0.0265	0.605***	1.0000			
Input 3	-0.390***	0.497***	0.702***	1.0000		
Input 4	0.2154	-0.698***	-0.533***	-0.832***	1.0000	
Input 5	-0.404***	-0.610***	-0.0957	0.1480	0.2370	1.0000

Note: Output 1 - Total early-stage Entrepreneurial activity (TEA); Input 1 - Long-term unemployment rate (%); Input 2 - Young people neither in employment nor in education training (%); Input 3 - Employment rate of recent graduates (%); Input 4 - Household disposable income ratio S80/S20 (%); Input 5 - Gross fixed capital formation (GFCF) as % of population.

Table 5
Scores of technical efficiency of TEA in European countries under DEA-(CRS).

Eastern Group	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Hungary	0.6123	0.8761	0.6912	0.5813	0.8698	0.8545	0.8143	0.6909	0.7575	0.9194	1.0000
Poland	0.8218	0.7941	0.8521	0.8130	0.8459	0.8436	0.8101	0.8299	1.0000	0.9906	0.6954
Romania	0.3440	0.4557	0.4045	0.8808	0.7989	0.9110	1.0000	0.9242	0.9658	1.0000	1.0000
Slovakia	0.8145	0.9619	1.0000	1.0000	0.7614	0.7245	0.8265	0.7168	0.7288	0.9229	1.0000
Northern Group	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Estónia	0.6098	0.8615	0.7157	0.6551	0.7713	0.6916	0.4941	0.7065	0.8918	1.0000	1.0000
Finland	0.4854	0.3494	0.3980	0.4236	0.4041	0.3681	0.3906	0.4611	0.4690	0.5106	0.5393
Ireland	0.4286	0.4432	0.3767	0.4068	0.3519	0.5030	0.3481	0.5202	0.6082	0.4794	0.5672
Sweden	0.2781	0.2609	0.3155	0.3757	0.4047	0.5414	0.4521	0.5183	0.5656	0.5797	0.5516
Western Group	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belgium	0.2916	0.3911	0.4132	0.6136	0.5613	0.5500	0.5804	0.6566	0.5779	0.5693	0.5408
Germany	0.4849	0.5878	0.5649	0.6899	0.6556	0.6233	0.6435	0.5716	0.5386	0.6037	0.5458
France	0.5240	0.4472	0.5898	0.5619	0.5071	0.4564	0.5362	0.6385	0.5485	0.3986	0.5890
Luxembourg	0.6535	0.7716	0.6714	0.7080	0.7284	0.8224	0.6378	0.9005	0.8055	0.7654	0.9129
Netherlands	0.4936	0.7746	0.6538	0.7195	0.9835	0.9077	0.9564	0.6209	0.9479	0.8475	1.0000
Southern Group	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Spain	0.6979	0.4716	0.3724	0.5245	0.5378	0.5165	0.5063	0.5319	0.4754	0.5717	0.6152
Greece	1.0000	0.9064	0.5745	0.9461	0.8744	0.7774	1.0000	0.8591	0.6830	0.5516	0.7233
Italy	0.5993	0.5046	0.3224	0.5403	0.5798	0.4922	0.6837	0.6989	0.5816	0.5439	0.5291
Portugal	0.3922	0.4177	0.4462	0.7743	0.8114	0.8544	1.0000	0.9772	0.8661	0.9590	1.0000
Slovenia	1.0000	0.8956	0.6542	0.4993	0.7078	0.8217	0.8200	0.7659	1.0000	1.0000	0.9952

reached by Poland and Hungary in 2016 and 2018, respectively, by Romania in 2014, 2017 and 2018 and by Slovakia in 2010, 2011, and 2018.

In the Northern European Group, the maximum efficiency is achieved by Estonia, in 2017 and 2018. In the Western European Group, the Netherlands shows a maximum efficiency in 2018, while in Southern countries the maximum scores are achieved by Greece in 2008 and 2014, by Portugal in 2014 and 2018, by Slovenia in 2008, in 2016 and in 2017. For all the groups of countries considered in the analysis, the interpretation is that those countries in the referred years are on the efficiency frontier while all the other countries of their group – for example, Finland, Ireland and Sweden are considered as inefficient in

Northern Europe, while Belgium, Germany, France and Luxembourg are considered as inefficient in Western Europe, and finally Spain and Italy are considered as inefficient in Southern Europe.

4.2. Results of second stage DEA

Table 6 presents the correlation matrix among scores of technical efficiency (dependent variable) and six explanatory variables, for each group of countries and for the second stage DEA. The results of Table 6 show that the values of the correlation coefficients have a significant correlation between the Score Efficiency and explanatory variable 5 (Total patent applications), but lower than the critical value of 0.8 for

Table 6
Correlation Matrix among variables included in second stage-FRM.

Eastern Group	Score Effi	Var 1	Var 2	Var 3	Var 4	Var 5	Var 6
Score Efficiency	1.0000						
Var 1	0.3077	1.0000					
Var 2	0.0958	-0.1491	1.0000				
Var 3	0.1802	0.1887	-0.1680	1.0000			
Var 4	0.3173	0.840***	-0.1879	0.1984	1.0000		
Var 5	-0.0220	0.0214	0.3626	0.0774	0.0850	1.0000	
Var 6	-0.1048	-0.673***	0.3010	0.0099	-0.697***	0.522***	1.0000
Northern Group							
Score Efficiency	1.0000						
Var 1	-0.672***	1.0000					
Var 2	-0.0205	0.0130	1.0000				
Var 3	-0.0334	0.0937	0.2973	1.0000			
Var 4	-0.578***	0.964***	-0.0400	0.0841	1.0000		
Var 5	-0.716***	0.861***	-0.1378	0.0248	0.838***	1.0000	
Var 6	0.3686	-0.695***	0.1192	0.0524	-0.588***	-0.606***	1.0000
Western Group							
Score Efficiency	1.0000						
Var 1	0.578***	1.0000					
Var 2	0.0655	-0.0775	1.0000				
Var 3	0.419***	0.2703	-0.1344	1.0000			
Var 4	0.477***	0.955***	-0.0661	0.3068	1.0000		
Var 5	-0.2825	-0.616***	0.1456	-0.2885	-0.705***	1.0000	
Var 6	-0.0469	0.450***	-0.0192	-0.460***	0.430***	-0.0299	1.0000
Southern Group							
Score Efficiency	1.0000						
Var 1	-0.399***	1.0000					
Var 2	-0.2000	0.1814	1.0000				
Var 3	-0.1645	0.2178	0.2464	1.0000			
Var 4	-0.3064	0.659***	-0.0265	0.394***	1.0000		
Var 5	-0.612***	0.868***	0.2646	0.1694	0.571***	1.0000	
Var 6	-0.353***	0.2828	0.432***	-0.1841	-0.3218	0.507***	1.0000

Note: Var 1 - Expenditure on Social protection in PPS (purchasing power standard) per inhabitant; Var 2 - Foreign direct investment; Var 3 - Trade Freedom; Var 4 - Median Income in PPS (purchasing power standard); Var 5 - Total patent applications (direct and PCT- Patent Cooperation Treaty national phase entries); Var 6 - Gini index.

Northern Group. Moreover, other results may lead to higher collinearity concerns between some explanatory variables, in one hand, between the Expenditure on Social protection in PPS (Var1) and Median Income in PPS (Var4) for Eastern, Northern and Western groups respectively and, in the other hand, between Expenditure on Social protection in PPS (Var1) and Total patent applications (Var5) for Northern and Southern groups.

Table 7 shows the results of the specification tests for the one-part models and for both of the two-part models, for the second stage of DEA. For the Eastern European groups of countries, logit, probit, log-log, and cloglog one-part model and two-part model of the first component specifications, and based on the results of the RESET test, GOFF I and GOFF II tests, all the null hypotheses are not rejected, which is a clear statistical evidence that all four specifications are adequate, except for the second component of the two-part model, which rejects all of the null hypotheses. In the results for the Northern group (the logit, probit, log-log, and cloglog specifications one-part model), the statistical evidence rejects all of the null hypotheses, while in the two-part model under first and second component specifications, the statistical evidence does not reject all of the null hypotheses, which proves that all four specifications are adequate. Regarding the results of the Western group countries, logit, probit, log-log, and cloglog one-part model and two-part model first component specifications, and based on the results of the RESET test, GOFF I and GOFF II tests, it is not possible to reject all of the null hypotheses. As a result, there is statistical evidence proving that all four specifications are adequate, except loglog specification under one-part and two-part second component, where the statistical evidence in that specification rejects all of the null hypotheses.

Finally, in the results for the Southern group (the logit, probit, log-log, and cloglog specifications in one-part model, and two-part first and second component), the statistical evidence does not reject all of the null hypotheses, hence, this is a statistical evidence proving that all four

specifications are adequate.

The results obtained using the FRM specifications are shown in Tables 8–11 for the groups of Eastern Europe, Northern Europe, Western Europe and Southern Europe, respectively.

Results for the Eastern European group (Table 8) in the one-part model (combining inefficient and efficient countries) Logit and Probit models show that Expenditure on Social protection positively affects TEA technical efficiency at the 5% level of significance. Moreover, Foreign Direct Investment and the Gini Coefficient have a positive effect, while Total Patent Application has a negative effect on TEA technical efficiency, at 1% level of significance. The median income presents a positive effect, but only at the 10% level of significance on TEA technical efficiency. However, when we considered the first component of the two-part model (only efficient countries), according Logit, Probit, Loglog and Cloglog specifications, we can observe that Expenditure on Social protection and the Gini Coefficient have a positive effect on TEA technical efficiency, at a 5% level of significance, while the Total Patent Applications present a 5% negative effect on TEA technical efficiency.

The results of the R² coefficient range between 0.3022, shown in cloglog specification, and 0.3256, shown in loglog specification, for the one-part model. Those values are lower than those for the one-part models shown in the loglog and cloglog specification, which was expected. The R² coefficient of the first component of the two-part model has a moderate explanatory power when analysing the probability of one country of the Eastern European group to be on the TEA efficiency frontier (0.4603 in cloglog and 0.4436 in logit, respectively).

The results for the countries of the Northern European Group, for the four specifications of FRM are shown in Table 9. When observing the one-part model, it is possible to conclude that, at 1% level of significance, Expenditure on Social protection, Total Patent and Gini Coefficient present a negative effect on TEA efficiency scores; while the variable Median Income in PPS shows a positive effect on TEA

Table 7
Specification tests for the one-part model and two-part models (first and second components): 2008–2018 period for Model1.

Eastern Group	One-Part Models				Two-Part Models							
	Logit	Probit	Loglog	cloglog	First Component				Second Component			
Eastern Group	Logit	Probit	Loglog	cloglog	Logit	Probit	Loglog	Cloglog	Logit	Probit	loglog	Cloglog
RESET test	0.077	0.224	0.002	0.680	0.001	0.000	0.505	0.004	3.769**	3.586**	4.170**	3.235*
GOFF-I test	0.042	0.205			0.001	0.014		0.083	3.723**	3.596**		3.252*
GOFF-II test	0.034	0.210	0.006	0.657	0.092	0.009	0.645		3.765**	3.562**	4.192**	
P-test												
H1: FRM II–logit		0.035	0.097	0.007		0.000	0.000	0.005		3.854**	3.650**	3.849**
H1: FRM II–probit	0.281		0.396	0.127	0.786		0.000	0.010	3.556**		3.374*	3.635**
H1: FRM II–loglog	0.028	0.023		0.053	2.351	1.058		0.149	4.164**	4.163**		4.089**
H1: FRM II–cloglog	0.984	0.866	1.170		0.591	0.000	0.000		3.036*	3.111*	2.776*	
Northern Group	Logit	Probit	Loglog	cloglog	Logit	Probit	Loglog	Cloglog	Logit	Probit	loglog	Cloglog
RESET test	4.931**	5.052**	5.252**	4.382**	0.000	0.000	0.000	0.000	0.891	0.843	1.215	0.494
GOFF-I test	4.718**	5.084**		4.466**	0.000	0.000			0.920	0.828		0.486
GOFF-II test	4.869**	4.953**	5.225**		0.000	0.000			0.867	0.859	1.244	
P-test												
H1: FRM II–logit		5.155**	5.221**	4.515**		0.000	0.000	0.000		0.588	1.330	0.436
H1: FRM II–probit	5.065**		5.264**	4.308**	0.000		0.000	0.000	0.633		1.238	0.452
H1: FRM II–loglog	4.179**	5.007**		4.250**	0.000	0.000		0.000	0.894	0.812		0.413
H1: FRM II–cloglog	5.111**	5.096**	5.303**		0.000	0.000	0.000		0.880	0.874	1.252	
Western Group	Logit	Probit	loglog	cloglog	logit	Probit	Loglog	Cloglog	Logit	Probit	loglog	Cloglog
RESET test	2.761*	2.204	3.303*	1.113	0.000	0.000	0.000	0.000	2.250	1.980	2.897*	1.039
GOFF-I test	2.961*	2.083		1.008	0.000	0.000			2.528	1.888		0.957
GOFF-II test	2.538	2.401	3.483*		0.000	0.000			2.213	2.120	3.022*	
P-test												
H1: FRM II–logit		0.880	4.264**	0.736		0.000	0.000	0.000		0.903	3.671**	0.694
H1: FRM II–probit	1.154		3.846**	0.964	0.000		0.000	0.000	1.158		3.382*	0.884
H1: FRM II–loglog	2.497	1.851		0.721	0.000	0.000		0.000	2.134	1.632		0.640
H1: FRM II–cloglog	2.430	2.414	4.109**		0.000	0.000	0.000		2.227	2.188	3.630**	
Southern Group	Logit	Probit	loglog	cloglog	logit	Probit	Loglog	Cloglog	Logit	Probit	loglog	Cloglog
RESET test	0.388	0.304	0.575	0.184	0.422	0.378	0.525	0.252	0.486	0.375	0.791	0.185
GOFF-I test	0.661	0.265		0.159	0.404	0.315		0.086	0.989	0.282		0.128
GOFF-II test	0.393	0.388	0.742		0.149	0.427	0.572		0.476	0.563	1.097	
P-test												
H1: FRM II–logit		0.052	1.092	0.029		0.000	0.000	0.169		0.071	1.667	0.006
H1: FRM II–probit	0.142		0.739	0.091	1.102		0.000	0.878	0.018		0.995	0.098
H1: FRM II–loglog	0.644	0.225		0.038	1.583	0.955		1.561	0.988	0.031		0.063
H1: FRM II–cloglog	0.453	0.429	0.872		0.000	0.000	0.000		0.366	0.494	1.127	

Table 8
Estimation results for the FRM – Eastern group countries.

EASTERN PANEL	One-Part Models		Two-Part Models			
			First Component		Second Component	
	logit	Probit	Logit	Probit	Logit	Probit
	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	2.5539**	1.3778**	7.20146**	4.3218**	1.196011	0.69681
Foreign Direct Investment	0.06336***	0.03594***	1.30743	0.759032	0.03130*	0.01789*
Trade Freedom	-2.54250	-1.07740	211.5349	123.3601	-4.83860	-2.95280
Median Income in PPS	1.74902*	1.03833*	14.62803*	8.26068*	1.54574*	0.88510*
Total Patent Application	-0.92671***	-0.53096***	-7.13079**	-4.15584**	-0.48386*	-0.28122*
Gini Coefficient	9.66334***	5.63162***	67.7785**	39.5338**	5.80446*	3.39826*
<i>Cons</i>	-50.1777	-30.3581	-1328.545	-733.365*	-17.0630	-9.23709
<i>Obs</i>	44	44	44	44	36	36
<i>R</i> ²	0.3178	0.3108	0.4436	0.4380	0.2482	0.2408
	loglog	Cloglog	Loglog	Cloglog	Loglog	Cloglog
	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	2.38172**	1.08702**	4.97247**	5.45534**	1.06999	0.615261
Foreign Direct Investment	0.05679***	0.03176***	0.86989	0.994610	0.02809*	0.015818*
Trade Freedom	-2.65590	0.149468	159.664*	149.676	-3.79171	-2.695930
Median Income in PPS	1.46733*	0.99592*	8.281001	12.4139*	1.35658*	0.783236*
Total Patent Application	-0.80543***	-0.48027***	-4.48835**	-5.79953**	-0.42006*	-0.25488*
Gini Coefficient	8.27530***	5.21812***	42.35011**	55.3884**	4.9993*	3.10629*
<i>Cons</i>	-41.7417	-32.4132	-948.9929*	-982.6011	-16.5933	-8.36401
<i>Obs</i>	44	44	44	44	36	36
<i>R</i> ²	0.3256	0.3022	0.4253	0.4603	0.2580	0.2287

Notes: *, **, and *** mean statistically significance at 10%, 5%, and 1%, respectively.

Table 9
Estimation results for the FRM – Northern group countries.

NORTHERN PANEL	One-Part Models		Two-Part Models	
			Second Component	
	logit	Probit	Logit	Probit
	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	-4.40320***	-2.74778***	-2.541.9**	-1.58298**
Foreign Direct Investment	0.009641	0.006268	0.0001259	0.000109
Trade Freedom	5.938207	3.59614	5.517071	3.456656
Median Income in PPS	4.89943***	3.06365***	2.578353**	1.60717**
Total Patent Application	-0.316209***	-0.19562***	-0.238568***	-0.148107***
Gini Coefficient	-5.53225***	-3.44962***	-3.19667**	-1.99444**
Cons	-13.5614	-8.05958	-14.25831	-8.97473
Obs	44	44	42	42
R ²	0.6705	0.6740	0.5621	0.5628
	loglog	Cloglog	Loglog	Cloglog
	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	-3.27970***	-2.92579***	-1.89856**	-1.72996**
Foreign Direct Investment	0.004589	0.009048	-0.01132	0.001166
Trade Freedom	4.75371	3.289557	4.416	3.593674
Median Income in PPS	3.63631***	3.26650***	1.90447**	1.76073**
Total Patent Application	-0.23688***	-0.20754***	-0.17784***	-0.161349***
Gini Coefficient	-4.03991***	-3.69558***	-2.36513**	-2.18860**
Cons	11.30971	-6.546115	-11.52853	-9.387882
Obs	44	44	42	42
R ²	0.6583	0.6871	0.5568	0.5673

Table 10
Estimation results for the FRM – Western group countries.

WESTERN PANEL	One-Part Models		Two-Part Models	
			Second Component	
	logit	Probit	Logit	Probit
	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	6.94750***	4.26832***	6.88579***	4.24396***
Foreign Direct Investment	0.015241**	0.009052**	0.01408*	0.008370*
Trade Freedom	5.32977	3.155882	6.78879*	4.08845*
Median Income in PPS	-4.31035*	-2.63145*	-4.7996**	-2.95513**
Total Patent Application	0.02303	0.015545	-0.011778	-0.006607
Gini Coefficient	-2.53608	-1.62222	-1.46635	-0.946417
Cons	-36.4669**	-21.8327**	-40.8463**	-24.6366**
Obs	55	55	54	54
R ²	0.5436	0.5463	0.5565	0.5588
	loglog	Cloglog	Loglog	Cloglog
	DEA-CRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	5.19416***	4.48045***	5.1438***	4.48611***
Foreign Direct Investment	0.013065**	0.007903*	0.01217**	0.007320
Trade Freedom	4.35865	2.95499	5.52491*	3.96746*
Median Income in PPS	-3.20961*	-2.68824*	-3.57135**	-3.08895**
Total Patent Application	0.017767	0.020761	-0.00846	-0.004675
Gini Coefficient	-1.62986*	-2.00155*	-0.823076	-1.24657
Cons	-29.5911**	-21.4451**	-33.2279**	-24.3544**
Obs	55	55	54	54
R ²	0.5289	0.5609	0.5434	0.5714

Notes: *, **, and *** mean statistically significance at 10%, 5%, and 1%, respectively.

efficiency. The R² coefficients show consistent high values, with Probit and Cloglog specifications with largest results in the one-part models. However, when we analyse the results for the second component of the two-part model (only inefficient countries) we can observe the variables Expenditure on Social protection, and Gini Coefficient exert a negative pressure on TEA scores, at a 5% level of significance, while the effect of

Total Patent Application on TEA efficiency is statistically significant at 1%. The results of the R² coefficient in the second component of the two-part model show a large explanatory power when analysing the probability of one country of the Northern European group to be on the TEA efficiency frontier (0.5628, in Probit specification and 0.5673 in Cloglog specification).

Table 10 presents all specifications of FRM for the Western European group of countries. The effect of Expenditure on Social Protection on TEA efficiency is statistically significant at 1% level, leading to higher social and economic pressures in one-part and two-part models, second component. Additionally, the coefficient of Foreign Direct Investment also shows a positive effect on scores of TEA technical efficiency, with a 5% statistical significance level. Both coefficients are aligned with what was theoretically expected for the one-part model and second component of the two-part model.

The large values found for the R² coefficients are consistent for all specifications of the one-part models. Besides, the results obtained in the second component of the two-part models for the R² coefficients a large explanatory power under the probit and cloglog specifications (0.5588 and 0.5714).

The results for the countries of the Southern European Group, for all the specifications of FRM are presented in Table 11. Analysing the one-part model and second component of the two-part model it is possible to conclude that the coefficient of Expenditure on Social protection is positive and influences TEA efficiency at 1% level of significance, while the Total Patent Applications coefficient has a negative effect on the TEA efficiency at 1% level of significance. The large values found for the R² coefficients are highly consistent, with one-part models showing larger values than for the second component of the two-part model. Furthermore, when the first component of the two-part model is analysed, according to the four specifications, it is possible to conclude that the variables show no significant statistical evidence for supporting their effects on TEA efficiency at a 5% level of significance.

The results of the R² coefficient in the one-part model and the second component of the two-part model show a moderate explanatory power when analysing the probability of one country of the Southern European group to be on the TEA efficient frontier. Additionally, according to the R² obtained in the first component of the two-part model, the results of the subsample of efficient countries are lower than those of the sample of inefficient countries, which could explain the higher values of R²

Table 11
Estimation results for the FRM – Southern group countries.

SOUTHERN PANEL	One-Part Models		Two-Part Models			
			First Component		Second Component	
	Logit	Probit	Logit	Probit	Logit	Probit
	DEA-CRS	DEA-CRS	DEA-VRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	3.90993***	2.37507***	9.42280	6.17588	3.50566***	2.14009***
Foreign direct investment	0.004003	0.0029495	1.62102	0.947094	-0.021259	-0.0127718
Trade Freedom	-3.957213	-2.381115	-20.9889	-11.3781	-2.28875	-1.354106
Median Income in PPS	0.580771	0.243488	-8.95706	-5.43247	1.26118	0.684994
Total Patent Application	-0.851836***	-0.499773***	-1.69104	-0.982836	-0.836308***	-0.497981***
Gini Coefficient	0.480190	0.222302	-17.4061	-10.2261	2.212557	1.275901
Cons	-15.7281	-8.527738	153.7688	82.16567	-32.25217	-18.9179
Obs	55	55	54	54	48	48
R ²	0.4575	0.4577	0.2265	0.2243	0.4289	0.4290
	loglog	Cloglog	Loglog	Cloglog	Loglog	Cloglog
	DEA-CRS	DEA-CRS	DEA-VRS	DEA-CRS	DEA-CRS	DEA-CRS
Expenditure on Social	3.03225***	2.48633***	6.65466	6.75051	2.67310***	2.28595***
Foreign direct investment	0.0031786	0.0030676	0.920332*	1.372095	-0.015695	-0.0132268
Trade Freedom	-3.393645	-2.235437	-9.917608	-18.90934	-2.07879	-1.206832
Median Income in PPS	-0.649927	0.0046139	-5.33029	-7.45142	1.170629	0.476745
Total Patent Application	-0.70684***	-0.472648***	-0.949235	-1.375968	-0.67960***	-0.485051***
Gini Coefficient	0.460954	0.088254	-9.70593*	-15.16895	1.84835	1.134585
Cons	-12.1715	-8.00077	69.1878	145.2806	-24.91896	-18.8319
Obs	55	55	54	54	48	48
R ²	0.4547	0.4590	0.2204	0.2372	0.4237	0.4320

Notes: *, **, and *** mean statistically significance at 10%, 5%, and 1%, respectively.

obtained in the second component of the two-part model.

5. Results discussion

Based on the results already found and presented in the first and second stage of DEA, this paper sustains the statistical significance found for the most economic and social drivers of the TEA. In this relationship, the variation of the TEA score is analysed *vis-à-vis* the evolution of the economic and social drivers used in the second stage of DEA technique. The study reveals that the groups of countries analysed behave differently, since the EU is composed of countries with unique socioeconomic characteristics [10] that influence differently the drivers of entrepreneurial activity [5].

In addition, taking into account the different ranks of TEA-efficiency found in the first stage for the different countries (see Fig. 2 for first 2008–2012 period and Fig. 3 for 2013–2018 period), it is possible to conclude that among the Eastern Europe group, Romania and Hungary

show the highest average change with 11.37% and 6.44% on technical efficiency scoring of TEA. This means that, from 2008 to 2012, in terms of average variation, Romania and Hungary were the two countries that grew the most in TEA.

This average score is accomplished with particular positive average change on rate of return of median income by 4.80% and 3.55%. However, Romania presents the largest negative average variation (-35.98%) on rate of return of Foreign Direct Investment (FDI), while Hungary shows the highest positive change (20.59%) of rate of return of FDI.

The TEA scores in Estonia and Sweden are, respectively, 4.04% and 3.17%. These positive changes on TEA scores are accomplished by a high positive and significant (16.07%) change of total Patent applications in Estonia, and by a negative and significant change (20.25%) of rate of return of FDI in Sweden. Moreover, Estonia and Sweden present a positive change on rate of return of median income, of 1.06% and 2.00%, respectively.

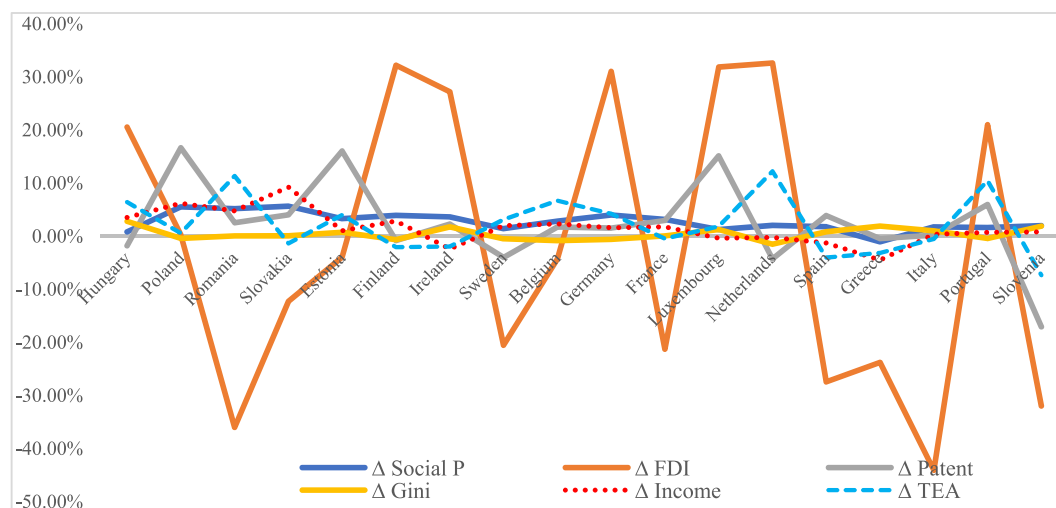


Fig. 2. Results for the First period (2008–2012)

Note: Data presented in Table B1 in Appendix supports the figure herewith presented.

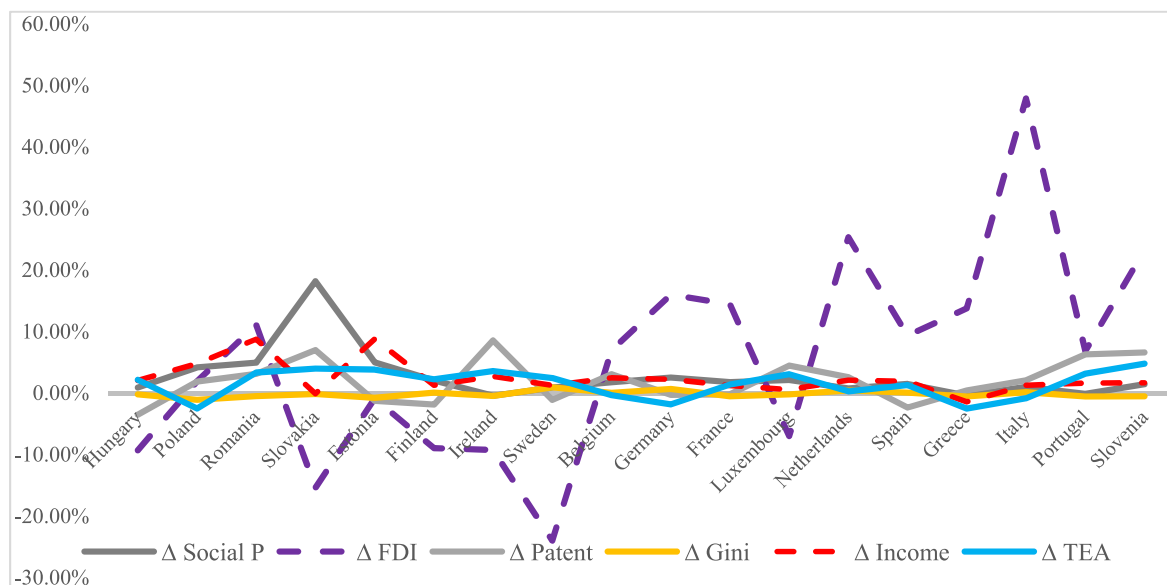


Fig. 3. Results for the second period (2013–2018)
 Note: Data presented in Table B2 in Appendix supports the figure herewith presented.

When considering the countries that compose the group of Western Europe, we can observe a positive and significant average variation of TEA efficiency scoring in the Netherlands, of 12.25%, followed by Belgium and Germany, with TEA scores of 6.74% and 4.27%, respectively. Nonetheless, this positive change is accomplished by a positive and significant average change of rate of return of Patent application of 32.65% for the Netherlands, while Germany presents a positive and significant change on rate of return of FDI of 31.09%. Furthermore, the change of the average of rate of return of median Income is positive in Belgium and Germany, with 2.35% and 1.61%, respectively, which contributes to explain the TEA efficiency changes.

Finally, among the Southern group countries, Portugal shows the highest average change in average scoring of TEA efficiency, of 10.48%, accomplished by the change of rate of return of Patent applications and FDI with 21.02% and 6.01%, respectively. However, Portugal presents a low (0.75%) change of average rate of return of median Income, while contrarily, we can observe Slovenia with a negative and significant change of TEA efficiency (7.31%) accomplished by the negative change of the rate of return of Patent applications and FDI with scores of 17.05% and 31.96%, respectively.

In summary, Total Patent Application had a negative (low magnitude coefficient) statistical significance on TEA for Eastern, Northern and Southern EU countries. This might be explained as a result of the patent application formalities and bureaucracy generated an increase in R&D costs, affecting the generation of future innovations, in these countries. Entrepreneurship, in practice, implies flexibility and trial-error processes, especially in small and medium-sized companies.

These results reveal that in the 2008–2012 period, social conditions (expenditure on social protection and the Gini coefficient) do not show significant variations between countries or sub-regions in Europe. In this case, the mixed results of the measures of social protection on the entrepreneur are not verified [65,66]. One of the possible explanations is the fact that there are common inclusive and sustainable social protection programmes in Europe [65], which avoid significant differences among countries.

In general, Expenditure on Social Protection has a positive (high magnitude coefficient) statistical significance on TEA in Eastern, Western and Southern EU countries, while it generates a negative (high magnitude coefficient) statistical significance on TEA in Northern EU countries. In the Eastern, Western and Southern EU countries, in contrast with Northern EU countries, presumably the dimensions of the

social welfare (employment and unemployment protection, among others) are intended to encourage workers to invest in specific skills and/or new businesses. ‘Risky’ investments are supposed to take place when workers have social support. In Northern European countries, there is probably a greater culture of risk and stigma regarding Expenditure on Social Protection, which generates idleness and inactivity.

In addition, the results also disclose that the degree of inequality in the distribution of income/wealth (GINI) of the efficiency of entrepreneurship was not statistically significant in several countries during the 2008–2012 period, with the exception of Eastern European countries, where the Gini coefficient presents a large statistically significant positive coefficient on TEA. It is expectable that social stratification based on income [27,2] can generate different entrepreneurial activities as families with the best incomes are also those with the best resources to capture business opportunities [36]. Eastern European entrepreneurs are probably characterised by necessity-driven entrepreneurship, which is related to income inequality or other income-related factors. Generally, opportunity-driven entrepreneurship is not influenced by the country’s income inequality, as was the case in the rest of Europe (Northern, Southern and Western countries). It is very likely that entrepreneurs in these countries take other factors into consideration, such as personal fulfilment.

Regarding the phenomenon of globalisation between 2008 and 2012, the Trade Freedom variable was not included in this discussion of results, because it did not present useful outcomes for analysis. However, Foreign Direct Investment disclosed significant differences across countries. Thus, results corroborate that the effectiveness of FDI in domestic entrepreneurship is confusing [54] and negative in some cases [59]. For instance, in Eastern and Southern European countries, results are generally negative whereas in Northern and Western European countries they are predominantly positive. In fact, not all countries can benefit from Foreign Direct Investment equally [57]. It is possible to argue that institutional and governance quality in Eastern and Southern Europe [63,60,61] has not been capable of using FDI to increase their entrepreneurial activities.

Economic growth and development, measured by the Median Income in PPS, does not reveal significant differences across countries in the period 2008–2013. As such, it is possible to claim that economic activity encourages entrepreneurship [69]. In general, the countries of the European Union are prosperous economies, thus, their entrepreneurs are expected to be innovative, internationalised, and focused on growth

[68].

Finally, regarding innovativeness during 2008–2012, based on Total Patent Applications, the results show that East and Western countries were the most active. It should be noted that success of entrepreneurship is strongly related to innovation [74,72,73].

When considering the 2013–2018 period of analysis (Fig. 3), we can observe that in the Eastern European countries the largest average of change in TEA scoring occurs in Slovakia with 3.98%, complemented by the largest increase in rate of change of Expenditure on Social protection of 18.19% and in rate of change of Patent applications of 7%; while the rate of change of median Income is negative and lower, scoring 0.09%. However, in Romania the TEA-efficiency change is positive with 3.35% accomplished by the change of rate of change of median Income scoring 8.77% and by the rate of change of FDI, whose average is 11.08%. When observing the Northern countries, Estonia shows the greater rate of change of median Income of 8.30%, which contributes to explain the positive change (3.81%) in TEA efficiency average score.

When considering the Western group of countries, Luxembourg presents a positive change on TEA efficiency of 3.08%, a positive change of rate of change of Patent applications of 4.16% and a low change of return of median Income of 0.54%. Contrastingly, Belgium and Germany show a negative change in the lower average medium of TEA efficiency of 0.34% and 1.83%, and these changes are accomplished by a positive average change on the rate of change of median Income of 2.48% and 2.25% respectively, and a positive rate of change of FDI of 6.97% and 15.99% in Belgium and Germany, respectively. For the Southern group of countries, the worst performance of scoring of TEA efficiency is provided by Slovenia and Portugal. Furthermore, Slovenia even registered a positive change of rate of change of FDI of 23.25%, a rate of change of Patent applications of 6.62% and a rate of median Income of 1.67%, while Portugal presents an average score of 3.14% for the change of TEA efficiency and this change is accomplished by a positive effect of the rate of change of median Income, FDI and Patent application of 1.63%, 6.82% and 6.30%, respectively (translating into positive rates of return of these three variables).

Therefore, during the 2013–2018 period, in comparison with the previous period (2008–2012) and considering the social conditions circumstances, namely on the Expenditure on Social protection, an increase is verified in the Eastern countries. In these countries, social protection was likely inclusive and sustainable and helped to promote entrepreneurship [65]. Regarding the innovativeness, economic growth and development context, the analysis is similar to the first period (2008–2012), although there is an upward trend in Total Patent Applications in southern European countries, with effects on entrepreneurial activities. Thus, in this second period, innovations were expected to be important for entrepreneurial activity in Southern countries [74,72,73].

Regarding the phenomenon of globalisation, there has been a significant change in the use of Foreign Direct Investment. This study highlights the international orientation of European companies, through FDI, which allows them access to new foreign markets, advanced technologies, more effective management methods, among others, in order to promote investment growth and generate business opportunities [58].

Moreover, and more specifically, countries in Eastern and Southern Europe benefit significantly from FDI. One way to combat the financial crisis is to invest in institutional capacity to create specific entrepreneurial conditions [57], as well as types of investments or international partnerships [62].

As observed from results, there is a need to increase TEA overall in different countries of the European community if the goal is to achieve a better performance of TEA, namely: higher economic growth, an increase in the use of advanced innovative technologies and Patent applications, and an increase in the FDI flows. Therefore, policymakers should carefully weigh the costs of entrepreneurship activities and the benefits of increasing economic growth and greater social conditions [5]. In order to attain TEA-efficiency, the results suggest that

stakeholders (national policymakers and multinational firms) should jointly optimise the regional social and economic development, considering some drivers used in our analysis, such as, FDI, advanced technologies (namely Patent applications), inequality income distribution, among others drivers, and simultaneously optimise entrepreneurial activities in different economic activities.

Entrepreneurial activities vary widely across countries and over time [5]. Concomitantly [9], suggest separating EU countries into regions. Since EU is composed of countries with unique socioeconomic characteristics, the results of this study allowed us to assess differences regarding entrepreneurial activity between groups/regions of countries (North, South, East and West Europe). Overall, after 2013 entrepreneurship played a central role in this recovery. It has helped countries to re-emerge, as entrepreneurs are opportunity-oriented and risk takers. However, the study highlights the importance of member states investing in several aspects that foster entrepreneurship, for instance, institutional and governance quality [60,61], legal, political conditions [63], and partnerships [62]. Therefore, the relative efficiency of TEA that could lead to socioeconomic growth is not always of added value in every country and can lead to higher social expenses.

6. Conclusions

In terms of regional and geographical economies in Europe, our results in first stage of the TEA-efficiency scores present some improvement targets and provide valuable insights into how each European country performs compared to other countries included in specific groups, as well as among other regional/geographical groups of countries, to contribute towards national wealth and affect economic growth. On the other hand, our results aid all stakeholders and regional representatives in developing more effective regulations and financial incentives or subsidies to promote the entrepreneurship activities at domestic level, and consequently, these national entrepreneurship activities are recognised by the European community – for instance, policies and/or pedagogical actions that promote a ‘culture of risk’ or incentives for self-employment, especially for the unemployed – in terms of the globalisation effect. The quality of the population’s education and the knowledge obtained are also decisive for developing entrepreneurial skills. The funding and capital available for entrepreneurship are very important in the diffusion of an entrepreneurial culture throughout the country. Moreover, the existence of several financial mechanisms can support entrepreneurs in the creation and development of companies with growth potential.

Moreover, the discussion of our results in the second stage of DEA underpins a closer perspective of how economic and social impacts emerge in TEA efficiency keeping the social and economic sustainable development, whose variables or factors are required to explain the evaluation of the total entrepreneurship activities for all economic sectors.

This study is unique as it overviews the performance of entrepreneurial activities in certain European countries in a period of demanding challenges (2008–2018) and assesses the impact of socioeconomic variables on entrepreneurial activities. In addition, it uses robust statistical methods to study such impacts, which is another contribution of this article.

It would be interesting in future studies to carry out similar analyses to compare the socioeconomic idiosyncrasies related to entrepreneurship in more European countries.

Regarding the limitations faced in this research, the lack of data on entrepreneurial activity in other European Union countries should be highlighted, which explains why they were not included in this study. Another limitation resides in the fact that the study analyses entrepreneurship with only a single TEA indicator. Future studies could include more indicators, such as the newly formed start-ups.

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Credit author statement

Pedro Mendonça da Silva: Conceptualization, Writing Original Draft, Data Curation, Visualization. **Victor Ferreira Moutinho:** Methodology, Software, Data Curation, Formal analysis, Validation, Data

Curation. **António Carrizo Moreira:** Validation, Writing- Reviewing and Editing, Visualization.

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Appendix

Table A1
Descriptive Statistics for variables included in first stage DEA

Eastern Group	Obs	Mean	St Deviation	Minimum.	Maximum
Output 1	44	9.319	2.217	3.98	14.2
Input 1	44	4.172	2.395	1	10
Input 2	44	4.838	1.342	3.039	8.333
Input 3	44	12.997	2.434	8.7	18.1
Input 4	44	76.047	5.386	66.2	8725
Input 5	44	0.228	0.049	0.161	0.338
Northern Group					
Output 1	44	8.624	3.7022	3.452	20.165
Input 1	44	3.043	2.3435	0.8	9.2
Input 2	44	4.423	0.7448	3.53	6.476
Input 3	44	10.752	3.588	6	19.4
Input 4	44	79.663	5.2879	64.5	88.3
Input 5	44	0.7812	0.3480	0.235	1.776
Western Group					
Output 1	55	6.491	2.193	2.85	12.29
Input 1	55	2.756	1.117	1.1	4.6
Input 2	55	4.228	0.383	3.581	5.213
Input 3	55	7.979	2.914	3.9	12.7
Input 4	55	84.381	5.648	71.8	92.8
Input 5	55	0.890	0.320	0.579	1.661
Southern Group					
Output 1	55	5.990	1.790	2.35	9.97
Input 1	55	7.278	4.516	1.8	19.5
Input 2	55	5.495	1.091	3.245	6.881
Input 3	55	14.303	4.674	6.5	22.1
Input 4	55	65.863	12.461	40	84.2
Input 5	55	0.381	0.116	0.192	0.674

Table A2
Descriptive Statistics for variables included in second stage FRM

Eastern Group	Obs	Mean	St Deviation	Minimum.	Maximum
Score Efficiency	44	0.820	0.159	0.344	1
Var 1	44	8.162	0.304	7.506	9.338
Var 2	44	6.772	4.990	-9.584	9.675
Var 3	44	4.467	0.008	4.452	4.477
Var 4	44	8.866	0.364	8.026	9.351
Var5	44	7.282	0.928	5.746	8.855
Var 6	44	3.430	0.118	3.226	3.608
Northern Group					
Score Efficiency	44	0.533	0.172	0.278	1
Var 1	44	8.823	0.452	7.877	9.253
Var 2	44	6.720	5.604	-10.243	12.291
Var 3	44	4.467	0.008	4.452	4.477
Var 4	44	9.650	0.324	8.910	9.950
Var5	44	7.795	1.439	5.030	9.551
Var 6	44	3.401	0.082	3.288	3.558
Western Group					
Score Efficiency	55	0.641	0.159	0.291	1
Var 1	55	9.282	0.165	9.018	9.666
Var 2	55	7.807	6.471	-9.726	12.095
Var 3	55	4.455	0.025	4.391	4.477

(continued on next page)

Table A2 (continued)

Eastern Group	Obs	Mean	St Deviation	Minimum.	Maximum
Var 4	55	9.939	0.158	9.725	10.295
Var5	55	10.181	1.494	7.196	12.125
Var 6	55	3.414	0.073	3.310	3.552
Southern Group					
Score Efficiency	55	0.698	0.202	0.322	1
Var 1	55	8.681	0.159	8.471	9.028
Var 2	55	7.727	3.870	-9.290	11.251
Var 3	55	4.453	0.027	4.391	4.477
Var 4	55	9.458	0.212	9.068	9.724
Var5	55	8.046	1.482	5.924	10.382
Var 6	55	3.492	0.140	3.165	3.600

Note: Var 1 - Expenditure on Social protection in PPS (purchasing power standard) per inhabitant; Var 2 - Foreign direct investment; Var3 - Trade Freedom; Var 4 - Median Income in PPS (purchasing power standard); Var 5 - Total patent applications (direct and PCT- Patent Cooperation Treaty national phase entries); Var 6 - Gini index.

Table B1

Data supporting Fig. 2 – Results for the First period (2008–2012).

Country	Δ Social P	Δ FDI	Δ Patent	Δ Gini	Δ Income	Δ TEA
Hungary	0.87%	20.59%	-1.78%	2.83%	3.55%	6.44%
Poland	5.56%	0.28%	16.69%	-0.38%	6.22%	0.60%
Romania	5.22%	-35.98%	2.56%	0.07%	4.80%	11.37%
Slovakia	5.68%	-12.25%	4.05%	0.10%	9.27%	-1.33%
Estónia	3.34%	-3.91%	16.07%	0.77%	1.06%	4.04%
Finland	3.95%	32.24%	-0.79%	-0.64%	2.88%	-2.03%
Ireland	3.65%	27.22%	2.32%	1.79%	-2.38%	-1.92%
Sweden	1.44%	-20.52%	-3.97%	-0.45%	2.00%	3.17%
Belgium	2.86%	-4.29%	1.76%	-0.81%	2.35%	6.74%
Germany	4.05%	31.09%	1.57%	-0.57%	1.61%	4.27%
France	3.19%	-21.26%	2.99%	0.08%	1.78%	-0.42%
Luxembourg	1.28%	31.90%	15.16%	1.27%	-0.34%	1.87%
Netherlands	2.07%	32.65%	-4.26%	-1.49%	-0.22%	12.25%
Spain	1.81%	-27.43%	3.91%	0.86%	-1.26%	-4.00%
Greece	-1.02%	-23.75%	-0.43%	1.93%	-4.47%	-3.14%
Italy	1.78%	-44.08%	0.25%	1.01%	0.38%	-0.49%
Portugal	1.67%	21.02%	6.01%	-0.41%	0.75%	10.48%
Slovenia	2.02%	-31.96%	-17.05%	1.93%	0.82%	-7.31%

Table B2

Data supporting Fig. 3 – Results for the second period (2013–2018)

Country	Δ Social P	Δ FDI	Δ Patent	Δ Gini	Δ Income	Δ TEA
Hungary	0.91%	-9.29%	-3.51%	-0.20%	2.06%	2.17%
Poland	4.17%	1.93%	1.86%	-1.10%	4.79%	-2.51%
Romania	4.94%	11.08%	3.13%	-0.50%	8.77%	3.35%
Slovakia	18.19%	-15.39%	7.00%	-0.15%	-0.09%	3.98%
Estónia	5.00%	-0.86%	-1.25%	-0.77%	8.80%	3.81%
Finland	2.04%	-8.96%	-1.86%	0.06%	1.27%	2.25%
Ireland	-0.44%	-9.23%	8.56%	-0.48%	2.73%	3.59%
Sweden	0.89%	-23.98%	-1.10%	0.94%	1.24%	2.45%
Belgium	1.75%	6.97%	3.07%	0.04%	2.48%	-0.34%
Germany	2.53%	15.99%	-0.27%	0.68%	2.25%	-1.83%
France	1.78%	14.43%	-0.20%	-0.53%	1.23%	1.37%
Luxembourg	2.12%	-7.00%	4.46%	-0.20%	0.59%	3.08%
Netherlands	0.76%	25.32%	2.58%	0.42%	2.10%	0.27%
Spain	1.48%	9.34%	-2.34%	0.08%	1.90%	1.29%
Greece	-0.38%	13.76%	0.45%	-0.55%	-1.41%	-2.52%
Italy	1.01%	47.89%	2.07%	0.14%	1.26%	-0.84%
Portugal	-0.12%	6.82%	6.30%	-0.55%	1.63%	3.14%
Slovenia	1.43%	23.25%	6.62%	-0.53%	1.67%	4.79%

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